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AMERICAN RIVER WATERSHED, CALIFORNIA: COMMON FEATURES PROJECT: NATOMAS BASIN

COMMUNICATION

FROM

THE ASSISTANT SECRETARY, CIVIL WORKS, THE DEPARTMENT OF THE ARMY

TRANSMITTING

THE COMMON FEATURES PROJECT AUTHORIZED BY SECTION 101(a)(1) OF THE WATER RESOURCES DEVELOPMENT ACT OF 1996

PART 2 OF 4



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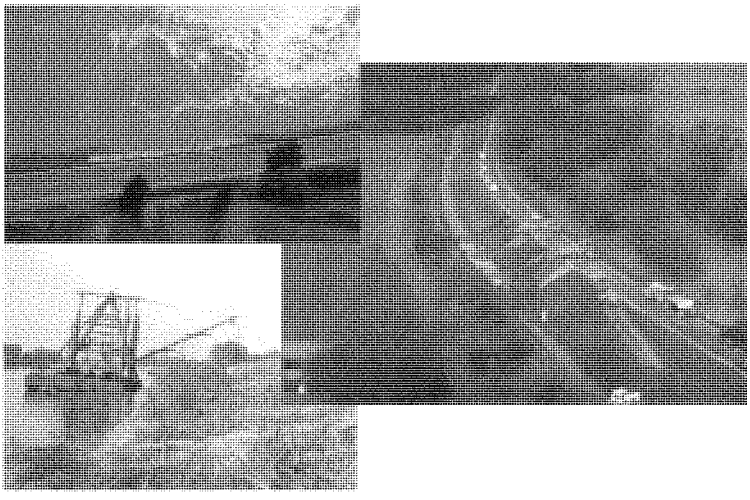
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AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

Post-Authorization Change Report
And Interim General Reevaluation Report

American River Watershed

Common Features Project
Natomas Basin
Sacramento and Sutter Counties, California



SAFCA
Sacramento
Area Flood
Control
Agency

US Army Corps
of Engineers ®
Sacramento District
August 2010

Appendix F - Geotechnical
(Part 1)

NATOMAS POST-AUTHORIZATION CHANGES REPORT
GEOTECHNICAL APPENDIX

August 2010

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ENCLOSURE F2: **Calculation Package**

ENCLOSURE F3: **Geotechnical Improvement Features**
ENCLOSURE F4 : **Risk aud Uncertainty Analyses**

ENCLOSURE F5 : **Expert Elicitation Report**

ENCLOSURE F6: **URS Seismic Analysis for CF GRR**

Natomas Post-Authorization Changes

Geotechnical appendix

1. INTRODUCTION

This Appendix presents the assessment of the geotechnical conditions and the proposed mitigation measures for the Natomas Post-Authorization Changes Report (NPACR). The Natomas Basin is protected by four levee units, managed by the Central Valley Flood Protection Board (CVFCB), part of the California State Department of Water Resources (DWR), and the Sacramento Valley Flood Control Agency (SAFCA). The levees are operated by Reclamation District 1000 (RD 1000). The four levee units are as follows:

- Levee Unit 1 extending along the east bank of the Sacramento River between the confluence with the Natomas Cross Canal at the upstream end and American River at the downstream end;
- Levee Unit 2 along the north bank of the American River between the confluence with the Sacramento River and the Natomas East Main Drainage Canal (NEMDC);
- Levee Unit 3 along the west bank of the NEMDC and the Pleasant Grove Creek Canal (PGCC), with a gap at Sankey Road; and
- Levee Unit 4 along the south bank of the Natomas Cross Canal (NCC) between the Pleasant Grove Creek Canal and Sacramento River.

The levees protecting the Natomas Basin are under current evaluation by the DWR as part of their Urban Levee Evaluation Program (ULE). SAFCA initiated the Natomas Levee Improvement Program (NLIP) to improve the conditions of the levee and to increase the levee integrity to the recurrent standards. Improvements of the levee geotechnical conditions and levee evaluation are currently ongoing.

The geotechnical report includes the assessment of the existing geotechnical conditions of the levees protecting the Natomas basin based on geomorphology, geotechnical subsurface explorations, seepage and stability analyses, and geotechnical risk based analyses. The report also includes proposed mitigation measures for the seepage and stability issues to improve the existing levees to the standard requested by the Corps of Engineers. Deterministic seepage and stability analyses as well as geotechnical reliability analyses of the seepage and stability mitigation measures are also included in the report. The reliability analyses were used by the economical analyses in the determination of the federal interest in the levee improvement. The following tasks were performed for this study:

- Review of existing sources of information.
- Review of the existing geotechnical conditions of the levees and their foundation.
- Description of each existing levee units including design features and subsurface conditions.
- Reliability analyses of the existing conditions of each levee units, including identification

of distinct reaches along each unit with similar geotechnical and economical conditions, identification of critical index point on each reach based on deterministic analyses, and reliability analyses for each identified index point.

- Proposed mitigation measures for each reach considering the load of different stages in the river/canal, including deterministic seepage and stability analyses and geotechnical reliability analyses for each index point and mitigation measures.

The evaluation of the existing condition was based on the historical subsurface investigation performed by the Corps of Engineers, DWR and SAFCA for the design of the project supplemented with additional recent investigation performed by the Corps for this feasibility study, by the DWR for the Urban Levee Evaluation (ULE) programs, and by SAFCA for the Natomas Levee Improvement Program (NLIP), such as cone penetrometer tests and laboratory testing performed on selected samples collected from borings drilled in some areas considered critical.

2. SOURCES OF INFORMATION

The primary sources of information for the subsurface conditions of the existing levee are as follows:

a. Natomas General Evaluation Report, American River Watershed Project (Common Features), California, URS, 2005.
b. Geotechnical Basis of Design, Geotechnical Evaluation Of Levees For Sac River Flood Control System Evaluation, Lower Sac River Area Phase IV, USACE, February 1993
c. Final Geotechnical Report, Natomas GRR, URS, 29 November 2005.
d. Problem Identification Report, Natomas Cross Canal, Kleinfelder, February 2006.
e. Alternatives Analyses Report for Seepage/Stability Mitigation, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sutter Co. California, Kleinfelder, 29 April 2006.
f. Natomas Levee Evaluation Study, Prepared for SAFCA by MBK Engineers, Kleinfelder, and others, July 14, 2006.
g. Alternatives Analysis Report for Seepage Mitigation, Sacramento River East Levee, Natomas Basin Evaluation, Reclamation District 1000, Sacramento and Sutter Co. California, Kleinfelder, 25 September 2006.
h. Geotechnical Data Report, Natomas Cross Canal South Levee, Natomas Basin Evaluation, Reclamation District 1000, Sacramento and Sutter Co. California", Kleinfelder, 4 January 2007.
i. Natomas Levee Improvement Program, Draft Geotechnical Design Report, SREL Reach4A, Kleinfelder, 17 December 2007
j. Natomas General Reevaluation Report, American River Watershed Project, Common Features California, URS, June 2008.
k. Natomas Geotechnical Reevaluation Report (GRR), American River Watershed Project Common Features: Subsurface Investigation Report, URS 1 June 2008.
l. Natomas North-West-South Draft Technical Review Memorandum, URS, September 2008.

m. Natomas Levee Improvement Program, Draft Geotechnical Design Report, SREL Phase 1 Reach 1 to Reach 4a, Kleinfelder, 31 October 2008.
n. American River GRR, URS, 13 November 2008.
o. Natomas Levee Improvement Program, Draft Geotechnical Basis of Design, SREL Phase 1, Reach 1 to Reach 4a, Kleinfelder, 14 November 2008.
p. Natomas Levee Improvement Program Geotechnical Draft Report SREL, Phase 1 Reach 1 to Reach 4a, Kleinfelder, 28 January 2009.
q. Natomas Levee Improvement Program, Geotechnical Basis of Design, Natomas Cross Canal South Levee, Kleinfelder, 30 January 2009.
r. Natomas East Main Drainage Canal - West Study Area, Phase 1 Geotechnical Evaluation Report, Kleinfelder, 1 April 2009.
s. Natomas East Main Drainage Canal – South, Draft Problem Identification Report, Kleinfelder, 12 June 2009.
t. Pleasant Grove Creek Canal Draft Geotechnical Data Report, Kleinfelder, 26 June 2009
u. Natomas Levee Improvement Program Supplemental Geotechnical Draft Report SREL 2, Reach 4b to Reach 9b, Kleinfelder, 8 July 2009.
v. Levee Improvement Program, Revised Alternative Analysis Report SREL 2, Reach 4b to Reach 9b, Kleinfelder, 8 July 2009.
w. Natomas Levee Improvement Program, Geotechnical Basis of Design, SREL 1b, Reach 4b, Kleinfelder, 20 July 2009.
x. Natomas Levee Improvement Program, Geotechnical Basis of Design, SREL 1b, Reach 4b, Kleinfelder, 20-Jul-09, Draft Geotechnical Basis of Design, SREL Phase 2, Reach 5 to Reach 9b, Kleinfelder, 27 July 2009.
y. Sacramento River East Levee, SREL 3 (Reaches 10-15), Draft Alternatives Analysis Report, Kleinfelder, 2 September 2009.
z. Natomas Levee Improvement Program Supplemental Geotechnical Draft Report SREL 2, Reach 4b to Reach 9b, Kleinfelder, 9 September 2009
aa. American River North Levee, Draft Geotechnical Data Report, Kleinfelder, 11 September 2009.
bb. Natomas East Main Drainage Canal – North, Draft Problem Identification Report, Kleinfelder, 18 September 2009.
cc. Natomas East Main Drainage Canal – North, Draft Geotechnical Data Report, Kleinfelder, 18 September 2009
dd. Natomas East Main Drainage Canal – South, Draft Geotechnical Data Report, Kleinfelder, 23 October 2009.
ee. Natomas Levee Improvement Program (NLIP), Draft Geotechnical Basis Of Design (BOD)- Sacramento River East Levee (SREL), Reach 5 to Reach 9, Kleinfelder, 16 October 2009.
ff. Natomas East Main Drainage Canal – South, Draft Alternatives Analysis Report, Kleinfelder, 2 November 2009.
gg. Sacramento River East Levee, SREL 4 (Reaches 16 - 20), Draft Alternatives Analysis Report, Kleinfelder, 6 November 2009.
hh. Sacramento River East Levee, SREL 3 (Reaches 10-15), Draft Geotechnical Data Report, Kleinfelder, 25 November 2009.

ii. Natomas East Main Drainage Canal – North, Draft Geotechnical Data Report (1st Supplemental) , Kleinfelder, 14 December 2009.

The references used for geotechnical analyses are as follows:

a. Geotechnical Levee Practice SOP EDG-03, dated April 2007.
b. EM 1110-2-1913, Design and Construction of Levees (2000).
c. WES TM 3-424 (1956).
d. EM 1110-2-1619, Risk Based Analysis for Flood Damage Reduction Studies (1996).
e. EM 1110-2-1902, Slope Stability (2003).
f. EM 1110-2-1914, Design, Construction, and Maintenance of Relief Wells (1992).
g. ER 1110-1-8100, Laboratory Investigations and Testing (1997).
h. ETL 1110-2-561, Reliability Analysis and Risk Assessment for Seepage and Slope Stability Failure Modes for Embankment Dams (2006).
i. ETL 1110-2-569, Engineering and Design – Design Guidance for Levee Underseepage (2005).
j. CESPK, Levee Task Force Report and the project specific review comments prepared by the Task Force (2003).
k. ETL 1110-2-547, Introduction to Probability and Reliability Methods for Use in Geotechnical Engineering, USCAE, 30 September, 1995.
l. ETL 1110-2-556, Risk Based Analysis in Geotechnical Engineering for Support of Planning Studies, USACE, 28 May, 1999 with Errata Sheet in 5 March 2003.
m. ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies, USACE, 3 January, 2006.
n. EM 1110-0-1519, Risk-Based Analysis for Flood Damage Reduction Studies", USACE, 1 August 1996.
o. "Factors of Safety and Reliability in Geotechnical Engineering", Duncan Michael J., ASCE, Journal of Geotechnical and Environmental Engineering, April 2000
p. "Reliability-Based Design in Civil Engineering" Milton E. Harr, 1987.
q. "Manual for Geotechnical Engineering Reliability Calculations" by J. Michael Duncan, Michael Navin, and Katherine Patterson, Virginia Polytechnic Institute and State University, December 1999.

3. GENERAL LEVEE DESCRIPTION

3.1 General Description.

The levees analyzed by the NPAC are urban levees protecting the Natomas Basin located along the east bank of the Sacramento River from Verona to American River, the south bank of American River between its confluence with the Sacramento River on the west side and with NEMDC on the east side, the west bank of NEMDC and Pleasant Grove Creek Canal, and on the south bank of Natomas Cross Canal. The NPAC Study Area is shown on Figure 3-1 and the Natomas Basin system levee units are shown in Table 3-1.

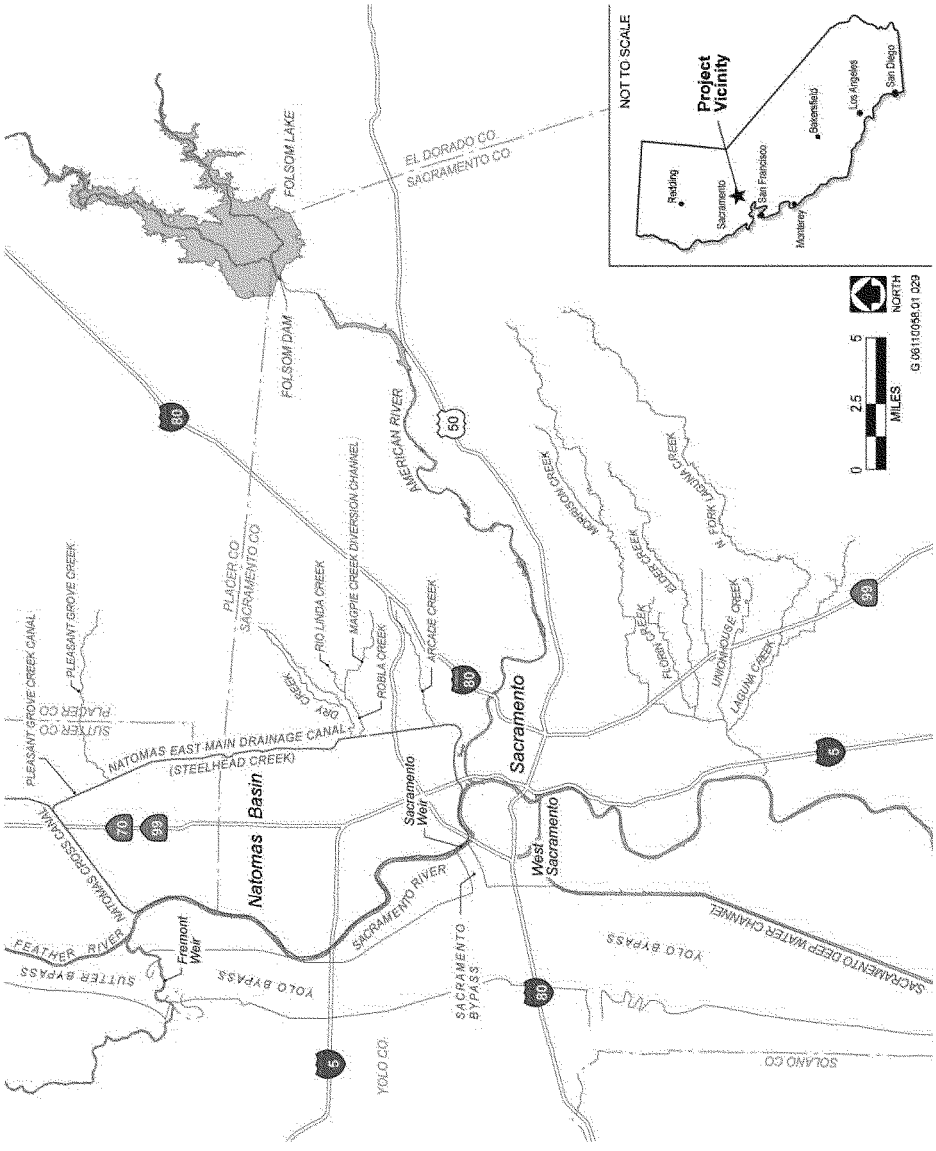


Figure 3-1 - Natomas Basin Study Area

Table 3-1 - Natomas Basin Levee Units

Levee Unit	Unit Length (miles)	River	RM at beginning of unit	RM at end of unit
Unit 1	18.60	Sacramento River East Bank	79.21	61.00
Unit 2	2.33	American River North Bank	0.00	2.33
Unit 3	17.30	Natomas East Main Drainage Canal	2.33	14.54
		Pleasant Grove Creek Canal	0.00	2.00
Unit 4	4.38	Natomas Cross Canal South Bank	0.00	4.13

3.2 Levee Unit 1 - Sacramento River East Bank Levee

The Levee Unit 1 located along the east bank of the Sacramento River extends between River Mile 79.21, at the confluence with Natomas Cross Canal (Levee Mile 0.0) on the north side, and RM 61.0, at the confluence with the American River at the south side (Levee Mile 18.6). The levee was constructed by the Natomas Company of California between 1912 and 1914 using a suction dredge. As shown in Figures 3-2 and 3-3, the dredge sand from the channel bottom was pumped through a system of pipes into a trench excavated in the natural ground. The material obtained from excavation was deposited along the sides of the trench being used as starter dikes. Persistent seepage was observed near the intersection of the Sacramento River east levee and the Natomas Cross Canal, with the most recent events observed in 2004 and 2006. However, observations date back to 1938. Through seepage and slope stability problems were observed along the upstream reaches of the levees on the Sacramento River and emergency flood fighting work was performed, particularly in the vicinity of the Pump Station #2 (known also as the Pritchard's Lake Pump Station) where during the 1997 flood, a section of the levee experienced slope failure.

The existing levee embankment has the side slopes generally of 1(V) on 2(H) on the landside and 1(V) on 3(H) on the waterside except in the area where encroachments on the levee right-of-way included fill over the levee waterside slope. The levee height varies between 19 and 22 feet, with the crest between elevation 43 and 38.5 feet. The Garden Highway runs along the levee crest. Between Natomas Cross Canal (Levee Mile 0.0) and Power Line Road (Levee Mile 12.03) the levee embankment has a 10-foot wide landside stability berm extended to about the half of the levee height. The stability berm was constructed over a drainage blanket layer that was extended as a chimney drain on the levee slope, to prevent internal erosion due to the water seepage through the levee embankment. Filter fabric was placed between the drainage layer and the levee fill. A slurry wall was constructed between Power Line Road (Levee Mile 12.03) and the south end at the American River (Levee Mile 18.60) to prevent seepage and internal erosion by seepage through the levee. The slurry wall was constructed in 2 different phases and the depth varies between 25 and 45 feet. A 5 foot deep unlined irrigation ditch is found 10 feet from the landside toe between levee miles 0.0 and 12.03 (Power Line Rd). A second 3 foot deep unlined irrigation ditch between levee miles 12.03 to the end of the levee unit 1 is excavated 5 feet from the

landside levee toe. Encroachments on the waterside levee slope consist of houses constructed on the riverbank, fences along the levee crest on the shoulder of the highway, power poles in the levee landside and waterside slopes, and utility lines including pressurized pipes for the irrigation crossing the levees. Discharge lines or intake lines from 5 pump stations are crossing the levee on the east bank of the Sacramento River. Pump station No. 2, approximately 1.15 miles upstream of Elverta Road, was removed leaving the existing sump at the landside levee open and the discharge line crossing the levee embankment unplugged. Heavy seepage observed during the 2005/2006 flood was associated with sand boils in the open sump. Flood fighting was conducted at this location, consisting of backfilling the sump with gravel and filter fabric. Seepage through the levee was shown on previous flood events also along upstream and downstream of this pumping station. Geophysical studies show an anomaly in the levee upstream of the pipes crossing the levee.

Heavy seepage was also observed at the Pump Station #1 located in the vicinity of the RD1000 offices. A deep slurry wall was recently constructed at that location under WRDA 99 authority, extending the existing deep cut-off wall upstream on a couple of hundreds of feet. The pipe crossing the levee was inspected and the soil underneath jet grouted.

The riverbank is covered by heavy vegetation that extends on the levee slope, and in some places up to the levee crest. The heavy vegetation includes large diameter trees, brush and shrubs. Access to the waterside levee toe for inspection or flood fighting is occasionally denied by the owners of the riverbank. Encroachment on the landside slope includes fences, power poles, utilities and in some places, downstream of Power Line Road orchards are planted on the levee slope. The landside slope is also covered by scattered brush and large diameter trees. Typical cross section of the levee with stability berm north of the Power Line Road is shown on Figure 3-2. Figure 3-3 shows a typical cross section of the levee south of the Power Line Road, with a cut-off wall.

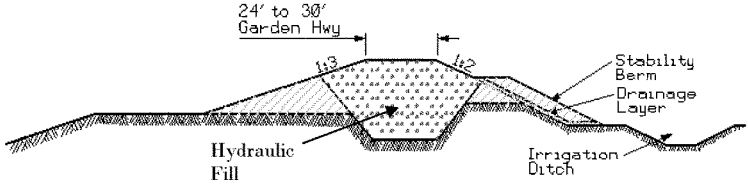


Figure 3-2 - Typical Cross Section, Sacramento River East Levee North of Power Line Road

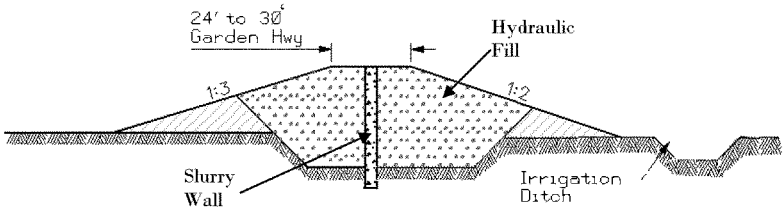


Figure 3-3-Typical Cross Section, Sacramento River East Bank South of Power Line Road

3.3 Levee Unit 2 - North Bank American River between Sacramento River and Natomas Main Drainage Canal

Levee Unit 2 located along the north bank of the American River extends between the confluence with Sacramento River at River Mile (RM) 0.0 (Levee Mile (LM) 0.0) on the west side and RM 1.7 (LM 2.33) at the confluence with NEMDC on the east side. The levee was constructed by the Natomas Company between 1912 and 1914 using long-boom clamshell dredges with buckets up to 6 cubic yards capacity. The dredge cut a new drainage channel (Bannon Slough) extending eastward from the Sacramento River along an alignment more than 1,500 feet north of the American River low flow channel. The material excavated from the channel was used to create the levee unit 2. This material consisted of a mixture of sand, silt and clay that provided a much more consistent medium for levee construction than the sands used to construct the levee along the Sacramento River East Bank. The most prevalent performance deficiencies recorded for the American River north levee are seepage related. Historical maps from 1938 indicate the American River levee was affected by high water. Seepage was observed on some areas along the landside of the levee, but there are no indications if the seepage was through the levee foundation or levee embankment or if any sand boils were associated with the seepage activity.

The Garden Highway is also located on the crest of the Levee Unit 2. The levee height varies between 19 and 20.5 feet with the side slopes of 1(V) on 3(H) on the waterside and 1(V) to 1.5 to 2 (H) on the landside. The levee crest is typically 30 feet wide to accommodate the Garden Highway being wider up to 60 feet at the Arden Garden Connector. The levee embankment is constructed of impervious clay material. The levee has a drainage canal near the waterside toe which is an extension of the East Main Drainage Canal and an irrigation ditch 4 to 6 feet deep along the landside toe from the Garden Highway ramp at Azusa Street to where the Garden Highway ramps off. The levee crown width is reduced to 20 feet where the Garden Highway ramps off. A typical cross section is shown on Figure 3-4.

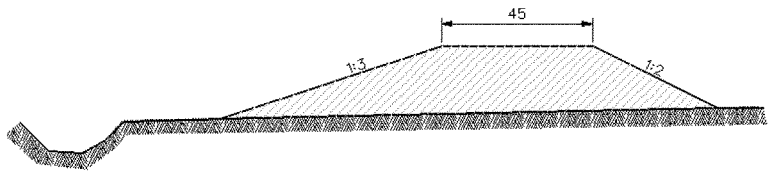


Figure 3-4 - Typical Cross Section Levee Unit 2, American River North Bank between Sacramento River and NEMDC

3.4 Levee Unit 3 - Natomas Main Drainage Canal and Pleasant Grove Creek Canal West Levee

Levee Unit 3 is located along the west bank of the Natomas East Main Drainage Canal continuing along the west bank of the Pleasant Grove Creek Canal, between American River on the south side and Natomas Cross Canal on the north side. The Levee Unit 3 was created to intercept flows in the tributary streams east of the Natomas Basin and divert them around the Basin to the Sacramento River in low flow and to the American River in flood stage. The NEMDC west levee was constructed from the material excavated from the new channel by a long-boom clamshell dredge by the Natomas Company between 1912 and 1914. The levee material consisted of a mixture of sand, silt and clay that provided a much more consistent medium for levee construction than the sands used to construct the Sacramento River East Levee (SREL). The NEMDC west levee had a standard geometry with a 20 foot crown width, a 3H:1V waterside slope and a 2H:1V landside slope.

In 1996 SAFCA raised approximately 4.4 miles of the NEMDC west levee between Northgate Boulevard and the mouth of Dry Creek as part of the Defense Appropriations Act of 1993 (PL 102-396). As part of this project a new pumping facility ("NEMDC Pumping Facility") was constructed at the upstream limit of the raised levee section. Following completion of the project, the City of Sacramento constructed the Arden Garden Connector Project connecting Arden Way in North Sacramento to the Garden Highway in Natomas by bridging the NEMDC and widening the crown of the west levee by at least 40 feet between the new bridge and Northgate Boulevard, a distance of approximately 1,500 feet. As a result, this portion of the Lower NEMDC west levee is overbuilt in a manner similar to the section of the American River North Levee (ARNL) to which it connects. Natural high ground divided the area between the Pleasant Grove Canal and NEMDC west levee with the water flowing north to the Natomas Cross Canal through Pleasant Grove Canal and south to the American River through NEMDC. At that location the ground is slightly lower than the levee crests on both Pleasant Grove and NEMDC canals and therefore flooding of the area may occur through this gap. There is no temporary closure of the gap at this location. The area flooded is limited to a small agricultural area. Figure 3-5 shows a typical cross section of the Levee Unit 3. Penetrations crossing the levee consist of water lines and discharge lines from the two existing pump stations. Woody vegetation covers the waterside levee slope mostly on the downstream end of the levee.

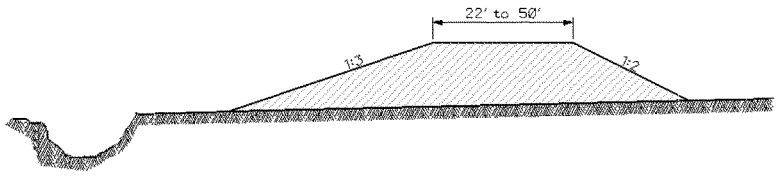


Figure 3-5 - Typical Cross Section Levee Unit 3, NEMDC and Pleasant Grove West Bank

3.5 Levee Unit 4 - Natomas Cross Canal South Bank.

The 4.38 mile long levee extends along the south bank of the Natomas Cross Canal between RM 0.07 (LM 0.0) at the Natomas Main Drainage Canal on the east side and RM 4.45 (LM 4.38) at the confluence with the Sacramento River on the west side. The levee was constructed from the material excavated from the NCC channel by a long-boom clamshell dredge. The levee height varies between 12 and 25 feet, with the crown width between 23 and 50 feet and side slopes of 1(V) on 2(H) on the landside and 1(V) on 3(H) on the waterside. The levee was constructed of silts and clays with low to medium plasticity. Stability berms 10 to 15 feet high, 15 to 20 feet wide were constructed along three reaches of the levee, between levee miles (LM) 0.00 and LM 0.67, LM 0.86 and LM 1.27 and between LM 2.15 and LM 4.25. The berms are constructed with a chimney drain to prevent internal erosion due to seepage through the embankment and to lower the phreatic line during high water stages in the canal. A 5 to 10 foot deep irrigation ditch is located 100 to 130 feet from the levee toe between LM 0.0 and LM 2.10. The ditch is concrete lined within the CALTRANS Right-of-Way near the State Highway 99. A 10 foot deep unlined irrigation ditch is located 100 feet from the landside levee toe between LM 2.54 and LM 0.02. A 3 foot deep unlined irrigation ditch is located on a small berm 10 feeoot from the landside levee toe between LM 3.62 and LM 4.38. There are four (4) pump stations located along the levee. The Odysseus Farms pump station near LM 4.30 includes an 18-inch pipe crossing the levee embankment 4 feet below the levee crown and a discharge riser at the landside levee toe. Bennett Pumping Plant near station 3.28 includes 3 pipes crossing the levee 6 and 20 feet below the levee crown. The R.D. 1000 Pump Station near LM 2.52 includes an unlined 10-foot deep sump 100 feet from the levee toe and three pipes crossing the levee 5 feet below the levee crest. Natomas Mutual Water Company Northern Pumping Plant near LM 2.11 includes 5 pipes crossing the levee embankment 5 to 10 feet below the levee crest and an 8 foot deep concrete lined sump about 40 feet from the levee toe. Typical cross section is shown on Figure 6. The most prevalent performance deficiencies which have been historically recorded for the Natomas Cross Canal south levee are seepage related. Seepage and sand boils were observed during the floods in 1938 (historical map), 1963, 1965, 1987. A slide occurred in 1986 on the landside slope.

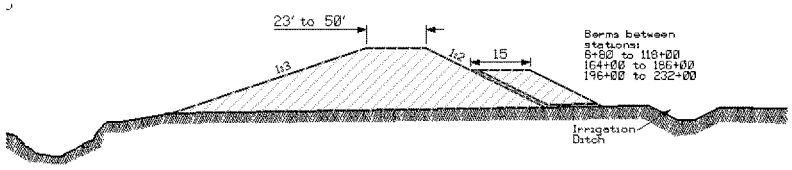


Figure 3-6 - Levee Unit 4 Typical Cross Section

4. FOUNDATION CONDITIONS

4.1 General

Preliminary assessments of the subsurface conditions along the project are derived from the results of the subsurface investigations performed by many studies shown in Paragraph 2. The materials encountered during the subsurface exploration consisted primarily of alluvial sand and low plasticity silts and low plasticity silts and clays in various proportions, with occasional high plasticity layers and scattered gravel.

4.2 Regional Geology and Geomorphology.

A geomorphic study was performed by William Lettis & Associates, Inc. in 2008 as part of the URS contract. The Results are provided in the URS Geotechnical Report in 2009 for this study and shown on the plans in Enclosure F1. The surficial geologic maps were developed using aerial photography, early United States Geological Survey (USGS) topographic maps, published surficial geologic maps, and early and modern soil survey maps. The basic stratigraphic units that occur within the project area; from oldest to youngest, are (1) Middle to late Pleistocene Riverbank Formation (approximately 450,000 to 130,000 years old); (2) Latest Pleistocene Modesto Formation (approximately 42,000 to 12,000 years old); (3) Holocene deposits (less than 11,000 thousand years old); and (4) Historical floodplain and channel deposits (less than approximately 150 years old).

- The Riverbank Formation (Pleistocene), are semi-consolidated to unconsolidated, weakly to moderately cemented, and include one to several well developed silica-iron duripan horizons (i.e. hardpans). Well-developed hardpan horizons are laterally extensive zones of very low hydraulic conductivity within Pleistocene Formations, and act to retard water flow. These alluvial deposits consist of sand, silt, and clay with gravel.
- Modesto Formation (Pleistocene) (Qml and Qmu), are unconsolidated and slightly weathered to unweathered gravel, sand, silt, and clay deposited at the border of existing streams.
- Basin Deposits (Holocene) (Qb) are fined-grained silt and clay derived from the same sources as modern alluvium (Qa). Basin deposits are differentiated from alluvium on the basis of composition including only those deposits that are finer grained and frequently

organic-rich. These deposits were distal deposits where energy conditions were much lower. Alluvium (Holocene) (Qa) are unconsolidated and unweathered gravel, sand, and silt deposited by present-day stream and river systems and may have high hydraulic conductivity values. Alluvium deposits are differentiated from older stream-channel deposits (Qao and Qal) by their position in modern channels. The deposits form natural levees along the main course of the Sacramento River, and broad alluvial fans of low surface relief along the western and southwestern side of the valley.

- Stream Channel Deposits (Historical) (Qsc): Historical alluvial deposits (generally less than approximately 150 years old) generally consisting of unconsolidated sand, gravel, and silt contained primarily in active river and tributary channels derived from hydraulic gold mining detritus. These deposits can also include materials deposited from hydraulic mining activities and may be highly susceptible to underseepage.

Additional geologic units of note indentified by William Lettis & Associates, Inc. include:

- Artificial Fill (Af): Circa 1937 (the date of the aerial photography used in the mapping process).
- Overbank deposits: Recent (Rob) and Holocene (Hob) age sand, silt, and clay deposited during high-stage water flow overtopping channel banks.
- Crevasse splay deposits (Rcs and Hcs): Recent (Rcs) and Holocene (Hcs) age fine to coarse sand with minor lenses of fine gravel deposited during breaching of natural or artificial levees.
- Channel deposits (Rch and Hch): Recent (Rch) age well sorted sands and fine gravels and Holocene (Hch) age sorted sands and silts that fine upward.
- Overflow channel (Rofc): Recent (Rofc) age overflow channel deposits consisting of vertically stratified sand, silt, and clay in floodplain channels occupied primarily when high-stage water overtops channel banks.
- Alluvial deposits (Ha): Holocene age undifferentiated sand, silt, and minor lenses of gravel that were under cultivation in 1937 (the date of the aerial photography used in the mapping process).
- Marsh Deposits (Hs/Ha and Hs): Recent deposits (Hs/Ha) typically overlying alluvium or perennially or seasonally submerged in 1937 (Hs) (the date of the aerial photography used in the mapping process).

The Natomas Cross Canal south levee transverses, from east to west, the Modesto Formation, Holocene fan deposits, basin deposits, narrow Holocene and recent channel deposits that are inset to the basin deposits, and Sacramento River natural levee deposits that are eastward prograting onto the American Basin. Because of this geomorphic variability at the ground surface, there is probability of similar variability in the subsurface stratigraphy. For instance, the alluvial fan and basin deposits probably laterally interfinger at depth, representing seasons or years when sedimentation from west-trending drainages dominated and alternates with seasons or years when fine-grained sedimentation from floodwater occupying the American Basin dominated. This relationship probably occurs along the western side of the Natomas Cross Canal south levee, where sedimentation from the Sacramento River is vertically interbedded with fines from

floodwater occupying the American Basin. The stratigraphic relationships beneath the Natomas Cross Canal are further complicated by the possible presence of Riverbank Formation in the shallow subsurface. Surficial geologic mapping indicates the presence of islands or knobs of Riverbank Formation at the ground surface within the interior basin, along the western half of the Natomas Cross Canal. The distribution of the Riverbank Formation along the east and west margin of the American Basin suggests that an older, possibly early Pleistocene, paleochannel or paleo-floodplain once flowed through the basin leaving the remnants of Riverbank Formation along the west margin of the basin, and eroded the toes of the Riverbank alluvial fans along the east margin of the basin. This former waterway is buried by fine-grained basin deposits, and is expressed only by the remnant Riverbank surficial geology and a north-south topographic through the basin. Deeper beneath the Natomas Cross Canal there may be coarse-grained channel deposits from this old waterway that are overlain by fine grained deposits that have in filled the basin during the Holocene period. Historical overbank deposits comprise the majority of sediments beneath the western and southern Natomas basin levees along the Sacramento and American Rivers. The river along the Sacramento River east levee includes the watersheds of both the Feather and Sacramento rivers, and thus was often prone to flooding. Because of this flooding and associated sedimentation, the banks of the river are comprised of silty sand deposits that form natural levees. The natural levees are a geomorphic landform comprised of individual deposits. Here the levee primarily overlies natural levee deposits, including crevasse splay and overbank deposits. Overbank deposits are slightly finer-grained sand, silt, and clay deposited via sheet flow when the river is at flood stage and overtops natural and artificial levees. The depositional process associated with these map units results in laterally and vertically discontinuous sediments in the shallow subsurface.

Based on the surficial geologic and geomorphic assessment report prepared by William Lettis & Associates, Inc. for USACE Common Features GRR (2008), six areas underlain by major buried channels and/or crevasse splays are of special concern in the Sacramento River east levee. The preliminary conceptual surface and subsurface geologic relationships, as they relate to levee structures in these areas, are described below.

a) Sacramento River-Feather River Confluence. The area along the northeastern bank at the confluence of the Sacramento and Feather rivers shows a complex pattern of fluvial deposits. Well developed natural levee deposits flank the Feather River directly north of the Sacramento River-Feather River confluence. A prominent crevasse splay deposit is directly east of the confluence, and marks the southern margin of the natural levees on the Feather River. This crevasse splay serves as a "divide" between the natural levees deposited by the Feather River north of the confluence, and natural levees deposited by the combined Sacramento and Feather rivers. Cross-cutting relationships among deposits demonstrate that episodes of flooding and sedimentation repeatedly have occurred in this area

b) South of Joe's Landing. Joe's Landing, south of the Natomas Cross Canal exhibits a complex of young crevasse splay and overbank deposits that overlie older natural levees constructed by flooding of the Sacramento River. These younger splay and overbank deposits are associated with the Sacramento Series fine, sandy loam textures at the ground surface. The plan view extent of the splay deposits in this area indicates geomorphic complexity suggesting lateral discontinuity and vertical heterogeneity in the subsurface materials beneath the levee in this area.

c) Prichard Lake Pumping Station. At the Prichard Lake Pumping Station, surficial geologic mapping reveals a southwest-trending paleochannel that probably represents a former position of the Sacramento River. This mostly in-filled paleochannel is expressed in the topography as a gentle through, and is delineated on aerial photography by its contrasting tone. The southeast-trending paleochannel diverges from the Sacramento River near the Prichard Lake Pumping Station, and is greater than 10 miles long. It rejoins the Sacramento River near the Natomas Main Drainage Canal, or the historical Second Bannon Slough. Near the Prichard Lake Pumping Station, the topographic low associated with the paleochannel contains younger marsh, basin and distributary channel sediments deposited in the paleochannel after it was abandoned by the ancestral Sacramento River. Coarse grained channel deposits are presumed to underlie finer-grained overbank deposits beneath the levee near Pritchard Lake Pumping Station.

d) Elkhorn Pumping Station. The Elkhorn Pumping Station is located near the distributary channel of a relatively broad, well-developed crevasse splay complex (herein referred to as the Elkhorn crevasse splay deposit). Collectively, the sediments within this deposit underlie the majority of the Sacramento International Airport. The morphology of this splay complex consists of several distributary channels that, in places, cross-cut one another, and numerous individual splay deposits, suggesting repeated episodes of flooding and sediment deposition. The Elkhorn crevasse splay deposit is evident on the historical topographic maps, and is associated with the youthful Sacramento fine sandy loam on the historical soil map. This crevasse splay deposit is the largest south of the confluence of the Sacramento and Feather rivers, and is possibly the most complex and best expressed on either of these rivers. This deposit is estimated to be latest Holocene to Recent in age, and much of the sediment in the deposit likely consists of mining debris. This area is geomorphically complex, and the deposits within the distributary channel directly beneath the levee are likely to exhibit similarly complex stratigraphy, and could include layers of sand and gravel interbedded with finer-grain silt and clays.

e) Mound Ranch area. The ground surface in the Mound Ranch area was substantially modified by agricultural practices prior to 1937, and the identification of individual overbank and crevasse splay deposits from 1937 aerial photography was difficult. However, a series of narrow east-southeast-trending channels that connect to the Sacramento River are mapped. These channels are evident in the 1907 historical topographic map as sublinear depressions, but appear modified to serve as irrigation or drainage canals as of 1937. These small channels can be interpreted as overflow channels which probably transported water and sediment from the Sacramento River onto the floodplain during high flow stages. Thus, in this area, there are possible localized, buried, channel deposits present beneath the levee.

f) Natomas Main Drainage Canal Area. The surficial geologic map shows that the Natomas Main Drainage Canal area is located where the paleochannel (that emanates from the Prichard Lake Pumping Station area) probably underlies the present levee. Subsequent to abandonment, the paleochannel acted as a slough, conveying flow from the American River Basin and Bush Lake into the Sacramento River. The sediments of this paleochannel buried beneath the levee probably consist of a fining upward sequence of gravel, sand, silt and clay, representing coarse-grained channel deposits blanketed by finer grained silt and clay. The area directly north of Interstate 80 contains fine-grained basin deposits that, as in the Bush Lake area, reflect ponding of floodwaters to the north of north sloping natural-levee and crevasse-splay sediments deposited on the northern side of the Sacramento River.

The results of the geomorphologic studies are shown on the plan views in Enclosure F1

4.3 Levee and Foundation Geotechnical Conditions

Information on the foundation and levee embankment provided by the subsurface investigation performed in the past by the Corps of Engineers, California Department of Water Resources (DWR) levee evaluation program, SAFCA, and their contractors are used for the risk and uncertainty analyses of the existing conditions. The subsurface investigation includes borings, sonic drilling and CPT drilled along the levee crest and landside or waterside of the levees, surficial geomorphology studies, and helicopter electromagnetic (HEM) surveys. The levee geometry was based on the existing data in the National Levee Database supplemented by recent LiDAR survey and bathymetric survey provided by the DWR as part of the Urban Levee Evaluation (ULE) program. The location of the borings used in this study and the soil information are provided on the plans and profiles in Enclosure F1.

4.3.1. Sacramento River East Bank Levee, Levee Unit 1

Starting from the upstream limit at LM 0.0 to LM 2.46 the levee foundation consists primarily of fine grained layers with occasional thin sand layers to elevations -70 to -90 feet. Between LM 2.46 and LM 4.26 a thick layer of sand and silts extends to elevation -60 underlying a 20 foot thick layer of gravel between LM 2.65 and LM 2.84. Fine grained soils interspersed with silty sands were found below the impervious blanket between LM 4.26 and LM 5.30. Sand and silty sand underlain by clay at about elevation -65 are the predominant layers below the impervious blanket between LM 5.30 and LM 6.44. The clay layer underlying the same sands and silty sand was found at about elevation -40 between LM 6.44 and LM 7.39. Between LM 7.39 and LM 10.80 the deep soils are primarily silty sands interspersed with sand overlaying a deep layer of gravel at elevation -55. The gravel layer extends to about elevation -70 where fine grained soil or sand was found. From LM 10.80- to LM 12.03 the deeper layer was a mix of sand, silty sand and silt to the bottom of the boring at elevation -75. Borings drilled landside of the levee show the same formation, generally 5 to 35 feet of impervious blanket composed of clays and silts overlay the sandy aquifer composed of sandy soil with occasional discontinuous layers of clay up to 25 feet thick.

The ground water levels were measured in piezometers installed along the levee. From the piezometer measurements it can be seen that the ground water decreases during the summer time. In general the ground water varied from 2 to 18 feet below the ground surface, depending upon the season.

The levee was constructed by hydraulically depositing sand in a core trench excavated in the natural ground, to the top of the levee. Consequently sand can be found at a depth below the natural ground surface. A 10-foot wide landside berm was constructed on a drainage layer to half of the levee height to increase the levee landside slope stability. The drainage blanket was extended on the levee slope to the entire height of the berm to intercept seepage through the levee embankment and to prevent internal erosion due to seepage through the levee.

4.3.2 American River North Bank Levee Unit 2

Wahler Associates investigated the American River levee and the foundation conditions for Reclamation District 1000 after the flood of 1986. The results of the subsurface investigations provided in an initial appraisal report are used in the evaluation of the foundation and levee geotechnical conditions. Additional investigation along the waterside toe of the existing levee was performed in 1999 by Taber Consultants for the Corps of Engineers, for the construction of a slurry wall along the American River Levee. The subsurface profile along the lower American River levees has been shaped by recent and historic overbank deposits and levee breaks. The fine-grained blanket varies greatly in thickness, from 10 to 50 feet in relatively short distances, and very often it is intersected by paleo-channels that deposited coarser materials near the surface. Levee materials are generally sandy (silty sand, poorly graded sand). The current channel of the American River is higher than the Sacramento River, which may account for the aquitard member (or Pleistocene contact) being found generally shallower than in the Sacramento River area. The levee predominantly consists of firm to stiff silt, lean clay, clayey silt, and silty clay.

4.3.3 Natomas East Main Drainage Canal and Pleasant Grove Creek Canal, East, Levee Unit 3

Wahler Associates investigated the Natomas East Main Drainage Canal and Pleasant Grove Creek Canal levee and the foundation conditions for the Reclamation District 1000 after the flood of 1986. The results of the subsurface investigations provided in an initial appraisal report are used in the evaluation of the foundation and levee geotechnical conditions. Most of the alignment is situated atop Pleistocene age materials from the Modesto and Riverbank formations, except for the area south of Arcade Creek, which is underlain by Holocene age alluvial deposits. This indicates the presence of a Pleistocene age hardpan horizon beneath the levee embankment which tends to minimize seepage and stability problems. Permeable members beneath the hardpan are usually interbedded thin layers of silt and sand, and are located 20 to 40 ft beneath the levee toe. These layers are originated by small tributary channels flowing towards the Natomas basin. Incised buried paleo-channels cross the NEMDC-W alignment at several locations. The main channels, as mapped by the geomorphic assessment are located near LM 0.1, 0.6, 0.8, 2.1, 3.5 to 4.2, 4.7, 5.9, 7.6, 8.1, 8.4, 9.6, 11.3, 11.45, 13.15, 13.3, 13.4, 13.6, 13.8 to 14.0, 14.4, 14.6 to 14.7, and 15.0 to 16.0. These features might have eroded the top of the Pleistocene hardpan and filled it with more permeable materials, yielding potential for localized underseepage. A low lying area located near LM 2.5 was characterized by shallow marsh deposits and vernal pools. Towards the south end of the NEMDC, the profile grades coarser due to old meander deposits from the American River and Arcade Creek (WLA, 2008).

4.3.4 Natomas Cross Canal South Bank Levee Unit 4

The levee foundation and the embankment were investigated by previous subsurface explorations performed by the Corps of Engineers, SAFCA and their contractors and by more recent exploration performed by SAFCA for the Natomas Levee Improvement Program (NLIP). Levee material for the NCC south levee is composed mainly of clays and silts. The foundation of

the levee along the south bank of the Natomas Cross Canal consists of an upper impervious blanket overlying a sandy aquifer. The foundation between LM 1.54 and the confluence with the Sacramento River (LM 4.38) consists of soft to stiff, low to high plasticity clay and silt. Also encountered were hard cemented clay and silt, silty sand, and poorly graded sand. Between LM 1.15 and LM 1.54 the 8 to 30-foot thick fine grained blanket consists of firm to hard, low to high plasticity silt and clay, cemented silt and clay and pockets of silty sand overlying an 8 to 40-foot thick layer of dense to very dense sand and gravel. The substratum extends to a depth of 30 to 40 feet below the landside levee toe. The sand layer overlays 18 to 30 feet thick layer of stiff to hard silt.

The levee consists predominantly of firm to very stiff, low to high plasticity clay and silt. Some sand was encountered in the levee foundation near Highway 99. The levee is composed of dredged fill which was excavated from the low flow channel along the waterside levee toe.

5. EXISTING CONDITIONS GEOTECHNICAL RISK AND UNCERTAINTY ANALYSES

5.1 General.

Deterministic analyses performed in previous studies done by the Corps for levee evaluation, by the DWR for the Urban Levee Evaluation and by SAFCA as part of the NLIP program were used to determine the critical areas along all levee units, to divide the levees in reaches with similar geotechnical, hydraulic and economic conditions and to determine the index point for a risk and uncertainty analyses. The levees were divided in the following reaches shown in Table 5-1 and on Figure 5-1:

Table 5-1 - Natomas Reaches and Index Points Locations

Basin	Reach	River/ Creek/Canal	Levee Unit	Begin LM	End LM	Begin RM	End RM
Natomas	A	Sacramento River	1	18.60	15.50	60.80	63.92
	B			15.50	5.00	63.92	74.42
	C			5.00	0.00	74.42	79.20
	D	NCC	4	4.38	0.00	0.00	5.00
		PGCC	3	17.30	16.08	0.00	0.37
	E	PGCC	3	16.08	12.55	0.37	3.45
	F	NEMDC		12.55	7.89	14.50	10.38
	G			7.89	4.25	10.38	6.81
	H			4.25	0.00	7.20	2.50

Basin	Reach	River/ Creek/Canal	Levee Unit	Begin LM	End LM	Begin RM	End RM
	I	American. River North	2	0.00	2.33	1.83	0.00

Seepage and stability deterministic analyses performed in the past with the results provided in the reports shown on Paragraph 2 were used to identify the weakest link for each reach considered in the Natomas Basin. Results of deterministic analyses showing the hydraulic gradients at the toe of the levee and the slope stability factors of safety for a steady state conditions for each flood are provided in Enclosure F4. Maps showing deficiencies regarding seepage and stability are also provided in Enclosure F4.

Geotechnical reliability analysis was performed in accordance with the Corps of Engineers guidance as detailed in the reference listed in Paragraph 2. Poor performance modes leading to levee failure considered in the analyses were underseepage through the levee foundation leading to piping and instability of the landside levee slope under steady state conditions. Sudden drawdown conditions may result in levee slope failure but it is unlikely to provide flooding of the area, the failure occurring when the water is at low elevation. Therefore this condition was not considered in the analysis. Addition judgment based conditional probability of poor performance considering the existing and past erosion history of the levee and riverbank, maintenance, seepage/sand boils and sliding historical conditions, encroachments, vegetation on the levee slopes and within the levee critical area, animal burrows and other external damaging conditions was included in the R&U analysis. The external erosion was included in the judgment curve, together with the history of seepage and sand boils observed in the area during high water elevation, maintenance conditions, vegetation on the levee slopes, rodent activity, encroachments and utility penetrations.

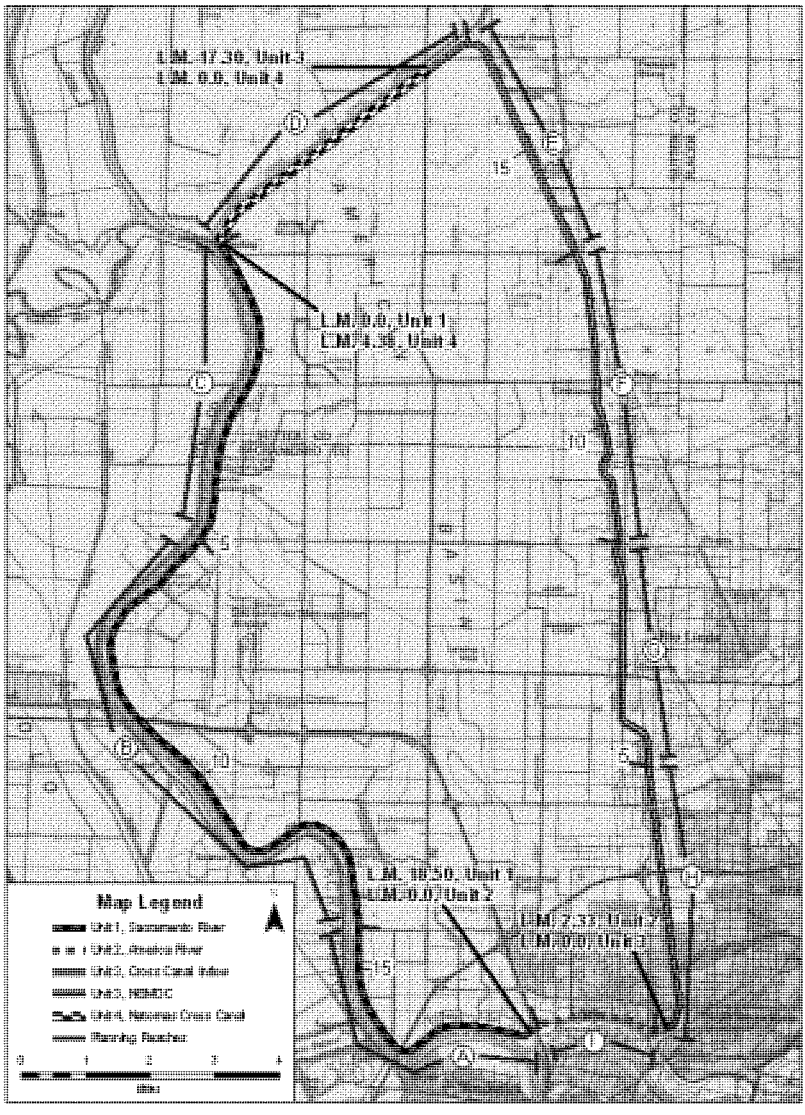


Figure 5-1 – Natomas Basin Reaches

The probability of poor performance was evaluated by assessing the foundation and embankment materials and assigning values for the probability moments of the random variables considered in

the analyses. The First-Order-Second-Moment (FOSM) method, as recommended in ETL 1110-2-556, "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies" dated 28 May 1999, was followed during the evaluation of the existing conditions of each levee unit. In this approach, the uncertainty in performance is taken to be a function of the uncertainty in model parameters. The standard deviations of a performance function were estimated based on the expected values (means) and the standard deviation of the random variable means. The performance functions considered were slope stability and underseepage piping stability. Levees constructed either of fine grained clays (along the Natomas Cross Canal), having stability berms with drainage layers extended along the levee slope that captures any seepage through the levee (Sacramento River east levee from the Natomas Cross Canal to Power Line Road) and at the levee toe, or having cut-off wall constructed through the levee embankment (SREL from Power Line Road to the confluence with the American River and the American River levees) are unlikely to be susceptible to internal erosion.
The final result of the FOSM is a reliability index, Beta (β), representing the amount of standard deviation of the performance function by which the expected value exceeds the limit equilibrium state. The limit equilibrium state for the slope stability and underseepage piping stability was defined using a factor of safety of 1.0. The standard deviation and variance of the performance function are calculated from the standard deviation and variance of the foundation and embankment parameters using the Taylor's series method based on a Taylor's series expansion of the performance function about the expected values. The partial derivatives were calculated numerically using an increment of plus and minus one standard deviation centered on the expected mean value. The variance of the performance function was obtained by summing the products of the partial derivatives of the performance function considering the variance of the corresponding parameters. For the existing condition of the levee, the probability of failure Pr(f) was expressed as a function of the river water elevation and other factors including soil strengths, permeabilities, and subsurface stratification. Reliability (R) is defined as:

$$R = \left(1 - \Pr(f)\right)$$

The combined geotechnical conditional probability of poor performance, considering the probability of poor performance due to underseepage failure, slope stability and judgment probability is

$$\Pr(f) = 1 - ((1-\Pr(f)_{us})*((1-\Pr(f)_{st}) * (1-\Pr(f)_{jd}))$$

Where:
- $\Pr(f)$ = total probability of poor performance
- $\Pr(f)_{us}$ = probability of poor performance due to underseepage
- $\Pr(f)_{st}$ = probability of poor performance due to slope stability (in steady state condition)
- $\Pr(f)_{jd}$ = judgment probability of poor performance

A set of conditional-probability-of-poor performance versus floodwater-elevation graphs were developed as related to underseepage piping, stability and judgment.
The probability of geotechnical poor performance of a levee is conditional on the uncertainties

associated with hydrologic and hydraulic aspects of determining the water surface profile during a flood. These uncertainties can be combined with the geotechnical uncertainties and in the @RISK model. This is accomplished, for economic purposes, through estimation of two index elevations for each levee reach within the study area. These index elevations are defined as follows:

The Probable Non-Failure Point (PNP) is the water elevation below which it is highly likely that the levee would not fail.

The Probable Failure Point (PFP) is the water elevation above which it is highly likely that the levee would fail.

The terms "highly likely that the levee would fail" is defined by the ETL as having 85% probability of occurrence. Therefore, the probability of failure at the PNP is 15% and the probability of failure at the PFP is 85%. It should be noted that only for flood damage economic studies the probability of poor performance curve at 85% should be assumed to correspond to PFP and probability of poor performance of 15% shall be assumed to correspond to PNF. The use of the poor performance curves shall be not used to predict failure for studies other then flood damage economic studies.

The reaches to be analyzed were selected based on soil profiles based on the available subsurface investigation and on deterministic calculations on cross sections where the geotechnical conditions were considered critical (such as thin impervious blanket, thick aquifer, soft material in the levee or top foundation layer). The following reaches shown on Table 5-2 were selected as critical for the geotechnical risk analyses:

Table 5-2 - Risk and Uncertainty Analyses Index Points

Reach	River/ Creek/Canal	Levee Unit	Typical Cross Section LM/RM
A	Sacramento River	1	16.7/62.6
B			13. 9/66.2
C			1.33/78.0
D	NCC	4	4.27/0.1
E	PGCC	3	15.0/1.3
F	NEMDC		9.0/11.7
G1			6.43/9.0
G2			4.85/7.5
H			0.99/3.5
I	American. River North	2	1.28/0.9

5.2 Underseepage Reliability

Subsurface conditions based on past investigations as described previously, geomorphology of the area, and past history were considered in selection of the most critical reaches of each levee unit. Generally the conditions along the Sacramento River consist of a natural waterside berm of sands and silts and a natural top blanket consisting of silts grading to clay in the basin with the permeability decreasing with distance to basin. The impervious blanket thickness, soil type (for determination of the permeability ratio), and aquifer thickness were determined for selection of the cross section representing a characteristic reach of every levee unit. Existing subsurface investigation showing the location of the borings, soil profiles and boring logs are provided in Enclosure F1. The expected value, standard deviation and the coefficient of variation of the permeability ratios between the horizontal permeability through the sandy aquifer and vertical permeability of the impervious blanket, blanket thickness and thickness of the sandy aquifer for each reach and for the each index point are provided in the Enclosure F4. The information was based on the soil profile and existing subsurface investigation. Underseepage analysis was performed using the blanket theory as described in the Corps ETL 1110-2-556. Final element analyses using SEEP2D program part of the GMS version 6 were developed to independently check the blanket theory results. Statistical analysis was used for each reach in determination of the coefficients of variation of the permeability ratios an, blanket thickness and thickness of the underlying aquifer as shown on Enclosure 4. A critical gradient $i_c = 0.80$ was used considering the unit weight of the blanket 112pcf. The unit weight of the blanket was considered the same for all sections analyzed. The standard deviation for the blanket thickness and the thickness of the sand layer in the foundation was calculated for each index point of each levee unit and was used in underseepage reliability evaluation. The phreatic line obtained by the SEEP2D program using the finite element method was also used in the stability analysis for each water elevation. Reliability analysis was performed using Taylor's Series Method. In the Taylor method, random variables are quantified by their expected values, standard deviations, and correlation coefficients. The variables used in the generalized equation for underseepage analysis are shown on Figure 5-2 and are as follows:

$$X_3 = \sqrt{z * d * \left(\frac{k_f}{k_b}\right)}$$

$$i_o = \frac{h_0}{D_b} = \frac{H\left(\frac{k_f}{k_b} D_f D_b\right)}{D_b\left[C_R \frac{e^{2L_R} - 1}{e^{2L_R} + 1} + x_2 + \left(\frac{K_f}{K_{bL}} D_f D_{bL}\right)\right]}$$

Where

$$h_0 = \frac{H * L_e}{L_1 + L_2 + L_e}$$

$$L_1 = C_R * \frac{e^{2L_R} - 1}{e^{2L_R} + 1}$$

$$Pr(F) = P(i_{critical} < i_o)$$

Where: X_3 = C_R = effective exit distance
z = D_b = blanket thickness (it is assumed that the blanket thickness is the same on the waterside and landside $D_b=D_{bl}=D_{br}$)
d = D_f = aquifer thickness
k_f = horizontal permeability of the aquifer
k_b = vertical permeability of the blanket
k_f/k_b = permeability ratio between horizontal permeability of the aquifer and vertical permeability of the impervious blanket
L_R = actual length of the riverside blanket
L_L = actual length of landside blanket assumed infinite (∞)
H = total head on levee
h_0 = water head at the landside levee toe
i_0 = upward seepage gradient through the landside blanket
L_1 = effective length of the waterside blanket
L_2 = X_2 = base width of natural blanket beneath the levee embankment (X_2)
L_e = C_R when the landside length of the natural blanket is assumed infinite

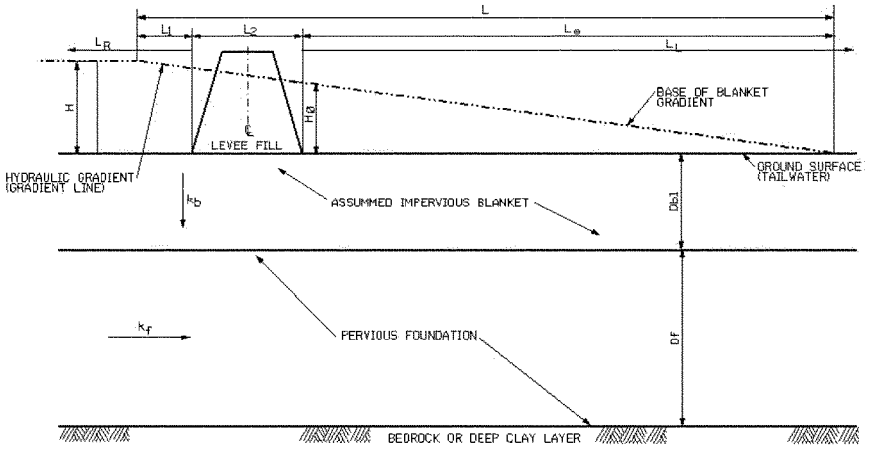


Figure 5-2 - Underseepage Analysis – Blanket Theory

An equation is used to calculate seepage gradient for a range of water levels on the waterside of the levee. From previous studies, the Taylor Series method appears to be more conservative and appropriate for this level investigation. The critical areas selected as index points for the risk

analysis were determined using the final element method developed by the SEEP2D program. Permeability ratios between the horizontal permeability of the sand layer and vertical permeability of the impervious blanket, used in the blanket R&U analyses were based on the subsurface investigation and recommendations of the previous studies listed in the paragraph 2. The detailed results of the underseepage reliability analyses for each index point are provided in the Enclosure F4.

5.3 Slope Stability Reliability

A sensitivity study was done to determine which parameters in the slope stability calculations were most influential. For this study, those variables are soil strength and unit weights of the soil in the levee embankment and in the foundation. Statistical descriptors for these variables were determined using available site-specific information and published statistical data. The piezometric lines or pore pressures for each water elevation were determined using the finite element program SEEP2D.

5.3.1. Cases Analyzed and Methods Used for Analyses.

The cases analyzed for stability risk analyses considered long-term conditions with steady state seepage along the landside slope of the levee. The phreatic surface developed for the steady state condition was determined using the SEEP2D finite element computer program developed as part of the GMS. The limit equilibrium computer program "UTEXAS3" was used to perform the stability analyses. Circular failure surfaces were assumed and the embankment was modeled as homogeneous. All analyses consisted of running a search routine to identify the critical failure surface using the Spencer's Method. Five random variables were defined for each unit. Stability analyses were performed for different assumed river stages. Details of the results of the stability risk analysis are provided in Enclosure F4.

5.3.2 Soil Strength Parameters.

Soil strength parameters used in the stability analyses were the drained soil parameters as determined in previous studies listed in Paragraph 2. The coefficient of variation for soil strength parameters and unit weight of the fill material in the levee or the top impervious blanket were obtained using methodologies outlined in ETL 1110-2-556, and those proposed by Harr in the "Reliability-Based Design in Civil Engineering", and Duncan in the "Manual for Geotechnical Engineering Reliability Calculations". Cohesion of 50 psf was considered for the embankment fill when the levee embankment was constructed of sandy materials, to avoid shallow slipping surfaces close to the infinite slope failure.

5.3.3 Seismic Assessment

Seismic assessment was considered for the entire basin. However, the Corps ETL 1110-2-569 does not require the seismic risk to be included in the risk based analysis. Detailed seismic assessment was developed by the URS for the Common Features GRR. The assumptions and summary of the assessment is provided in this report.

The purpose of the deformation and vulnerability evaluations was to evaluate the post-seismic vertical displacements at the levee crest and estimate the seismic vulnerability of the levees using a four-tiered classification system. The vulnerability classification system adopted in the American River Common Features project includes the following four tiers/classes:

- Probably uncompromised;
- Possibly compromised;
- Likely compromised;
- Compromised.

Depending on the calculated post-seismic displacements, each study-section was classified into one of the above four classes. The following steps were used for the vulnerability evaluations.

a. Estimate the Newmark type displacements.

Using the minimum K_y/K_{max} ratio, estimated for each study-section, Newmark-type displacements were calculated from the charts shown in Enclosure F2. Displacements were estimated for an earthquake magnitude of $M_w = 7.0$, which represent the 200-yr event.

b. Estimate Weighted Freeboard Loss.

A 0.7 ft of vertical displacement for every 1.0 ft of Newmark displacement was used to estimate the freeboard loss (vertical displacements) from the Newmark-type displacement values (assuming a 1:1 failure surface means that a 1ft displacement along the failure surface results in approximately 0.7ft freeboard loss).

c. Estimate Vulnerability Class.

Depending on the calculated freeboard loss value, each study-section was classified into one of the four vulnerability classes shown on Table 5-3.

Table 5-3-Seismic Vulnerability Classes

Amount of Deformation	Significant Damage to Internal Structures	Remaining Freeboard for Post Seismic Evaluation (2-Year Flood Water Surface Elevation)	Post Seismic Flood Protection Ability
< 1 foot	No	> 1 foot	Probably Uncompromised
1 foot to 3 feet	Possibly	> 1 foot	Possibly Compromised
3 feet to 10 feet	Likely if existing	None	Likely Compromised
Unlimited (flow slide condition)	Yes	None	Compromised

Detailed results of the seismic analyses provided by the URS for the Common Features GRR are provided in Enclosure F6.

5.3.4 Probability Analysis.

The Probability of Poor Performance of the stability of a slope (P_{rf}) is defined as the probability that the critical failure surface could be loaded to the limit equilibrium state. This infers the slope is loaded to its maximum capacity.

5.4 Judgment Base Reliability Analysis

A judgment based conditional probability function was based on existing conditions of the levee such as encroachments on the levee slopes, vegetation on the levee slopes, existing cracks and holes due to animal burrows, and based on the past history of sand boils, or slope failures. Generally past experience with poor performance at utility crossing and rodent activity indicates the risk of failure is pretty significant in the analyzed areas. The judgment based curve is included for each analyzed levee cross section and in the combined curve of failure.
The risk of poor performance based on judgment for the Natomas Basin levees is pretty high considering the existing conditions of the levee. The maintenance and the inspection f the Natomas levees is difficult or in many reaches impossible particularly on the waterside slope due to the heavy vegetation and encroachments into the levee slope that reaches the crest of the levee on almost the entire length. The inventory of the levee penetrations within the Natomas levee shows numerous penetrations which were not constructed conforming to the Corps requirements or without any approval from the Corps of Engineers or the maintenance agency. The past history of the Natomas levee shows more flood fighting during high river stages than the other study areas. Consequently, if the water reaches an elevation close to the crest of the levee it was considered that the levee may require additional flood fighting and the risk of failure is much higher than the rest of the analyzed levee units.
In June 2009, an expert elicitation was conducted for the purpose of developing the geotechnical judgment portion of the curves for the Common Features project. This expert elicitation was conducted in accordance with ETL 1110-2-561, "Appendix E, Expert Elicitation in Geological and Geotechnical Applications" 31 January 2006. The members of the expert elicitation team were highly recognized professional specialists, representing the Reclamation Districts managing and operating the levee system, and specialists in erosion and in geotechnical issues. A list of the members and the minutes of the meeting are included in Enclosure F5. The expert elicitation focused on the judgment part of the geotechnical risk and uncertainty curves for the flood control structures. The expert elicitation was conducted over a three-day period in which the most representative reaches of each basin of the study were discussed. The expert elicitation team discussed and reached consensus on the impact of different factors of the judgment curve, such as:

a) the vegetation on the levees and within the levee right of way
b) penetrations through the levee and foundation
c) encroachments into the levee and levee right-of-way
d) erosion of the riverbank and waterside slopes of the levee

e) animal burrows

The expert elicitation also concluded that up to a certain water elevation, the risk of poor performance as determined by analyses or considered in the judgment portion of the curves may not necessary coincide with the risk of failure. Based on historical performances of the levees, it appears that the risk of failure as determined in the analyses may be conservative and the poor performance of a levee may not lead to a catastrophic levee failure, even if distresses of the levee embankment need to be repaired after the flood to bring the levee to the pre-flood performance. Consequently, the risk of catastrophic failure may be reduced based on the historical past performance, and consequently the curves may be altered. The conclusion reached by the panel was that the risk of failure as a function of stage of the river may be reduced by 50% when the river reached 4-5 feet above the landside toe, by 30% when the river stage is up to 8-9 feet above the landside levee toe, and by 10% when the river reaches 11-12 feet above the landside toe. Geotechnical R&U curves for poor performance and risk of failure considering the conclusions of the expert elicitation were provided for further analysis in HEC-FDA. The judgmental curves for the existing conditions are provided in Enclosure F4

5.5 Combined Reliability Analysis

The total conditional probability of failure as a function of floodwater elevation has been developed by combining the probability of failure functions for three failure modes; underseepage, slope instability, and judgment. The reliability is the probability of no failure due to each mode considered in the calculations. The analysis also assumed that no flood fighting is employed.

5.6 Results of the Reliability Analysis

5.6.1 Natomas Basin Levee Unit 1, Reach A, Sacramento River East Levee LM 15.50 to 18.60, (RM 61.0 to 64.0) – Index Point LM 16.7 (RM 62.6)

5.6.1.1 General

The cross section at LM 16.7 was considered critical for the reach A between LM 15.50 and 18.60. The geomorphologic study shows old meanders of the river. Erosion of the riverbank was not observed in this reach of the river, the velocities shown by hydraulic analyses being very low. The average levee crest within this reach is at elevation 40 feet with the levee toes at elevation 20 feet. The levee crest width is 20 feet with the side slopes 1(v) on 2(H) on the landside and 1(V) on 3(H) on the waterside. A shallow seepage cut-off wall was considered in the analysis. Foundation soils consist of a natural impervious blanket with the thickness varying between 5 and 12 feet, with an average of 8 feet overlaying a sand deposit more than 100 feet thick averaging 108 feet. Soil profiles and borings used for Risk and Uncertainty (R&U) analyses are provided in the Enclosure F1 and also shown on the spreadsheet for the Reach A risk analysis in Enclosure F4. The composition of the natural blanket consists of clayey (CL) materials overlying the sandy aquifer consisting of poorly graded sand to silty sand. The levee was constructed of dredged sand and has a 45 feet deep seepage cut-off wall on the upstream end which deepens to

75 feet at the downstream end to the confluence with the American River. The results of the reliability analyses are shown in Enclosure F4.

5.6.1.2 Underseepage Reliability Analysis

The permeabilities as considered in the seepage reliability analysis are based on the representative borings drilled within the area and on previous studies shown in Paragraph 2 and are as follows:

Table 5-4 - Permeabilities, Reach A Sacramento River East Levee LM 16.7 (RM 62.6)

Material	Horizontal permeability		Vertical Permeability	
	cm/sec	ft/day	cm/sec	ft/day
Sand, silty sand (SM/SP)	$2x10^{-4}$	0.57	$2x10^{-5}$	0.057
Clay in Impervious Blanket (CL)	$1x10^{-5}$	0.028	$1x10^{-6}$	0.007
Poorly Graded Sand (SP)	$2x10^{-3}$	5.7	$2x10^{-4}$	0.57

The variance of each parameters considered in the analysis for this reach are determined based on the borings drilled within the reach. The standard deviation and coefficient of variation determination for the blanket thickness and sandy aquifer thickness are shown in Enclosure A and summarized in Table 5-5 as follows.

Table 5-5 - Random Variables, Reach A Sacramento River East Levee LM 16.7 (RM 62.6)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	8	2	28
Permeability Ratio (k_f/k_b)	1425	946	66
Foundation Sand thickness (d)	108	3	3

The analyzed cross section is shown on Figure 5-3.

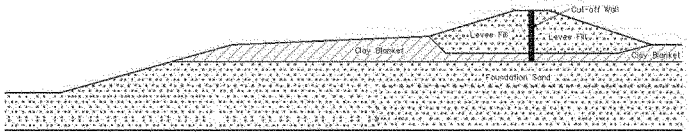


Figure 5-3 - Reach A Cross Section, Sacramento River East Levee LM 16.7 (RM 62.6)

Uncertainty analyses performed for this reach resulted in the following curve.

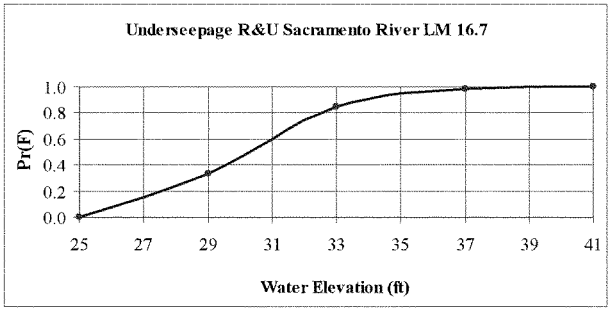


Figure 5-4 - Underseepage Reliability Analysis, Reach A Sacramento River East Levee LM 16.7 (RM 62.6)

5.6.1.3 Stability Reliability Analysis

The levee is constructed of dredged sand and has a shallow cut-off wall extending through the levee to prevent internal erosion due to seepage through the levee embankment. The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 5-6. A cohesion of 50 psf for the levee material was considered in stability analyses to prevent shallow failure surfaces close to infinite slope failures.

Table 5-6 - Random Variables, Reach A Sacramento River East Levee LM 16.7 (RM 62.6)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Sand in Foundation and Levee internal Friction Φ(degrees)	33	4	12.0
Foundation Clay "Blanket" Cohesion (psf)	50	20	40
Foundation Clay "Blanket" Φ(degrees)	26	3	12
Sand in Foundation and Levee Unit Weight γ(pcf)	125	5	4
Foundation Clay Unit Weight γ(pcf)	115	5	4

The cross section and critical slope failure surface for the maximum water elevation is shown on Figure 5-5.

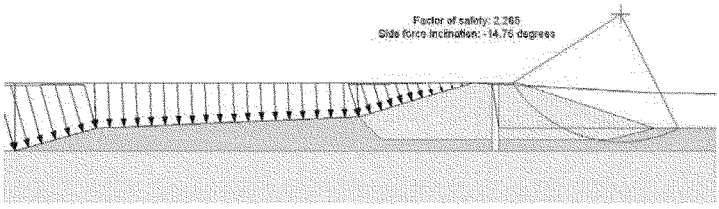


Figure 5-5 - Critical Slope Failure, Reach A Sacramento River East Levee LM 16.7 (RM 62.6)

The probability analysis performed for this cross section resulted in the following curve.

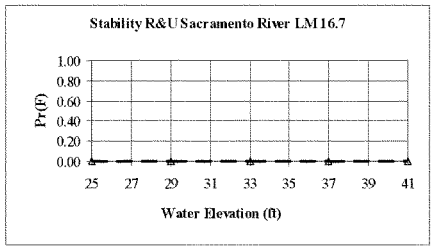


Figure 5-6 - Stability R&U Analysis, Reach A Sacramento River East Levee LM 16.7 (RM 62.6)

As shown in the above figure, there is no risk for stability failure for this reach. All factors of safety calculated for all river stages were above the considered factor of safety 1.

5.6.1.4 Judgment Reliability

The risk of failure by internal erosion due to seepage through the levee was not considered, as the levee embankment has a 30 to 45 feet deep seepage cut-off wall extending into the levee foundation. The riverbank erosion was considered minimal as very low velocities are expected within the area and there is no history of erosion of the levee or riverbank in the past. There are aged utilities past design life penetrating the levee embankment and power poles in the landside and waterside levee slope. The most critical area includes discharge lines from an existing pumping station with history of leaking. Encroachments on the levee embankment consist of fences, posts, hedges, including buildings. The waterside slope is covered by heavy vegetation and encroachments in the area consisting of fences, power poles, and buildings, which extend to the levee crown.. Rodent activity is however minimal due to heavily populated urban area. Utilities penetrating the levee are not constructed conforming to the current Corps requirements. The judgmental curve was estimated by the expert elicitation team. The judgment based conditional probability of poor performance is shown in Figure 5-7.

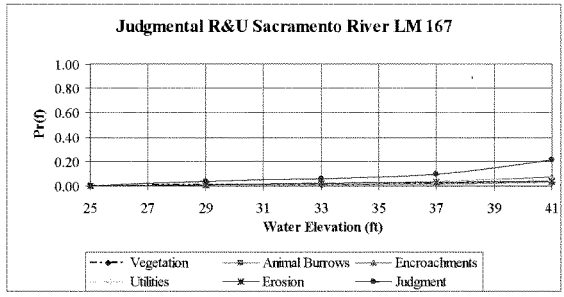


Figure 5-7 - Judgment R&U, Reach A Sacramento River East Levee LM 16.7 (RM 62.6)

5.6.1.5 Combined Reliability

The levee landside toe at the considered index point in Reach A is at elevation 21 feet with the levee crest at elevation 41 feet. The 85 percent probability of having a localized poor performance occurs for a flood stage of 33 feet, 8 feet below the levee crest, and the 15 % probability at elevation 26.5 feet, 5.5 feet above the landside levee toe. As seen on the graphics, the high risk of the poor performance is a combination of risks between the underseepage through the levee foundation and judgment, the underseepage resulting in high gradients at the toe of the levee having the highest impact on the levee performance, the judgmental curve having less impact. The combined probability of failure is as shown in Figure 5-8.

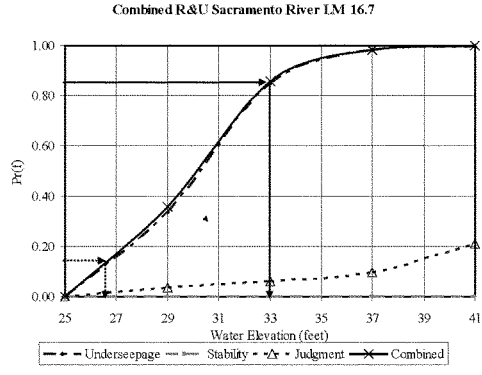


Figure 5-8 - Combined R&U Reach A Sacramento River East Levee LM 16.7 (RM 62.6)

5.6.2 Natomas Basin Levee Unit 1, Reach B Sacramento River East Bank LM 5.0 to 15.5 (RM 672 to 64.0), Index Point LM 13.9

5.6.2.1 General

The critical cross section at LM 13.9 (RM 66.2) was considered as representing the reach between the LM 12.0 and 15.5. The geomorphologic study shows old meanders of the river. Sand boils and heavy seepage during the high water stages were reported. Erosion of the riverbank was also observed in this reach of the river. The average crest of the levee within this reach is at elevation 41.5 feet (considering the vertical datum NAVD 88) having a maximum height of 18 feet. The landside levee toe for the analyzed index point was considered at elevation 21.3 feet. The levee crest width is 20 feet and the side slope 1(V) on 2(H) on the landside and 1(V) on 3(H) on the waterside. The levee was constructed of dredged sand as on the entire levee along the Sacramento River in the Natomas Basin. Foundation soils consist of a natural blanket with the thickness varying between 6 and 30 feet, with an average of 16 feet overlaying a deposit of silty sand to poorly graded sand varying in thickness between 7 and 89 feet averaging 40 feet as shown on the borings within the reach. The composition of the natural blanket consists primarily of lean clay material (CL) with some exceptions when silt was encountered. Locations of the borings used in the analysis and the soil profiles are provided in Enclosure F1. A shallow cut-off wall 35-40 feet deep was constructed through the levee embankment to prevent internal erosion of the embankment material due to seepage through the embankment. Detailed results of the reliability analyses are provided in Enclosure F4.

5.6.2.2 Underseepage Reliability Analysis

The permeabilities considered in the seepage analyses are based on the materials encountered in the existing borings and are shown in Table 5-7.

Table 5-7 - Permeabilities Levee Unit 1 Reach B Sacramento River East Bank LM 13.9 (RM 66.2)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio k_v/k_h
	cm/sec	ft/day	cm/sec	ft/day	
Lean Clay (CL)	$4x10^{-6}$	0.0112	$1x10^{-6}$	0.0028	0.25
Silt (ML)	$2x10^{-4}$	0.228	$5x10^{-5}$	0.057	0.25
Poorly Graded Sand (SP)	$2x10^{-3}$	5.7	$2x10^{-4}$	0.57	0.1
Sand, Silty Sand (SP/SM)	$2x10^{-4}$	0.57	$2x10^{-5}$	0.057	0.1

The mean permeability ratio between the horizontal permeability of the sand layer and vertical permeability of the impervious blanket is 1823.
The variance of each parameters considered in the analysis for this reach are determined based on the borings drilled within the reach. The standard deviation and coefficient of variation

determination for the blanket thickness and sandy aquifer thickness are shown in Appendix A and summarized in Table 5-8 as follows.

Table 5-8 - Underseepage Random Variables, Levee Unit 1 Reach B Sacramento River East Bank LM 13.9 (RM 66.2)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	16	9	56
Permeability Ratio (k_f/k_b)	1623	795	49
Foundation Sand thickness (d)	40	30	75

The analyzed cross section is shown on Figure 5-9.

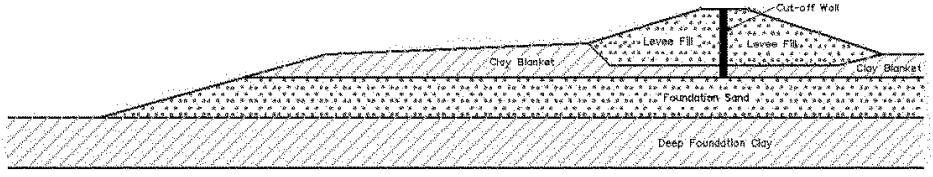


Figure 5-9 - Cross Section, Levee Unit 1 Reach B Sacramento River East Bank LM 13.9 (RM 66.2)

Uncertainty analyses performed for this reach resulted in the following curve.

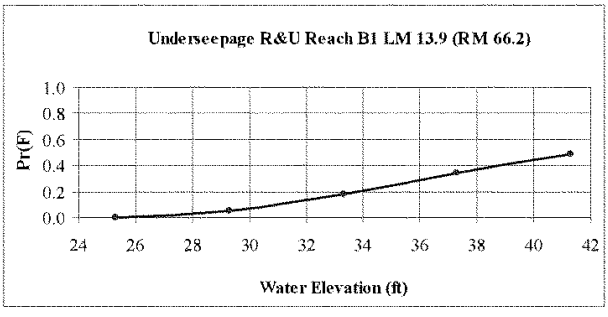


Figure 5-10 - Underseepage R&U Levee Unit 1 Reach B Sacramento River East Bank LM 13.9 (RM 66.2)

5.6.2.3 Stability Reliability Analysis

The levee is constructed of dredged sand and has a shallow slurry cut-off wall through the embankment to prevent internal erosion due to seepage through the levee embankment. The

expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 5-9. A cohesion of 50 psf for the levee material was considered in stability analyses to prevent shallow failure surfaces close to infinite slope failures.

Table 5-9 - Stability Random Variables, Levee Unit 1 Reach B Sacramento River East Bank LM 13.9 (RM 66.2)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Sand in Foundation and Levee internal Friction Φ(degrees)	33	4	12.0
Foundation Clay "Blanket" Cohesion (psf)	50	20	40
Foundation Clay "Blanket" Φ(degrees)	26	3	12
Sand in Foundation and Levee Unit Weight γ(pcf)	125	5	4
Foundation Clay Unit Weight γ(pcf)	115	5	4

The cross section and critical slope failure surface for the maximum water elevation is shown on Figure 5-11.

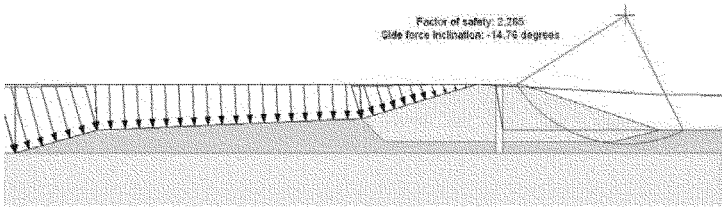


Figure 5-11 - Critical Slope Failure, Levee Unit 1 Reach B Sacramento River East Bank LM 13.9 (RM 66.2)

The probability analysis performed for this cross section resulted in the following curve.

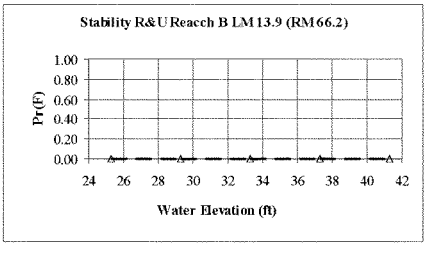


Figure 5-12 - Slope Stability R&U Curve, Levee Unit 1 Reach B Sacramento River East Bank LM 13.9 (RM 66.2)

All factors of safety calculated for all river stages were above the considered factor of safety 1 (equilibrium).

5.6.2.4 Judgment Reliability

Based on the geomorphology study the levee foundation in this area is an old oxbow; and the levee history shows "sand boiling" activity in the past during high river stages. The risk of failure by internal erosion due to seepage through the levee was not considered, due to the levee embankment having a slurry wall through the embankment thereby preventing seepage through the levee. The erosion due to wind waves and water velocities was included in the judgmental probability of failure considering the past history of erosions on the riverbank. There are numerous utilities penetrating the levee embankment encroachments on both waterside and landside slopes. The levee slopes are covered by heavy woody vegetation consisting of brush and shrubs covering the levee slopes and big diameter trees. The heavy vegetation extends on some locations up to the levee crown. The levee waterside slope cannot be inspected due to the heavy vegetation growth covering the riverbank and the levee slope. Encroachments on the levee embankment consist of fences, posts, hedges, utility penetrations and buildings. All these reasons lead to a perceived higher risk of levee failure during flood stages. The judgment based conditional probability of failure was determined by an expert elicitation panel and is provided on Figure 5-13.

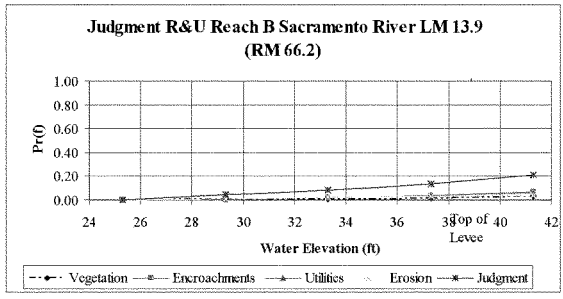


Figure 5-13 - Judgment Reliability, Levee Unit 1 Reach B Sacramento River East Bank LM 13.9 (RM 66.2)

5.6.2.5 Combined Reliability

The combined probability of failure along the Sacramento River East Levee LM 13.8 (RM 66.2) is shown in Figure 5-14. As seen on the graphics, the underseepage through the levee is the main contributor to the poor performance, the judgmental curve having a small impact.

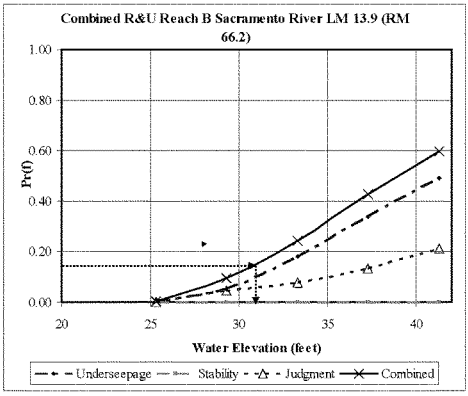


Figure 5-14 - Combined R&U, Reach B Sacramento River East Levee LM 13.9 (RM 66.2)

The analyzed index point has the landside levee toe at elevation 21.3 feet and the crest elevation 41.3 feet. The combined fragility curve indicates the 15% risk of poor performance corresponds to a the water at elevation 31.3 feet, 10 feet above the landside levee toe, and the 85% to a water elevation above the levee crest, the probability of a poor performance at the levee crest being no greater than 60%.

5.6.3 Natomas Basin, Reach C Levee Unit 1 Sacramento River East Levee LM 0.0 to 5.0 (RM 79.2 to RM 74.45), Index Point LM 1.33RM 78.0

5.6.3.1 General

The cross section at LM 1.33 was considered critical for Reach C on the Sacramento River east bank between LM 0.0 and 5.0. The geomorphologic study shows old meanders of the river. Sand boils and heavy seepage during the high water stages were reported. Erosion of the riverbank was also observed in this reach of the river. The average levee crest within the reach was considered at elevation 44 feet and the toe of the levee at elevation 27 feet (the elevations are in vertical datum NAVD 88). The crest width is 20 feet and side slopes 1(V) on 2(H) landside and 1(V) on 3(H) waterside. The levee was constructed of dredges sand and has a stability berm on the landside slope with a chimney drain to reduce the seepage through the levee and the internal erosion, and increase the landside stability. Foundation soils consist of a natural blanket with the thickness varying between 11 and 37 feet, with an average of 19 feet overlaying a sand deposit 13 to 43 feet thick averaging 29 feet as shown on the borings within this reach. The composition of the natural blanket consists of lean clay (CL) with some exception where clayey silts and silt was encountered (CL, ML). The aquifer consists mainly of poorly graded sandy soils (SP). Location of the borings used for the analyses of Reach C and soil profiles are provided in Enclosure F1. Major features on Reach C are the Highway 99 and Howsley Road and the Northern and Bennett pumping plants. Detailed results of the reliability analyses are provided in Enclosure F4.

5.6.3.2 Underseepage Reliability Analysis

The permeabilities considered in the seepage analyses are based on the existing borings within the area are summarized in Table 5-10.

Table 5-10 - Permeabilities, Reach C Sacramento River East Levee LM 1.33(RM 78.0)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio k_v/k_h
	cm/sec	ft/day	cm/sec	ft/day	
Lean Clay (CL)	$4x10^{-6}$	0.0112	$1x10^{-6}$	0.0028	0.25
Clayey Silt (CL/ML)	$2x10^{-4}$	0.228	$5x10^{-5}$	0.057	0.25
Poorly Graded Sand (SP)	$2x10^{-3}$	5.7	$2x10^{-4}$	0.57	0.1

The variance of each parameters considered in the analysis for this reach are determined based on the borings drilled within the reach. The standard deviation and coefficient of variation determination for the permeability ratio, blanket thickness and sandy aquifer thickness are summarized in Table 5-11 as follows.

Table 5-11 - Random Variables, Reach C Sacramento River East Levee LM 1.33(RM 78.0)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	19	8	41
Permeability Ratio (k_f/k_b)	1713	753	44
Foundation Sand thickness (d)	29	12	43

The analyzed cross section is shown on Figure 5-15.

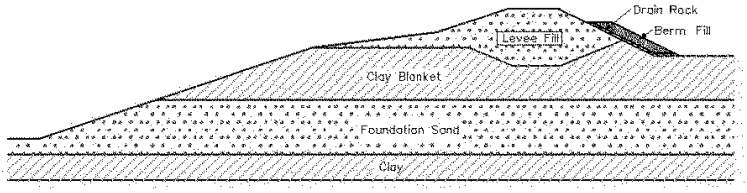


Figure 5-15 - Cross Section, Reach C Sacramento River East Levee LM 1.33(RM 78.0)

Uncertainty analyses performed for this reach resulted in the following curve

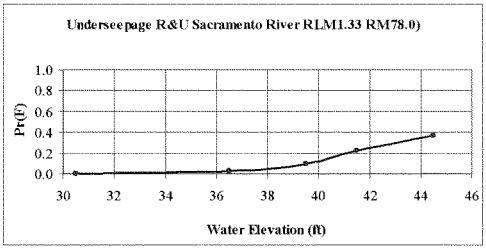


Figure 5-16 - Underseepage Reliability Analysis, Reach C Sacramento River East Levee LM 1.33(RM 78.0)

5.6.3.3 Stability Reliability Analysis

The levee was considered to have 1(V) on 3(H) waterside slope and 1(V) on 2(H) landside slope. The levee is constructed of dredged sand and has a landside stability berm placed on a layer of drainage material that extends along the landside slope, to prevent interior erosion due to seepage through the levee and to increase the stability of the landside slope. The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 5-12. A cohesion of 50 psf for the levee material was considered in stability analyses to prevent shallow failure surfaces close to infinite slope failures.

Table 5-12 - Random Variables, Reach C Sacramento River East Levee LM 1.33(RM 78.0)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Sand in Foundation and Levee internal Friction Φ(degrees)	33	4	12
Foundation Clay "Blanket" Cohesion (psf)	50	20	40
Foundation Clay "Blanket" Φ(degrees)	26	3	12
Sand in Foundation and Levee Unit Weight γ(pcf)	125	5	4
Foundation Clay Unit Weight γ(pcf)	115	5	4

The cross section and critical slope failure surface for the maximum water elevation is shown on Figure 5-17.

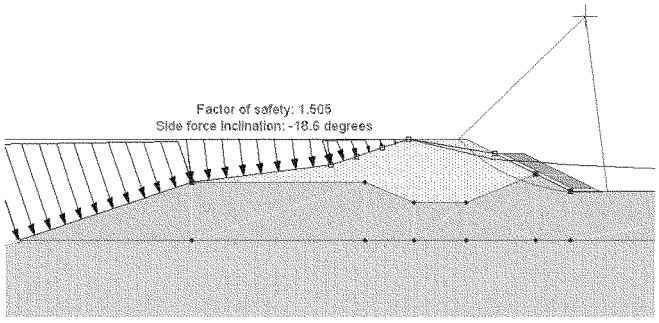


Figure 5-17 - Critical Slope Failure, Reach C Sacramento River East Levee LM 1.33(RM 78.0)

The probability analysis performed for this cross section resulted in the following curve.

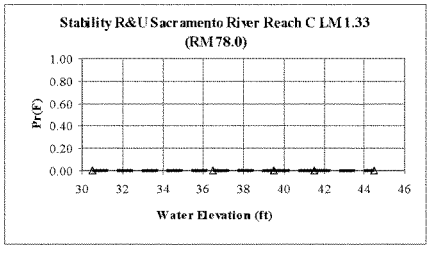


Figure 5-18 - Stability Reliability Analysis, Reach C Sacramento River East Levee LM 1.33(RM 78.0)

As shown in the above figure, there is no risk for stability failure for this reach. All factors of safety calculated for all river stages were above the considered factor of safety 1.

5.6.3.4 Judgment Reliability

The levee was constructed in an area with meanders of the river, the waterside slope is covered by heavy vegetations growth and encroachments current extend to the levee crown, including numerous utilities penetrating the levee that are not conforming to the Corps requirements. The risk of failure by internal erosion due to seepage through the levee was not considered, as the levee embankment has a stability berm on the landside that was constructed on a drainage layer extended along the slope that intercepts any water seeping through the levee and no seepage through the levee was observed after the berm was constructed. The riverbank was eroded in the past by high river stages. The erosion due to wind waves and water velocities was included in the judgmental probability of failure due to past history of erosions on the riverbank. There are utilities penetrating the levee embankment and power poles in the landside and waterside levee

slope. The levee slopes are covered by heavy vegetation consisting of brush covering the levee toes and large diameter trees. The heavy vegetation growth extends on some locations up to the levee crown. The levee waterside slope could not be inspected due to the heavy vegetation covering the riverbank and the levee slope and due to the encroachments on the waterside levee slope. Encroachments on the levee embankment consist of fences, posts, hedges, including buildings. All these reasons lead to a high risk of levee failure during flood stages. The judgment risk and uncertainty curve, as determined by the expert elicitation panel is shown in Figure 5-19

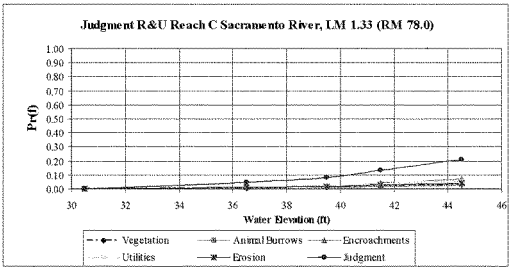


Figure 5-19 - Judgment R&U, Reach C Sacramento River East Levee LM 1.33(RM 78.0)

5.6.3.5 Combined Reliability

The combined probability of failure along the Reach C on the Sacramento River East Levee at the LM 1.33 (RM 78.0) is shown in Figure 5-20. As seen on the graphics, the underseepage poor performance is the main contributor for the risk and uncertainty curve of the levee, the stability being neglected since the risk was 0. The encroachments, vegetation, animal rodents and erosion combined have a small contribution to the risk of poor performance. The combined R&U curve resulted in 15% risk of poor performance at the water 9.2 feet below the levee crest (12 feet above the levee landside toe) and 85% risk of poor performance when the water is above the levee crest elevation, the risk of poor performance at the levee crest being only 50%.

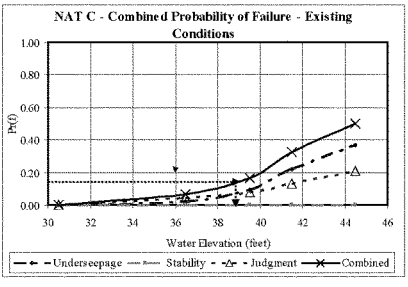


Figure 5-20 - Combined Probability of Failure, Reach C Sacramento River East Levee LM 1.33(RM 78.0)

5.6.4. Natomas Basin Levee Unit 4 Reach D Natomas Cross Canal LM 0.0 to 4.38 (RM 5.0 to 0.0)

5.6.4.1 General

The cross section at the upstream end of the levee at LM 0.1 (RM 4.3) was considered critical for the Reach D on Natomas Cross Canal between the LM 0.0 and 5.0 (RM5.0 to 0.0). The average levee crest at this reach is at elevation 45.0 and the levee toe was considered at elevation 29 feet, the levee being average 26 feet high. The levee crest considered in the analyses was 20 feet wide with the side slopes 1(V) on 3(H) on the water side and 1(V) on 2(H) on the landside. The levee was constructed of silts and clays with low to high plasticity excavated from the low flow channel located along the waterside levee toe. A 15-foot wide stability berm constructed of the same material as the levee embankment was placed along the landside levee slope, to half of the levee height. The berm was placed on a free drainage blanket extended along the levee slope to intercept any seepage through the levee embankment and to reduce the internal erosion. The consistency of the levee material as found in the exploratory borings was found to be firm to very firm. The foundation consists of a fine grained blanket 6 to 16 feet thick, averaging 10 feet underlain by a permeable sand layer 26 to 60 feet thick, averaging 37 feet. The blanket consists of predominantly lean clay and high plasticity clay with sand and extends along the bank waterside of the levee. The sandy aquifer consists of poorly graded sand, poorly graded sand with silt or with silt and gravel, with the fines ranging from 5% to 12%. The locations of the borings used in the analysis and the soil profiles are provided in Enclosure F1. The soil parameters used for seepage analysis are shown on Table 5-13. The results of the risk analyses are provided in Enclosure F4.

5.6.4.2 Underseepage Reliability Analysis

The permeabilities considered in the reliability analyses are as follows:

Table 5-13 - Permeabilities Reach D Natomas Cross Canal LM 0.1(RM 4.3)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio k_v/k_h
	cm/sec	ft/day	cm/sec	ft/day	
Lean Clay (CL)	$4x10^{-6}$	0.112	$1x10^{-6}$	0.0028	0.25
Clayey Silt (CL/ML)	$2x10^{-4}$	0.228	$5x10^{-5}$	0.057	0.25
Poorly Graded Sand (SP)	$2x10^{-3}$	5.7	$2x10^{-4}$	0.57	0.1

The variance of each parameters considered in the analysis for this reach are determined based on the borings drilled within the reach. The standard deviation and coefficient of variation determination for the permeability ratio, blanket thickness and sandy aquifer thickness are shown in Table 5-14 as follows.

Table 5-14 - Random Variables Reach D Natomas Cross Canal LM 0.1(RM 4.3)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	10	3	29
Permeability Ratio (k_f/k_b)	1606	854	53
Foundation Sand thickness (d)	37	13	34

The analyzed cross section is shown on Figure 5-21.

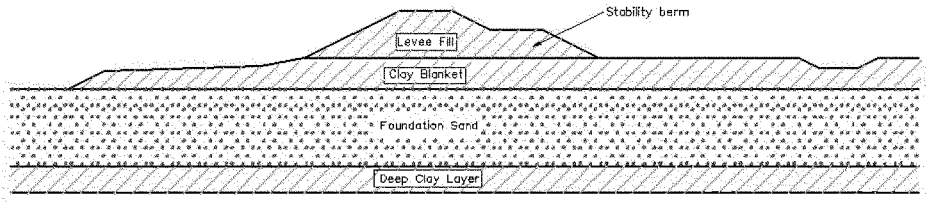


Figure 5-21 - Levee Cross Section Reach D Natomas Cross Canal LM 0.1(RM 4.3)

Uncertainty analyses performed for this reach resulted in the following curve.

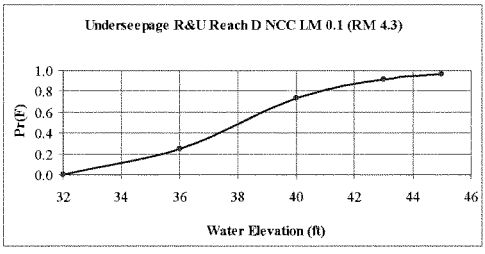


Figure 5-22 - Underseepage R&U, Reach D Natomas Cross Canal LM 0.1(RM 4.3)

5.6.4.3 Stability Reliability Analysis

The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 5-15.

Table 5-15 - Random Variables Reach D Natomas Cross Canal LM 0.1(RM 4.3)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Levee Fill internal Friction Φ(degrees)	32	4	12.0
Foundation Clay "Blanket" Cohesion (psf)	50	20	40
Foundation Clay "Blanket" Φ(degrees)	28	3	12
Levee Unit Weight γ(pcf)	120	5	4
Foundation Clay Unit Weight γ(pcf)	115	5	4

The cross section and critical slope failure surface for the maximum water elevation is shown on Figure 5-23.

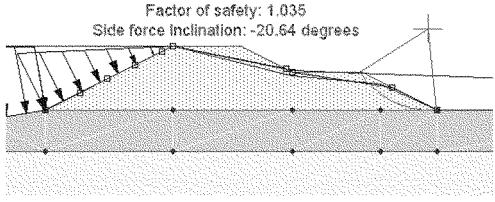


Figure 5-23 - Critical Failure Surface Reach D Natomas Cross Canal LM 0.1(RM 4.3)

The results of the steady state stability risk analysis are shown in Figure 5-24 below.

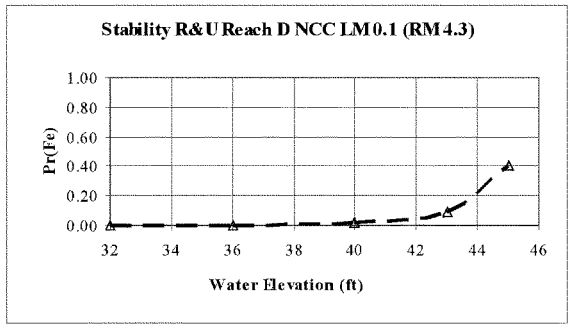


Figure 5-24 - Stability Analysis R&U Reach D Natomas Cross Canal LM 0.1(RM 4.3)

5.6.4.4 Judgment Reliability

The waterside slope is covered by heavy vegetations growth. The risk of failure by internal erosion due to seepage through the levee was not considered, as the levee embankment is constructed of impervious fill that is unlikely to be erodible. The judgment based conditional

probability of failure was considered higher due to cracks in the levee observed during inspections, animal burrows, and heavy vegetation growth. The heavy vegetation growth consists of dense brush and big diameter trees on the waterside slope. Utilities such as pressurized pipes for irrigation and from other pump stations penetrate the levee embankment on numerous locations. Power poles are constructed in the levee landside and waterside slopes. The erosion due to wind waves and water velocities was included in the judgmental probability of failure due to past history of erosions on the canal bank. However, the probability of failure is lower for the Natomas Cross Canal than for the Sacramento River levees part of the Natomas Basin due to less encroachments on the levee slopes and better access for inspection and maintenance. The judgment based probability of poor performance curve as determined by the expert elicitation opinion is shown in Figure 5-25.

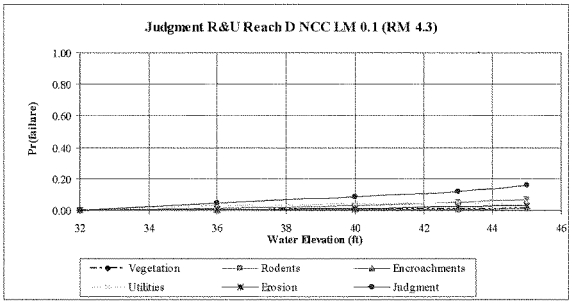


Figure 5-25 - Judgment R&U Reach D Natomas Cross Canal LM 0.1(RM 4.3)

5.6.4.5 Combined Reliability

The combined R&U curve is shown on Figure 5-26 below. The levee crest was considered at elevation 45 feet and the landside toe at elevation 29 feet. The underseepage through the levee foundation resulting in high gradients even at low water elevations are the main factors contributing to the high risk of poor performance. At higher elevations, when water reaches 5 feet below the levee crest, the stability of the landside slope is considering also a factor impacting the risk of poor performance, the judgmental risk being lower in this case. The 85 percent probability of poor performance for the Reach D, Natomas Cross Canal south bank levee, occurs for a flood stage of 41 feet, 4 feet below the levee crest, while the 15% probability of poor performance at water elevation 34 feet, 11 feet below the levee crest and 5 feet above the landside levee toe. The combined probability of poor performance on the Natomas Cross Canal is shown in Figure 5-26.

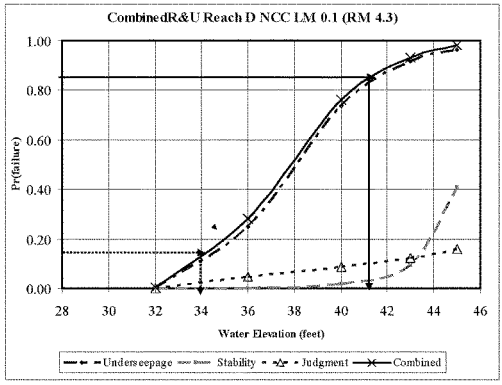


Figure 5-26 - Combined R&U Reach D Natomas Cross Canal LM 0.1(RM 4.3)

5.6.5 Natomas Levee Unit 3, Reach E Pleasant Grove Creek Canal (PGCC LM 16.09 to 12.55, RM 0.37 to 3.45) & Reach F Natomas East Main Drainage Canal (NEMDC LM 12.55 to 7.89 RM 0.0 to 10.38)

5.6.5.1 General

The existing conditions of the levees and their foundation on the east bank of the Pleasant Grove Creek Canal (Reach E) and the upstream reaches of the Natomas Main Drainage Canal (reach F and partially G) are similar and one index point at the levee mile LM 6.43 (NEMDC RM9.0) was considered critical for these reaches. The boundary between the NEMDC and the PGCC is defined by the Sankey Road area, which is a natural topographic high area, forming a drainage divide along the study area alignment. At Sankey Road, the NEMDC drains south to the American River and the PGCC drains north to the NCC. The average levee crest along the PGCC varies between 45 and 47 feet with an average of 46 feet and the landside toe is at 35 feet, the levee height being between 10 and 16 feet. The levee crest along the NEMDC varies between 41 and 47 feet averaging 43 feet. The ground surface varies between 20 feet at the downstream end and 35 feet at the upstream end, the levee height varying between 8 and 23 feet. The levee crest is currently occupied by, alternately, a paved patrol road/bicycle path. The NEMDC and PGCC levees were constructed between 1912 and 1914. The levee's original configuration (before improvements – 1994 through 1996) consisted of an approximately 20-foot wide crest with landside and waterside slopes of 1(V) on 2(H) and 1(V) on 3(H), respectively. The typical levee section also indicates the presence of a centerline core trench. Improvements along the PGCC consisted of retained and reinforced road crossings at grade at Howsley, Fifield, and Sankey Roads and the eastern end of a chimney or blanket drain installed along the southern levee of the NCC, near the end of the study area, north of Howsley Road. Numerous pipes cross the PGCC and NEMDC levees. No specific areas or locations of boils were identified from available reports and interviews for either the NEMDC or PGCC levees. No areas of waterside

or landside instability were reported on either the NEMDC or PGCC levees, including conditions after flood events of 1986 and 1987. A "sinkhole" was near the northern end of the PGCC on the waterside of the levee, before the intersection with the NCC (north of Howsley Road). The sinkholes were caused by the collapse of animal burrows created by beavers. Collapse features were observed along the waterside toe of the PGCC levee north of Howsley Road, associated with numerous, large diameter (about 1 to 3 feet) tunnels or burrows observed at the waterside toe of the levee and extend more than 10 feet into the levee.

The upper levee foundation generally consists of sandy lean clay, lean clay, with interlayers of medium dense to very dense, silty and clayey sand that extends to about 35 to 40 feet below the crest of levee. On the north end of reach E, below the base of the upper levee foundation, interbedded fat clay, sandy fat clay, lean clay, sandy lean clay, silt clayey sand, silty sand, poorly graded sand, sandy silt, and silt were encountered.

The levee fill material along reach F on NEMDC west bank generally consists of lean clay and sandy clay. The upper levee foundation generally consists of sandy lean clay, lean clay, with interlayers of silty and clayey sand that extends to about 17 to 20 feet below the crest of levee. Below this depth is very dense silt. At the considered index point the upper impervious blanket thickness varies between 5 and 10 feet with an average of 7 feet and consists of impervious clay materials. The locations of the borings and the soil profiles used in analysis are provided in Enclosure F1. The soil parameters used for seepage analysis are shown on Table 5-16. The results of the risk analyses are provided in Enclosure F4.

5.6.5.2 Underseepage Reliability Analysis

The permeabilities considered are as follows:

Table 5-16 - Permeabilities, Levee Unit 3, NEMDC LM 6.43 (RM 9.0)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio k_v/k_h
	cm/sec	ft/day	cm/sec	ft/day	
Lean Clay (CL)	$4x10^{-6}$	0.0112	$1x10^{-6}$	0.0028	0.25
Poorly Graded Sand (SP)	$2x10^{-3}$	5.7	$2x10^{-4}$	0.57	0.1
Gravel, Sandy Gravel Sandy Gravel	$1x10^{-2}$	28	$1x10^{-3}$	2.8	0.1

The variance of each parameters considered in the analysis for this reach are determined based on the borings drilled within the reach. The standard deviation and coefficient of variation determination for the blanket thickness and sandy aquifer thickness are summarized in Table 5-17 as follows.

Table 5-17 - Underseepage Random Variables, Levee Unit 3, NEMDC LM 6.43 (RM 9.0)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	7	2	33
Permeability Ratio (k_f/k_b)	3629	3562	98
Foundation Sand thickness (d)	7	3	47

Uncertainty analyses performed for this reach resulted in the following curve.

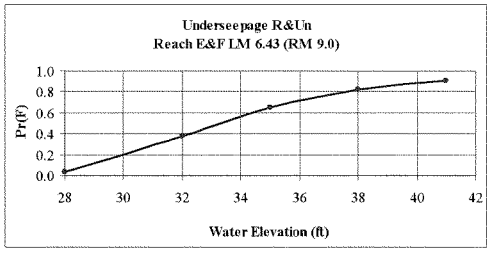


Figure 5-27 - Underseepage Levee Unit 3, NEMDC LM 6.43 (RM 9.0)

5.6.5.3 Stability Reliability Analysis

The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 5-18.

Table 5-18 - Random Variables Levee Unit 3, NEMDC LM 6.43 (RM 9.0)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Silty Sand Φ(degrees)	33	4	12
Foundation Clay Cohesion (psf)	50	20	40
Foundation Clay Φ(degrees)	28	3	12
Silty Sand Unit Weight γ(pcf))	130	5	4
Foundation Clay Unit Weight γ(pcf)	112	4	4

The typical cross section and a critical slope failure surface is shown on Figure 5-28.

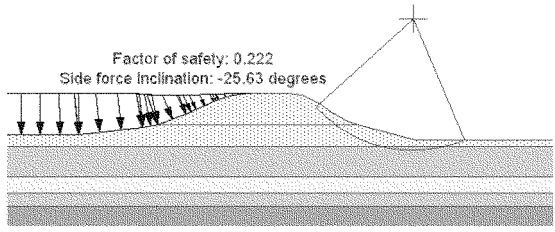


Figure 5-28 - Critical Failure Surface Levee Unit 3, NEMDC LM 6.43 (RM 9.0)

The results of the steady state stability risk analysis are shown in Figure 5-29 below.

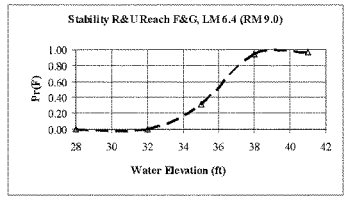


Figure 5-29 - Stability Analysis R&U Levee Unit 3, NEMDC LM 6.43 (RM 9.0)

5.6.5.4 Judgment Reliability

The waterside slope is less covered by woody vegetations than the Sacramento River levee or Natomas Cross Canal. However, active animal burrows were observed in the area, some of them resulting in levee collapse. The risk of failure by internal erosion due to seepage through the levee was not considered, as the levee embankment is constructed of impervious fill that is unlikely to be erodible. The judgment based conditional probability of failure was considered higher due to cracks in the levee constructed of high plasticity clay and animal burrows. Utilities such as pressurized pipes for irrigation penetrate the levee embankment on numerous locations. The erosion due to wind waves and water velocities is minimal and was included in the judgmental probability of failure. However, the probability of failure is lower for the NEMDC and PGCC than for the Sacramento River levees part of the Natomas Basin due to less encroachments on the levee slopes and better possibilities for inspection and maintenance. The judgment based probability of poor performance curve as determined by the expert elicitation opinion is shown in Figure 5-30.

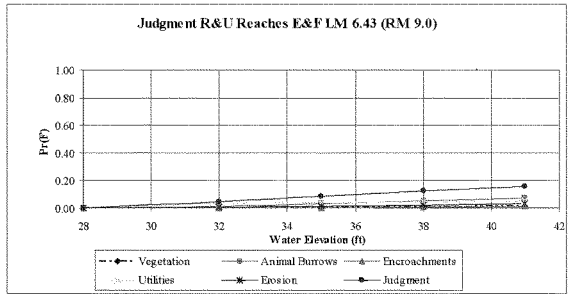


Figure 5-30 - Judgment R&U Levee Unit 3, NEMDC LM 6.43 (RM 9.0)

5.6.5.5 Combined Reliability

The levee crest was considered at elevation 41 feet and the landside toe at elevation 24 feet. The underseepage through the levee foundation resulting in high gradients even at low water elevations leading to high risk of slope instability are the main factors contributing to the high risk of poor performance. The judgmental risk was determined as being lower in this case. The 85 percent probability of poor performance for the Reaches E&F on PGCC and NEMDC east bank levees occurs for a flood stage of 36 feet, 5 feet below the levee crest, while the 15% probability of poor performance occurs at water elevation 30 feet, 11 feet below the levee crest and 6 feet above the landside levee toe. The combined probability of poor performance on the Reaches E and F along the east bank of the PGCC and NEMDC is shown in Figure 5-31.

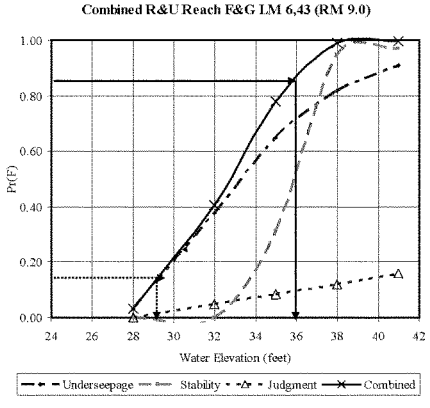


Figure 5-31 - Combined R&U Levee Unit 3, NEMDC LM 6.43 (RM 9.0)

5.6.6 Natomas Levee Unit 3, Reach G &H Natomas East Main Drainage Canal (NEMDC) LM 7.89 to 0.0 (RM 10.38 to 2.54)

5.6.6.1 General

Reaches G and H have similar foundation and levee conditions and therefore one index point at LM 4.85 (RM 7.5) on NEMDC LM 4.87 (RM 7.5) was considered critical for both reaches. Reach G extends from the intersection with Elverta Road to the RD 1000 Pump Station 6. The levee height varies between 7 and 15 feet having a 20 foot wide crest covered by asphalt and 1(V) on 2(H) landside slope and 1(V) on 2(H) to 2.5 (H) waterside slopes. The levee fill material consists of lean clay. The upper levee foundation generally consists of sandy lean clay and lean clay, with interlayers of dense to very dense, silty and clayey silts extending 20 to 40 feet from the natural ground. This layer overlay a layer of interbedded silt and lean clay with clayey sand, silty sand, sandy silt, and silt. Locations of the boring and soil profiles used in the analysis and soil profiles are provided in Enclosure F1. Major features encountered within this reach are the Elverta Road and Elkhorn Boulevard intersecting the levee crest. The landside of the levee in this reach is primarily undeveloped agricultural land with occasional private residences. The waterside and landside levee slopes are relatively clean of woody vegetation.
Reach H extends from the Rd 1000 Pump Plant #6 to the downstream end of NEMDC at the intersection with the American River. The levee height varies between 10 and 25 feet having a 20 foot wide crest covered by asphalt and 1(V) on 2(H) landside slope and 1(V) on 2(H) to 2.5(H) waterside slopes. The levee fill material consists of lean clay and sandy lean clay with minor amounts of clayey sand and sandy silt. The upper levee foundation generally consists of lean to fat clay, lean clay, and sandy lean clay that extends between 7 and 34 feet below the natural ground overlying a 24 to 35 feet thick layer of interbedded silt, silty or clayey sands, and poorly graded sands. Locations of the boring logs used in the analysis and soil profiles are provided in Enclosure F1. Major features in Reach H include the Arden-Garden, San Juan, and West El Camino, I-80, Main Avenue bridges, City of Sacramento Pumping Station, and sections chimney/blanket drain and seepage cutoff trench constructed on either side of discharge pipes at the City's pump station, RD 1000 Pump Station. I-80 crossing over the NEMDC is centered in what once was the Magpie Creek drainage channel. The landside of levee along Reach H upstream of Arcade Creek is mostly agricultural area while downstream of Arcade Creek is residential and commercial development.
The results of the risk and uncertainty analyses are provided in Enclosure F4.

5.6.6.2 Underseepage Reliability Analysis

The permeabilities and the variation of the permeability ratio, blanket thickness, and the thickness of the aquifer were based on borings in the vicinity of the index point at LM 4.85 (RM 7.5). The thickness of the impervious blanket in the vicinity of the selected index point varies between 5 and 20 feet and consists of clays and clays with silt overlaying a sandy aquifer 40 to 60 feet thick. The borings used for the R&U analyses are shown in the analyses spreadsheet (see Enclosure F4) and the permeabilities variations are summarized in Tables 5-19 below.

Table 5-19 - Permeabilities, Unit 3, Reach G &H, NEMDC LM 4.85 (RM 7.5)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio k_v/k_h
	cm/sec	ft/day	cm/sec	ft/day	
Lean Clay (CL)	$4x10^{-6}$	0.0112	$1x10^{-6}$	0.0028	1
Silt, Clays with Silt (CL, ML)	$2x10^{-4}$	.228	$5x10^{-5}$	0.057	0.25
Poorly Graded Sand (SP)	$2x10^{-3}$	5.7	$2x10^{-4}$	0.57	0.1

The standard deviation and coefficient of variation for the permeability ratios, blanket thickness and sandy aquifer thickness are summarized in Table 5-20 as follows.

Table 5-20 - Random Variables, Unit 3, Reach G &H, NEMDC LM 4.85 (RM 7.5)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	12	6	52
Permeability Ratio (k_f/k_b)	1552	968	62
Foundation Sand thickness (d)	50	8	16

Risk and uncertainty underseepage analyses performed for this reach resulted in the following curve.

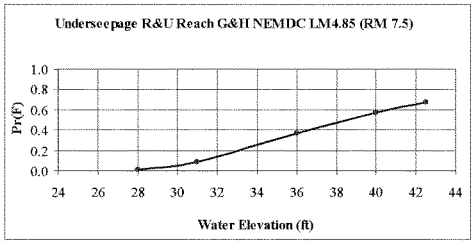


Figure 5-32 - Underseepage R&U Unit 3, Reach G &H,NEMDC LM 4.85 (RM 7.5)

5.6.6.3 Stability Reliability Analysis

The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 5-21.

Table 5-21- Random Variables Unit 3, Reach G &H, NEMDC LM 4.85 (RM 7.5)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Clayey Sand Φ(degrees)	30	4	12
Lean Clay Cohesion (psf)	50	20	40
Lean Clay Φ(degrees)	28	3	12
Clayey Sand Unit Weight γ(pcf))	130	5	4
Lean Clay Unit Weight γ(pcf)	110	4	4

The cross section and a critical slope failure surface are shown on Figure 5-33.

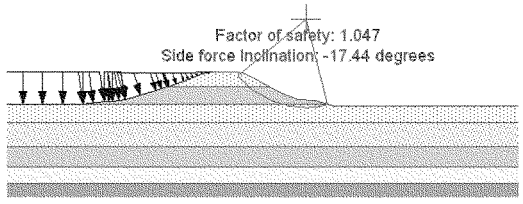


Figure 5-33 - Critical Failure Surface Unit 3, Reach G &H, NEMDC LM 4.85 (RM 7.5)

The results of the steady state stability risk analysis are shown in Figure 5-34 below.

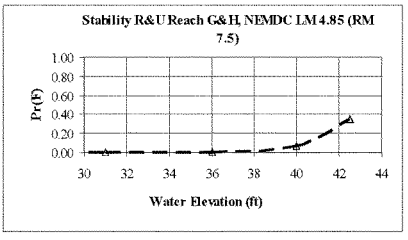


Figure 5-34 – Stability Analysis R&U Unit 3, Reach G &H, NEMDC LM 4.85 (RM 7.5)

5.6.6.4 Judgment Reliability

The waterside and landside slopes are clear of vegetation and encroachments. However, penetrations by pipes crossing the levee from the existing pump stations and also bridges crossing the levees have a higher impact on the judgmental R&U curve. The risk of failure by internal erosion due to seepage through the levee was not considered, since the levee embankment is constructed mainly by less erodible soils such as lean clay. The erosion due to wind waves and water velocities was included in the judgmental probability of failure. The judgment based probability of failure curve is shown in Figure 5-35.

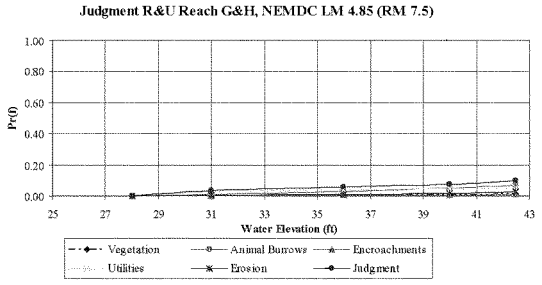


Figure 5-35 - Judgment R&U Unit 3, Reach G &H, NEMDC LM 4.85 (RM 7.5)

5.6.6.5 Combined Reliability

The levee crest elevation at the index point is 43 feet and the landside levee toe at 25 feet, the levee height being 18 feet. The high underseepage gradients leading to levee slope instability at higher water elevations are the main contributors for the high risk of poor performance of the levee. The 85 percent probability of localized poor performance for the NEMDC in reaches G and H occurs for a flood stage above the levee crest elevation. The 15% risk of poor performance occurs at elevation 31.5 feet, 6.5 feet above the landside toe of the levee. The combined probability of poor performance on the NEMDC at LM 4.85 is shown in Figure 5-36.

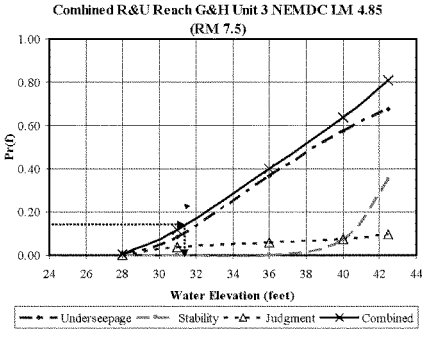


Figure 5-36 - Combined R&U Unit 3, Reach G &H, NEMDC LM 4.85 (RM 7.5)

5.6.7 American River North Bank, Levee Unit 2, Reach I, LM 0.0 to 2.33 (RM 0.0-1.83)

5.6.7.1 General

Wahler Associates investigated the American River levee and the foundation conditions for Reclamation District 1000 after the flood of 1986. The results of the subsurface investigations

provided in the initial appraisal report are used in the evaluation of the foundation and levee geotechnical conditions. Additional investigation along the waterside toe of the existing levee was performed in 1999 by Taber Consultants for the Corps of Engineers, for the construction of a slurry wall along the American River Levee. The soils in the foundation of the levee along American River range consist mostly of fine grained material. The foundation includes also firm to stiff silt, lean clay, clayey silt and silty clay. Also loose to dense silty sand layers less than 5 feet thick was encountered in the foundation. The depth to the water varies between 9 and 27 feet below the natural ground surface. Locations of the borings used for the analysis and the soil profiles are shown in Enclosure F1. The levee predominantly consists of firm to stiff silt, lean clay, clayey silt, and silty clay. The levee height varies between 19 and 20.5 feet with the side slopes of 1(V) on 3(H) on the waterside and 1(V) to 1.5 to 2 (H). The levee crest is typically 45 feet wide to accommodate the Garden Highway. The levee embankment is constructed of impervious clay material. The levee has a drainage canal near the waterside toe which is an extension of the East Main Drainage Canal and an irrigation ditch 4 to 6 feet deep along the landside toe from the Garden Highway ramp at Azusa Street to where the Garden Highway ramps off. The levee crown width is reduced to 20 feet where the Garden Highway ramps off. The index point on Reach I was selected as being the critical cross section representative for this reach at the LM 1.28 (RM 0.9). Detailed analyses results are shown in Enclosure F4.

5.6.7.2 Underseepage Reliability Analysis

The permeabilities, permeability ratio, thickness of the impervious blanket and underlying aquifer were determined based on the borings within the vicinity of the considered index point. The thickness of the impervious blanket varies between 18 and 37 feet and the blanket consists of clays and clay with sandy clays. The impervious blanket overlays a sandy aquifer 3 to 17 feet thick of poorly graded sand and silty sand. The permeabilities are provided in Table 5-22.

Table 5-22 - Permeabilities, Reach I American River LM 1.28 (RM 0.9)

Material	Horizontal permeability		Vertical Permeability		Permeability Ratio k_v/k_h
	cm/sec	ft/day	cm/sec	ft/day	
Lean Clay (CL)	$4x10^{-6}$	0.0112	$1x10^{-6}$	0.0028	0.25
Silt, Clays with Silt (CL, ML)	$2x10^{-4}$	0.228	$5x10^{-5}$	0.057	0.25
Poorly Graded Sand, Silty Sand (SP)	$2x10^{-3}$	5.7	$2x10^{-4}$	0.57	0.1

The standard deviation and coefficient of variation determination for the permeability ratio, blanket thickness and sandy aquifer thickness are summarized in Table 5-23 as follows.

Table 5-23 - Random Variables, Reach I American River LM 1.28 (RM 0.9)

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket Thickness (z)	29	7	25
Permeability Ratio (k_f/k_b)	1261	1060	84
Foundation Sand thickness (d)	9	6	66

Risk and uncertainty analyses performed for this reach resulted in the following curve.

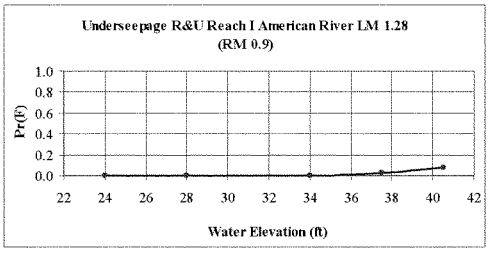


Figure 5-37 - Underseepage R&U Reach I American River LM 1.28 (RM 0.9)

5.6.7.3 Stability Reliability Analysis

The expected values of the soil properties, the standard deviation, and the coefficient of variation used in the stability risk analysis are shown in Table 5-24.

Table 5-24 - Stability Random Variables Reach I American River LM 1.28 (RM 0.9)

Parameter	Expected Value (mean)	Standard Deviation	Coefficient of Variation (%)
Foundation Silt Φ(degrees)	29	3	12
Levee Fill (Silt) cohesion (psf)	50	20	40
Levee Fill (Silt) Φ(degrees)	27	3	12
Foundation Silt Cohesion (psf)	50	20	40
Levee Fill. Unit Weight γ(pcf)	125	5	4

The cross section and critical slope failure surface for the maximum water elevation is shown on Figure 5-38.

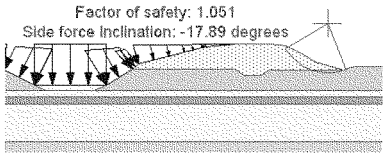


Figure 5-38 - Critical Failure Surface Reach I American River LM 1.28 (RM 0.9)

The results of the steady state stability R&U analysis are shown in Figure 5-39 below.

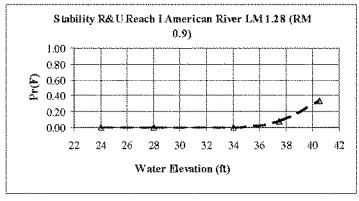


Figure 5-39 - Stability Analysis R&U Reach I American River LM 1.28 (RM 0.9)

5.6.7.4 Judgment Reliability

The waterside slope is covered by vegetation. Discovery Park with old trees is located waterside of the levee slope. The erosion due to wind waves and water velocities was included in the judgmental probability of failure. The landside is mainly residential area with encroachments extending into the levee right of way, encroachments including swimming pools close to the levee landside toe. Penetrations and power poles are also frequent in the area. Erosion was considered minimal since there is no history of excessive erosion and hydraulic analyses show low velocities within this reach. The animal burrow is more controlled in residential areas than on agricultural areas. The judgmental R&U curve as determined by the expert elicitation panel is provided on Figure 5-40.

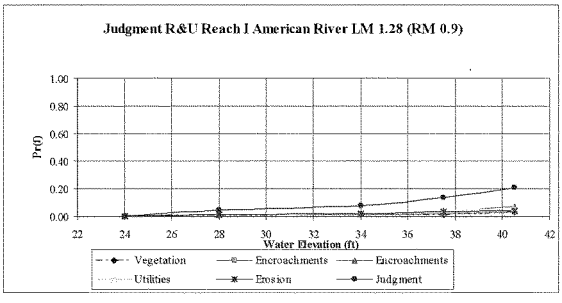


Figure 5-40 - Judgment Probability of Failure Reach I American River LM 1.28 (RM 0.9)

5.6.7.5 Combined Reliability

The combined probability of failure on the index point of Reach I, American River North Bank is shown on Figure 5-41. The levee crest at this location is at elevation 40.5 feet and the landside levee toe at elevation 20, the levee being 20.5 feet high. The underseepage through the levee foundation resulting in high gradients at high water stages in the river lead to levee slope instability and are the main factors contributing to the risk of poor performance of the levee. The 85 percent probability of having a localized poor performance occurs for a flood stage above the levee crest and the 15% risk of failure for a river stage at elevation 36 (considering NAVD 88 vertical datum), 16 feet above the landside levee toe and 4.5 feet below the levee crest.

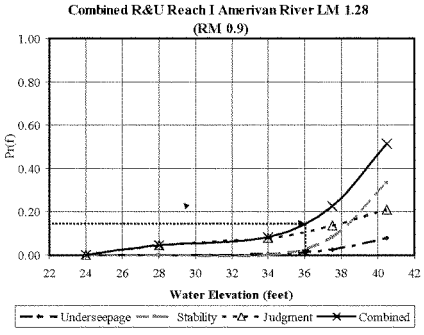


Figure 5-41 - Combined Probability of Reach I American River LM 1.28 (RM 0.9)

6. LEVEE IMPROVEMENT

6.1 General

Based on the past history of levee distress during high water elevations, on the numerous deterministic analyses done in the past and for this study, and on the risk and uncertainty analyses, all reaches considered in the study are deficient either due to excessive seepage or stability of the levee slopes. The seepage through the levee foundation results in high gradients at the levee toe. The high pore pressure within the levee embankment and/or in the foundation soil as determined by seepage analyses, or soft foundation soils at the toe of the levee or under the landside slope of the levee result in levee slope instability. Consequently mitigation measures would be required to provide gradients below the maximum allowable gradients or to improve the slope stability to a factor of safety above the minimum allowable factor of safety. The mitigation features considered in the geotechnical analyses included measures needed to reduce the impact of the woody vegetation on the levee slopes, including discouraging burrowing animal population, of the utility penetrations through the levee embankment, and of the encroachments into the levee right of entry. Such measures include construction of an adjacent landside levee or widening the existing levee on the landside. Most used mitigation features to

reduce the underseepage through the levee foundation and/or to improve the landside slope stability are seepage cut-off walls, landside berms, and relief wells. The proposed mitigation alternatives in those reaches where an adjacent levee or widen levee was considered would apply to the new levee section. Where an irrigation or drainage ditch is located close to the levee toe creating high exit gradients at the bottom of the ditch or ditch slopes instability, the ditches are proposed to be filled and relocated to a distance which assures the levee stability. The proposed improvement features are shown on Enclosure F3.
Deterministic seepage and stability analyses were performed for mitigation measures for the cross sections considered critical on the Reaches A to I on the Natomas Basin for different water elevations up to the crest of the levee and above. The results of the deterministic analyses are provided in Enclosure F2. The risk and uncertainty curves for the existing conditions were revised considering all analyzed geotechnical mitigation features. The results of the R&U analyses for each mitigation feature are provided in Enclosure F4.
To address the seismic vulnerability of the system, the mitigation features were analyzed to be less seismic sensible.
Most used seepage and stability measures to reduce the gradients at the levee toes and to increase the slope stability factors of safety are as follows.

6.1.1 Seepage Cut-off Walls

Low permeability seepage cut-off walls will reduce the gradient at the landside levee slope by cutting off the seepage through the levee or by increasing the seepage path through the levee foundation. The seepage cut-off wall may be fully penetrating, with the tip elevation in an existing deep impervious layer or partially penetrating, if the deep impervious layer is nonexistent or at a depth impractical for construction. If the cut-off walls are only partially penetrating wall with the tip elevation above an impervious layer the seepage is reduced by increasing the length of the seepage path, the wall being less efficient than a fully penetrating wall. The cut-off wall may be constructed through the levee embankment or through an adjacent constructed levee embankment to reduce the impact of the waterside vegetation and encroachments. An impervious cap is constructed through the levee to the crest elevation above the top of the cut-off wall to minimize the seepage through the levee embankment above the top of the cut-off wall. Reducing the underseepage through the foundation and levee embankment would reduce the pore pressure in the levee foundation increasing of the stability factor of safety to a higher value. Advantages of seepage cut-off walls are the minimum real estate requirement. Disadvantages of cut-off walls are the fact that any defects in the wall construction may go undetected and their effectiveness may not be determined unless piezometers are installed landside of the levee and measurements made during high river stages. Another disadvantage is that any damages to the wall that may occur during the service life of the wall, particularly during seismic events, cannot be observed, including location identified for remediation. Considering that the damages due to a seismic event cannot be observed after the event, the proposed cut-off wall was located within the levee (existing or adjacent levee) crest, not at the levee toe, to minimize the deformation of the wall and the levee embankment. Also a more flexible wall constructed of soil/cement slurry mix would be less vulnerable to a seismic event, the potential cracks in the wall being self-healing.

6.1.2 Landside Berms

Landside berms are constructed on the landside levee slope and may be wide to mitigate the seepage through the levee foundation or thick and narrow to increase the stability of the landside levee slope. Underseepage berm may be constructed of a drainage fill placed over a thin filter layer and covered by compacted random fill (partially drainage berms) or completely by any random fill with no specific drainage layer at the base (impervious seepage berms). The partially drainage berms are not as wide as the impervious berms since it provides free drainage of the seepage water from the levee foundation. Stability berms may be constructed of a random fill material placed on a free drainage layer at the bottom of the berm extended along the landside levee slope as a chimney drain to capture any seepage through the levee. A thin filter sand layer would be placed between the free drainage layer and the levee slope and natural ground. Geotextile fabric may be placed between the free drainage layer and the levee fill. Advantages of seepage and stability berms are that the maintenance of the berms is simple and not expensive and any damages to the berms, particularly due to a seismic event, may be observed on time and remediated. Another advantage of the seepage berms is that any damage due to a seismic event may be observed on time and the berm remediated before the next flood event. However, construction of seepage or stability berms requires additional real estate, which is difficult to be obtained in a developed urban area.

6.1.3 Relief Wells

Relief wells are constructed at the levee landside toe and are spaced so that the gradients between the wells are reduced to a maximum allowable gradient at the levee toe. Relief wells consists of a perforated pipe placed in a pre-drilled hole surrounded by a filter pack constructed of free drainage layers with the gradation corresponding to the natural ground, designed such as no material from the levee foundation can be removed by water moving into the wells. Water collected by relief wells need to be discharge either in a pump station or temporary ponding by a ditch or collector system. However relief wells are efficient only if the upper impervious blanket is well defined with a much lower permeability than the underlying aquifer. It is impractical to place relief wells if the foundation consists of interbedded layers of clays and more permeable sandy soils. The relief wells would require additional real estate for their installation and particularly for a collector system, which may consist of a ditch excavated in the upper impervious blanket. The wells are also vulnerable to seismic activities. The filter pack and the perforated pipe and riser may be completely lost after an earthquake. Because relief wells may only flow on an intermittent basis sometimes several years apart, it is necessary to conduct regular and expensive maintenance of the relief wells to ensure that they perform properly.

6.2 Water Elevations

Water elevations corresponding to six (6) flood stages used in the deterministic analyses were provided by the hydraulic specialists. LiDAR topography and levee crest survey provided by the National Levee Database (NLDB) were used to determine the levee crest, the available freeboard and the necessary levee rise to obtain the protection for each stage including 3 feet of freeboard. Table 6.1 shows the water elevations corresponding to the 6 flood events, the crest elevation as

determined by the NLDB for each cross section analyzed, the existing freeboard, and the necessary levee raise for each flood stage considered. Deterministic stability and seepage analyses performed for each elevation of each stage were used to develop the risk and uncertainty curves for each levee alternative proposed for each reach. The deterministic analyses details and their results are provided in Enclosure 2. A summary of the results and analyzed mitigation measures is also shown on the summary table in Enclosure 3.

Table 6-1 - Water Elevations/Levee Crest Elevations

REACH A SREL LM 16.7 RM 62.60				
Crest Elevation:	40.75			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	39.92	0.83	YES	42.92
5	36.73	4.02	NO	39.73
4	34.70	6.05	NO	37.70
3	34.00	6.75	NO	37.00
2	33.45	7.30	NO	36.45
1	31.29	9.46	NO	34.29
REACH B-1, 2, 3, 4, 5 SREL LM 14.3 RM 65.00				
Crest Elevation:	40.56			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	39.99	0.57	YES	42.99
5	36.92	3.64	NO	39.92
4	34.98	5.58	NO	37.98
3	34.27	6.29	NO	37.27
2	33.72	6.84	NO	36.72
1	31.97	8.59	NO	34.97
REACH B-6 SREL LM 6.5 RM 73.00				
Crest Elevation:	42.37			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	42.40	-0.03	YES	45.40
5	41.35	1.02	YES	44.35
4	39.86	2.51	YES	42.86
3	38.97	3.40	NO	41.97
2	38.31	4.06	NO	41.31
1	36.08	6.29	NO	39.08

REACH C-1 SREL LM 4.0 RM 75.20				
Crest Elevation:	42.81			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	43.11	-0.30	YES	46.11
5	42.24	0.57	YES	45.24
4	40.86	1.95	YES	43.86
3	39.95	2.86	YES	42.95
2	39.26	3.55	NO	42.26
1	37.08	5.73	NO	40.08
REACH C-2 SREL LM 1.3 RM 78.00				
Crest Elevation:	44.40			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	44.44	-0.04	YES	47.44
5	43.58	0.82	YES	46.58
4	42.21	2.19	YES	45.21
3	41.26	3.14	NO	44.26
2	40.55	3.85	NO	43.55
1	38.43	5.97	NO	41.43
REACH D-1 NCC LM 3.92 RM 0.53				
Crest Elevation:	44.62			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	45.13	-0.51	YES	48.13
5	44.16	0.46	YES	47.16
4	42.76	1.86	YES	45.76
3	41.80	2.82	YES	44.80
2	41.07	3.55	NO	44.07
1	38.97	5.65	NO	41.97
REACH D-2 NCC LM 1.17 RM 3.23				
Crest Elevation:	44.85			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	45.16	-0.31	YES	48.16
5	44.23	0.62	YES	47.23
4	42.84	2.01	YES	45.84
3	41.88	2.97	YES	44.88
2	41.11	3.74	NO	44.11

1	39.00	5.85	NO	42.00
REACH E PGCC LM 15.70 RM 0.74				
Crest Elevation:	46.20			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	45.03	1.17	YES	48.03
5	43.89	2.31	YES	46.89
4	42.56	3.64	NO	45.56
3	41.56	4.64	NO	44.56
2	40.75	5.45	NO	43.75
1	38.81	7.39	NO	41.81
REACH F NEMDC LM 8.30 RM 10.80				
Crest Elevation:	41.42			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	43.03	-1.61	YES	46.03
5	39.76	1.66	YES	42.76
4	38.97	2.45	YES	41.97
3	38.10	3.32	NO	41.10
2	37.24	4.18	NO	40.24
1	35.62	5.80	NO	38.62
REACH G NEMDC LM 6.45 RM 9.00				
Crest Elevation:	40.98			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	43.05	-2.07	YES	46.05
5	39.78	1.20	YES	42.78
4	38.99	1.99	YES	41.99
3	38.11	2.87	YES	41.11
2	37.25	3.73	NO	40.25
1	35.63	5.35	NO	38.63
REACH H NEMDC LM 1.0 RM 3.50				
Crest Elevation:	43.17			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	44.37	-1.20	YES	47.37
5	39.07	4.10	NO	42.07
4	37.53	5.64	NO	40.53
3	35.99	7.18	NO	38.99

2	34.93	8.24	NO	37.93
1	32.55	10.62	NO	35.55
REACH I ARN LM 1.30 RM 1.20				
Crest Elevation:	41.34			
Flood Stage	**WSE**	**Existing Freeboard**	**Raise Required**	**WSE+3ft Levee Crest Elev.**
6	43.95	-2.61	YES	46.95
5	38.19	3.15	NO	41.19
4	35.66	5.68	NO	38.66
3	35.06	6.28	NO	38.06
2	34.60	6.74	NO	37.60
1	31.24	10.10	NO	34.24

6.3 Seepage analyses

Seepage analyses were run assuming steady state conditions have developed. The representative permeabilities have been selected based on the existing subsurface (Including field and laboratory data). The SEEP2d computer program based on finite element method part of the Department of Defense Groundwater Modeling System (GMS) was used for the seepage modeling. Two types of seepage gradients were evaluated for each analyzed cross section: (1) the average gradient and (2) the localized exit gradient. The average gradient is defined as the total head drop across the landside blanket divided by the blanket thickness. This gradient value controls a blowout type of failure through a low-permeability blanket and is often referenced in typical levee design and evaluation manuals. The localized exit gradient is defined as the gradient reported by SEEP2D along the ground surface of the model. This gradient value controls a progressive piping type of failure. For ideal unidirectional flow through a homogeneous material, the average gradient equals the exit gradient. However, when the flow tends to be multi-directional, as can happen around the toe of a levee, or when the blanket is composed of several sub-layers, the localized exit gradient is generally different from the average gradient.

6.3.1 Seepage Criteria

The criteria adopted for the seepage analyses were recommended by the CESPK Levee Seepage Task Force in their report "Recommendations for Seepage Design Criteria, Evaluation and Design Practices" dated July 2003 and by the ETL 1110-2-569, "Engineering and Design – Design Guidance for Levee Underseepage" (2005)
The following criteria for seepage gradients are considered for all seepage analyses:

1) For underseepage conditions, considering the steady state occurred at the design water elevation, the maximum permissible value of the average gradients through the landside blanket at the levee toe is 0.5, based on a critical gradient of 0.8 (considering the minimum unit weight of the natural impervious blanket of 112 cfs).

2) If a seepage berm is considered, the maximum permissible value of the average gradients through the landside blanket at the berm toe is 0.8 for a 300 to 400 foot wide berm.
3) Drainage ditches should be located such that the exit gradient in the bottom of the ditch does not exceed 0.5 at the landside levee toe and does not exceed 0.8 at a distance 150 feet landward of the landside levee toe and beyond. Between the landside levee toe and 150 feet landward of the landside levee toe, the maximum allowable exit gradient in the bottom of the ditch should increase linearly from 0.5 to 0.8. The exit gradient should be computed assuming the water level in the ditch is at the bottom of the ditch.

6.3.2 Methodology and Assumptions

Two-dimensional, steady state seepage modeling using the finite element computer program SEEP2D was conducted to estimate the pore pressure in the levee and foundation soils to be used in the stability analysis and to determine the head through at the levee toe. The program can represent multiple soil types with anisotropic hydraulic conductivity. All analyses were completed for steady-state flow conditions without consideration of time (i.e., no transient analyses). Both saturated and unsaturated flow conditions were evaluated in the same model using conductivity functions that defined the variation in material conductivity with pore water pressure (negative and positive).
The model was extended to the centerline of the river/canal on the waterside and 2000 feet landside of the levee toe. Three types of boundary conditions have been assigned.

- Head Boundary Condition was assumed for all nodes where the flow enters or exits the system, such as the nodes along the waterside slope up to the assumed water elevation and for all nodes along the riverbank to the centerline of the river/canal.
- Exit Face Boundary Conditions was assumed for nodes along the face where the free surface is likely to exit the model such the levee landside slope and ground surface. Tailwater was considered along the ground surface landside of the levee toe.
- No Flow Boundary was considered on the vertical face, on the waterside and landside faces of the model, and for the bottom nodes.

Existing ditches were considered with no water in the ditch as stated above.
The material properties used in the analyses are based on the DWR studies for Urban Levee Evaluation, on URS preliminary reports for the F3 for Common Features GRR and on Kleinfelder reports made for the Natomas Levee Improvement program listed in paragraph 2.

6.3.3 Permeabilities used in Seepage Analyses

The properties used in the deterministic analyses for the existing conditions and for the analyses of the geotechnical mitigation features are shown in Table 6-2 and in Enclosure 2.

Table 6-2 – Hydraulic Conductivity

Material Type	Hydraulic Conductivity		
	Horizontal kh cm/sec	kh/kv	Horizontal kh ft/day
Clay Fill	10^{-6}	4	0.0028
Cutoff Wall	10^{-6}	1	0.0028
Random Fill	$2x10^{-4}$	4	0.567
Drainage Gravel	10^{-2}	10	28.35
Drainage Sand	$5x10^{-3}$	10	14.18
Clayey Sand (SC), Silty Clay (CL-ML)	$4x10^{-5}$ or $7x10^{-5}$	4	0.11 or 0.2
Lean Clay (CL), Fat Clay (CH)	10^{-5}	4	0.028
Elastic Silt (MH)	$4x10^{-5}$ to 10^{-5}	4	0.11 or 0.028
Silt (ML)	$2x10^{-4}$	4	0.567
Silty Sand (SM)	10^{-3} or $5x10^{-3}$	4	2.835 or 14.18
Poorly-Graded Sand (SP), Well-Graded Sand (SW)	10^{-2}	10	28.35
Poorly-Graded Sand w/ Silt (SP-SM), Well-Graded Sand w/ Silt (SW-SM)	10^{-2} or $5x10^{-3}$	10	14.18 or 28.35

A summary of the results of the seepage analyses are provided in Enclosure F2 for the existing conditions and proposed mitigation features.

6.4 Stability Analyses.

6.4.1 Static Slope Stability

Static slope stability analyses were performed for several representative critical cross sections in each reach for the existing conditions and considering the mitigation features applicable. The stability condition was analyzed using drained effective strength parameters for all materials in compliance with the standard for levee design and analysis described in EM 1110-2-1913, Design and Construction of Levees Manual, loading condition Case III, steady state seepage from full flood stage, fully developed phreatic surface. The slope stability analyses were performed for the existing conditions and for all mitigation measures considered constructible for the representative levee sections of each reach.

6.4.1.1 Methodology.

The computer program UTEXAS4 was used for stability analyses. The stability analyses used Spencer procedure which assumes all side forces having the same inclination and all requirements for static equilibrium are satisfied. The stability analyses used automatic search on a fixed grid with circular surface.

6.4.1.2 Cases Analyzed

The steady state analysis was based on the assumption of a fully developed phreatic surface

through the embankment. Saturated and moist unit weights were used in the embankment and the pore pressure corresponding to the pore pressures developed by the SEEP2D in the levee embankment and its foundation were automatically applied to the base of each slice. External water pressures from the river stage were applied as a hydrostatic force against the waterside slope. Steady seepage case was analyzed for the landside slope for each water elevation considered in seepage analyses and provided by the Hydraulic specialist for different river stages and at the crest of the levee. The slope stability for the end of construction case was not included in the study and will be analyzed during the design phase of the project. Consolidated drained strength parameters (S strength) were used for the static analyses.

6.4.1.3 Slope Stability Criteria

The criteria adopted for the stability analyses were primarily based on the recommendations provided in Table 6-1b, Minimum Factors of Safety: Levee Slope Stability, in the Design and Construction of Levees Manual (EM 1110-2-1913, 2000).
The allowable minimum factors of safety considered for the steady state stability analysis is Fs greater or equal to 1.4.
When considered appropriate, in clayey materials a vertical tension crack that penetrates 2 feet below the surface was assumed. The crack was assumed to be filled with water. To avoid surficial infinite slope solutions (i.e., raveling), when necessary, a minimum mass of the sliding surface was used. The search was not restricted to failure surfaces that pass through the levee crest, because lower failure surfaces are considered potentially dangerous for progressive failure.

6.4.1.4 Material Properties

The material strength parameters and unit weights are based on the DWR studies for Urban Levee Evaluation, on URS preliminary reports for the F3 for Common Features GRR and on Kleinfelder reports made for the Natomas Levee Improvement program listed in paragraph 2. Strength parameters for new construction, including adjacent levees or widened portion of the levees and berms, were based on engineering judgment of the new fill material soil types and the expected construction techniques. The strength parameters for the cut-off wall considered the slurry cut-off wall constructed of soil/bentonite mix. The strength parameters used in the analyses are summarized in Table 6-3 and in Enclosure F2.

Table 6-3 – Material Parameters

Material Type	Effective Strength Parameters		
	Φ' (^{0})'	C' (psf)	γ (pcf)
Clay Fill	28	50	115
Soil/Bentonite Cutoff Wall	0	50	85
Random Fill	32	0	120
Drainage Gravel	35	0	135
Drainage Sand	35	0	130

Material Type	Effective Strength Parameters		
	Φ' (^{0})'	C' (psf)	γ (pcf)
Clayey Sand (SC), Silty Clay (CL-ML)	28-32	50	120
Lean Clay (CL), Fat Clay (CH)	24-30	50 or 150	115
Elastic Silt (MH)	28-30	50	120
Silt (ML)	28-32	0	120
Silty Sand (SM)	30-35	0	125
Poorly-Graded Sand (SP), Well-Graded Sand (SW)	32-35	0	135
Poorly-Graded Sand w/ Silt (SP-SM), Well-Graded Sand w/ Silt (SW-SM)	32-35	0	130

The results of the stability analyses for the existing conditions and analyzed geotechnical mitigation features are provided in Enclosure F2 for each cross section considered representative of a reach and for each water elevation.

6.4.2 Seismic stability

Seismic analyses performed by URS for a contract for the Common Features GRR, are provided in Enclosure F5.

6.5 Proposed Geotechnical Mitigation Features

The mitigation feature for each representative cross section were specific for each reach based on the constructability and also considering the other factors impacting the levee integrity such as minimizing the impact of the utility penetrations, encroachments , and vegetation. Erosion impact was not considered since this is addressed by the hydraulic impact and remediation. The analyzed mitigation features are described below for each cross section and reach. Basically two alternatives were analyzed, the mitigation features applying to each alternative as appropriate. The two alternatives are

- Mitigation features applied on the existing levee. The levee would be raised in place as needed to provide the necessary freeboard of 3 feet for each flood stage analyzed. To comply with the Corps policy regarding the woody vegetation and encroachments, all woody vegetation and encroachments waterside and landside of the levee within the levee right of way would need to be removed. To assure the integrity of the levee regarding seepage through the levee foundation the existing irrigation and drainage ditches landside of the levee would need to be relocated to a distance where there is no impact on the levee integrity. All penetrations through the levee would be relocated in conformance with the Corps policy.
- Mitigation features applied to an adjacently constructed levee on the landside of the

existing levee at the same elevation as the existing levee or raised to provide the required freeboard for each stage analyzed. The adjacent levee will incorporate a portion of the existing levee in its embankment. This alternative may provide a new levee embankment which will respect the Corps policy regarding vegetation and encroachments without sacrificing the existing vegetation and encroachments waterside of the existing levee. Additional real estate would be required to construct the new adjacent levee. However, there are some reaches where an adjacent levee would be impractical due to extensive residential and commercial development landside of the levee. The drainage and irrigation ditches landside of the levee would be relocated at a distance where these excavations in the landside impervious blanket would have a minimum impact on the levee integrity. All penetrations through the levee would be relocated in conformance with Corps policy.

Enclosure 3 shows all alternatives analyzed considering the existing levee crest elevation or raised levee to provide the minimum required freeboard for each flood stage analyzed.

6.5.1 Levee Unit 1, Sacramento River East Levee, Reach A

The existing conditions of the Reach A are characterized by a seepage cut-off wall maximum 45 feet deep on the upstream end of the reach up to the existing RD1000 pumping station at approximate LM 17.5 continuing with a deep seepage cut-off wall into the existing clay layer from the pumping plant to the end of the reach at confluence with American River. The risk analyses on the existing conditions show a high risk of poor performance mainly due to high gradients at the toe of the levee. Encroachments consisting of residential and commercial buildings extend on the waterside to the crest of the levee on fill placed on the riverbank and residential buildings landside of the levee to the limits of the levee right of entry. Heavy woody vegetation covers the levee landside and waterside slopes. The landside and waterside slopes of the embankment is 1(V) on 3(H) and the levee crest is wider than 20 feet to accommodate the two lines of the Garden Highway.
Two alternatives are analyzed. The alternatives were considered only for the levee upstream of the existing RD 1000 Pump Station 1 where the cut-off wall is shallow. No remediation would be required east of the Pump Station No.1.

6.5.1.1 Reach A, Alternative 1

Alternative 1: Alternative 1 consists of applying different mitigation measures on the existing levee at the existing location. Seepage mitigation would consist by construction of a deep seepage cut-off wall with the tip at elevation -68.5, will be placed in the existing levee waterside of the existing shallow cut-off wall. The new cut-off wall will decrease seepage gradient at the toe of the levee to less than the maximum allowable gradient for the river elevation up to the crest of the levee. The seepage cut-off wall needs to be deeper to elevation - 85 in case the levee is raised to provide the necessary freeboard for the higher flood events. A cut-off wall deeper than 85 feet would be much expensive (it cannot be constructed by the traditional open trench method and should be used deep soil mixing methods either with augers or other methods). To obtain the minimum required factor of safety for slope stability for steady state condition a drained berm would be required on the landside slope. The berm would be placed on a 2-foot

thick free drainage layer and 6-inches thick filter sand layer which would be extended on the levee slope as a chimney drain to capture all seepage through the levee embankment and reduce the potential for internal erosion. The ditch at the landside toe will be relocated and the landside levee slope reshaped to 1(V) on 3(H) slope. The construction of the cut-off wall by a conventional open trench method will require excavation of the levee to 1/3 to create a wide working platform, which will disturb traffic on the Garden Highway and will require alternate routes for temporary access to the properties waterside of the levee. Also the excavation may remove partially the existing vegetation and may reduce the encroachments to the levee crest. All utilities penetrating the levee need to be relocated and modified conforming to the Corps requirements. Figures 6-1 and 6-2 illustrate the Alternative 1 for the Reach A for the levee at the existing elevation or higher elevation to accommodate a higher flood event. Raising the levee includes acquiring additional real estate.

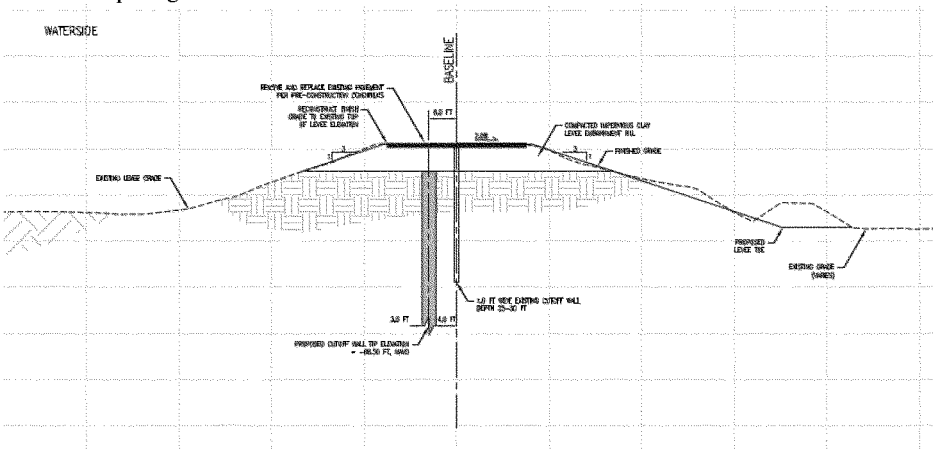


Figure 6-1 - Reach A Alternative 1 – Cut-off Wall through Existing Levee

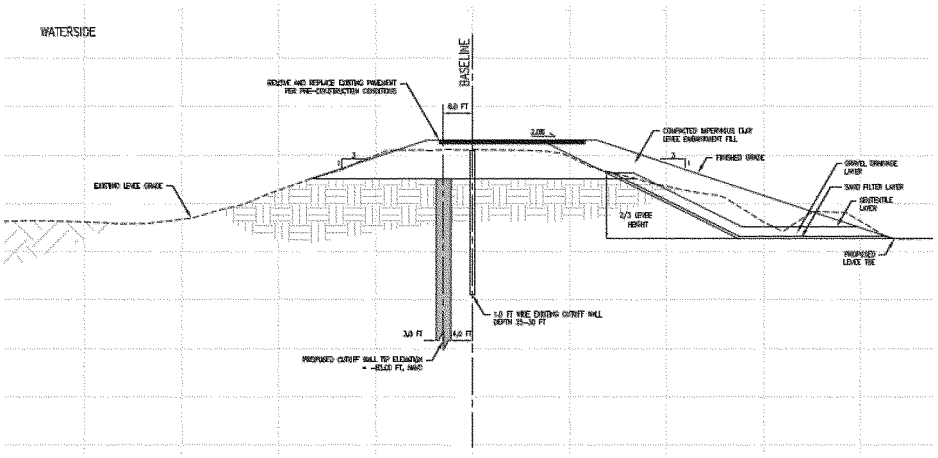


Figure 6-2 - Reach A, Alternative 1 – Cut-off Wall and Stability Berm Through Raised Levee

6.5.1.2 Reach A Alternative 2

Alternative 2 consists of widening the existing levee on the landside to abandon the waterside slope in order to create a vegetation planting berm on the waterside. Seepage mitigation would consist of a deep seepage cut-off wall within the existing levee crest to elevation -68.5 waterside of the existing shallow cut-off wall. If the levee needs to be raised for higher flood events the cut-off wall depth needs to be extended to elevation -85 and a stability berm to be placed on the landside levee slope. The berm would be placed on a 2-foot thick free drainage layer and 6-inches thick filter sand layer which would be extended on the levee slope as a chimney drain to capture all seepage through the levee embankment and reduce the potential for internal erosion. Same advantages and disadvantages as for the Alternative 1 regarding encroachments, utility penetrations, and vegetation apply to Alternative 2. Figures 6-3 and 6-4 show the alternative 2 for the existing levee height and raised for 500 year-flood respectively.

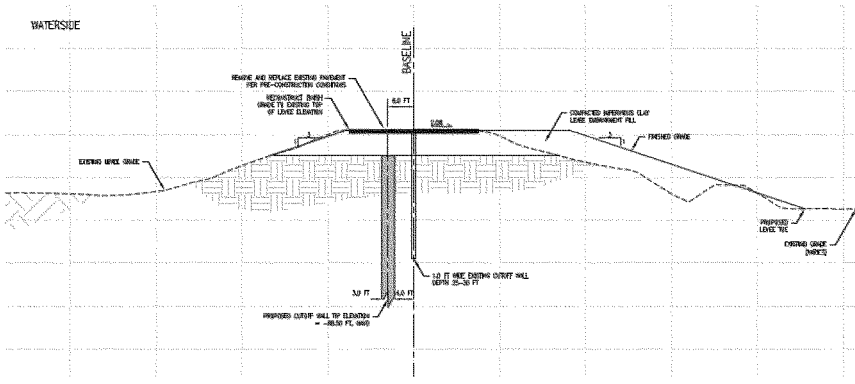


Figure 6-3 - Reach A, Alternative 2–Cut-off Wall through Wider Levee

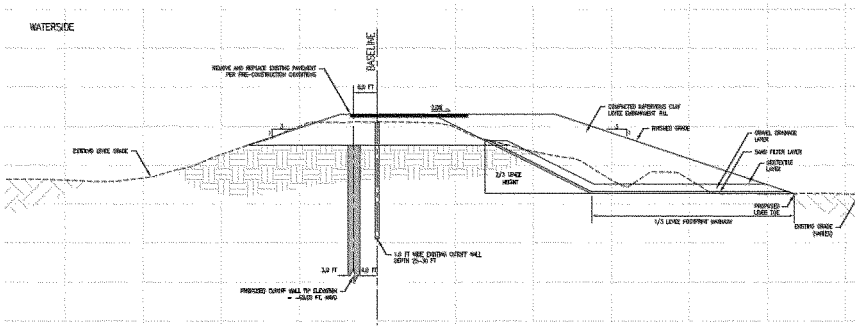


Figure 6-4 - Reach A, Alternative 2 –Cut-off Wall and Stability Berm through Raised Wider Levee

6.5.2 Levee Unit 1, Sacramento River East Levee, Reach B

A seepage cut-off wall 25 to 40 feet deep exist between Reach A and Power Line Road of Reach B. Upstream of the Power Line Road the seepage curt-off wall is replaced by a stability berm landside of the levee constructed of random fill placed on a free drainage layer and filter sand. Geotextile was placed between the berm fill and the free drainage layer. The risk analyses on the existing conditions show a high risk of poor performance mainly due to high gradients at the toe of the levee. The foundation of the levee consists mainly of poorly graded sand covered by a thin layer of impervious blanket. Heavy seepage was reported during previous flood events and is also marked on historical seepage maps in 1938. To analyze the diversity in the foundation along

the reach B, this reach was divided in 6 sub-reaches. Encroachments consisting of residential and commercial buildings extend on the waterside to the crest of the levee. Heavy woody vegetation covers the levee landside and waterside slopes. The landside and waterside slopes of the embankment is 1(V) on 3(H) and the levee crest is approximate 20 feet. Garden Highway runs along the crest of the levee. However, there is sufficient room on the landside to extend the levee either by an adjacent levee on the landside or to construct wide seepage berms.
A couple of mitigation measures are analyzed within these 6 reaches as follows.

6.5.2.1 Reach B Alternative 1

Alternative 1 consists of applying different seepage mitigation measures on the existing levee or on the raised in place levee embankment as needed for the analyzed river stages. The seepage mitigation measures consist seepage berms landside of the existing or raised in place levee (Figures 6-5 and 6-6 respectively), of seepage cut-off walls in the existing or raised in place levee (Figures 6-7 and 6-8 respectively), or combination of them (Figure 6-9 and 6-10), at sub-reaches where there is no existing cut-off wall through the levee embankment and its foundation. The seepage berm width and thickness varies based on the foundation conditions on each sub-reach and based on the water elevation analyzed. The berms would be constructed of random fill placed on a 2-foot thick layer of drainage fill and 6 inches of filter material. Geotextile may be placed between the free drainage layer and the berm fill. The landside levee slope will be reshaped to the 1(V) on 3(H) slope. The main advantage of this alternative is that the required additional real estate is smaller than if an adjacent levee would be constructed, except at the locations where a berm is required or proposed. However the disadvantage of this alternative is that it does not comply with the Corps policies regarding vegetation and encroachments unless the vegetation waterside of the levee and all encroachments within the levee right of way are removed. All utility penetrations would be relocated and modified to correspond to the Corps criteria.

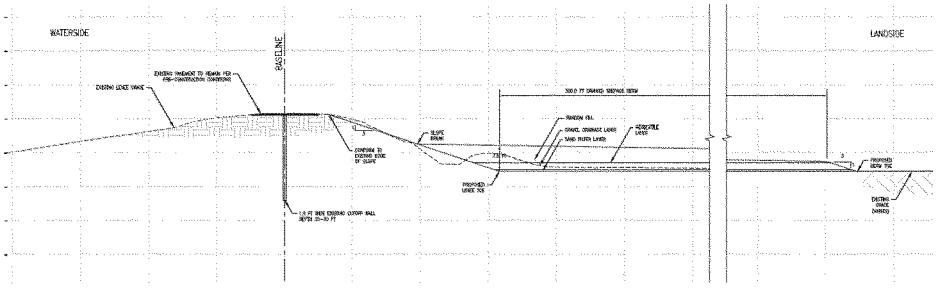


Figure 6-5- Reach B, Alternative 1A – Seepage Berm Landside of Existing Levee

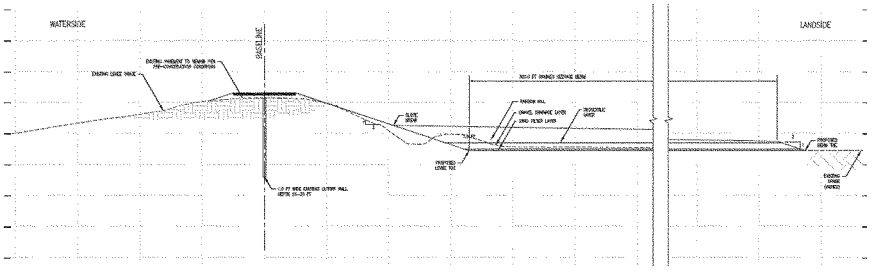


Figure 6-6- Reach B, Alternative 1A – Seepage Berm Landside of Raised in Place Levee

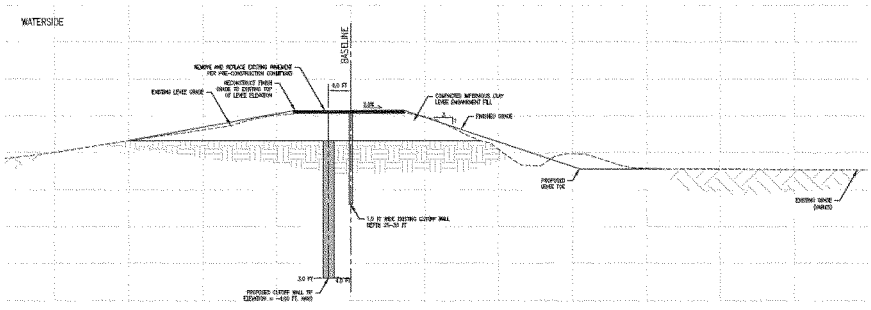


Figure 6-7 - Reach B, Alternative 1B – Cnt-off Wall through Existing Levee

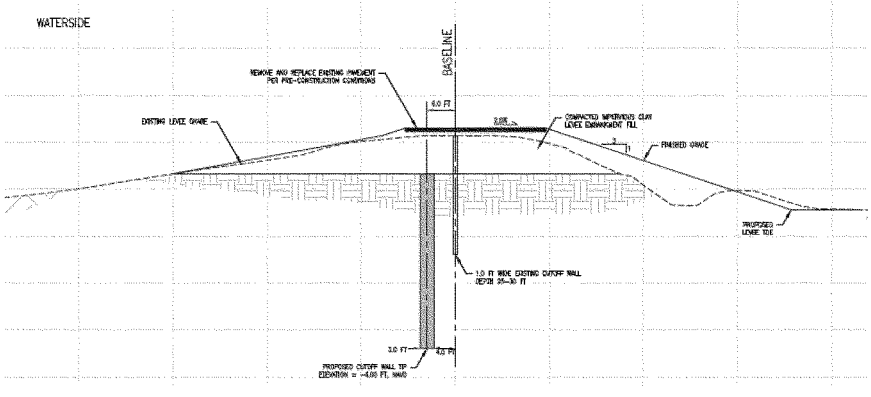


Figure 6-8 - Reach B, Alternative 1B – Cut-off Wall throngh Raised in Place Levee

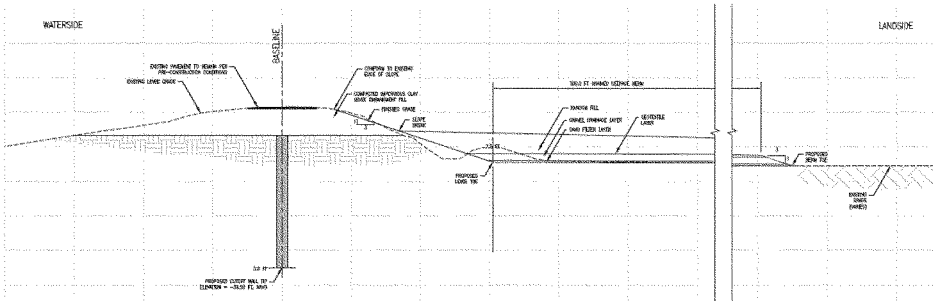


Figure 6-9- Reach B, Alternative 1C – Combination of Cut-off Wall and Seepage Berm Landside of Existing Levee

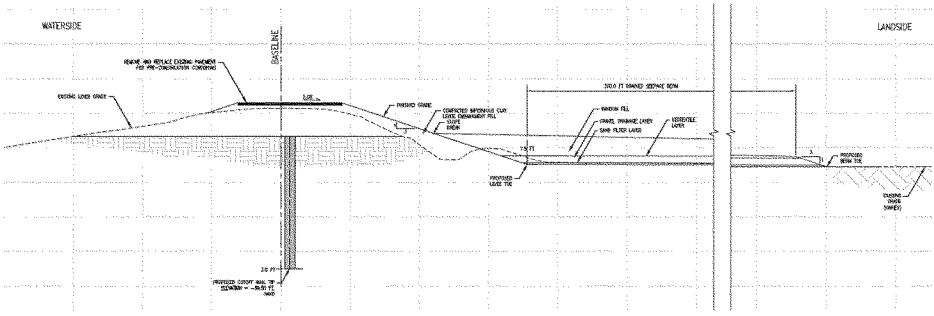


Figure 6-10- Reach B, Alternative 1C – Combination of Cut-off Wall and Seepage Berm Landside of Raised in Place Levee

6.5.2.2 Reach B, Alternative 2

Alternative 2 consists of an adjacent levee constructed landside of the existing levee. The existing seepage berm would be removed for the construction of the adjacent levee along the reaches where a stability berm exists on the landside levee slope. The adjacent levee would be constructed of imported compacted impervious fill from a borrow area. The adjacent levee would be constructed at the same elevation as the existing levee or raised as needed for the stage analyzed. To mitigate the underseepage through the levee foundation a seepage cut-off wall would be required (Figures 6-11 and 6-12). For some reaches where the seepage cut-off wall depth is limited by the constructability or where there is no existing cut-off wall in the levee embankment and its foundation, an additional drained seepage berm is required (Figures 6-13 and 6-14). The seepage berm width or the depth of the cut-off wall varies from one sub-reach to the other, based on the foundation conditions and also based on the water elevation analyzed. The construction of the seepage cut-off wall by conventional trench method will be from a

platform constructed on the entire width of the adjacent levee to provide stability of the excavated trench. If a drained seepage berm would be required the berm width would vary between 80 and 300 feet and would be constructed of a minimum 2-foot thick layer of free drained material, such as drain rock placed, on 6-inches of filter sand. The drain rock may be covered by any random material, with a layer of geotextile placed between the drain rock and random fill. This alternative will shift the levee prism on the landside and will permit preservation of the woody vegetation on the waterside of the levee as long as the vegetation is in accordance with the Corps vegetation policy. This alternative would not require removal of the encroachments waterside of the levee as long as these encroachments are outside of the levee prism. All utilities penetrating the levee need to be relocated and modified conforming to the Corps requirements. Table 1 in Enclosure 3 indicated the levee miles limits of each sub-reach in Reach B and analyzed alternatives for each sub-reach as shown on the sheets 5 to 22 of the enclosure F3. Alternative 2 will require acquisition of additional real estate landside of the existing levee to construct the adjacent levee and the seepage berm if necessary.

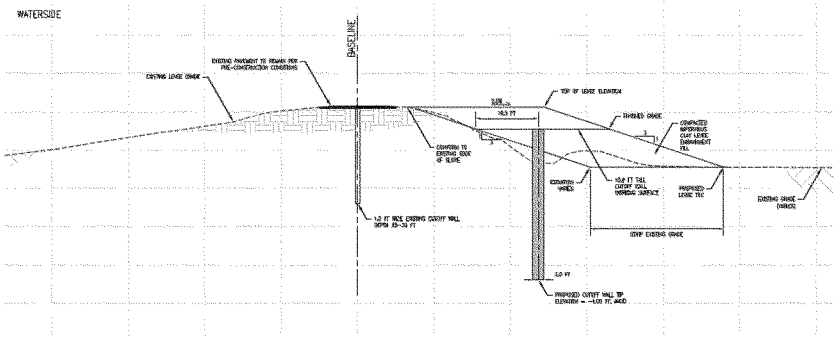


Figure 6-11 - Reach B Alternative 2A – Cut-off Wall through Adjacent Levee

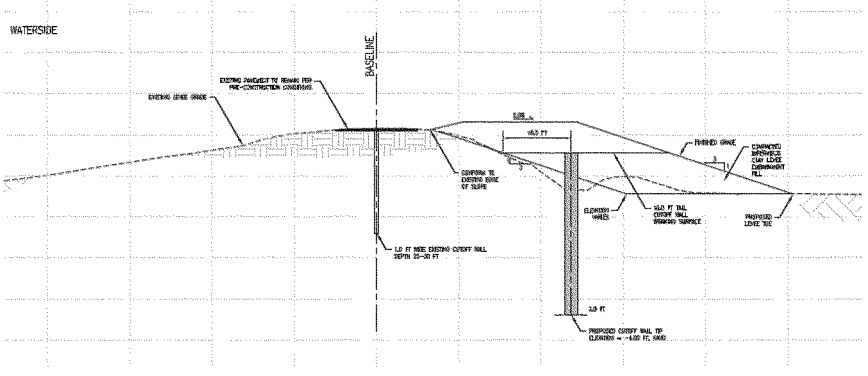


Figure 6-12 - Reach B, Alternative 2A – Cut-off Wall through Adjacent Raised Levee

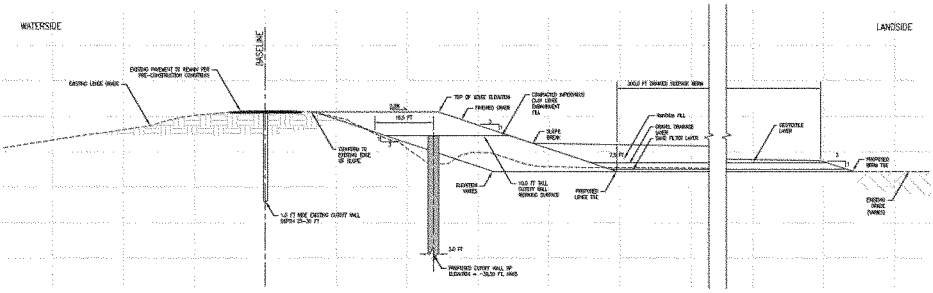


Figure 6-13 - Reach B, Alternative 2B – Cut-off Wall through Adjacent Levee and Seepage Berm

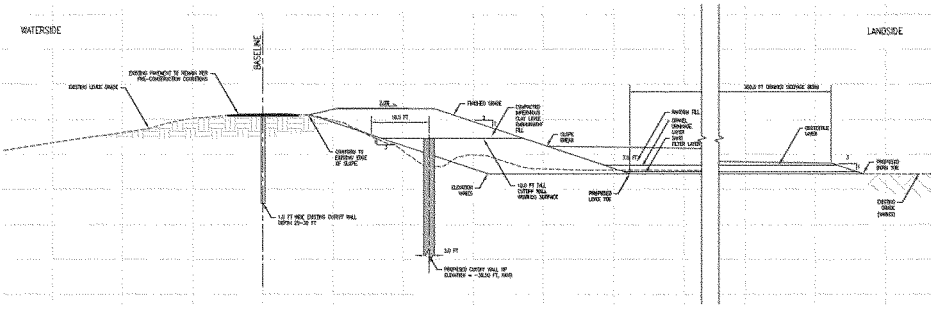


Figure 6-14 - Reach B, Alternative 2B – Cut-off Wall through Adjacent Raised Levee and Seepage Berm

6.5.3 Levee Unit 1, Sacramento River East Levee, Reach C

The existing conditions of Reach C are characterized by a stability berm placed on the landside levee slope. The levee is constructed of dredged sand, same method as on the along east bank of the Sacramento River within the Natomas Basin. The foundation consists of alternate layers of sands and silty sand overlaid by a more impervious blanket of clays and silts. The levee waterside and landside slopes are covered by heavy woody vegetation, encroachments consisting of residential and commercial buildings are constructed waterside of the levee slopes, numerous utility penetrations, including piping system from pump stations, water supply lines, irrigation lines, and power lines are crossing the levee. The risk analyses on the existing conditions show a high risk of poor performance mainly due to underseepage through the levee foundation resulting in high gradients at the toe of the levee. Heavy seepage, sand boils, and slides were observed during the past flood events since 1938 until the last flood in 2006. To analyze the diversity in the foundation along the reach B, this reach was divided in 2 sub-reaches. Table 1 in Enclosure 3 shows the critical sections analyzed in each sub-reach. The landside and waterside slopes of the

embankment are 1(V) on 2(H) and 1(V) on 3(H) respectively, and the levee crest is approximate 20 feet. Garden Highway runs along the crest of the levee. However, there is sufficient room on the landside to extend the levee either by an adjacent levee on the landside or to construct wide seepage berms.
A couple of geotechnical mitigation measures were analyzed within these 2 reaches considering part of two major alternatives, as follows

6.5.3.1 Reach C Alternative 1

Alternative 1 consists of applying different seepage mitigation measures on the existing levee or on the raised in place levee embankment as needed for the analyzed river stages. To mitigate the underseepage through the levee foundation a deep seepage cut-off wall (fully penetrating) to the lower impervious strata in the foundation would be required (Figures 6-15 and 6-16). If the wall is not fully penetrating, a 80-foot wide seepage berm would be required landside of the levee slope (Figures 6-17 and 6-18). The depth of the cut-off wall varies (between 35 and 75 feet) with the height of the water elevation and with the foundation conditions. If the cut-off wall is shorter, not fully penetrating, a seepage berm may be needed on some reaches. The seepage berm would be constructed of random fill placed on a 2-foot thick layer of drainage fill and 6 inches of filter material. The advantage of this alternative is the additional real estate requirement is minimal, except for the seepage. However, the main disadvantage is that it does not comply with the Corps policies regarding vegetation and encroachments unless the vegetation waterside of the levee and all encroachments within the levee right of way are removed. All utility penetrations would be relocated and modified to correspond to the Corps criteria.

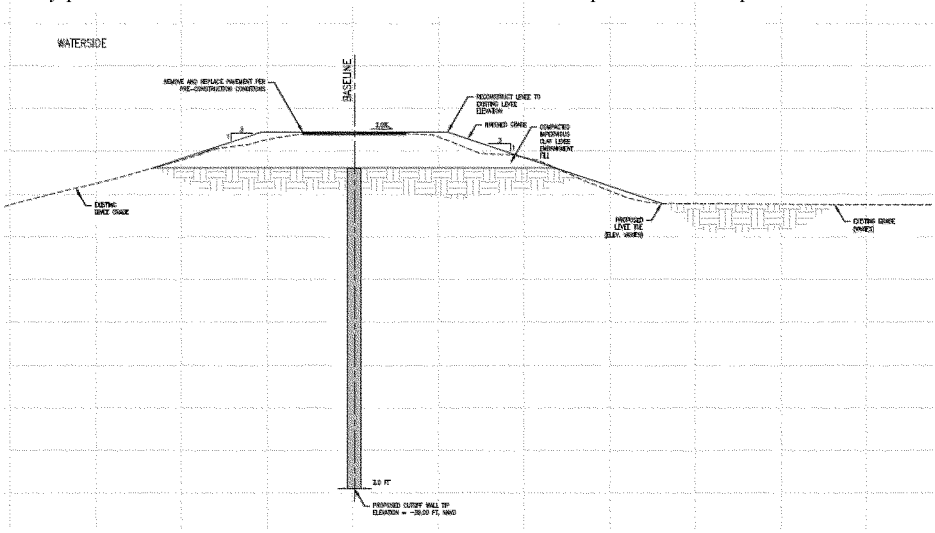


Figure 6-15 - Reach C, Alternative 1A – Fully Penetrating Cut-off Wall through Existing Levee

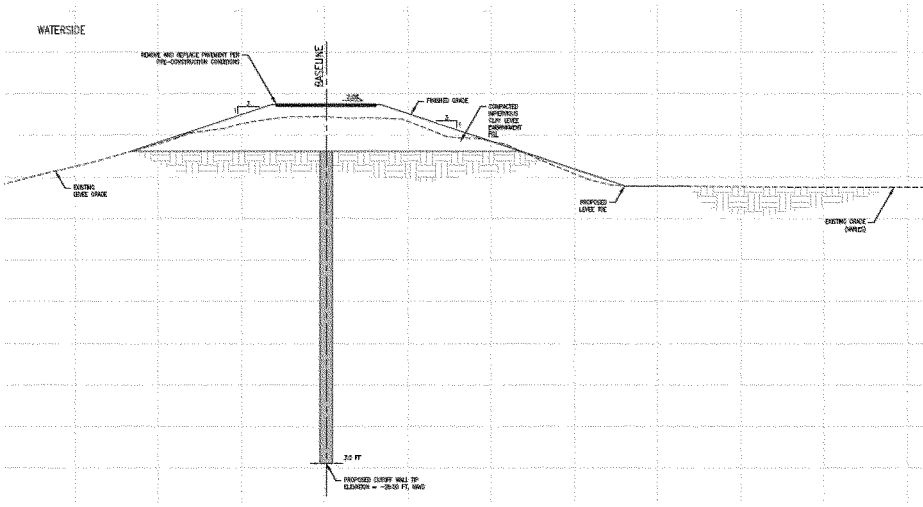


Figure 6-16 - Reach C, Alternative 1A – Fully Penetrating Cut-off Wall through Raised in Place Levee

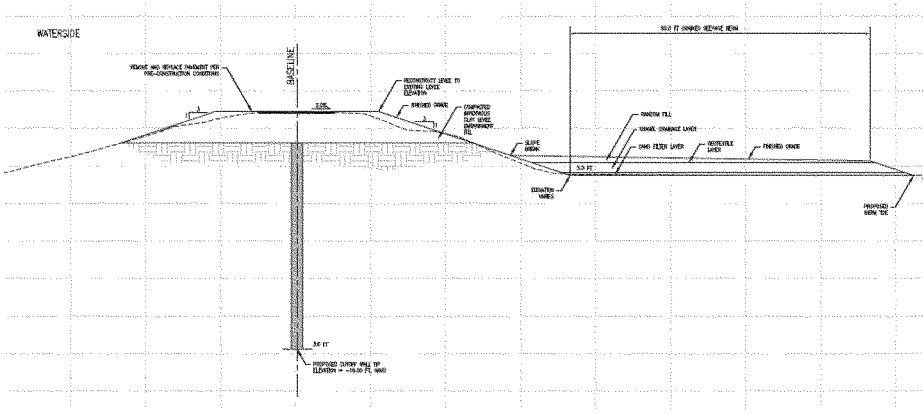


Figure 6-17 - Reach C, Alternative 1B – Partially Penetrating Cut-off Wall through Existing Levee and Seepage Berm

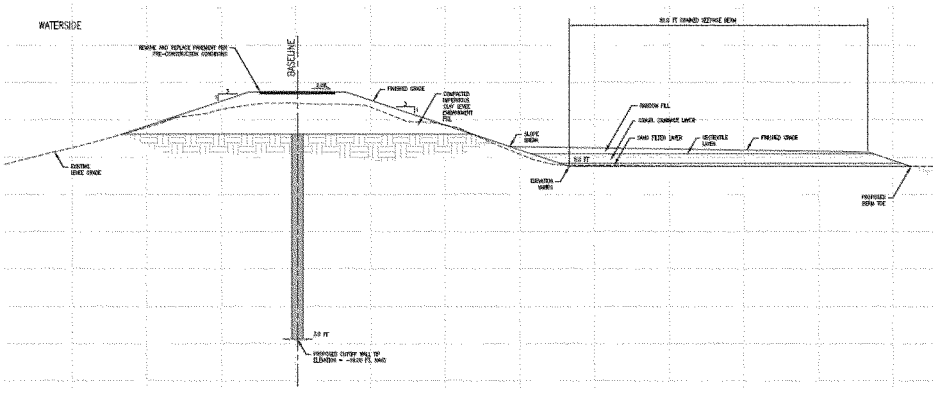


Figure 6-18 - Reach C, Alternative 1B – Partially Penetrating Cut-off Wall through Raised in Place Levee and Seepage Berm

6.5.3.2 Reach C Alternative 2

Alternative 2 consists of an adjacent levee constructed landside of the existing levee. The adjacent levee would be constructed of imported compacted impervious fill from a borrow area. The adjacent levee would be constructed at the same elevation as the existing levee or raised as needed for the river stage analyzed. To mitigate the underseepage through the levee foundation a seepage cut-off wall would be required (Figures 6-19 and 6-20). The depth of the cut-off wall varies with the river stages and depends of the foundation conditions. The construction of the seepage cut-off wall by conventional trench method will be from a platform constructed on the entire width of the adjacent levee to provide stability of the excavated trench. This alternative will shift the levee prism on the landside and will permit preservation of the woody vegetation on the waterside of the levee as long as the vegetation is in accordance with the Corps vegetation policy. This alternative would not require removal of the encroachments waterside of the levee as long as these encroachments are outside of the levee prism. All utilities penetrating the levee need to be relocated and modified conforming to the Corps requirements. Table 1 in Enclosure 3 indicated the limits of each sub-reach in Reach C. Alternative 2 will require acquisition of additional real estate landside of the existing levee to construct the adjacent levee and the seepage berm if necessary.

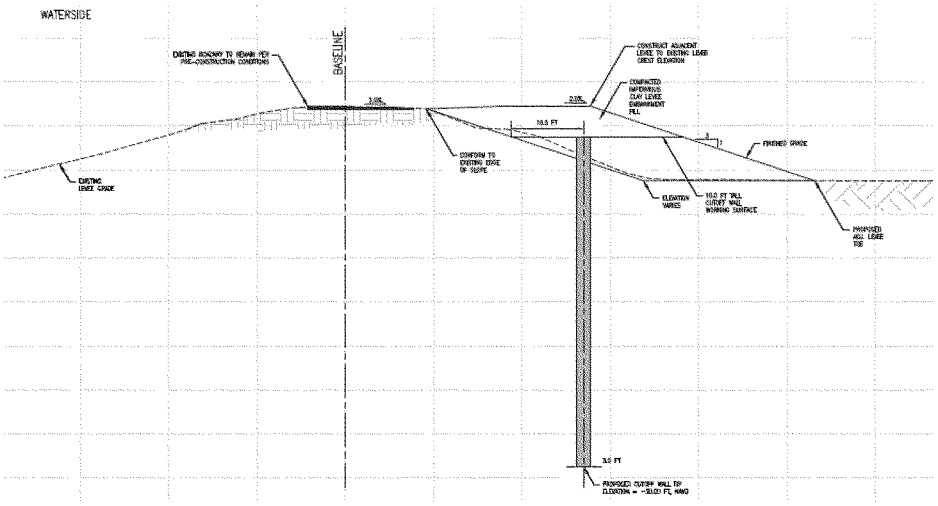


Figure 6-19 - Reach C, Alternative 2A – Cut-off Wall through Adjacent Levee

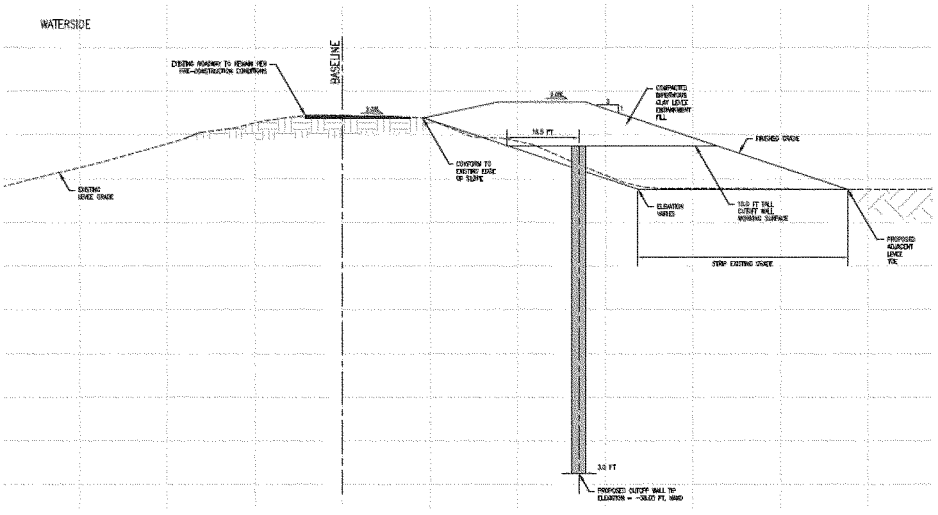


Figure 6-20 - Reach C, Alternative 2A – Cut-off Wall through Raised Adjacent Levee

6.5.4 Levee Unit 4, Natomas Cross Canal, Reach D

The levee along the south bank of the Natomas Cross Canal is constructed of impervious clay fill and has a stability berm on the landside slope constructed on a drainage layer extended on the levee slope as a chimney drain. The landside and waterside slopes of the embankment are 1(V) on 2(H) and 1(V) on 3(H) respectively, and the levee crest is approximate 20 feet. The foundation consists of alternate layers of sands and silty sand overlaid by a more impervious blanket of clays and silts. The risk analyses on the existing conditions show a high risk of poor performance mainly due to underseepage through the levee foundation resulting in high gradients at the toe of the levee. A drainage ditch is located less than 100 feet from the landside toe along the entire levee. Pipes from the existing pump stations crossed the levee embankment at least at two locations. Highway 99 Bridge is crossing the levee close to its upstream end. There are no buildings or other encroachments on the levee slopes or within the levee right of entry except a couple of power poles. Heavy woody vegetation covers the waterside levee slope up to the crest of the levee. Since there is no need to set back the levee or construct an adjacent levee, there was only one alternative analyzed, a seepage cut-off wall.

6.5.4.1 Reach D Alternative 1

Alternative 1 consists of construction of a fully penetrating seepage cut-off wall through the existing embankment. The embankment may be raised as needed to accommodate higher stages in the canal. The seepage cut-off wall depth varies with the water elevation in the canal and with the foundation conditions along the Reach D. The levee would be degraded to at least ½ of its height if the wall is of soil-bentonite slurry or 1/3 of its height for a soil/cement/bentonite slurry wall. The advantage of this alternative is the additional real estate requirement is minimal. However, the main disadvantage is that it does not comply with the Corps policies regarding vegetation unless the vegetation waterside of the levee is removed. All utility penetrations would be relocated and modified to correspond to the Corps criteria. Figures 6-21 and 6-22 illustrates the seepage cut-off wall through the levee at the existing crest elevation or raised as needed for higher river stages.

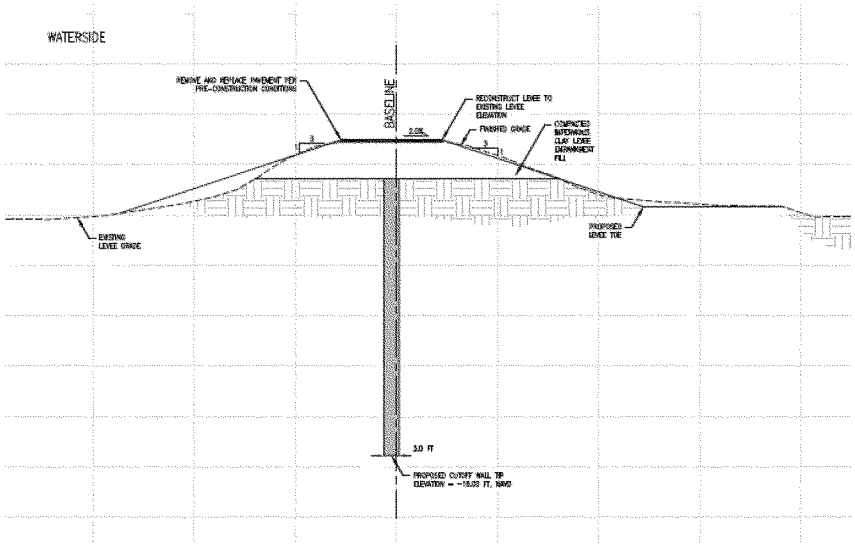


Figure 6-21 - Reach D, Alternative 1A – Cut-off Wall through Existing Levee

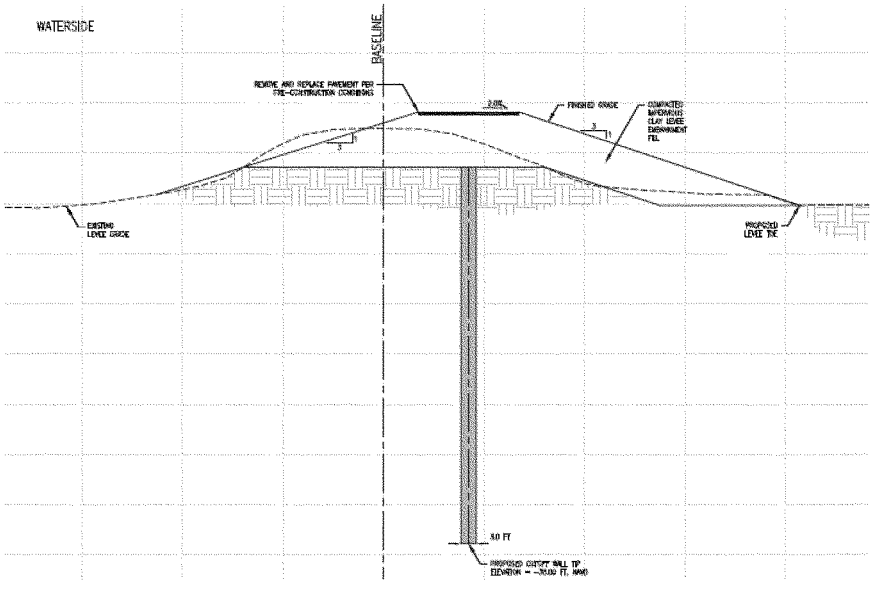


Figure 6-22 - Reach D, Alternative 1A – Cut-off Wall through Raised in Place Levee

6.5.5 Levee Unit 3, Pleasant Grove Creek Canal, Reach E

The levee along the west bank of the Pleasant Grove Canal is constructed of impervious fill. The levee has been raised in the past. The foundation consists of alternate layers of sands and silty sand overlaid by a more impervious blanket of clays and silts with permeable crevasses crossing the levee foundation. The levee waterside and landside slopes are covered by some woody vegetation, with limited encroachments and penetrations. The risk analyses on the existing conditions show a high risk of poor performance mainly due to underseepage through the levee foundation resulting in high gradients at the toe of the levee. High rodent activity was observed on this reach, leading to collapse of the levee embankment. The landside and waterside slopes of the embankment are steeper than the minimum 1(V) on 2(H) and 1(V) on 3(H) respectively, and the levee crest is approximate 20 feet.

6.5.5.1 Reach E Alternative 1

Alternative 1 consists of construction of a seepage cut-off wall in the existing levee or on the raised in place levee embankment as needed for the analyzed river stages. The levee would be degraded to at least ½ of its height if the wall is of soil-bentonite slurry or 1/3 of its height for a soil/cement/bentonite slurry wall. The advantage of this alternative is the additional real estate requirement is minimal. However, the main disadvantage is that it does not comply with the Corps policies regarding vegetation unless the vegetation waterside of the levee is removed. All utility penetrations would be relocated and modified to correspond to the Corps criteria. Figures 6-23 and 6-24 illustrate the seepage cut-off wall through the levee at the existing crest elevation or raised as needed for higher river stages.

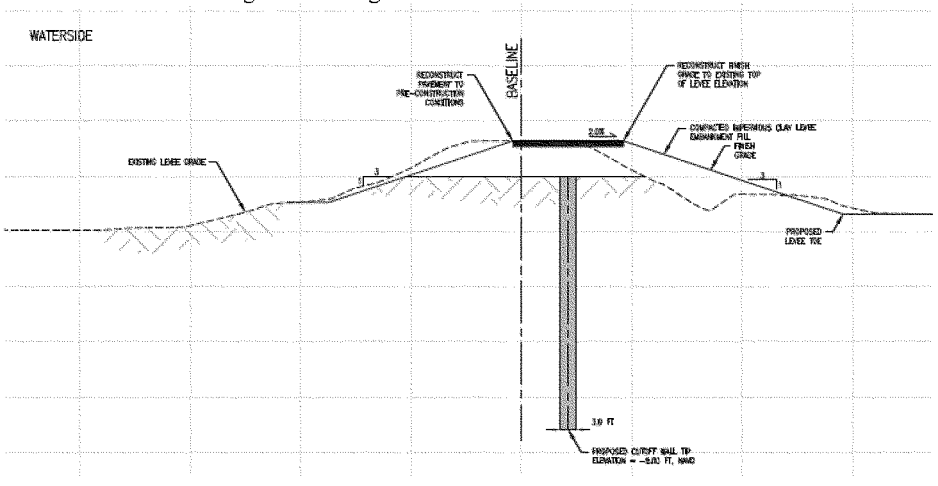


Figure 6-23 - Reach E, Alternative 1A – Cut-off Wall through Existing Levee

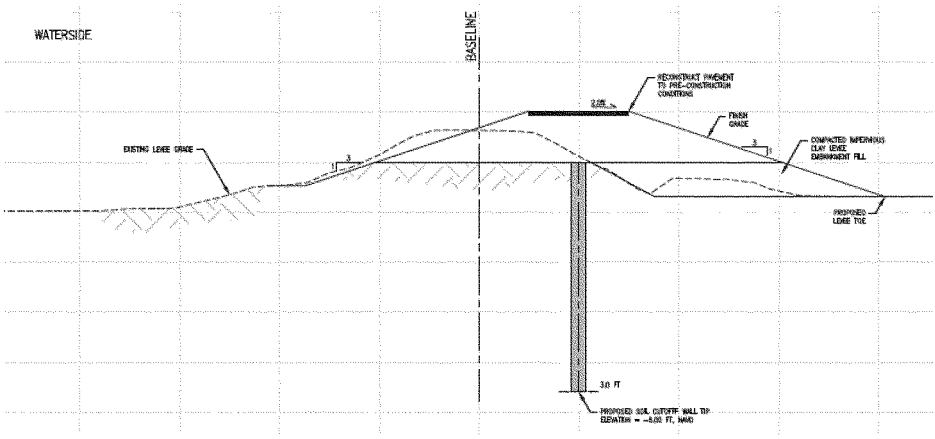


Figure 6-24 - Reach E, Alternative 1A – Cut-off Wall through Raised in Place Levee

6.5.5.2 Reach E Alternative 2

Alternative 2 consists of an adjacent levee constructed landside of the existing levee. The adjacent levee would be constructed of imported compacted impervious fill from a borrow area. The adjacent levee would be constructed at the same elevation as the existing levee or raised as needed for the stage analyzed. To mitigate the underseepage through the levee foundation a seepage cut-off wall would be required (Figures 6-25 and 6-26) to be constructed through the adjacent levee. The construction of the seepage cut-off wall by conventional trench method will be from a platform constructed on the entire width of the adjacent levee to provide stability of the excavated trench. This alternative will shift the levee prism on the landside and will avoid reconstruction of the expensive paved road to the new California standards. All utilities penetrating the levee need to be relocated and modified conforming to the Corps requirements. Alternative 2 will require acquisition of additional real estate landside of the existing levee to construct the adjacent levee.

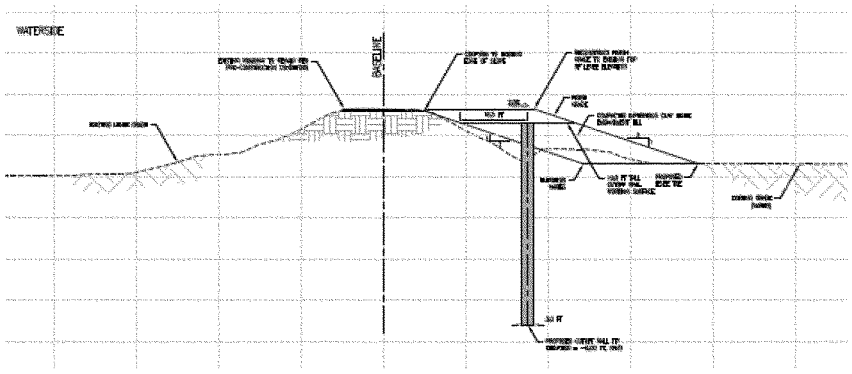


Figure 6-25 - Reach E, Alternative 2A – Cut-off Wall through Adjacent Levee

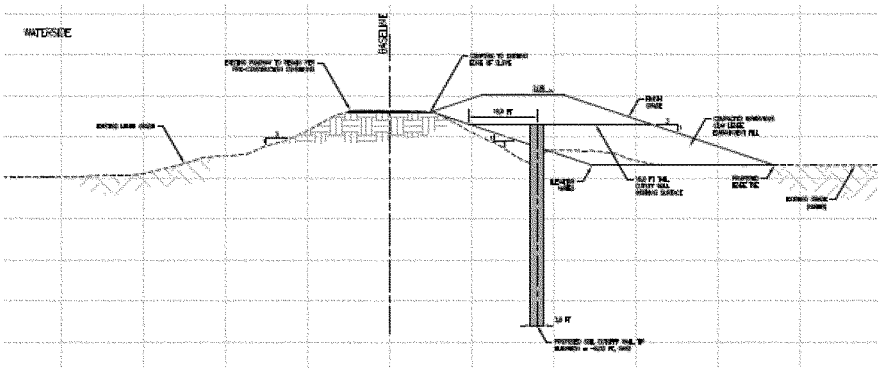


Figure 6-26 - Reach E, Alternative 2A – Cut-off Wall through Raised Adjacent Levee

6.5.6 Levee Unit 3, Natomas Main Drainage Canal, Reach F

The levee along the west bank of the Natomas Main Drainage Canal west bank is constructed of impervious fill. The levee has been raised in the past. The foundation consists of alternate layers of sands and silty sand overlaid by a more impervious blanket of clays and silts with permeable crevasses crossing the levee foundation. The levee waterside and landside slopes are covered by some woody vegetation, with limited encroachments and penetrations. The risk analyses on the existing conditions show a high risk of poor performance mainly due to landside slope stability with factors of safety lower than the minimum admissible. The landside and waterside slopes of the embankment are steeper than the minimum 1(V) on 2(H) and 1(V) on (3) respectively, and the levee crest is approximate 20 feet.

6.5.6.1 Reach F Alternative 1

Alternative 1 consists of construction of 20-foot wide stability berm on the landside slope of the existing levee or raised in place levee (Figures 6-27 and 6-28). The stability berm will be constructed of a 2 foot thick free drainage layer extended on the landside slope to be used as a chimney drain also and collect all seepage through the levee embankment. An alternative of the stability berm would be a flatter slope to 1(V) on 5(H) (Fig. 29). If the levee needs to be raised in place a drainage layer may be needed at the base of the flatter slope (Fig. 30). The drainage layer would be placed on a filter sand layer and covered by filter fabric as a separator between the free drainage layer and berm fill. The advantage of this alternative is the additional real estate requirement is minimal. However, the main disadvantage is that it does not comply with the Corps policies regarding vegetation unless the vegetation waterside of the levee is removed. Al utility penetrations would be relocated and modified to correspond to the Corps criteria.

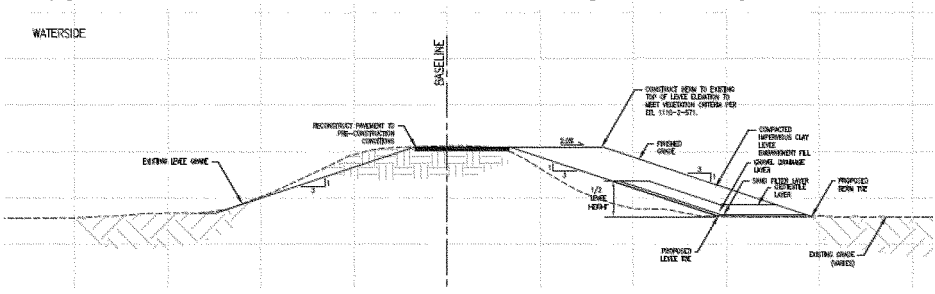


Figure 6-27 - Reach F, Alternative 1A – Landside Stability Berm on the Existing Levee

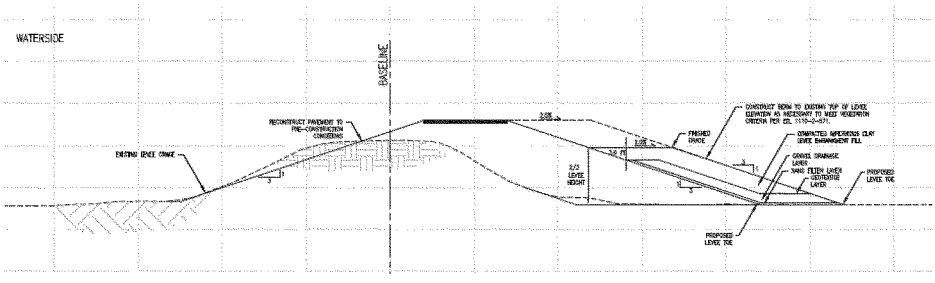


Figure 6-28 - Reach F, Alternative 1A – Landside Stability Berm on Raised in Place Levee

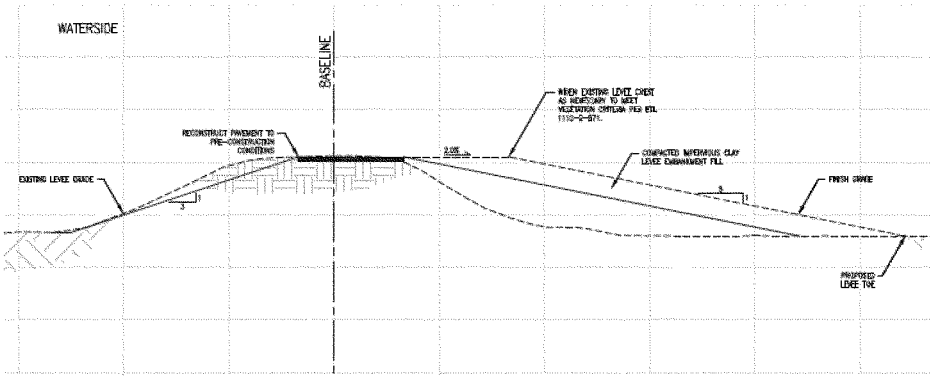


Figure 6-29 - Reach F, Alternative 1B – Flattened Landside Slope of Existing Levee

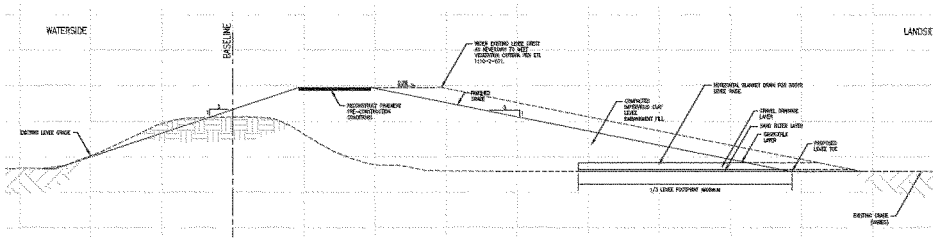


Figure 6-30 - Reach F, Alternative 1B – Flattened Landside Slope of Raised in Place Levee

6.5.6.2 Reach F Alternative 2

Alternative 2 consists of an adjacent levee constructed landside of the existing levee. The adjacent levee would be constructed of imported compacted impervious fill from a borrow area. The adjacent levee would be constructed at the same elevation as the existing levee or raised as needed for the stage analyzed. To provide additional stability of the landside slope a landside stability berm would be constructed on the landside slope of the levee (Figure 6-31). The stability berm will be constructed of a 2 foot thick free drainage layer extended on the landside slope to be used as a chimney drain also and collect all seepage through the levee embankment. An alternative of the stability berm would be a flatter slope to 1(V) on 5(H) (Figure 6-32). If the levee needs to be raised in place a drainage layer may be needed at the base of the flatter slope. The drainage layer would be placed on a filter sand layer and covered by filter fabric as a separator between the free drainage layer and berm fill. This alternative will shift the levee prism on the landside and will avoid reconstruction of the expensive paved road to the new California standards. All utilities penetrating the levee need to be relocated and modified conforming to the Corps requirements. Alternative 2 will require acquisition of additional real estate landside of

the existing levee to construct the adjacent levee.

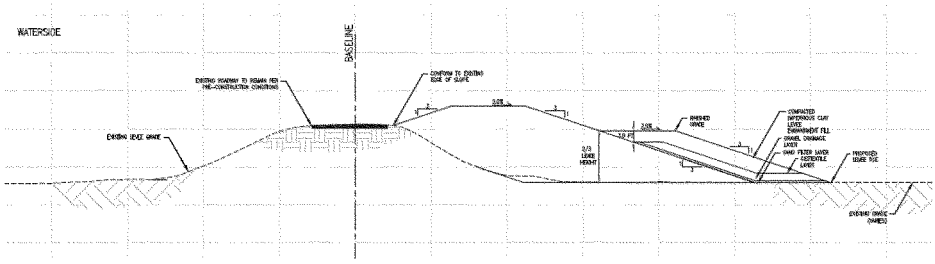


Figure 6-31- Reach F, Alternative 2A – Landside Stability Berm on Raised in Place Levee

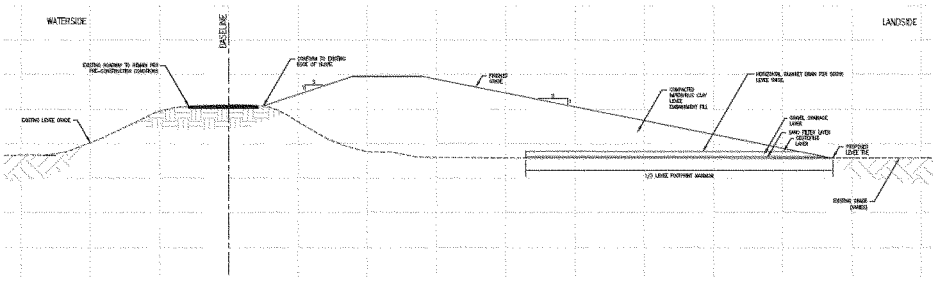


Figure 6-32 - Reach F, Alternative 2B – Flattened Landside Slope of Raised Adjacent Levee

6.5.7 Levee Unit 3, Natomas Main Drainage Canal, Reach G

The levee along the west bank of the Natomas Main Drainage Canal west bank is constructed of impervious fill. The levee has been raised in the past. The foundation consists of alternate layers of sands and silty sand overlaid by a more impervious blanket of clays and silts. The levee waterside and landside slopes are covered by some woody vegetation, with limited encroachments and penetrations. The risk analyses on the existing conditions show a high risk of poor performance mainly due to underseepage through the foundation leading to high exit gradient at the landside levee toe. The landside and waterside slopes of the embankment are steeper than the minimum 1(V) on 2(H) and 1(V) on 3(H) respectively, and the levee crest is approximate 20 feet. The levee waterside and landside slopes are covered by some woody vegetation with limited encroachments and penetrations.

6.5.7.1 Reach G Alternative 1

Alternative 1 consists of construction of a seepage cut-off wall in the existing levee or on the raised in place levee embankment as needed for the analyzed river stages. The levee would be degraded to at least ½ of its height if the wall is of soil-bentonite slurry or 1/3 of its height for a soil/cement/bentonite slurry wall. The advantage of this alternative is the additional real estate

requirement is minimal. However, the main disadvantage is that it does not comply with the Corps policies regarding vegetation unless the vegetation waterside of the levee is removed. Al utility penetrations would be relocated and modified to correspond to the Corps criteria. Figures 6-33 and 6-34 illustrate the seepage cut-off wall through the levee at the existing crest elevation or raised as needed for higher river stages.

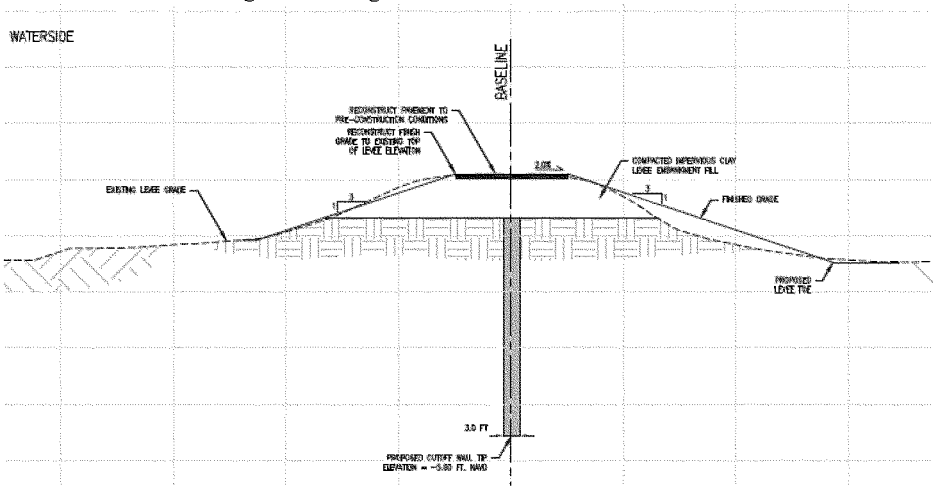


Figure 6-33 - Reach G, Alternative 1A – Cut-off Wall through Existing Levee

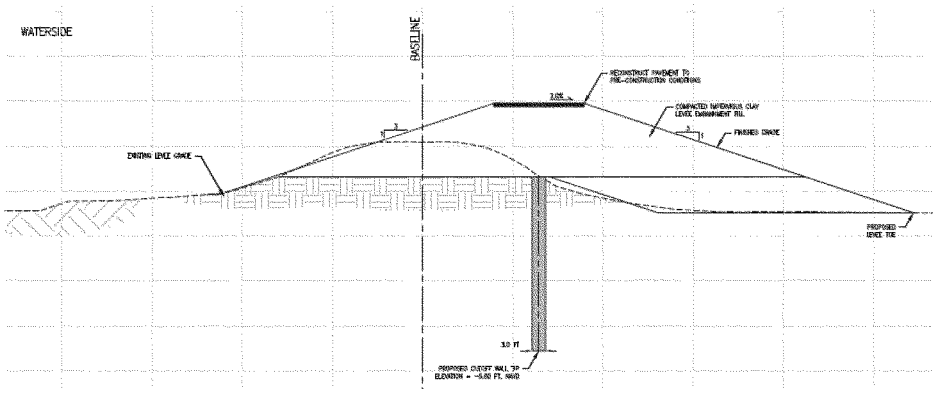


Figure 6-34 - Reach G, Alternative 1A – Cut-off Wall through Raised in Place Levee

6.5.7.2 Reach G Alternative 2

Alternative 2 consists of an adjacent levee constructed landside of the existing levee. The adjacent levee would be constructed of imported compacted impervious fill from a borrow area. The adjacent levee would be constructed at the same elevation as the existing levee or raised as needed for the stage analyzed. To mitigate the underseepage through the levee foundation a seepage cut-off wall would be required (Figures 6-35 and 6-36) to be constructed through the adjacent levee. The construction of the seepage cut-off wall by conventional trench method will be from a platform constructed on the entire width of the adjacent levee to provide stability of the excavated trench. This alternative will shift the levee prism on the landside and will avoid reconstruction of the expensive paved road to the new California standards. All utilities penetrating the levee need to be relocated and modified conforming to the Corps requirements. Alternative 2 will require acquisition of additional real estate landside of the existing levee to construct the adjacent levee.

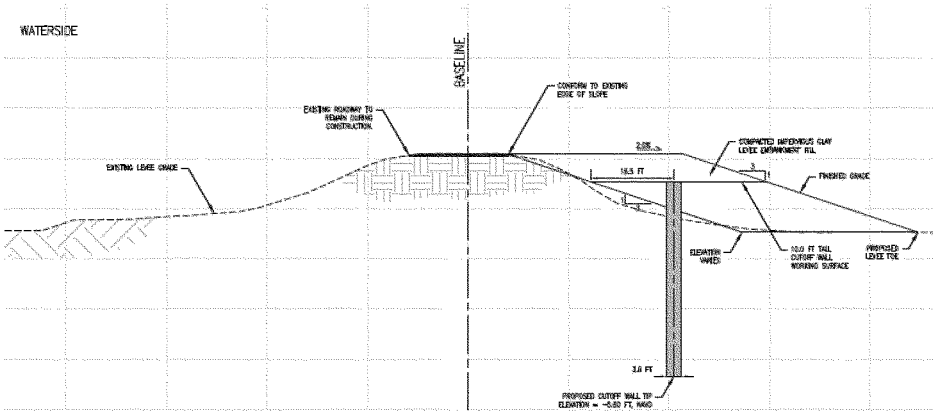


Figure 6-35 - Reach G, Alternative 2A – Cut-off Wall through Adjacent Levee

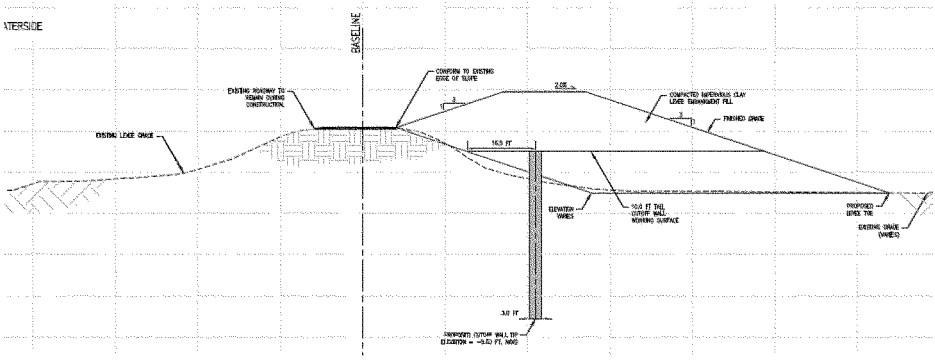


Figure 6-36 - Reach G, Alternative 2A – Cut-off Wall through Adjacent Raised Levee

6.5.8 Levee Unit 3, Natomas Main Drainage Canal, Reach H

The levee along the west bank of the Natomas Main Drainage Canal west bank is constructed of impervious fill. The levee has been raised in the past and reconstructed to the Corps standard. The foundation consists of alternate layers of sands and silty sand overlaid by a more impervious blanket of clays and silts. The levee is located waterside of a developed residential and commercial area constructed close to the landside levee slope. Consequently an adjacent levee would be not economical feasible since it would require acquisition of a large amount of expensive real estate. The risk analyses on the existing conditions show a high risk of poor performance mainly due to underseepage through the foundation leading to high exit gradient at the landside levee toe. The landside and waterside slopes of the embankment are steeper than the

minimum 1(V) on 2(H) and 1(V) on 3(H) respectively, and the levee crest is approximate 20 feet. The levee waterside and landside slopes are covered by some woody vegetation, with limited encroachments and penetrations.

6.5.8.1 Reach H Alternative 1

Alternative 1 consists of construction of a seepage cut-off wall in the existing levee or on the raised in place levee embankment as needed for the analyzed river stages. The levee would be degraded to at least ½ of its height if the wall is of soil-bentonite slurry or 1/3 of its height for a soil/cement/bentonite slurry wall. The advantage of this alternative is the additional real estate requirement is minimal. However, the main disadvantage is that it does not comply with the Corps policies regarding vegetation unless the vegetation waterside of the levee is removed. Al utility penetrations would be relocated and modified to correspond to the Corps criteria. Figures 6-37 and 6-38 illustrate the seepage cut-off wall through the levee at the existing crest elevation or raised as needed for higher river stages.

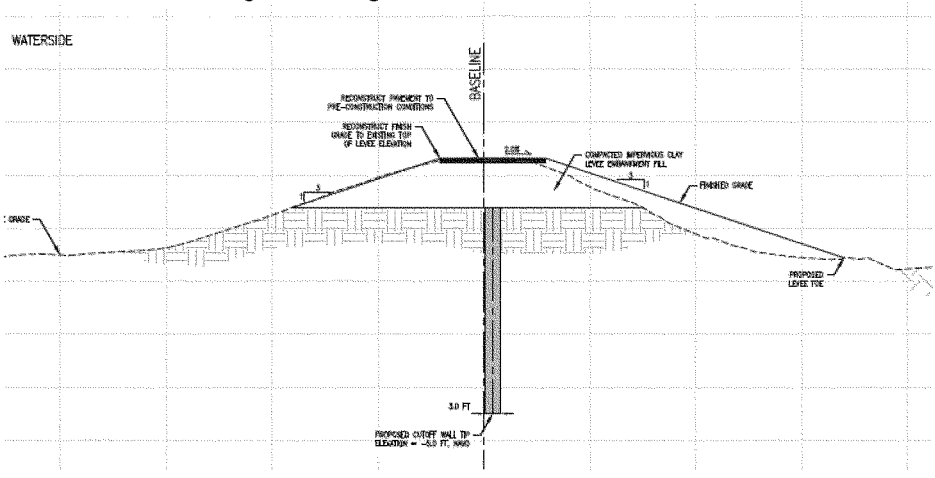


Figure 6-37 - Reach H, Alternative 1A – Cut-off Wall through Existing Levee

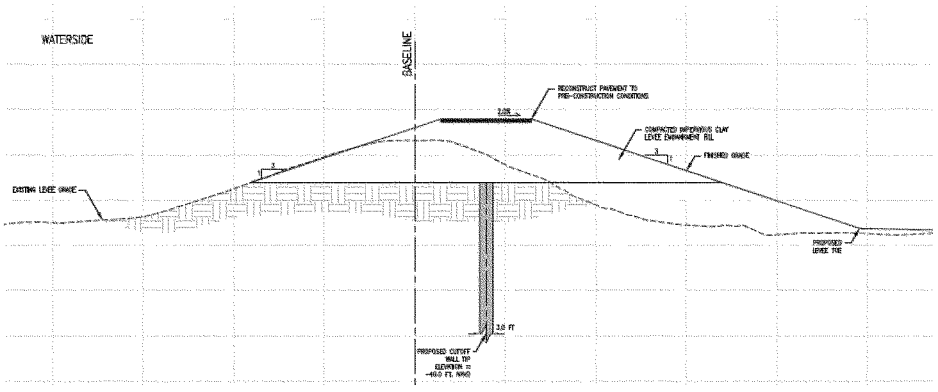


Figure 6-38 - Reach H, Alternative 1A – Cut-off Wall through Raised in Place Levee

6.5.9 Levee Unit 2, American River Right Bank, Reach I

The levee along the north bank of the American River is constructed of the same sandy fill as the levee on the Sacramento River East bank. The levee crest in this area is oversized to accommodate the Garden Highway. A canal is located waterside of the levee and the area on the waterside is heavily wooded vegetated extending on the levee slopes. Encroachments on the landside extend to the levee toe and the landside slope is also covered by woody vegetation. Excessive seepage was observed in the past landside of the levee and the high risk was determined to be the high gradient at the landside toe due to the foundation of the levee. There is sufficient space waterside of the levee if it sees necessary to extend the levee on the waterside without any hydraulic impact.

6.5.9.1 Reach I, Alternative 1

Alternative 1 consists of construction of a seepage cut-off wall in the existing levee or on the raised in place levee embankment as needed for the analyzed river stages. The levee would be degraded to at least ½ of its height if the wall is of soil-bentonite slurry or 1/3 of its height for a soil-cement-bentonite slurry wall. The advantage of this alternative is the additional real estate requirement is minimal. However, the main disadvantage is that it does not comply with the Corps policies regarding vegetation unless the vegetation waterside of the levee is removed. All utility penetrations would be relocated and modified to correspond to the Corps criteria. Figures 6-39 and 6-40 illustrate the seepage cut-off wall through the levee at the existing crest elevation or raised as needed for higher river stages.

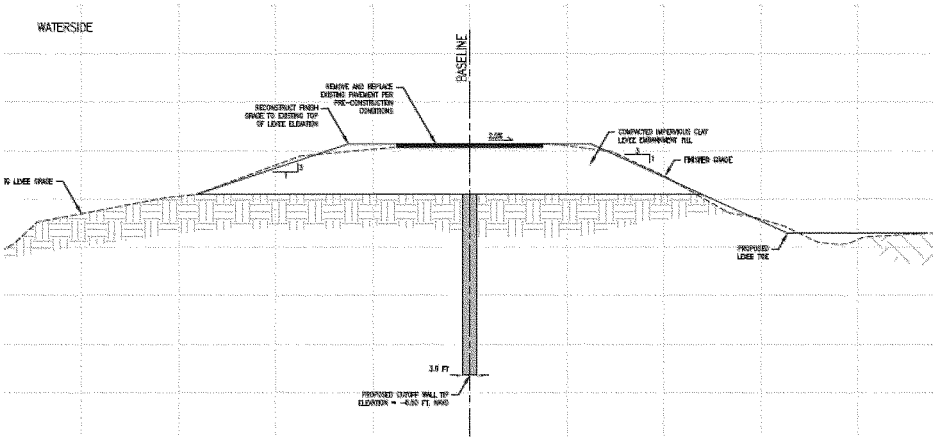


Figure 6-39 - Reach I, Alternative 1A – Cut-off Wall through Existing Levee

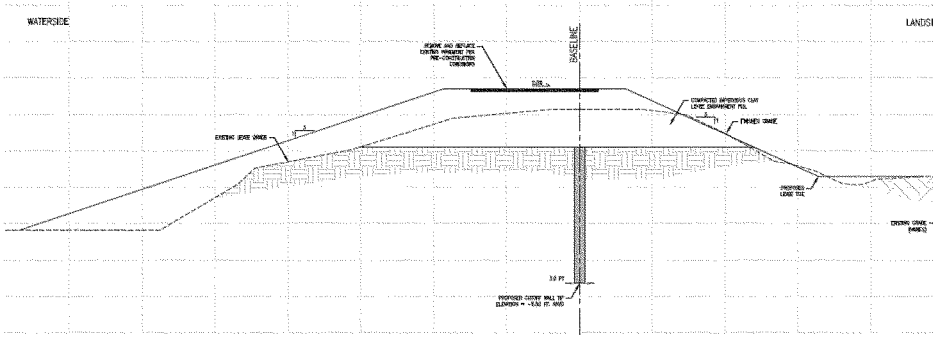


Figure 6-40 - Reach I, Alternative 1A – Cut-off Wall through Raised in Place Levee

6.5.9.2 Reach I, Alternative 2

Alternative 2 consists of widening the levee landside of the existing levee at the same elevation or raised as needed for higher river stages. The wider levee would be constructed of imported compacted impervious fill from a borrow area. To mitigate the underseepage through the levee foundation a seepage cut-off wall would be required (Figures 6-41 and 6-42) to be constructed through the levee. The construction of the seepage cut-off wall by conventional trench method will be from a platform constructed on the entire width of the adjacent levee to provide stability of the excavated trench. This alternative will shift the levee prism on the landside. All utilities penetrating the levee need to be relocated and modified conforming to the Corps requirements. Alternative 2 will require acquisition of additional real estate landside of the existing levee to

construct the adjacent levee.

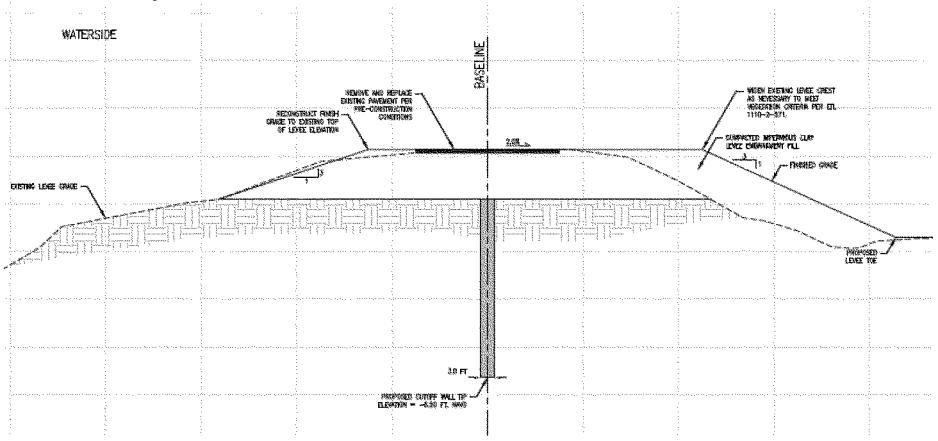


Figure 6-41 - Reach I, Alternative 2A – Cut-off Wall through a Wider Levee

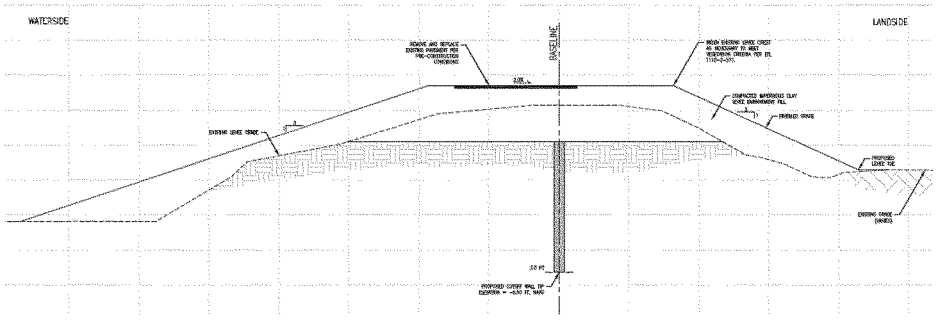


Figure 6-42 - Reach I, Alternative 2A – Cut-off Wall through Adjacent Raised Levee

6.6 Deterministic Analyses of Mitigation Features

The deterministic analyses were performed for representative cross sections of sub-reaches within each economical determined reach of the basin. Stability and seepage analyses performed considering the criteria and soil parameters described above, were performed for the existing condition, and for mitigation features applied for each alternative, for water elevations shown in Table 6.1. The proposed mitigation features for each alternative were used for the civil engineering design to determine the cost of each feature for various flood stages. Risk and uncertainty analyses were performed for the proposed features for each reach within the basin, to be used by the economical analysis.

Detailed results of the seepage and stability deterministic analyses are provided in the calculation package in Enclosure F2. Enclosure F2 "Calculation Package" includes a summary table with the seepage gradients and slope stability factors of safety obtained for each mitigation feature analyzed for each alternative, considering the water for each flood stage analyzed at typical cross sections of each sub-reach. For each cross section analyzed the package includes plan and soil profile where the cross sections is located showing the borings in the vicinity of the selected cross section and the geomorphologic features, a cross section the soil stratigraphy and the borings used for analyses, the GiNT boring log used for the analyses, and the computer output showing the results for different water elevations for seepage and stability analyses. The proposed features were designed to meet the Corps criteria regarding the exit gradient at the levee and berm toes and the slope stability factor of safety for steady state condition for each water elevation analyzed. The proposed features were used to establish the cost of each alternative. The deterministic analyses were the basis for risk analyses considering the proposed mitigation features.

7. Risk and Uncertainty for Mitigation Features

Risk and uncertainty (R&U) analyses were performed for the proposed mitigation features. The R&U analyses were performed for the same index points as used for the existing conditions. The risk and uncertainty considered a reduction in risk and increased performance regarding the seepage through the levee foundation and slope stability considering that the mitigation features were designed in conformance with the Corps criteria regarding the maximum gradient at the levee toe and seepage berm toe and regarding the minimum slope stability factor of safety for a steady state condition for each water elevation analyzed. Reductions in the judgmental curves were also considered for some of the mitigation features where the utility penetration, vegetation and encroachments are in conformance with the Corps requirements. Reduction in risk for the erosion component of the judgmental curve was considered function of the proposed mitigation. Revised R&U performance curves are also provided for each index point and each mitigation measure in Enclosure 4.
To produce the Geotechnical R&U Curves deterministic analysis for seepage and stability was performed and the parameters, (i.e., depth of a cutoff wall, width of the seepage berms), of a particular improvement measure were varied such that, at a specific flood frequency, typically the 100 or 200 year event, the levee met criteria. The geotechnical analysis of the improvement measures was done on sections at the same locations as the analysis for the existing conditions. The results of the analysis with improvement measures were compared to the analysis results of the existing conditions. Based on the difference in results between the levees with improvements compared to the existing conditions the R&U curves were adjusted to reflect the probability of failure with improvement measures at various flood stages.

For example; given the improvement measure selected for a particular section on a reach was a SB Cutoff Wall, the depth of the wall was varied until seepage and stability criteria were met for the 100 year water surface elevation. Once the required cutoff wall depth was found average vertical exit gradients (Iy)and stability factors of safety (FS) were calculated for the 500 year and 25 year water surface elevations using the same analysis model.

Using these 3 points, a curve was created displaying Water Surface Elevation vs. Average Vertical Exit Gradient, or Water Surface Elevation vs. Factor of Safety. A polynomial trend line was added to the curve and the equation of the line was determined. Using the trend line polynomial equation Iy and FS were calculated for the stages (points) on the existing conditions R&U curve, the existing conditions curve was then adjusted to account for improvement measures.

However, the risk of poor performance associated with the vegetation, encroachments, animal burrows, and erosion is still an issue. To reduce the judgment risk due to other factors, some additional measures need to be considered. Some of these measures include utilities penetrating the levee to be relocated/modified conforming to the Corps requirements (pressurized piped equipped with a positive closure through the freeboard; gravity pipes to be equipped with a flap gate at the outlet structure and with a sluice gate in a gatewell), encroachments need to be relocated outside the levee right of way, vegetation removed from the levee slopes, a better burrowing animal control, erosion protection placed on t he waterside levee slope and riverbank as needed to prevent erosion of the levee prism, and other as necessary to reduce judgmental risk factors. Consequently, the revised R&U curves do not include a revision of the judgmental curve only if portions of the curves are directly affected by the proposed mitigation features (i.e., utilities are relocated due to construction of a seepage cut-off wall).

7.1 Sacramento River East Levee Reach A

The main factor contributing to the poor performance of the levee in Reach A is underseepage through the levee foundation. The mitigation features analyzed for this poor performance consist of a slurry cut-off wall through the existing levee (alternative 1) or through an adjacent constructed levee (Alternative 2). The cut-off wall depth varies with the river stage and the flood protection provided. Consequently, an 80-foot wall would provide protection to 100 year flood but the risk may be still high for higher flood stages. To increase the crest of the levee to 200 year flood protection or higher the depth of the wall needs to be at least 100 feet. R&U curves for the existing conditions, for an 80 foot deep wall and for a 100 foot deep wall are shown on Figures 7-1, 7-2 and 7-3 respectively.

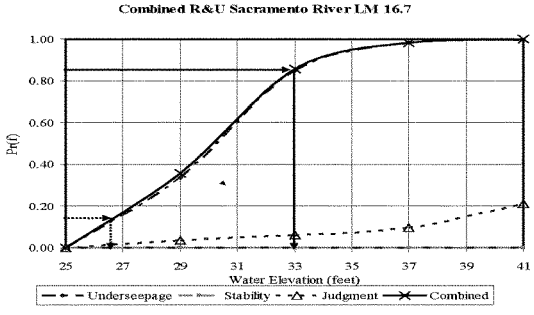


Figure 7-1 - Reach A Existing Conditions

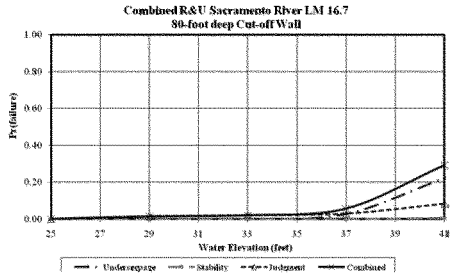


Figure 7-2 - Reach A Alternative 1 Deep Cut-off Wall in Existing Levee

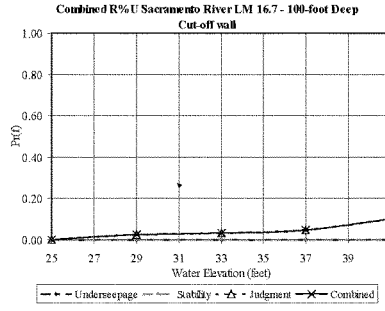


Figure 7-3 - Reach A Alternative 1 Deep Cut-off Wall in Adjacent Levee

As seen on the above curves, the risk of failure due to underseepage through the levee foundation was reduced completely by the 80 foot deep wall to an elevation corresponding to 36 feet, which correspond to the provided 100 year flood event. The 100-foot deep wall reduces the risk of poor performance when the water reaches the levee crest. Construction of the cut-off wall through the existing levee or through an adjacent constructed levee has the same effect on the R&U curve. A comparison of the existing conditions and the two alternatives is shown on Figure 7-4.

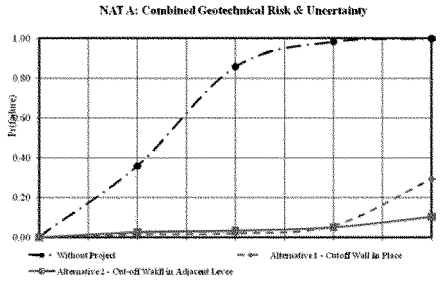


Figure 7-4 - Reach A-Existing Conditions vs. Deep Cut-off Wall in Existing Levee and Adjacent Levee

7.2 Sacramento River East Levee Reach B

The main factor contributing to the poor performance of the levee in Reach B is underseepage through the levee foundation. One mitigation feature analyzed for this poor performance consists of a deep slurry cut-off wall through the existing levee (Alternative 1) or through an adjacent constructed levee (Alternative 2). The wall would be constructed deep to the lower impervious layer in the foundation and consequently the river stages have no impact on the risk of poor performance. A second analyzed feature is a drained seepage berm, constructed on a 2-foot thick permeable drain layer placed on a 6-inches thick filter sand. The width of the berm varies with the river stages. Figures 7-5, shows the combined R&U for the existing conditions compared with the R&U curve for a deep cut-off wall (Figure 7-6) and a drained seepage berm (Figure 7-6).

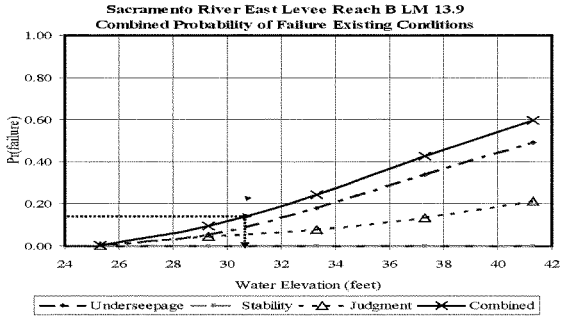


Figure 7-5 - Reach B Existing Conditions

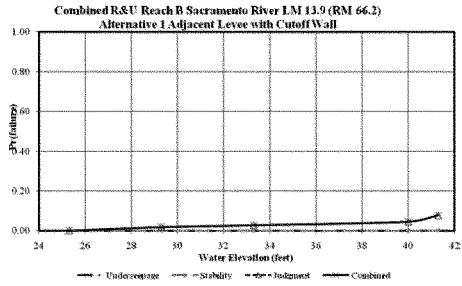


Figure 7-6 - Reach B Fully Penetrating Cut-off Wall

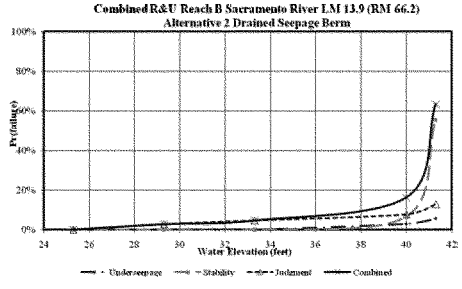


Figure 7-7 - Reach B Drained Seepage Berm

As seen on the above curves, the risk of failure due to underseepage through the levee foundation was reduced completely if a seepage cut-off wall would be constructed. The drained seepage berm may reduce the risk of poor performance to a tolerable risk for river stages within 5 feet of the levee crest. Construction of the cut-off wall through the existing levee or through an adjacent constructed levee has the same effect on the R&U curve.
A comparison of the existing conditions with the two described mitigation alternatives is provided in Figure 7-8.

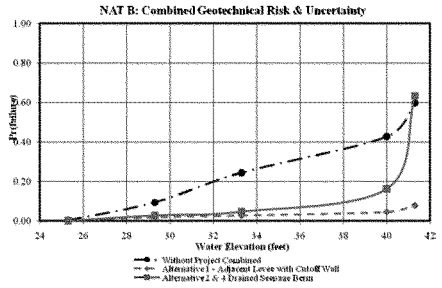


Figure 7-8 – Existing Conditions vs. Deep Cut-off Wall and Drained Seepage Berm

7.3 Sacramento River East Levee Reach C

As all along the Sacramento East Bank Levee the main factor contributing to the poor performance of the levee in Reach C is underseepage through the levee foundation. One mitigation feature analyzed for this poor performance consists of a fully penetrating slurry cut-off wall through the existing levee (Alternative 1) or through an adjacent constructed levee (Alternative 2). The wall would be constructed deep to the lower impervious layer in the foundation and consequently the river stages have no impact on the risk of poor performance. A second analyzed feature is a combination of a partially penetrating wall and a drained seepage berm constructed on a 2-foot thick permeable drain layer placed on a 6-inches thick filter sand. The width of the berm varies with the river stages. Figures 7-9, shows the combined R&U for the existing conditions compared with the R&U curve for a deep cut-off wall (Figure 7-10) and a combination of a cut-off wall and a drained seepage berm (Figure 7-11).

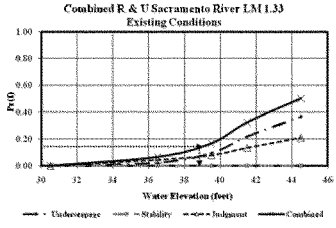


Figure 7-9 - Reach C – Existing Conditions

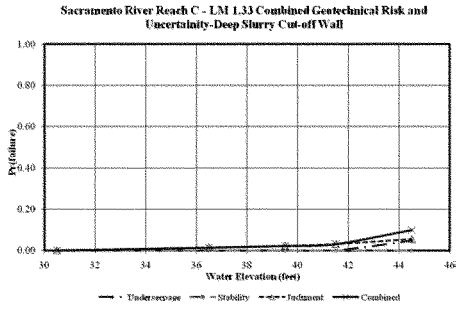


Figure 7-10 - Reach C – Fully Penetrating Cut-off Wall

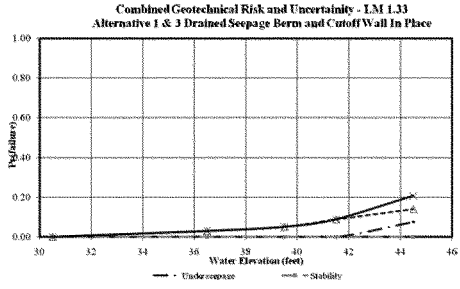


Figure 7-11 - Reach C – Combination of Partially Penetrating Cut-off Wall and Drained Seepage Berm

As seen on the above curves, the risk of failure due to underseepage through the levee foundation was reduced completely if a seepage cut-off wall would be constructed. However, considering high the cost of very deep cut-off wall, the wall may be replaced by a partially penetrating wall due to the depth of the impervious layer. To reduce the gradient below the maximum allowable gradient a drained seepage berm may be added landside of the levee. The drained seepage berm may reduce the risk of poor performance to a tolerable risk for river stages within 1 feet of the levee crest. Construction of the cut-off wall through the existing levee or through an adjacent constructed levee has the same effect on the R&U curve.
Figure 12 shows the R&U curves for the existing conditions compared with the shallow cut-off wall with a drainage seepage berm and with deep cut-off wall alternatives.

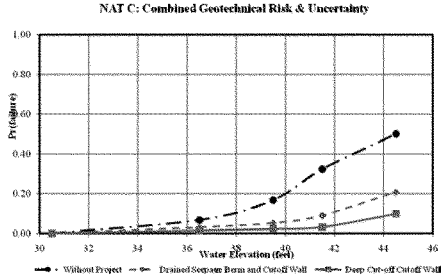


Figure 7-12 - Reach C – Existing Conditions vs. Drainage Berm and Cut-off Wall and Deep cut-off Wall Alternatives

7.4 Natomas Cross Canal Reach D

The main factor contributing to the poor performance of the levee in Reach D is underseepage through the levee foundation. Due to high pore pressures developed in the levee foundation and levee embankment by high river stages the stability of the landside levee slope for the steady state conditions become also critical for water elevations within 6 feet from the levee crest. A drainage canal and an irrigation canals are located close to the landside levee toe. Relocation of these canals and backfilling those with compacted impervious fill may become impractical. Therefore, only one alternative was analyzed for the entire Natomas Cross canal. To reduce the risk of poor performance of the levee a fully penetrating cut-off wall was considered through the existing levee (Alternative 1) or through an adjacent constructed levee (Alternative 2). The wall would be constructed deep to the lower impervious layer in the foundation and consequently the river stages have no impact on the risk of poor performance. Figures 7-13, shows the combined R&U for the existing conditions compared with the R&U curve for a deep cut-off wall (Figure 7-14) through the existing or adjacent levee.

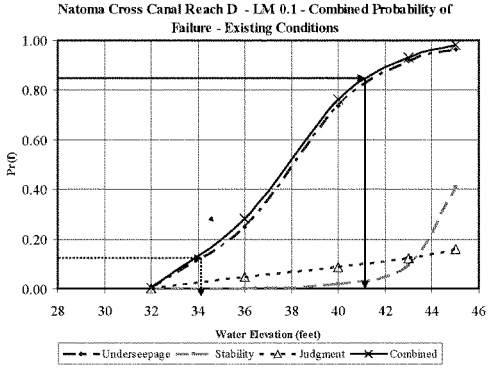


Figure 7-13 - Reach D – Existing Conditions

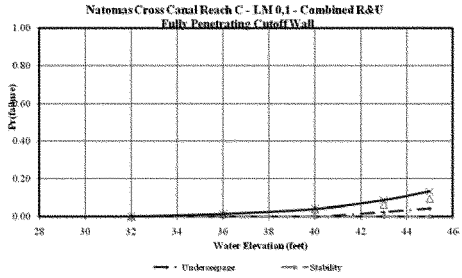


Figure 7-14 - Reach D – Fully Penetrating Cut-off Wall

As seen on the above curves, the risk of failure due to underseepage through the levee foundation was to allowable limits when the water reaches stages within 2 feet of the levee crest if a fully penetrating seepage cut-off wall would be constructed. Construction of the cut-off wall through the existing levee or through an adjacent constructed levee has the same effect on the R&U curve.

Figure 7-15 compares the R&U curves of the existing conditions with a deep cut-off wall in the existing or adjacent levee mitigation alternative.

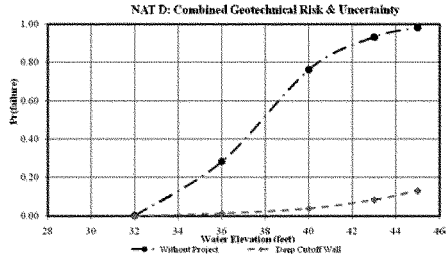


Figure 7-15 - Reach D – Existing Conditions vs. Deep Cut-off Wall in the existing or Adjacent levee Mitigation Alternative

7.5 Pleasant Grove Creek Canal Reach E

The main factor contributing to the poor performance of the levee in Reach E is underseepage through the levee foundation. Due to high pore pressures developed in the levee foundation and levee embankment by high river stages the stability of the landside levee slope for the steady state conditions become also critical having a high impact on the levee poor performance. A seepage cut-off wall was analyzed as a seepage and stability mitigation feature. The two alternatives being considered include constructing the wall through the existing levee

(Alternative 1) or through an adjacent constructed levee (Alternative 2). The wall would be constructed deep to the lower impervious layer in the foundation and consequently the river stages have no impact on the risk of poor performance. Figures 7-16 shows the combined R&U for the existing conditions compared with the R&U curve for a deep cut-off wall (Figure 7-17).

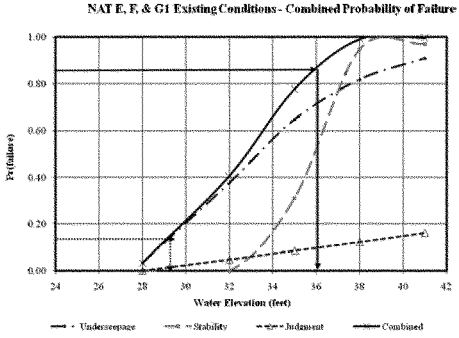


Figure 7-16 - Reach E – Existing Conditions

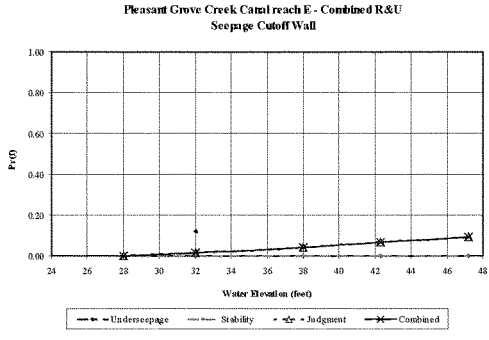


Figure 7-17 - Reach E – Fully Penetrating Cut-off Wall

Construction of the cut-off wall through the existing levee or through an adjacent constructed levee has the same effect on the R&U curve.

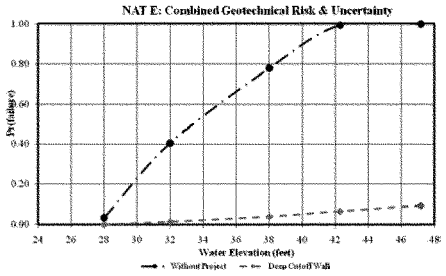


Figure 7-18 - Reach E – Existing Conditions R&U vs. Deep cut-off Wall in Existing or Adjacent Levee

7.6 Natomas East Main Drainage Canal Reach F

The main factor contributing to the poor performance of the levee in Reach F is underseepage through the levee foundation. Due to high pore pressures developed in the levee foundation and levee embankment by high river stages the stability of the landside levee slope for the steady state conditions become also critical having a high impact on the levee poor performance. Two mitigation features were analyzed to reduce the seepage through the levee foundation and to increase the landside slope stability. The two features are construction of a landside drained berm or flattened landside levee slope. Figures 7-19 shows the combined R&U for the existing conditions compared with the R&U curve for a drained seepage berm (Figure 7-20) and a flattened landside levee slope (Figure 7-21).

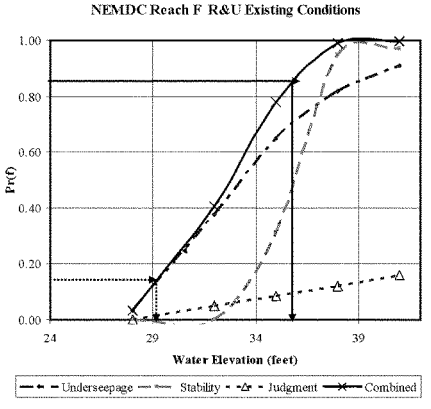


Figure 7-19 - Reach F– Existing Conditions

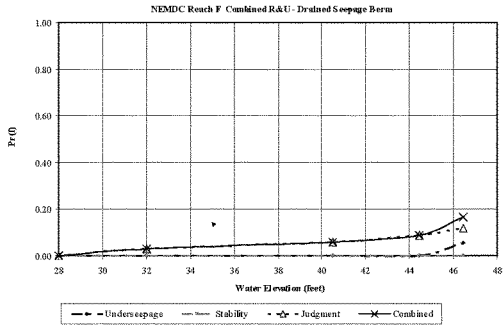


Figure 7-20 - Reach F – Drainage Seepage Berm

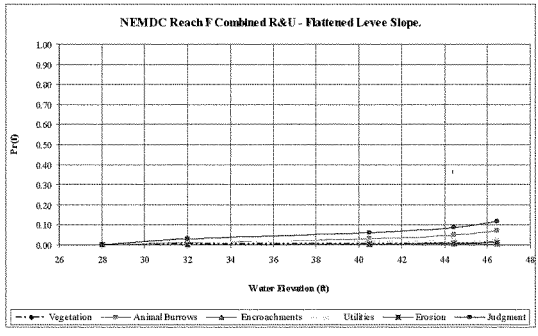


Figure 7-21 - Reach F – Flattened Levee Slope

Figure 7-22 shows the reduction of the risk from the existing conditions to the drainage seepage berm or flattened levee slope alternatives

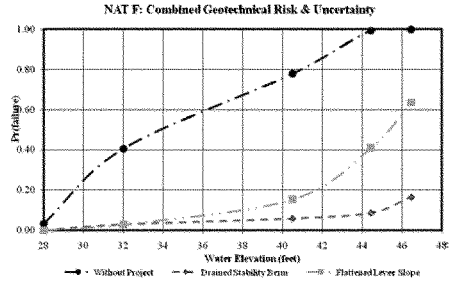


Figure 7-22 - Reach F – Existing Alternative vs Seepage Berm or Flattened Levee Slope Alternatives.

7.7 Natomas East Main Drainage Canal Reach G

The main factor contributing to the poor performance of the levee in Reach D is underseepage through the levee foundation. Due to high pore pressures developed in the levee foundation and levee embankment by high river stages the stability of the landside levee slope for the steady state conditions become also critical when the water reaches 7 feet below the levee crest having a high impact on the levee poor performance. A seepage cut-off wall was analyzed to reduce the pore pressure in the levee foundation and levee embankment and to increase also the stability of the landside levee slope. Figures 7-23 shows the combined R&U for the existing conditions compared with the R&U curve for a deep seepage cut-off wall (Figure 7-24).

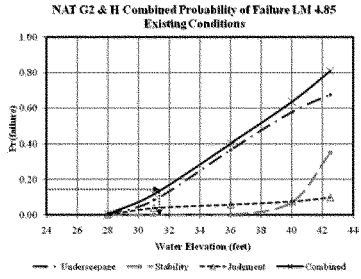


Figure 7-23 - Reach G– Existing Conditions

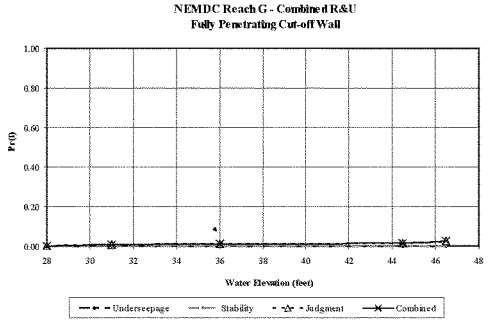


Figure 7-24 - Reach G – Fully Penetrating Cut-off Wall

Figure 7-25 shows the reduction of the risk from the existing conditions to a deep cut-off wall in the existing or adjacent levee.

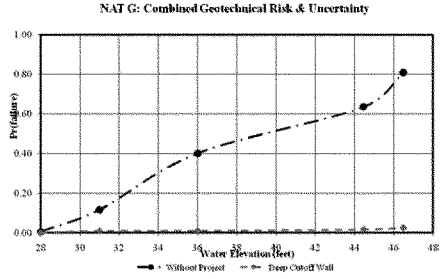


Figure 7-25 - Reach G – Existing Alternative vs. Deep Cut-off Wall in Existing or adjacent Levee Alternatives.

7.8 Natomas East Main Drainage Canal Reach H

The main factor contributing to the poor performance of the levee in Reach H is underseepage through the levee foundation. Due to high pore pressures developed in the levee foundation and levee embankment by high river stages the stability of the landside levee slope for the steady state conditions become also critical when the water reaches 7 feet below the levee crest having a high impact on the levee poor performance. A seepage cut-off wall was analyzed to reduce the pore pressure in the levee foundation and levee embankment and to increase also the stability of the landside levee slope. Figures 7-26 shows the combined R&U for the existing conditions compared with the R&U curve for a deep seepage cut-off wall (Figure 7-27). The risk of poor performance is below 15 % when the water reaches the levee crest.

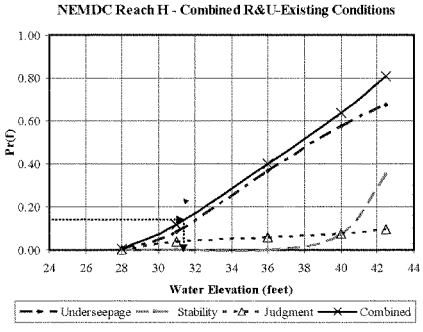


Figure 7-26 - Reach H– Existing Conditions

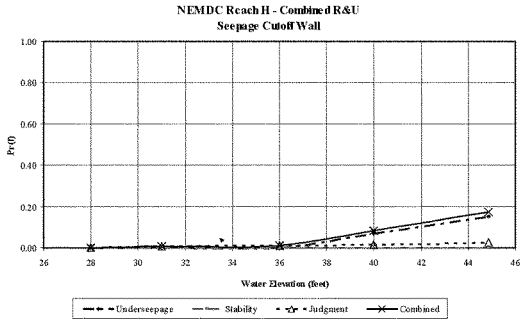


Figure 7-27 - Reach H – Seepage Cut-off Wall

Landside of Reach H the area is well developed, with housing close to the levee right-of-way, at some locations the right-of way is even less than the minimum 15 feet. Considering the existing condition, and the fact that the levee was recently raised by SAFCA, an adjacent levee is not feasible without sacrificing the developed area. Consequently the seepage cut-off wall would be constructed within the existing levee.
Figure 7-28 shows the risk reduction from the existing condition by constructing a fully penetrating cut-off wall.

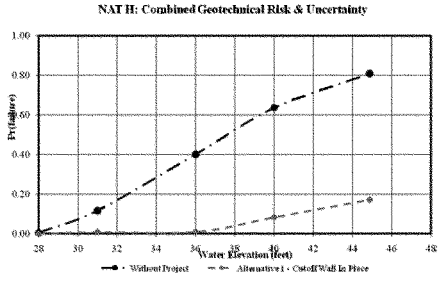


Figure 7-28 - Reach H – Existing Alternative vs. Deep Cut-off Wall in Existing Levee Mitigation Alternative

7.9 American River North Bank Reach I

The main factor contributing to the poor performance of the levee in Reach I is underseepage through the levee foundation. Due to high pore pressures developed in the levee foundation and levee embankment by high river stages the stability of the landside levee slope for the steady state conditions become also critical when the water reaches 7 feet below the levee crest having a high impact on the levee poor performance. A seepage cut-off wall was analyzed to reduce the pore pressure in the levee foundation and levee embankment and to increase also the stability of

the landside levee slope. Figures 7-29 shows the combined R&U for the existing conditions compared with the R&U curve for a deep seepage cut-off wall (Figure 7-30).

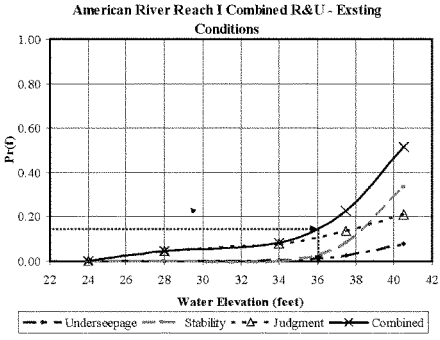


Figure 7-29 - Reach I– Existing Conditions

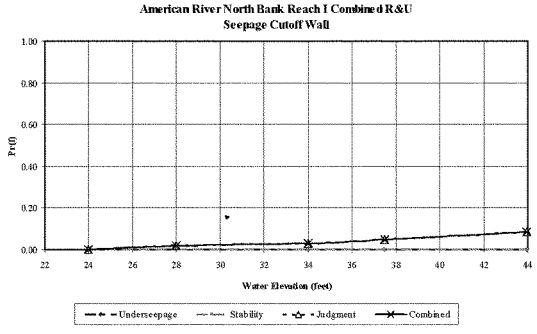


Figure 7-30 - Reach I – Seepage Cut-off Wall

Landside of Reach I the area is well developed, with housing close to the levee right-of-way, at some locations the right-of way is even less than the minimum 15 feet. Consequently the seepage cut-off wall would be constructed within the existing levee.
The risk reduction from the existing conditions to a fully penetrating seepage wall is shown on Figure 7-31.

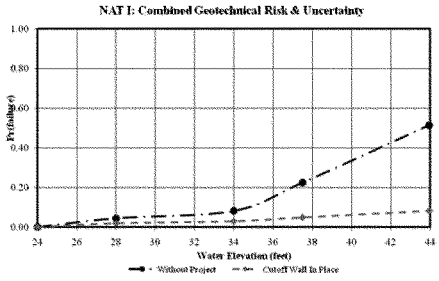


Figure 7-31 - Reach i – Existing Alternative vs. Deep Cut-off Wall in Existing Levee Mitigation Alternative

8. Anticipated Borrow Sites

There were several borrow sites identified for the remedial actions for the Natomas Basin as follows. Test pits and laboratory testing on the materials collected from the test pits were provided by SAFCA as part of the Natomas Levee Improvement Program (NLIP). Samples collected from tests pits excavated in the borrow areas were tested in laboratory to determine the material characteristic and availability. Laboratory tests included determination of moisture content, sieve analyses, Atterberg Limits, Triaxial Compression (unconsolidated undrained Q tests and consolidated undrained R-Bar tests with pore pressure measurements on remolded samples to 95% maximum density as obtained by Standard Proctor Tests ASTM D 698 with moisture between -2 and +3 % of optimum moisture, consolidation tests), consolidation tests, and permeability tests. The proposed remediation include seepage berms and seepage cut-off wall constructed from a 5-10 foot high working platform landside of the existing levee toe along the SREL and ARNL. This working platform consists also the base of the proposed adjacent levee. High plasticity clay may be used in the working platform or in a zoned levee embankment as long as it is covered by at least 5 feet of low plasticity clay, to prevent formation of tension cracks which may lead to slope failure if full with water. Random fill material with or material with high content of sand may be used in the seepage berms. The following borrow sites are proposed for the levee improvement.

8.1 Fisherman Lake Complex Borrow Site

The borrow site is located south of Del Paso Road, north of Radio Road and east of Power Line Road, about 400 feet east of the proposed landside levee toe in the vicinity of the Pumping Plant No. 3.. The area is near the historical Fisherman Lake and is reclaimed for agricultural purpose. This borrow site will be used for construction of the adjacent levee landside of the existing levee and for the seepage berms on the landside levee slope on the east bank of the Sacramento River and north bank of the American River levee remediation. The materials found in the proposed borrow area contains clays with low and high plasticity, silts and some sandy clays and silts.

8.2 South Sutter Borrow Site

The borrow site is located east of the Sacramento River East Levee, north of Elkhorn Boulevard, south of Teal Bend, west of the Sacramento International Airport, at approximate 500 feet from the levee landside toe. The material in this borrow area consists of lean clays, lean clays with sand, some high plasticity clays, silts and sandy silt, and poorly graded sand. The material from this borrow area may be used for the adjacent levee and seepage berms along the Sacramento River east bank levee, with the condition that the high plasticity berm is used only in the working platform for the seepage cut-off wall. The area is mainly agricultural land within 2 miles from the Sacramento Airport which regulates the land use. Special approval and conditions are required by the Federal Aviation Administration to be respected if the borrow area is used.

8.3 North Airport Borrow Site

The North Airport borrow site is located about a half of mile east of the Sacramento River east bank levee, north of the Sacramento International Airport. The area is also located within 2 miles from the Sacramento International Airport and consequently the same requirements of the Federal Aviation Administration should be meet if the borrow area is used. The borrow area is currently agricultural land and is designated as buffer lands for the Airport runway approaches, the purpose of it being to prevent land uses that are incompatible with Airport runways. Materials encountered in the borrow area consist of low plasticity clays, sandy clay, some higher plasticity clays, silty clay, sandy silt and clayey sand. The material may be used for the construction of the adjacent levee on the landside of the Sacramento River east bank levee and American River north bank levee and for the landside seepage berms.

8.4 Brookfield Borrow Site

The borrow site is located at the corner of the Pleasant Grove Creek Canal where it meets the Natomas Cross Canal within the Natomas basin, approximate 300 feet from the levee landside toe. The land is used for agriculture. Testing of the materials in the borrow area show the material consisting of mainly low plasticity clay with less than 5 % of higher plasticity clay (with the LL less than 55), some sandy or silty clay and silts. The material may be used for remediation of the Natomas Cross Canal south bank levee and for the Pleasant Grove Creek Canal west bank levee.

8.5 Triangle Borrow Site

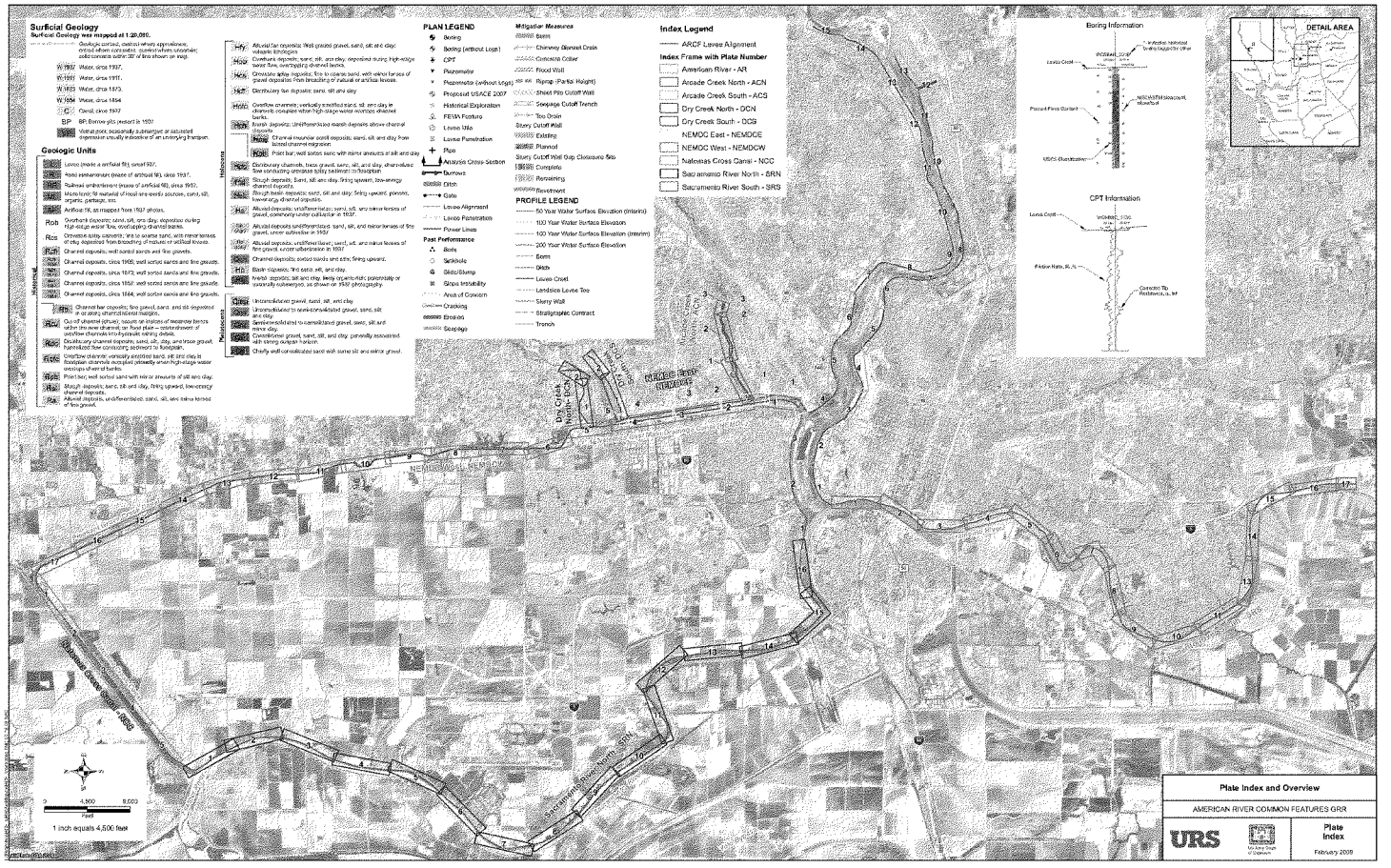
The borrow area is located east of the Natomas Basin, outside the protected area, south of the Natomas Cross Canal. This area is proposed to be used in case the material from the other borrow areas is insufficient. There were no sample collected from the area and no testing on the material. However, based on geomorphologic studies the material in the upper 5-10 feet is suitable for levee construction.

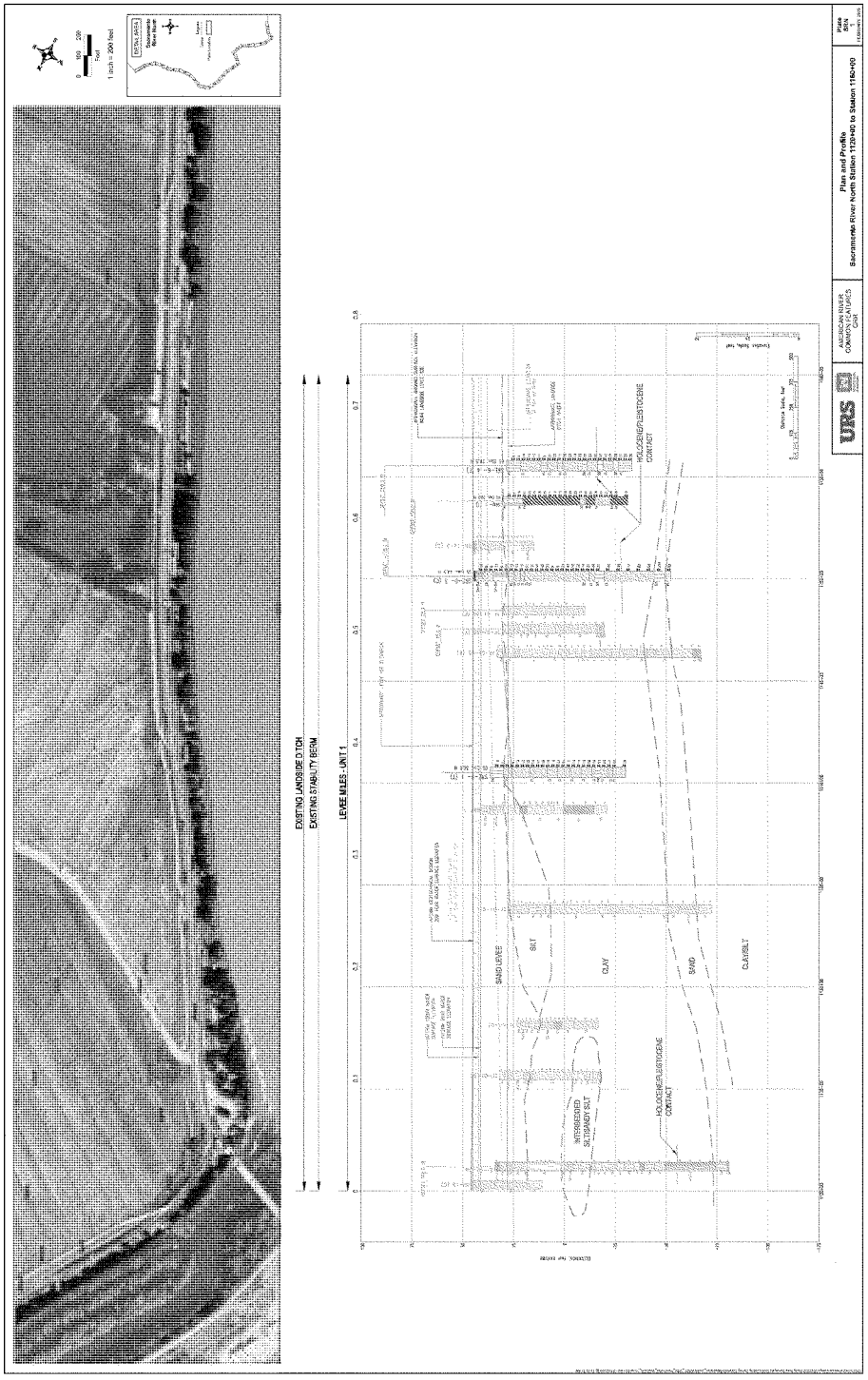
AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

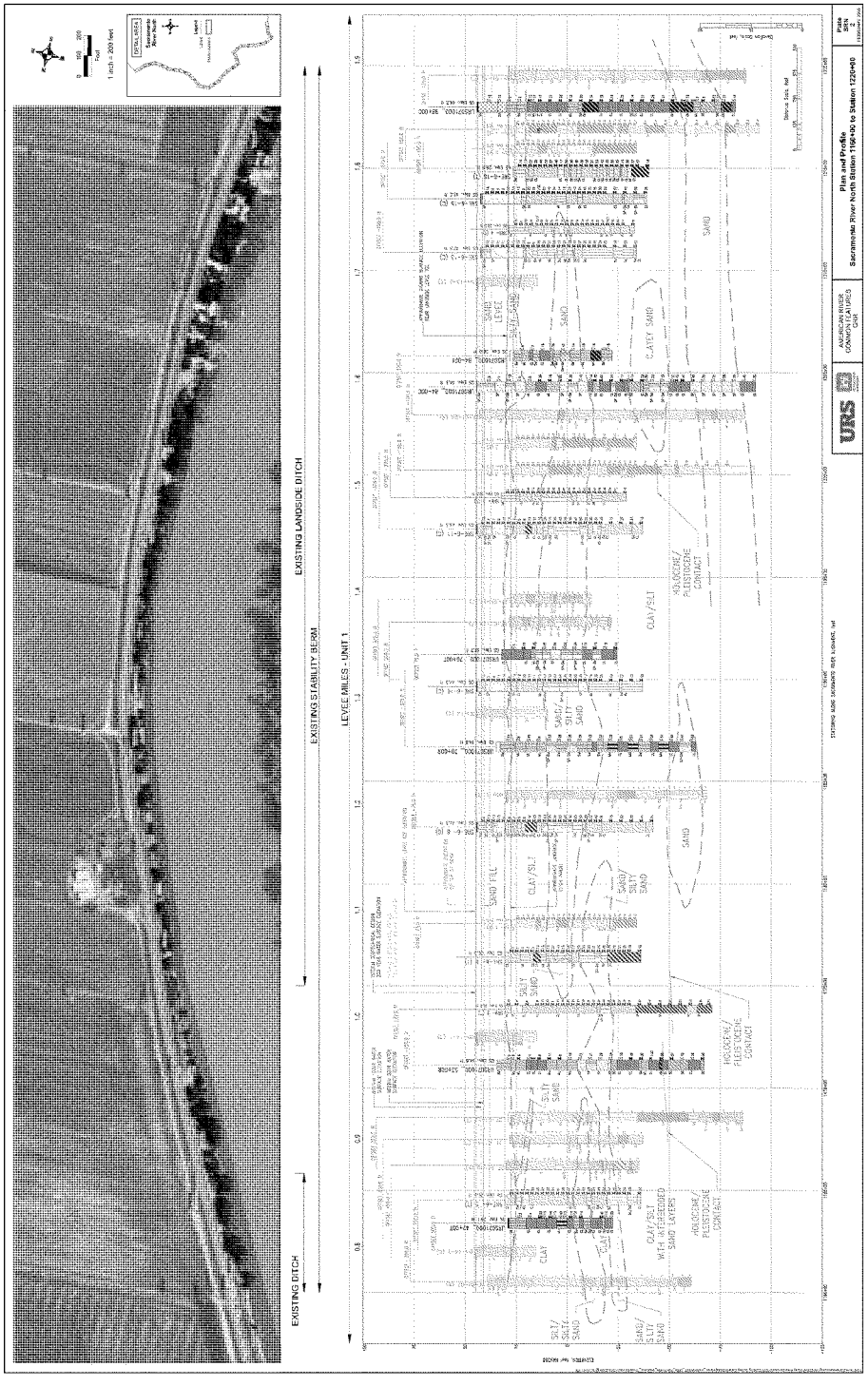
NATOMAS POST AUTHORIZATION CHANGE REPORT

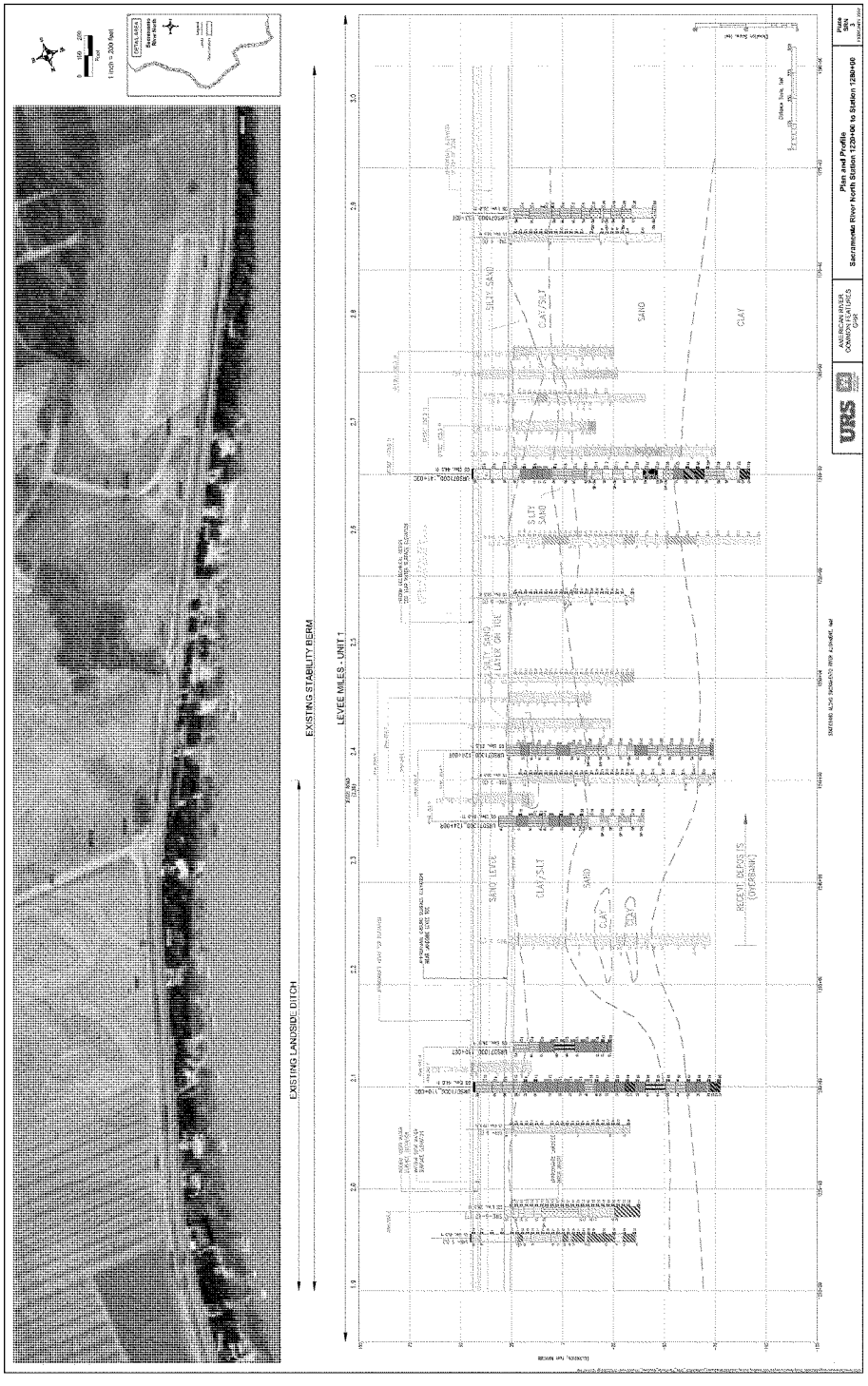
ENCLOSURE F-1A

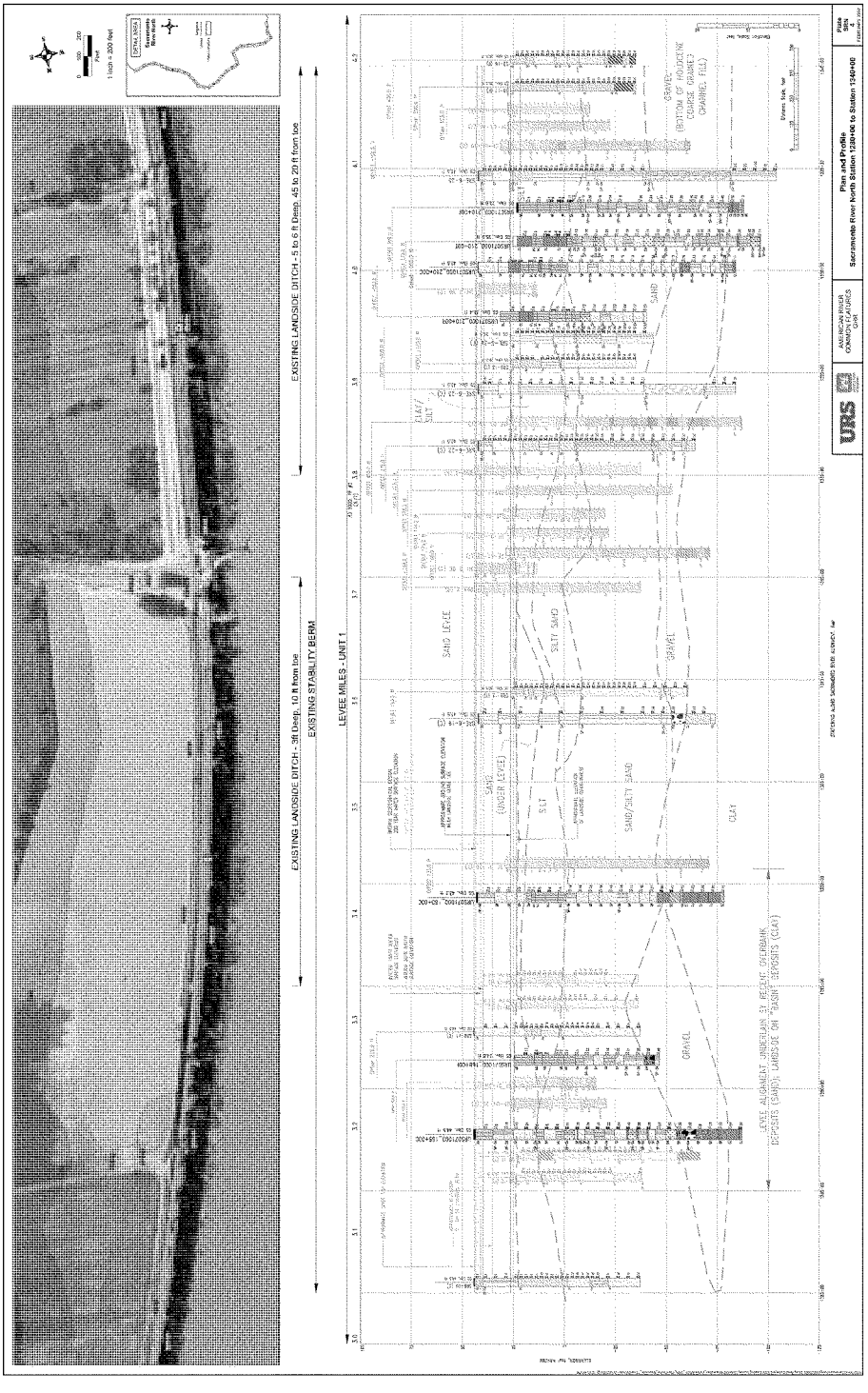
URS PLAN AND PROFILES

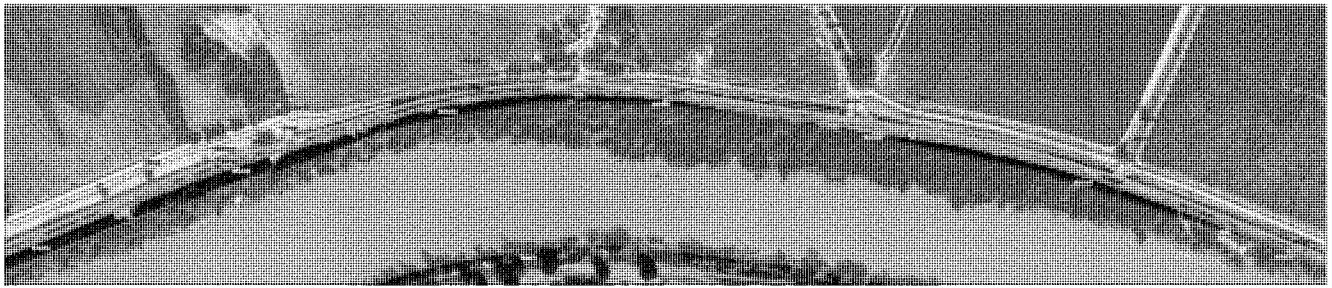

Surficial Geology
Surficial Geology was mapped at 1:20,000.
Geologic contact, dashed where approximate, dotted where concealed. Queried where uncertain; solid contacts within 20' of line shown on map.
W 1937 Water, circa 1937.
W 1911 Water, circa 1911.
W 1873 Water, circa 1873.
W 1854 Water, circa 1854.
Ditch, circa 1937
BP Borrow pits (extent in 1937
Vernal pools, seasonally submerged or saturated depression usually exclusive of an underlying hardpan.
Geologic Units
Levee (made of artificial fill), circa 1937.
Road embankment (made of artificial fill), circa 1937.
Railroad embankment (made of artificial fill), circa 1937.
Made land: fill material of local site-specific sources, sand, silt, organic, garbage, etc.
Artificial fill, as mapped from 1937 photos.
Overbank deposits: sand, silt, and clay, deposited during high-stage water flow, overlapping channel banks.
Otherwise active deposits: fine to coarse sand, with minor lenses of clay, deposited from breaching of natural or artificial levees.
Channel deposits, well sorted sands and fine gravels.
Channel deposits, circa 1906, well sorted sands and fine gravels.
Channel deposits, circa 1873, well sorted sands and fine gravels.
Channel deposits, circa 1857, well sorted sands and fine gravels.
Channel deposits, circa 1844, well sorted sands and fine gravels.
Channel bar deposits; fine gravel, sand, and silt deposited in or along channel/channel margins.
Cut-off channel (phase), course or portions of meander bends within the river channel; or fluid plug — entombment of overflow channels into hydraulic activity debris.
Distributary channel deposits; sand, silt, clay, and loose gravel; hummocked flow consisting adjacent to floodplain.
Overflow channel; vertically stratified sand, silt and clay in floodplain channels occupied primarily when high-stage water overtops channel banks.
Point bar; well sorted sand with minor amounts of silt and clay.
Slough deposits; sand, silt and clay, finning upward, low-energy channel deposits.
Alluvial deposits, undifferentiated; sand, silt, and minor lenses of fine gravel.
Holocene
Pleistocene
Alluvial fan deposits; Well graded gravel, sand, silt and clay; volcanic lithologies
Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overlapping channel banks.
Gravelly spray deposits; fine to coarse sand, with minor lenses of gravel deposited from breaching of natural or artificial levees.
Distributary fan deposits; sand, silt and clay
Overflow channels; vertically stratified sand, silt and clay in channels occupied within high-stage water overtops channel banks.
Basin deposits; Undifferentiated marsh deposits above channel deposits
Channel meander point deposits; sand, silt and clay; fine bioturbated channel migration
Point bar; well sorted sand with minor amounts of silt and clay
Distributary channels, fine gravel, sand, silt, and clay; channelized flow conducting unbroken spray sediment on floodplain
Slough deposits; Sand, silt and clay, fining upward, low-energy channel deposits.
Slough basin deposits; sand, silt and clay; fining upward, pinnate, low-energy channel deposits.
Alluvial deposits; undifferentiated; sand, silt, and minor lenses of fine gravel, current subsidence in 1937
Alluvial deposits, undifferentiated; sand, silt, and minor lenses of fine gravel, current subsidence in 1937
Channel deposits; vertical bands and silts; fining upward.
Basin deposits; fine sand, silt, and clay.
Marsh deposits; silt and clay, likely organic-rich; potentially or seasonally submerged, as shown on 1937 photography.
Undifferentiated gravel, sand, silt, and clay
Unconsolidated to semi-consolidated gravel, sand, silt and clay.
Semi-consolidated to consolidated gravel, sand, silt and minor clay.
Consolidated gravel, sand, silt, and clay, generally associated with Laguna Formation
Clayey well-consolidated sand with some silt and minor gravel.
PLAN LEGEND
Boring
Boring (without Logs)
CPT
Piezometer
Piezometer (without Logs)
Proposed USACE 2007
Historical Exploration
FEMA Feature
Levee Mile
Levee Penetration
Pipe
Armoring Cross-Section
Burrows
Ditch
Gate
Levee Alignment
Levee Penetrations
Power Lines
Past Performance
Boils
Sinkhole
Slide/Slump
Slope Instability
Area of Concern
Cracking
Erosion
Seepage
Mitigation Measures
Berm
Chimney Blanket Drain
Contiguous Collar
Flood Wall
Riprap (Partial Height)
Sheet Pile Cutoff Wall
Seepage Cutoff Trench
Toe Drain
Slurry Cutoff Wall
Existing
Planned
Slurry Cutoff Wall Gap Closures Site
Complete
Remaining
Environment
PROFILE LEGEND
50 Year Water Surface Elevation (Interim)
100 Year Water Surface Elevation
100 Year Water Surface Elevation (Interim)
200 Year Water Surface Elevation
Berm
Ditch
Levee Crest
Landside Levee Toe
Slurry Wall
Stratigraphic Contract
Trench
Index Legend
ARCF Levee Alignment
Index Frams with Plate Number
American River - AR
Arcade Creek North - ACN
Arcade Creek South - ACS
Dry Creek North - DCN
Dry Creek South - DCS
NEMDC East - NEMDCE
NEMDC West - NEMDCW
Natomas Cross Canal - NCC
Sacramento River North - SRN
Sacramento River South - SRS
Boring Information
Levee Crest
Natomas Cross Canal - NCC
CPT Information
Levee Crest
Friction Ratio, Rf, %
Corrected Tip Resistance, qt, tsf
DETAIL AREA
Dry Creek
Natomas Cross Canal - NCC
NEMDC West - NEMDCW
Sacramento River North - SRN
Sacramento River South - SRS
0
4,500
9,000
Feet
1 inch equals 4,500 feet
Plate Index and Overview
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate Index
February 2008

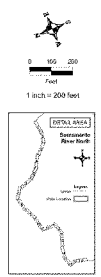

EXISTING LANDSIDE DITCH
EXISTING STABILITY BERM
LEVEE MILES - UNIT 1
SAND LEVEE
SILT
CLAY
SAND
CLAY/SILT
INTERBEDDED SILT/SAND/SILT
HOLOCENE/PLEISTOCENE CONTACT
HOLOCENE/PLEISTOCENE CONTACT
URS
AMERICAN RIVER CONSTRUCTION PROJECTS
Plan and Profile
Sacramento River North Station 1120+00 to Station 1180+00


EXISTING DITCH
EXISTING STABILITY BERM
EXISTING LANDSIDE DITCH
LEVEE MILES - UNIT 1
Plan and Profile
Sacramento River North Station 1190+00 to Station 1220+00
URS
AMERICAN RIVER COMMON FEATURES


EXISTING LANDSIDE DITCH
EXISTING STABILITY BERM
LEVEE MILES - UNIT 1
1 INCH = 200 FEET
URS
AMERICAN RIVER COMMON FEATURES 2013
Plan and Profile
Sacramento River North Station 1230+00 to Station 1280+00
Plate No. 3
SAND
CLAY/SILT
SILTY SAND
CLAY
RECENT DEPOSITS (OVERBANK)


EXISTING LANDSIDE DITCH - 5 to 6 ft Deep, 45 to 20 ft from toe
EXISTING LANDSIDE DITCH - 9ft Deep, 10 ft from toe
EXISTING STABILITY BERM
LEVEE MILES - UNIT 1
SAND LEVEE
SILT SAND
GRAVEL
SAND (UNDER LEVEE)
SILT
SAND/SILTY SAND
CLAY
GRAVEL
LEVEE ALIGNMENT UNDERLAIN BY RECENT OVERBANK DEPOSITS (SAND); LANDSIDE ON "BASIN" DEPOSITS (CLAY)
CLAY/ SILT
SAND
GRAVEL (BOTTOM OF HOUDINE COARSE GRAVEL/ COBBLE FILL)
URS
AMERICAN RIVER CONSULTANTS
Plan and Profile
Sacramento River North Station 1230+00 to Station 1340+00
Plate No. 4

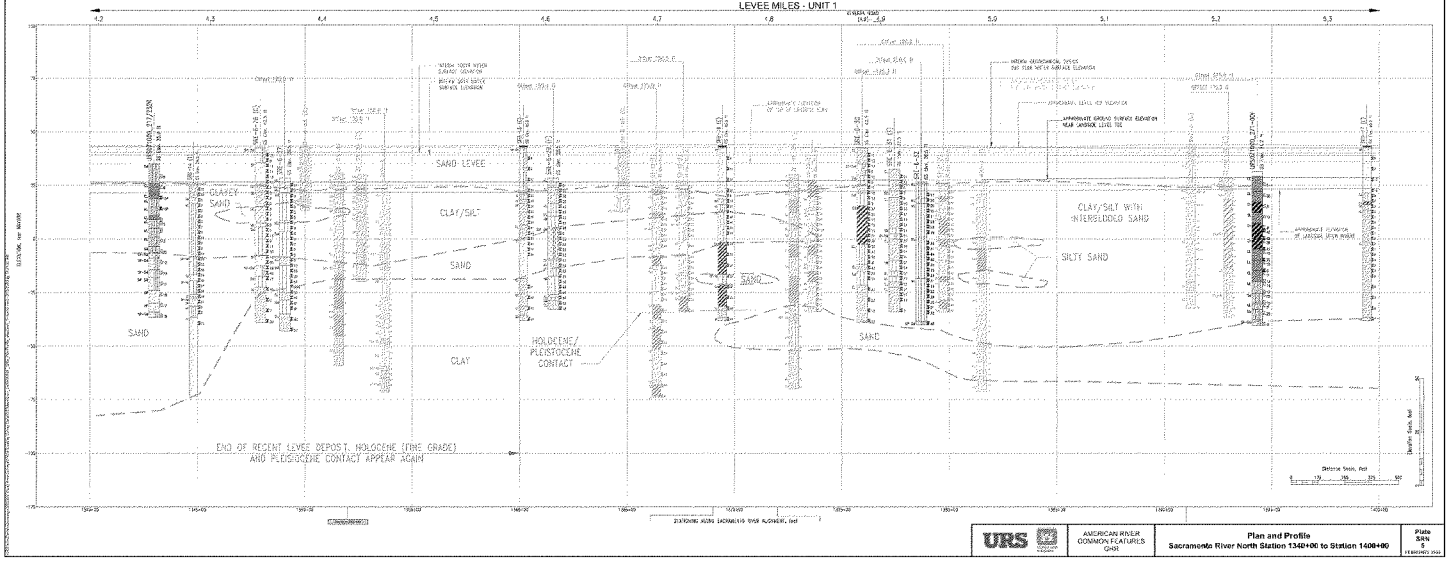




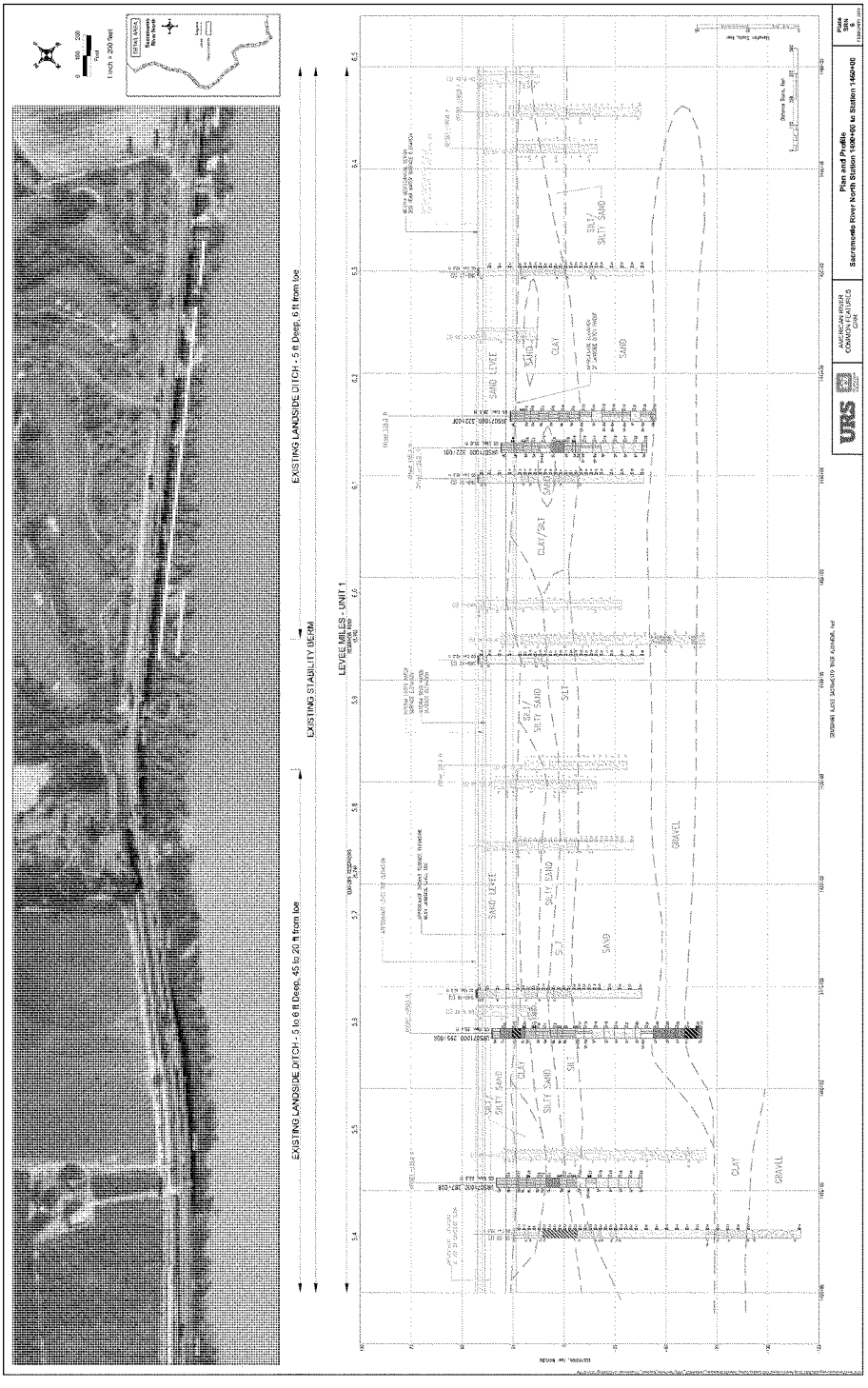
EXISTING LANDSIDE DITCH - 5 to 6 ft Deep, 45 to 20 ft from toe

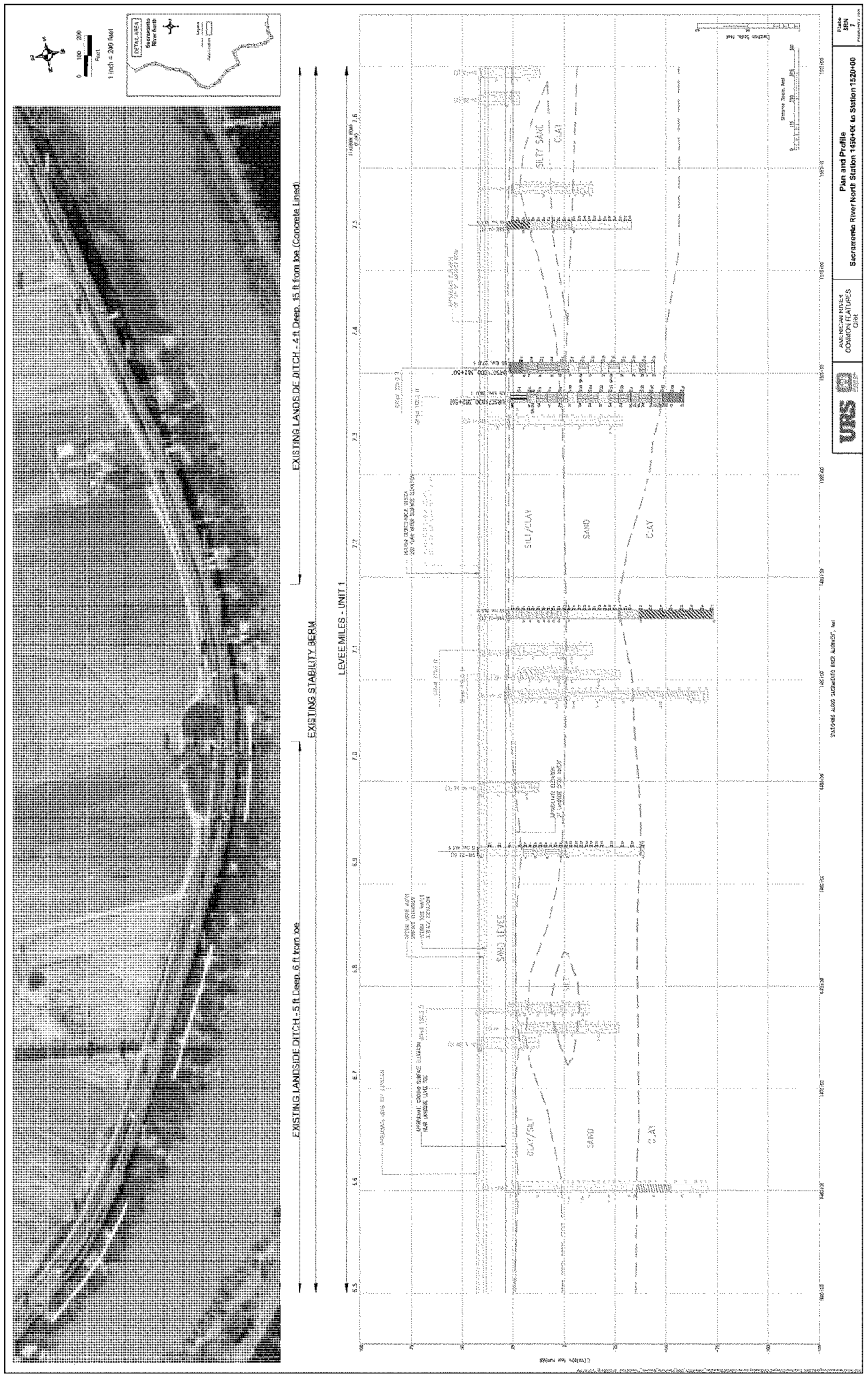
EXISTING STABILITY BERM

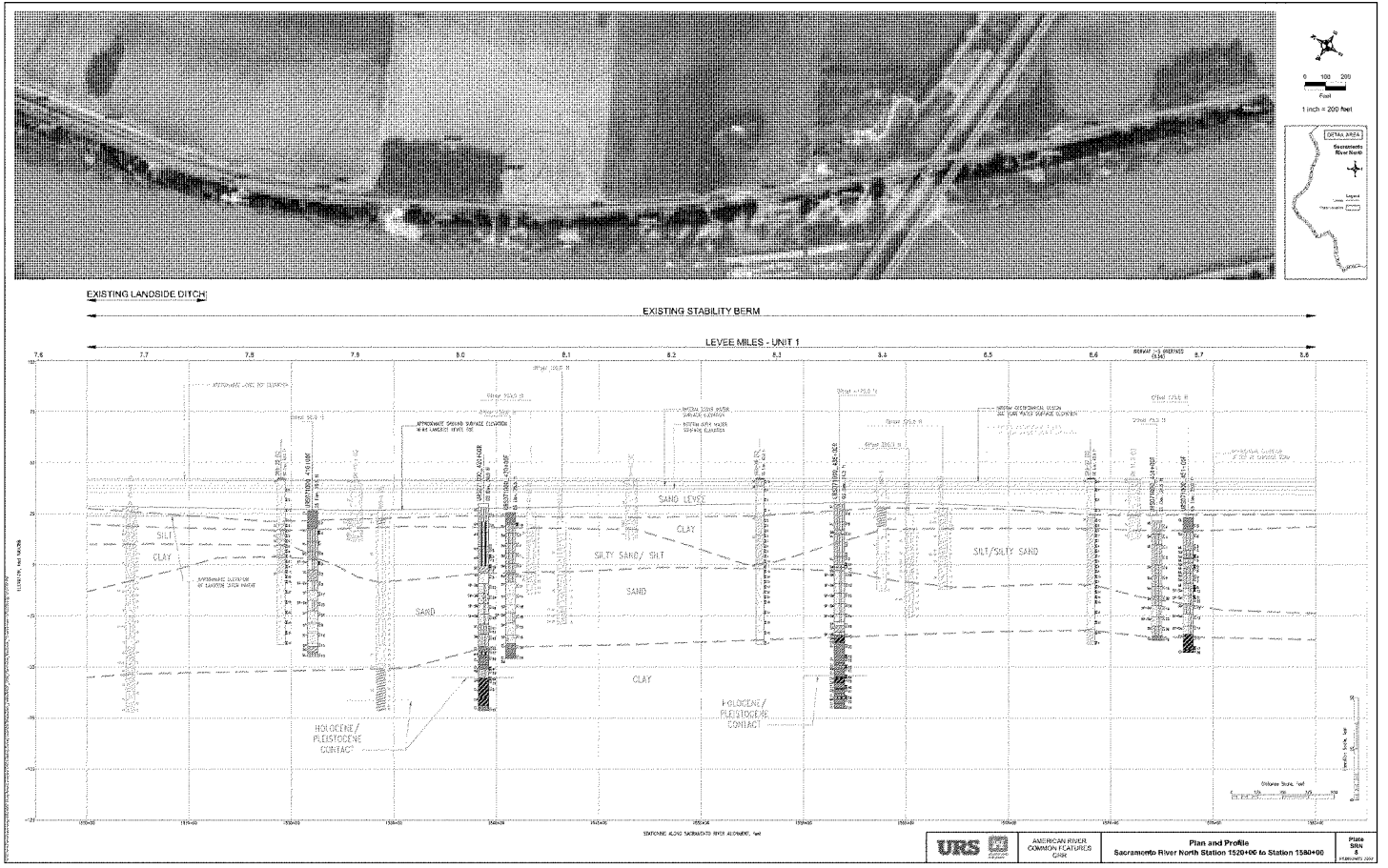
LEVEE MILES - UNIT 1

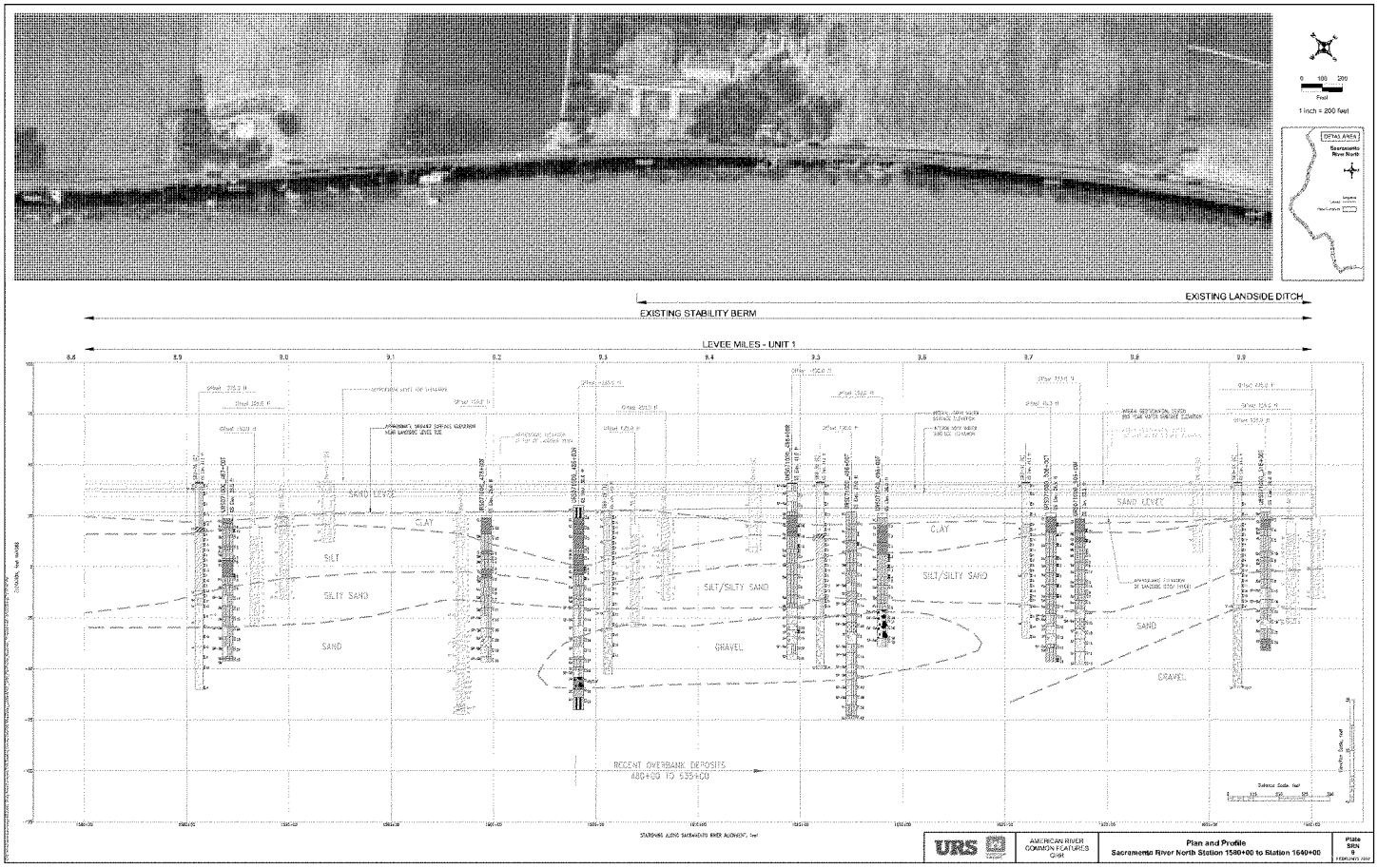


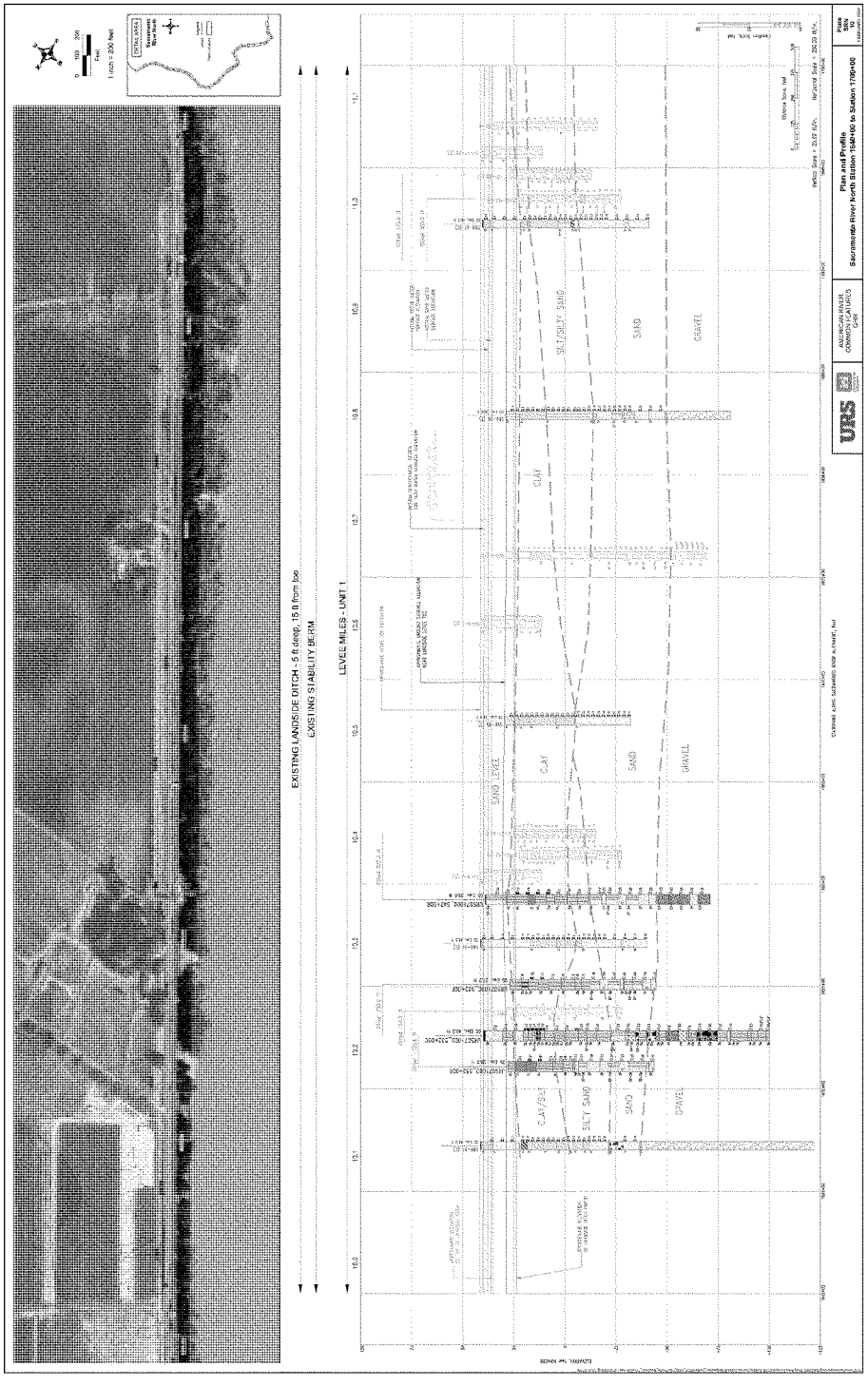
URS	AMERICAN RIVER COMMON FEATURES GRR	Plan and Profile Sacramento River North Station 1340+00 to Station 1400+00	Plate SRN 5 11 SEPTEMBER 2009

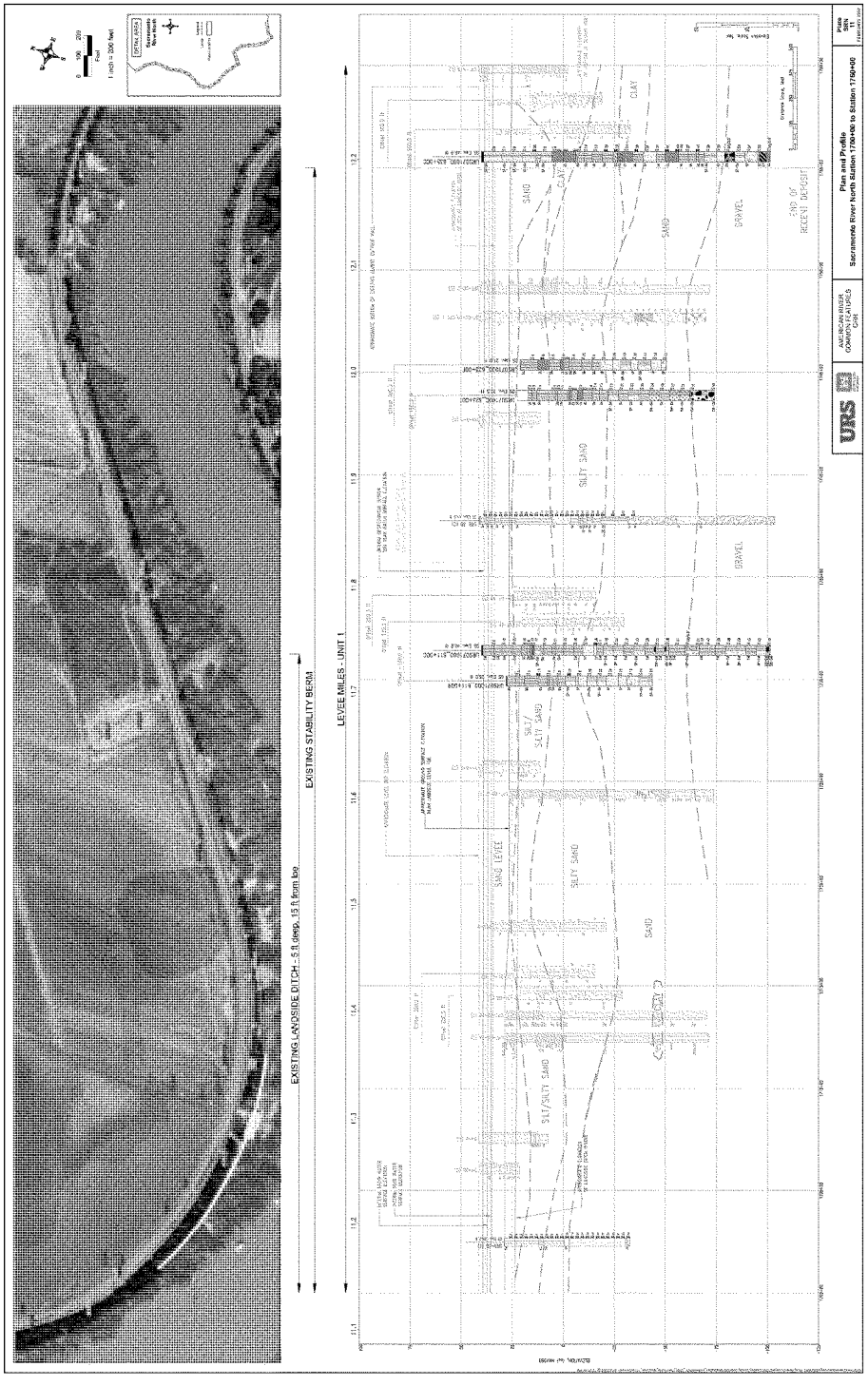

EXISTING LANDSIDE DITCH - 5 to 6 ft Deep, 45 to 20 ft from toe
EXISTING STABILITY BERM
EXISTING LANDSIDE DITCH - 5 ft Deep, 6 ft from toe
LEVEE MILES - UNIT 1
SAND LEVEE
CLAY
SILTY SAND
SILT
GRAVEL
CLAY/SILT
SAND
URS
AMERICAN RIVER COMMON FEATURES
Plan and Profile
Sacramento River North Station 1460+00 to Station 1460+00

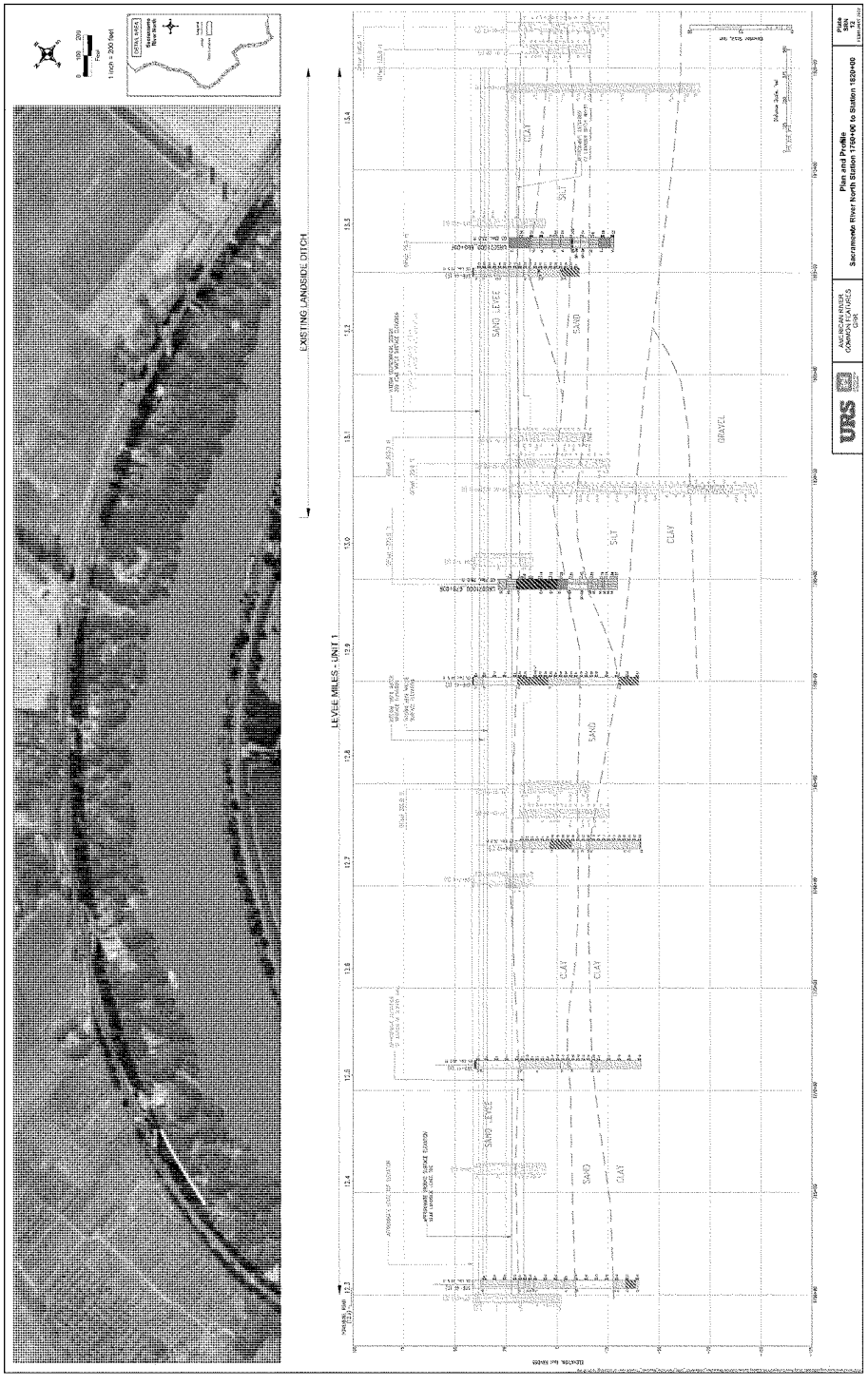

EXISTING LANDSIDE DITCH - 5 ft Deep, 6 ft from toe
EXISTING STABILITY BERM
EXISTING LANDSIDE DITCH - 4 ft Deep, 15 ft from toe (Concrete Lined)
LEVEE MILES - UNIT 1
1 inch = 200 feet
Sacramento River
Plan and Profile
Sacramento River North Station 1460+00 to Station 1520+00
AMERICAN RIVER COMMON FEATURES
URS

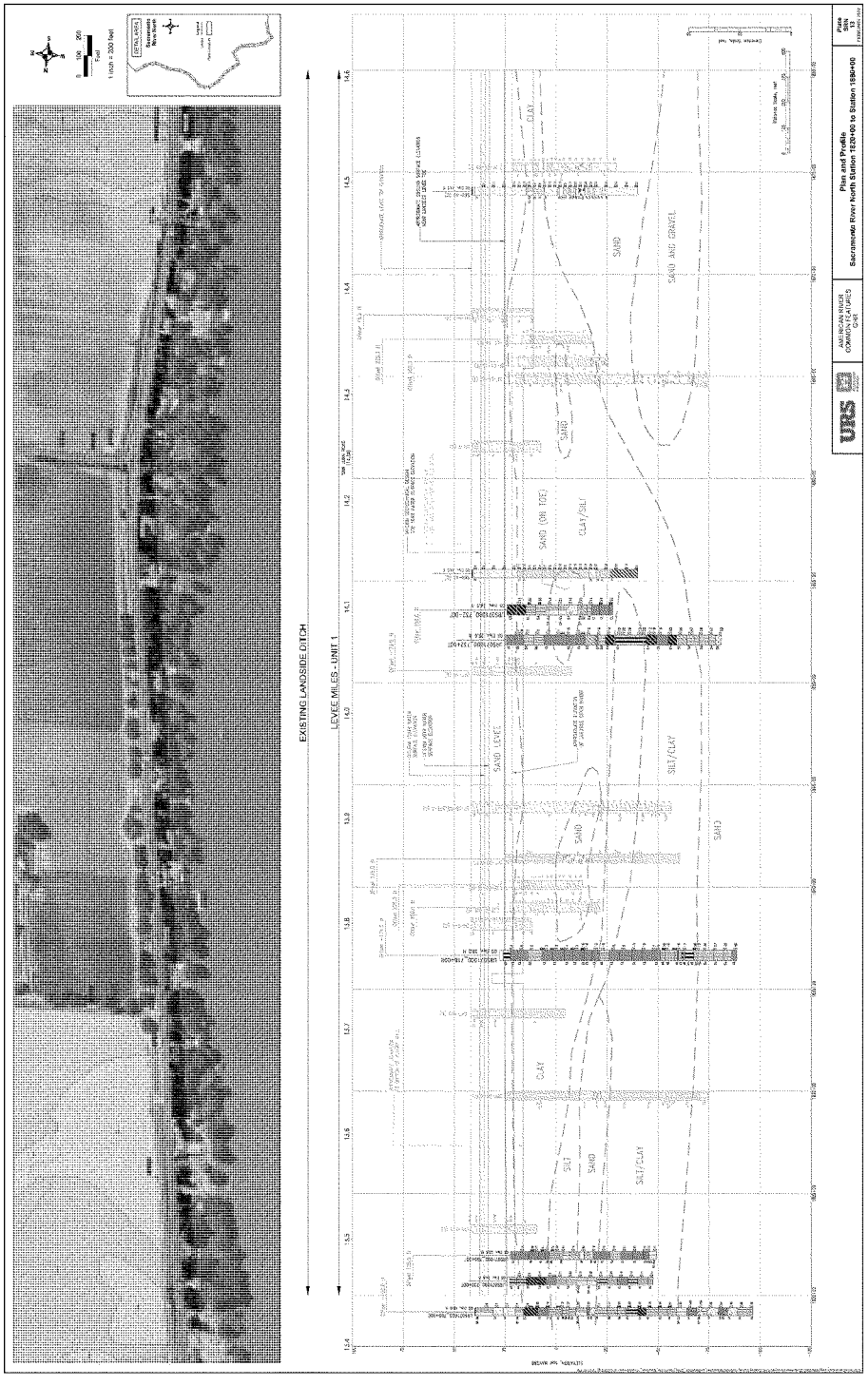

EXISTING LANDSIDE DITCH
EXISTING STABILITY BERM
LEVEE MILES - UNIT 1
SAND LEVEE
CLAY
SILTY SAND/ SILT
SAND
SILT/SILTY SAND
HOLOCENE/
PLEISTOCENE
CONTACT
1 inch = 200 feet
DETAIL AREA
Sacramento
River North

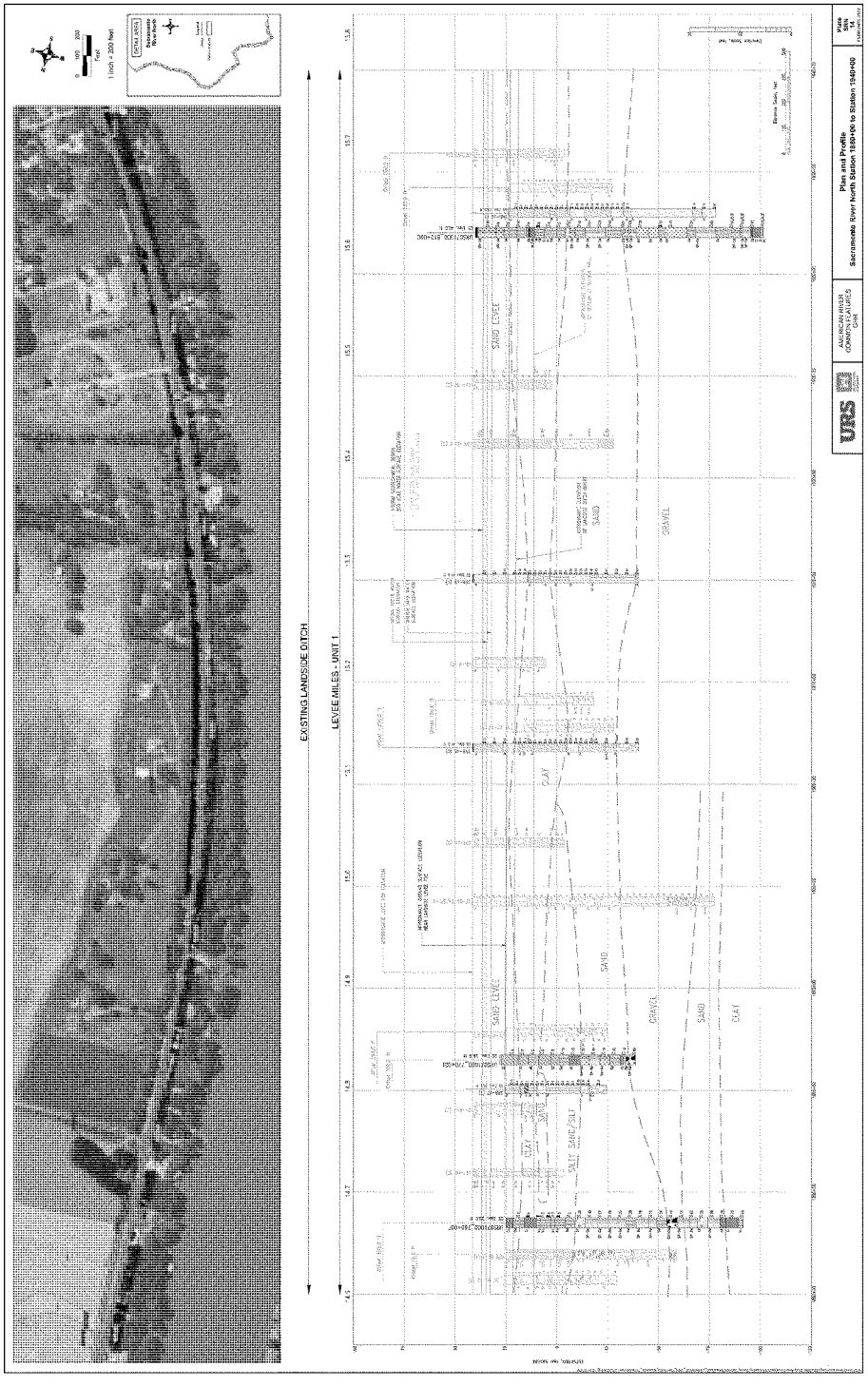

EXISTING LANDSIDE DITCH
EXISTING STABILITY BERM
LEVEE MILES - UNIT 1
SAND LEVEE
CLAY
SILT
SILTY SAND
SAND
SILT/SILTY SAND
GRAVEL
RECENT OVERBANK DEPOSITS
480+00 TO 535+00
1 inch = 200 feet
DETAIL AREA
Sacramento River North
AMERICAN RIVER COMMON FEATURES GRR
Plan and Profile
Sacramento River North Station 1580+00 to Station 1640+00

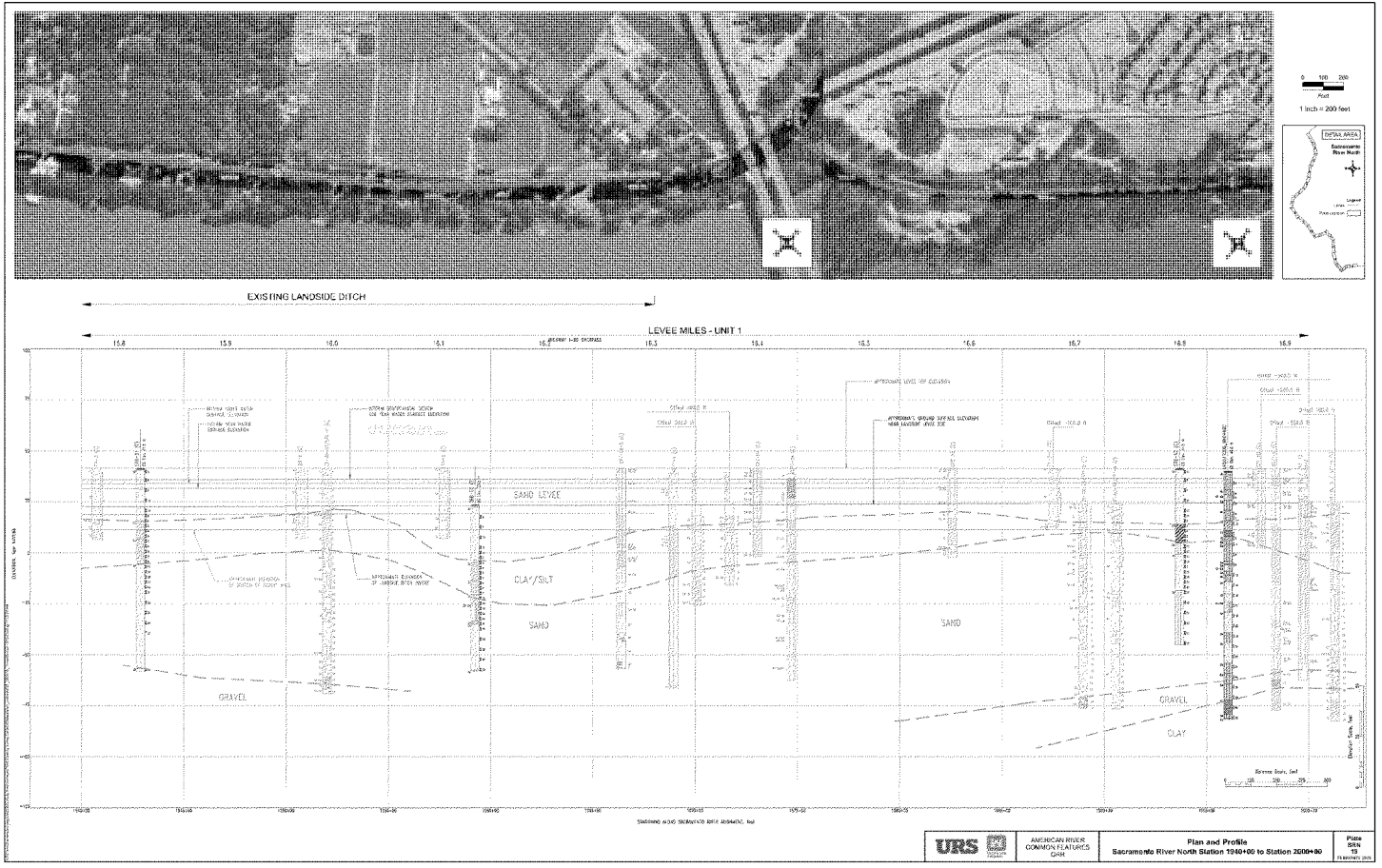

EXISTING LANDSIDE DITCH - 5 ft deep, 15 ft from toe
EXISTING STABILITY BERM
LEVEE MILES - UNIT 1
SAND LEVEE
CLAY
SAND
GRAVEL
SILTY SAND
CLAY/SILT
SILTY SAND
SAND
GRAVEL
SILT/SILTY SAND
CLAY
SAND
GRAVEL
URS
AMERICAN RIVER COMMON FEATURES
Plan and Profile
Sacramento River North Station 1540+00 to Station 1700+00

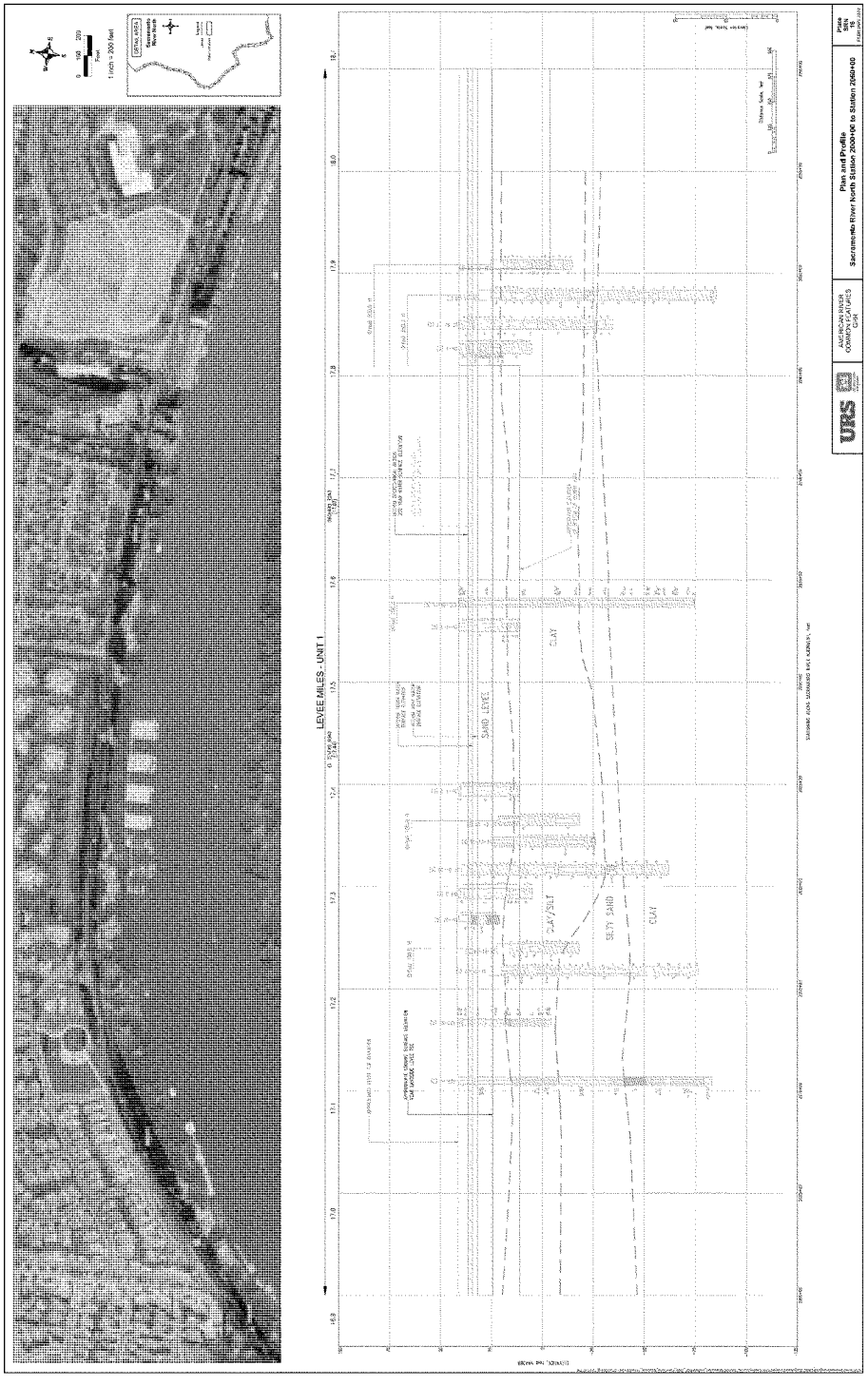

EXISTING LANDSIDE DITCH - 5 ft deep, 15 ft from toe
EXISTING STABILITY BERM
LEVEE MILES - UNIT 1
SAND
CLAY
SILTY SAND
GRAVEL
SAND OF RECENT DEPOSIT
SILT/SILTY SAND
SAND LEVEE
URS
AMERICAN RIVER COMMON FEATURES GRR
Plan and Profile
Sacramento River North Station 1750+00 to Station 1760+00
Plate No. 11

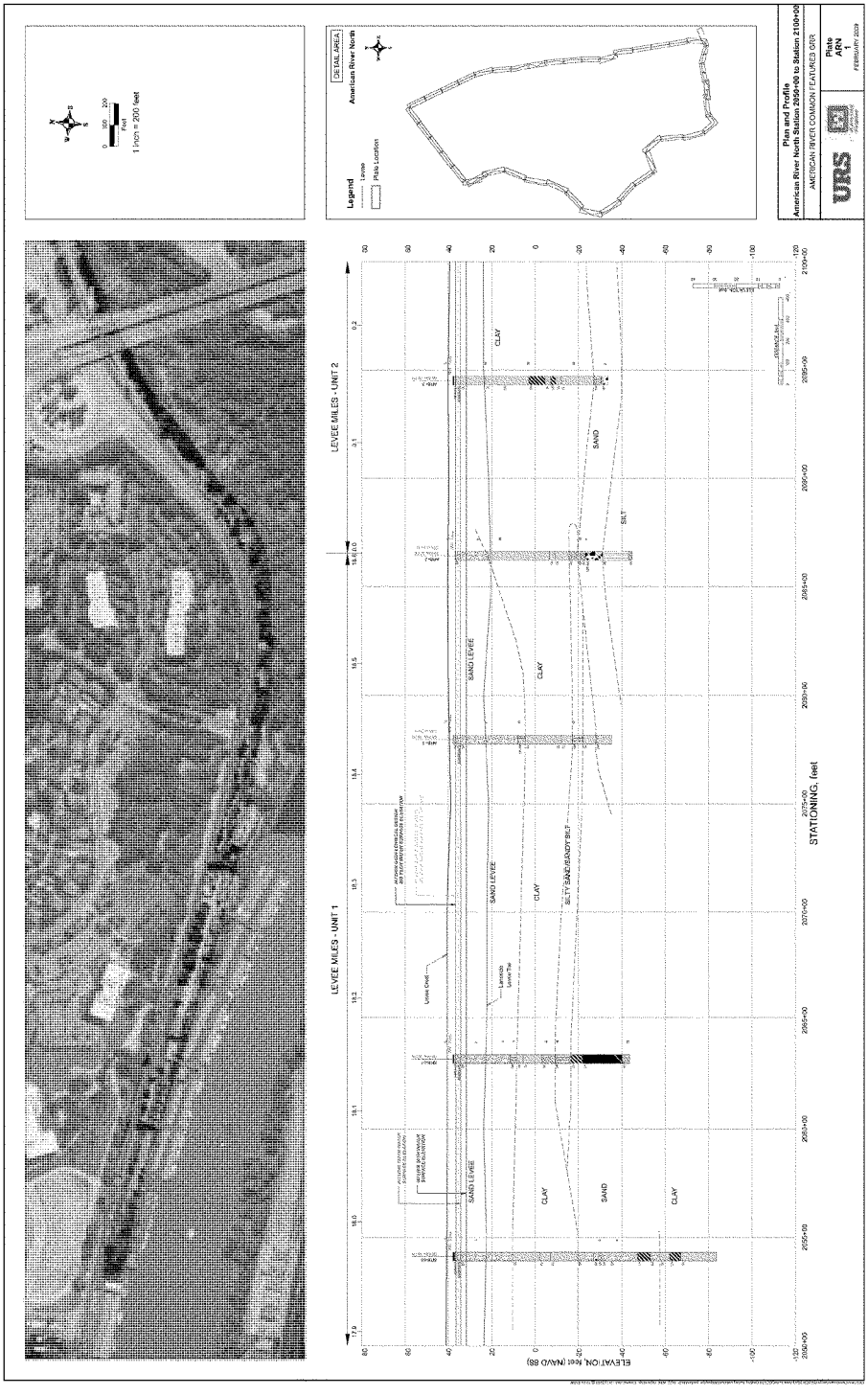

EXISTING LANDSIDE DITCH
LEVEE MILES - UNIT 1
SAND LEVEE
CLAY
SAND
SILT
GRAVEL
URS
AMERICAN RIVER COMMON FEATURES 2010
Plan and Profile
Sacramento River North Station 1760+00 to Station 1820+00
Plate No. 12

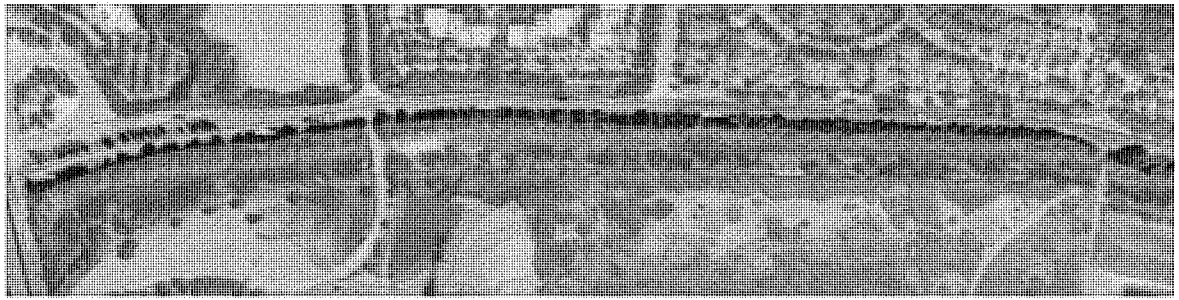

EXISTING LANDSIDE DITCH
LEVEE MILES - UNIT 1
SAND LEVEE
CLAY
SILT
SAND
SALT/CLAY
SILT/CLAY
SAND (OR TOE)
CLAY/SILT
SAND AND GRAVEL
URS
AMERICAN RIVER COMMON FEATURES
Plan and Profile
Sacramento River North Station 1630+00 to Station 1680+00
Plate No. 13

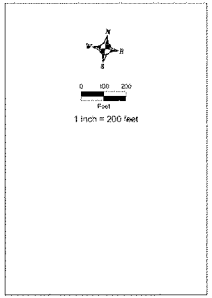

EXISTING LANDSIDE DITCH
LEVEE MILES - UNIT 1
SAND LEVEE
CLAY
SAND
GRAVEL
SILT / SAND / SILT
SAND
CLAY
GRAVEL
SAND
CLAY
SILT / SAND / SILT
SAND
GRAVEL
URS
AMERICAN RIVER
COMMON FEATURES
2008
Plan and Profile
Sacramento River North Station 1840+00 to Station 1940+00
Plate
No.
14

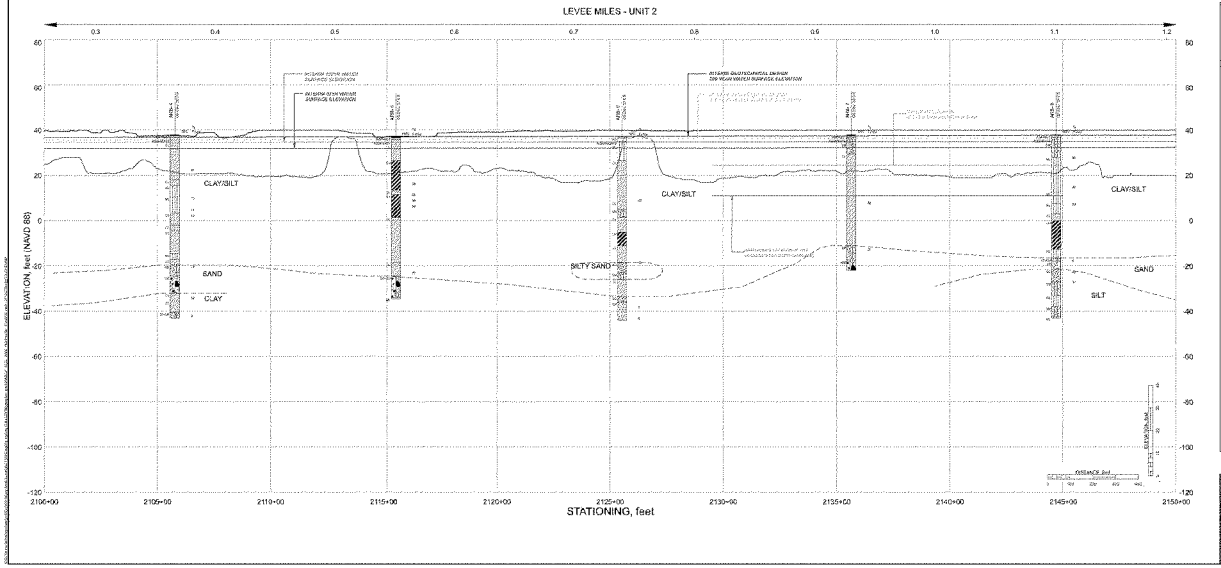

EXISTING LANDSIDE DITCH
LEVEE MILES - UNIT 1
SAND LEVEE
CLAY/SILT
SAND
GRAVEL
SAND
GRAVEL
CLAY
1 inch = 200 feet
INITIAL AREA
Sacramento River North
URS
AMERICAN RIVER COMMON FEATURES GRR
Plan and Profile
Sacramento River North Station 1940+00 to Station 2000+00

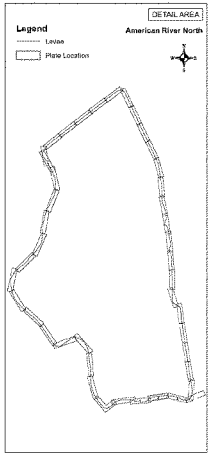

LEVEE MILES - UNIT 1
SAND LEVEE
CLAY
CLAY/SILT
SILTY SAND
CLAY
Plan and Profile
Sacramento River North Station 2660+00 to Station 2660+00
AMERICAN RIVER
CORRIDOR FEATURES
CSAC


1 inch = 200 feet
Legend
Levee
Plate Location
DETAIL AREA
American River North
Plan and Profile
American River North, Station 2050+00 to Station 2100+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
ARN
1
FEBRUARY 2009
LEVEE MILES - UNIT 1
LEVEE MILES - UNIT 2
ELEVATION, feet (NAVD 88)
STATIONING, feet
SAND LEVEE
CLAY
SAND
SILTY SAND/SANDY SILT
SILT





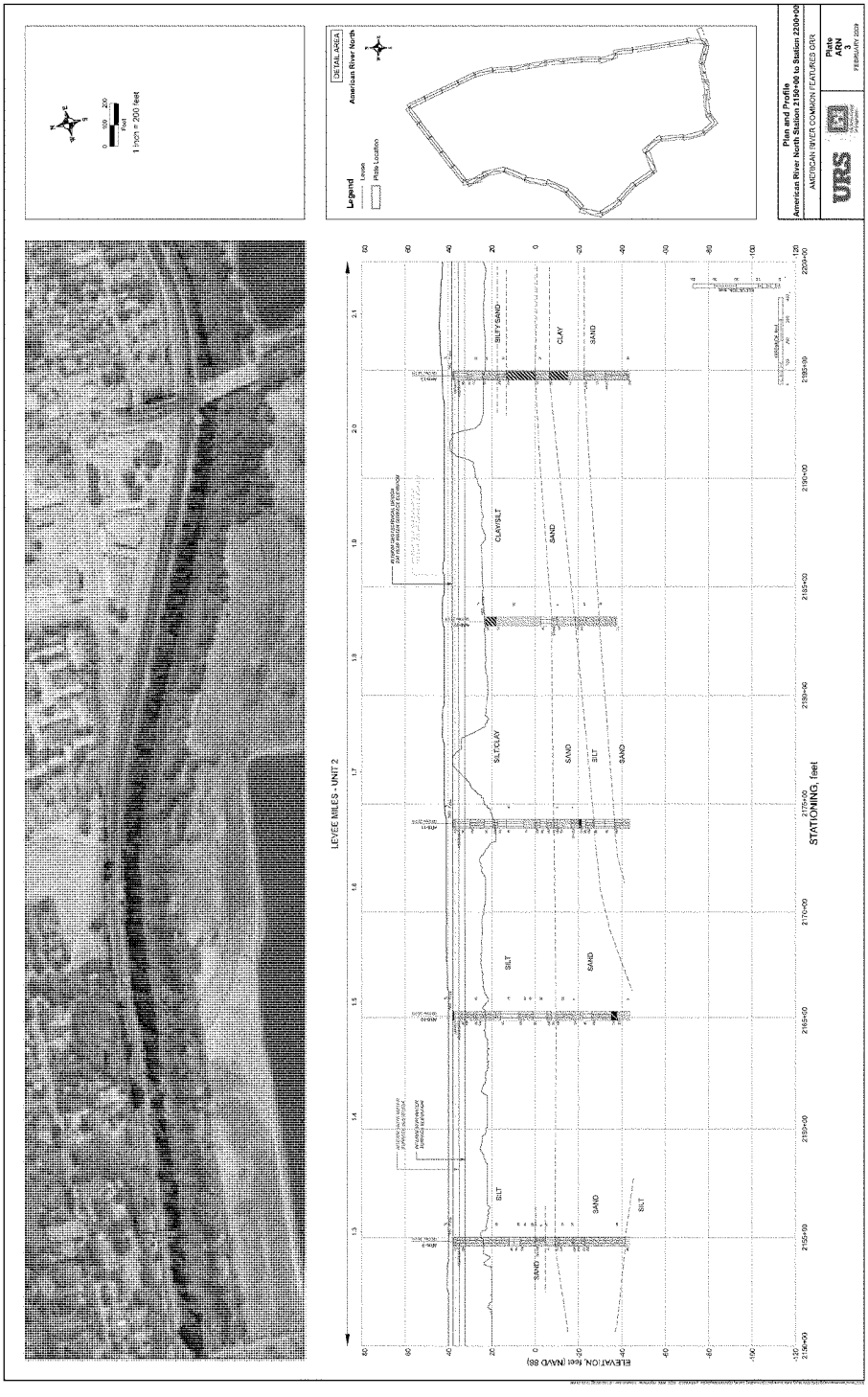


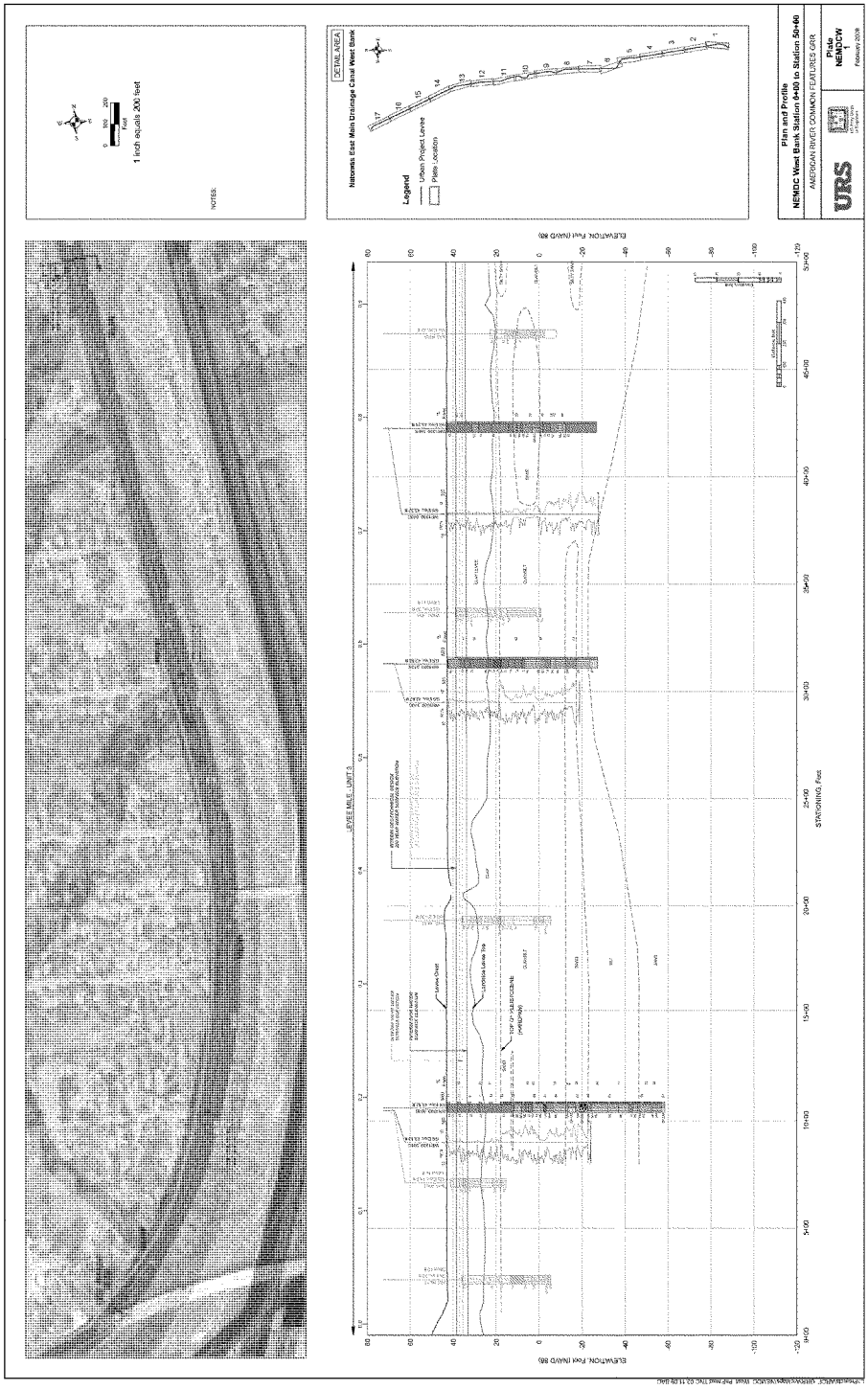


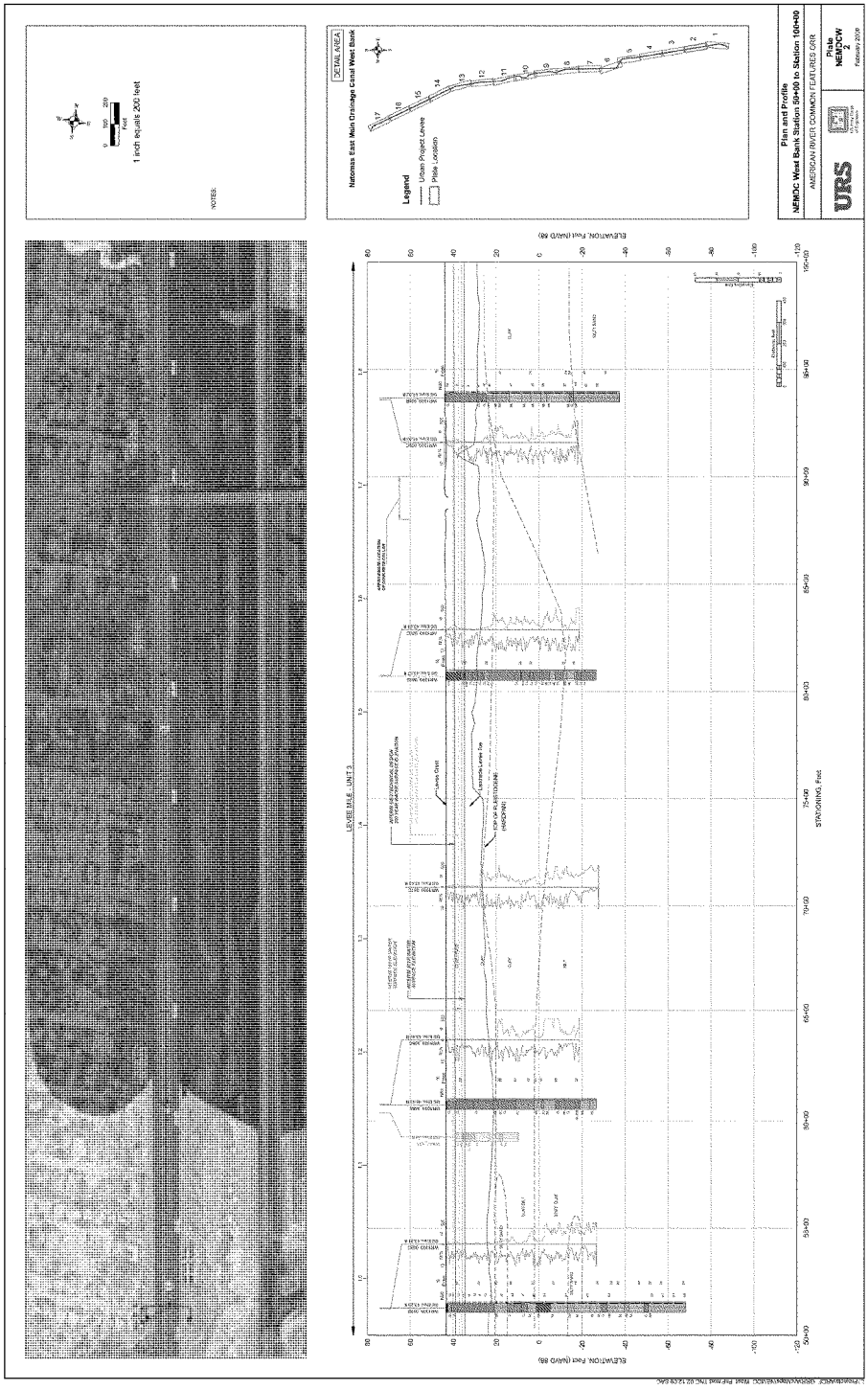
Plan and Profile
American River North Station 2100+00 to Station 2150+00
AMERICAN RIVER COMMON FEATURES GRR

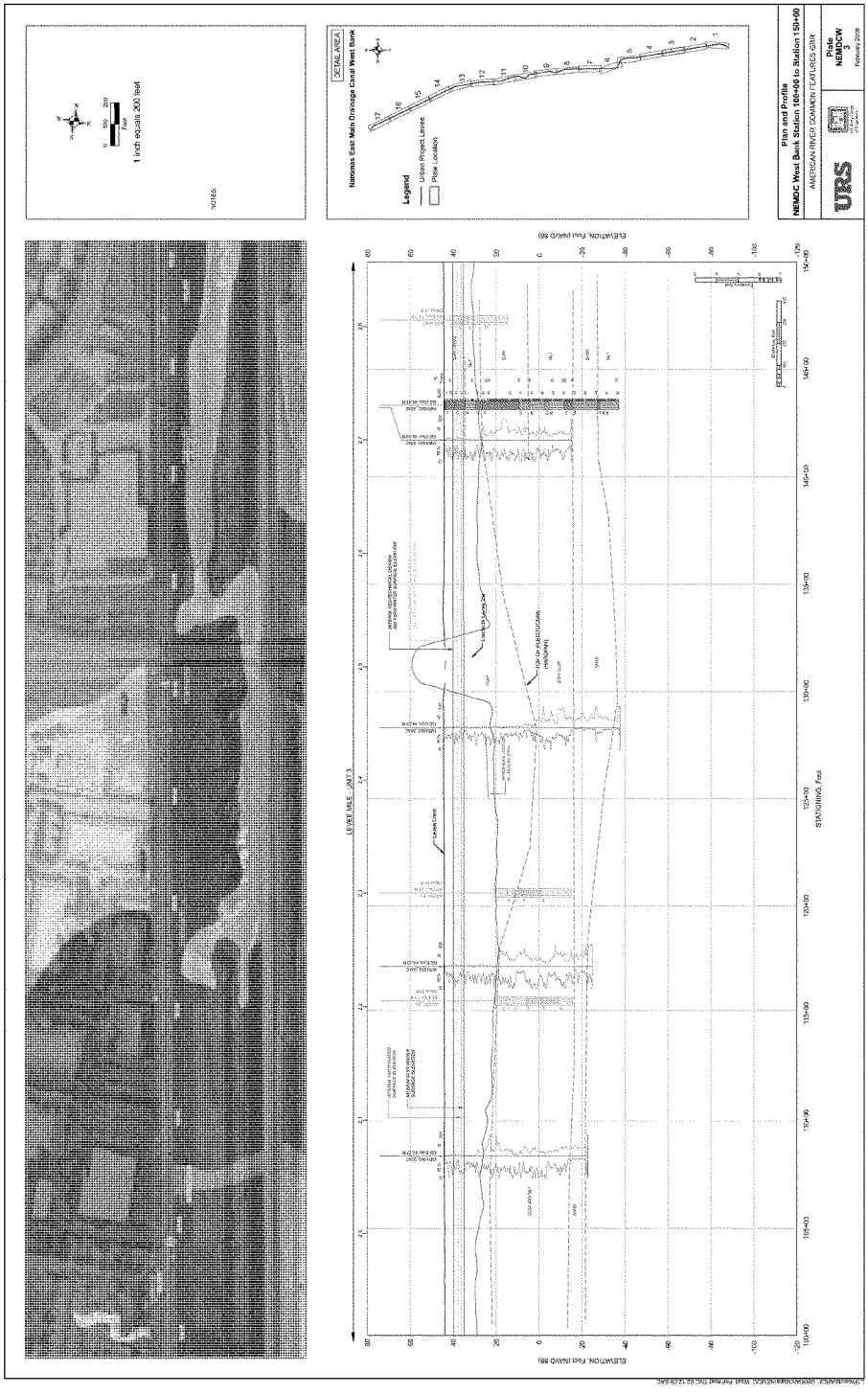
URS

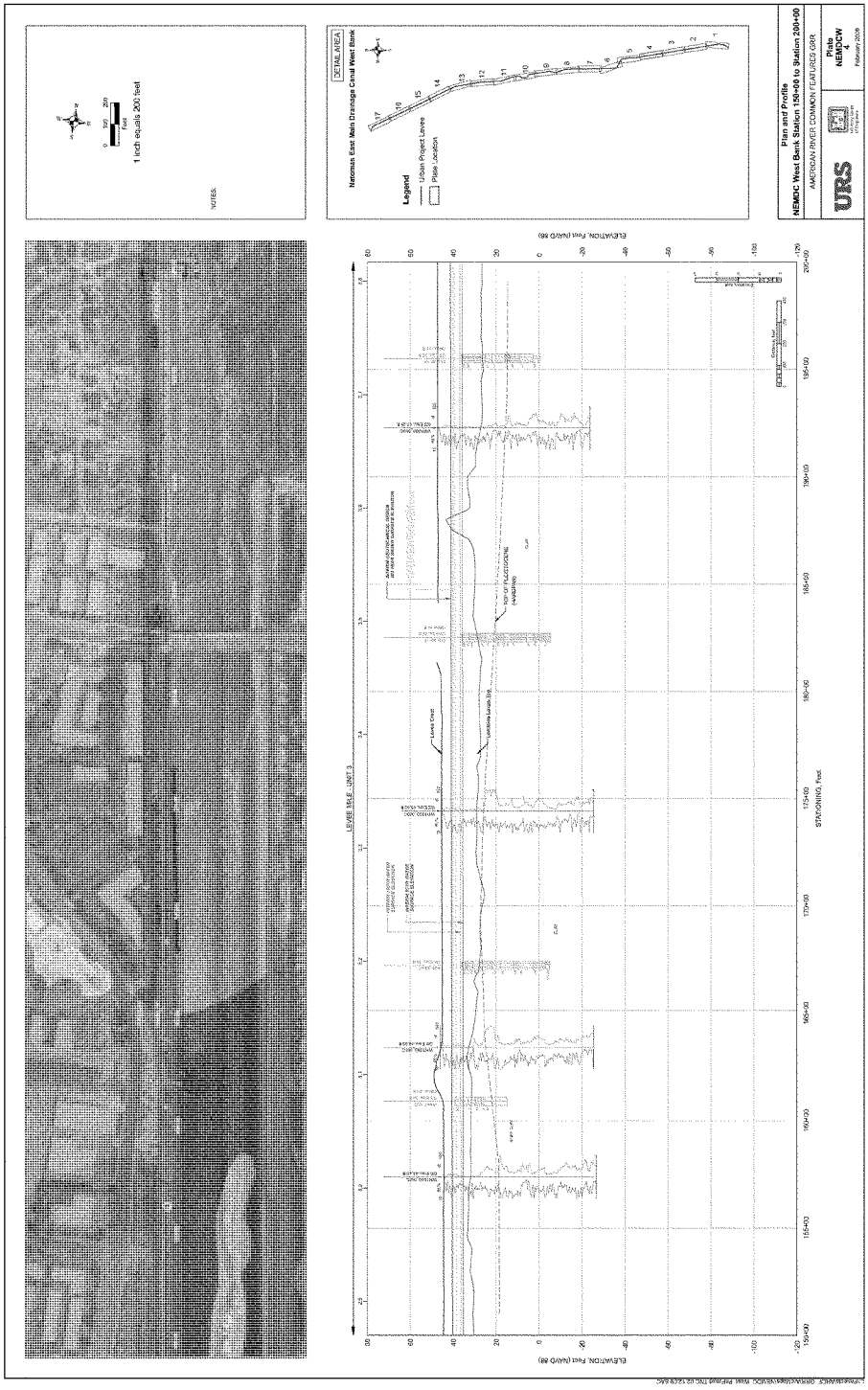
Plate
ARN
2
FEBRUARY 2009

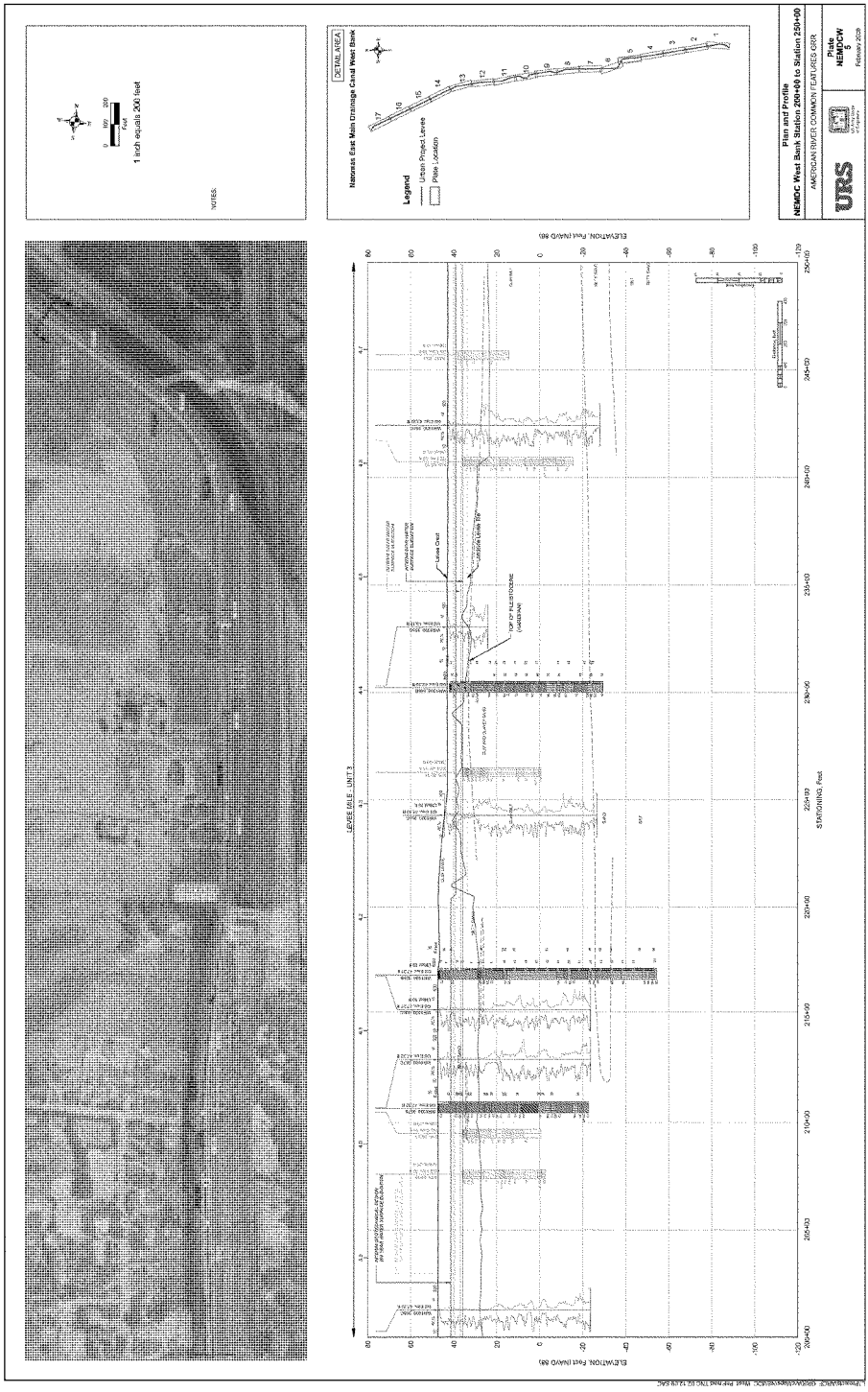

1 inch = 200 feet
DETAIL AREA
American River North
Legend
Levee
Plate Location
Plan and Profile
American River North, Station 215+00 to Station 220+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
ARN
1
FEBRUARY 2009
LEVEE MILES - UNIT 2
STATIONING, feet
ELEVATION, feet (NAVD 88)
SILTY SAND
CLAY
SAND
CLAY/SILT
SAND
SILT/CLAY
SAND
SILT
SAND
SILT
SAND
SILT
SAND
SILT


1 inch equals 200 Feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plate 3Location
Plan and Profile
NEMDC West Bank Station 4+00 to Station 50+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NEMDC-W
February 2008
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)

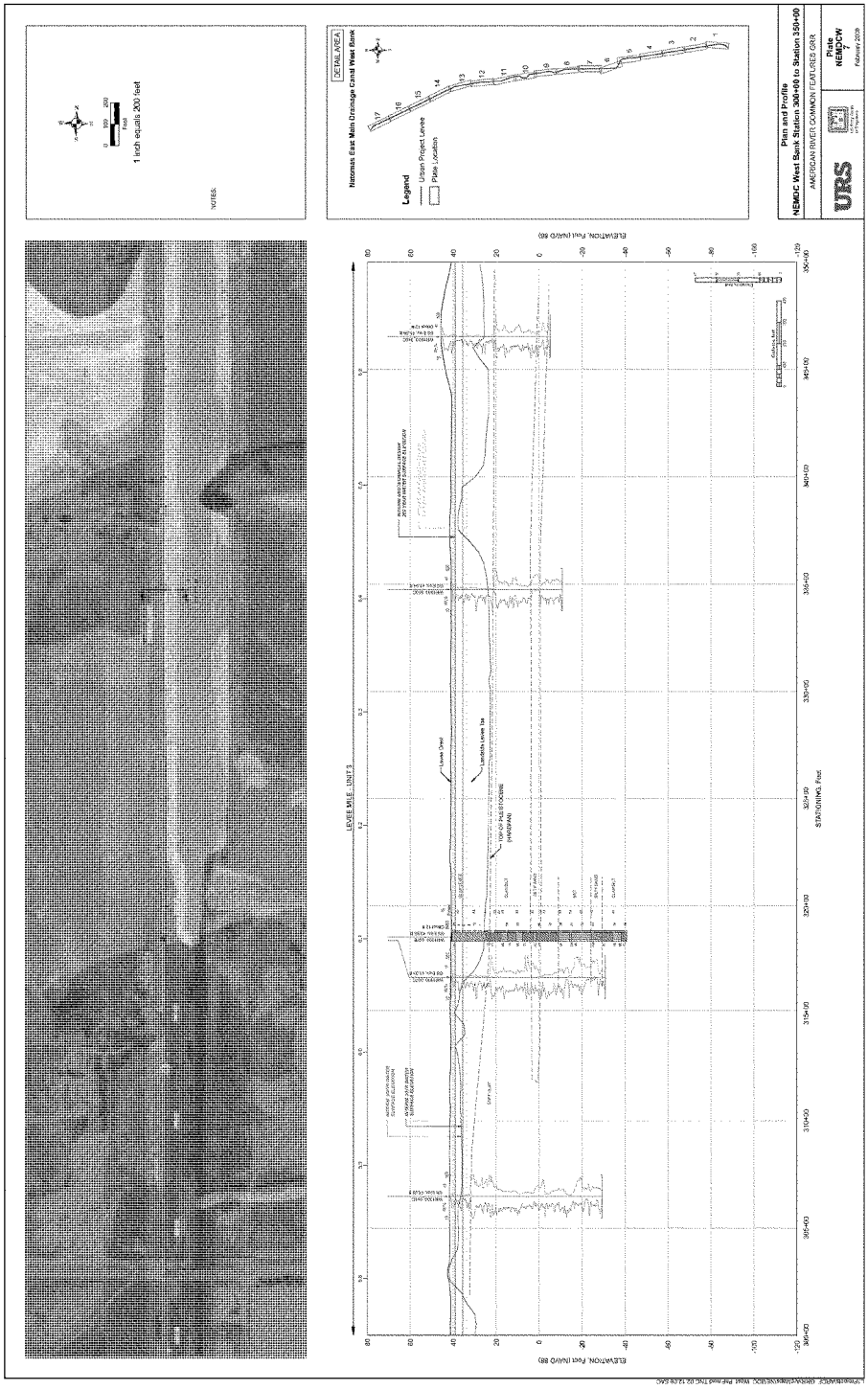

1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plate Location
Plan and Profile
NEMDC West Bank Station 39+00 to Station 100+00
AMERICAN RIVER COMMON FEATURES GRR
Plate
NEMDC W
7
February 2008
URS
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)


1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Pilot Location
Plan and Profile
NEMDC West Bank, Station 160+00 to Station 150+00
AMERICAN RIVER COMMON FEATURES GRR
Plate
NEMDCW
1
February 2009
URS
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)
Levee Crest
Waterside Berm
TOP OF PUNSTOCARB
(WASHING)
Landside Berm
Landside Ditch


1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plate Location
Plan and Profile
NEMDC West Bank Station 150+00 to Station 200+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NEMDCW
February 2009
LEVEE MILE - UNIT 3
ELEVATION, Feet (NAVD 88)
STATIONING, Feet


1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Place Johnson
Plan and Profile
NEMDC West Bank Station 209+00 to Station 259+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NEMDCW
February 2009
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)
Levee Crest
TOP OF PILE/STOONE
(ASSESSED)

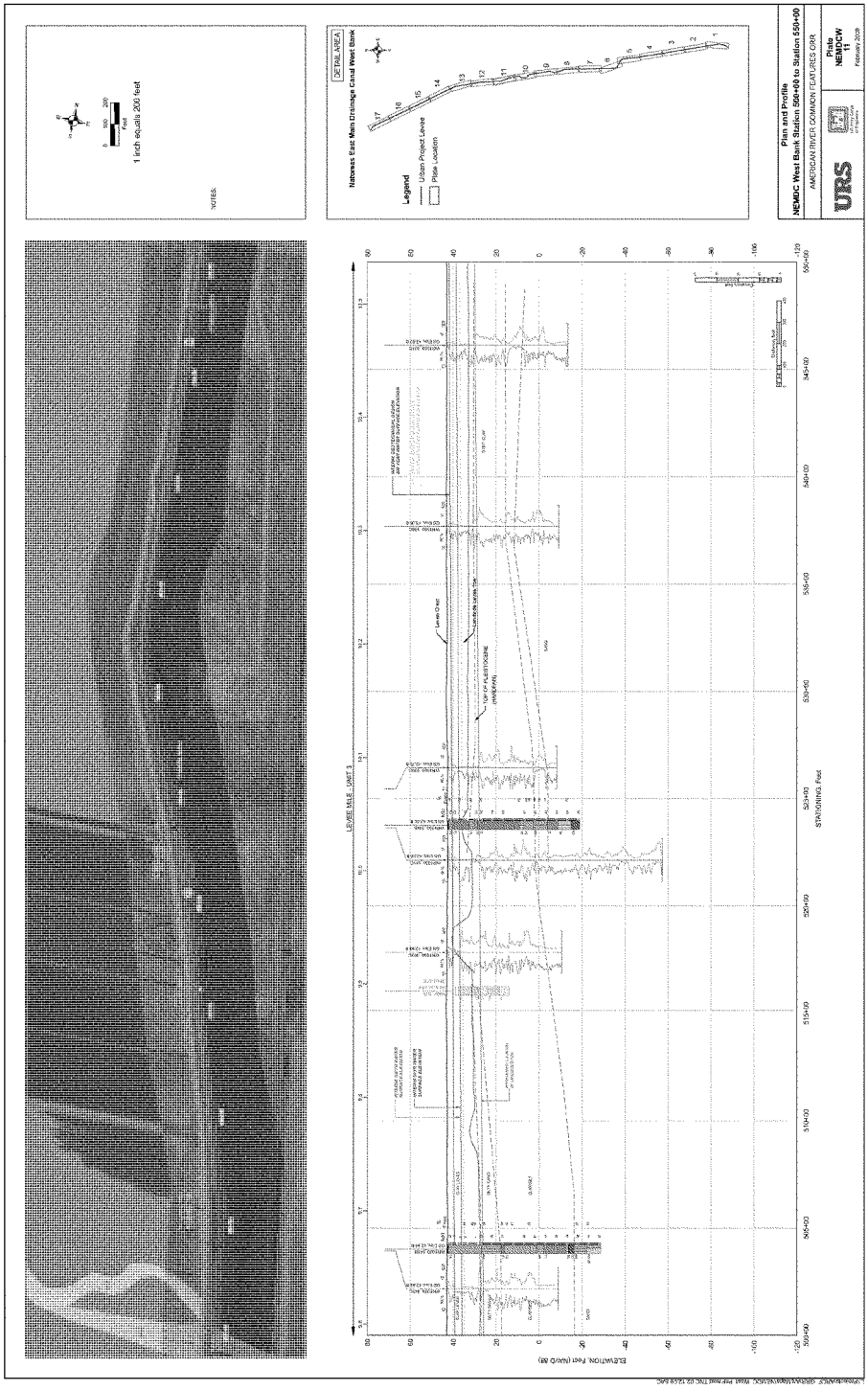
1 inch equals 200 feet
NOTES:
CENTRAL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plan Location
Plan and Profile
NEMDC West Bank Station 250+00 to Station 300+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NEMDC W
February 2009
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)

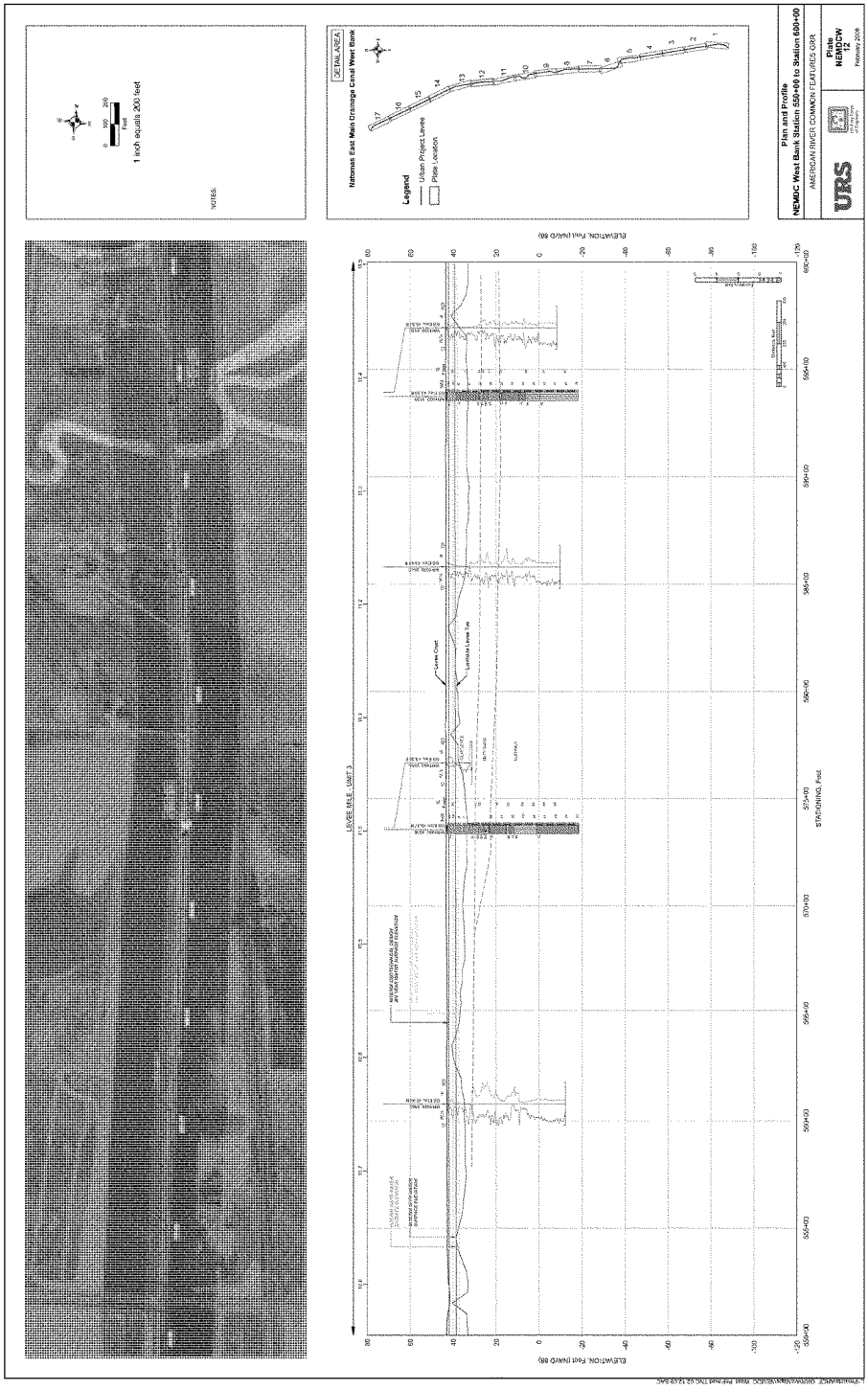

1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plate Location
Plan and Profile
NEMDC West Bank Station 308+00 to Station 359+00
AMERICAN RIVER COMMON FEATURES GRR
Plate
NEMDC-W
February 2009
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)

1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plate Location
Plan and Profile
NEMDC West Bank Station 350+00 to Station 400+00
AMERICAN RIVER COMMON FEATURES GRR
Plate
NEMDC-W
URS
February 2008
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)
Levee Crest
Landside Levee Toe
TOP OF FLOODZONE
(+160.0 ft)

1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Pilot Junction
Plan and Profile
NEMDC West Bank Station 406+00 to Station 459+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
KEMDCW
1
February 2009
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)

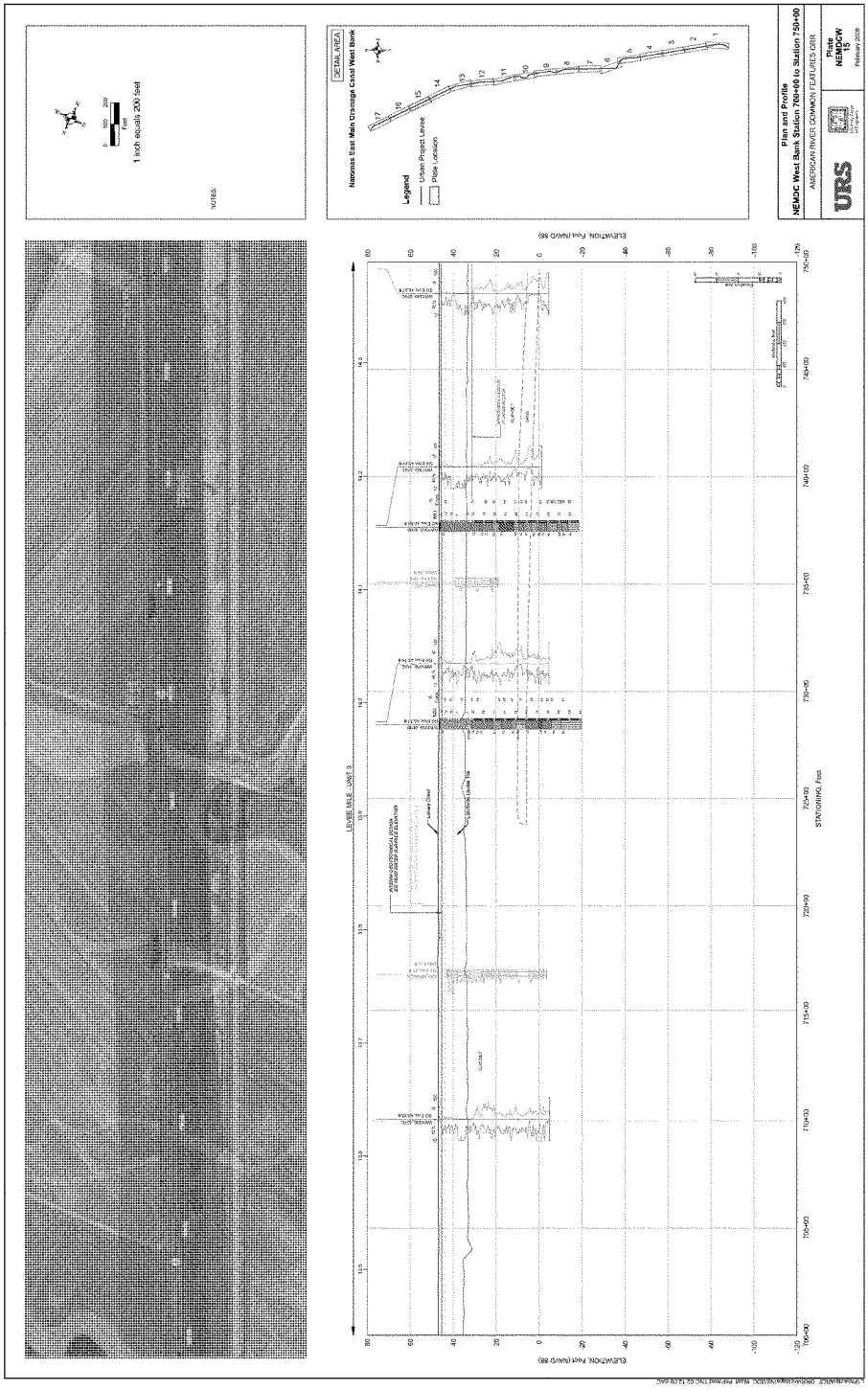
1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Place Location
Plan and Profile
NEMDC West Bank Station 450+00 to Station 500+00
AMERICAN RIVER COMMON FEATURES GRR
Plate
NEMDCW
10
February 2008
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)


1 inch equals 200 feet
NOTES:
DETAIL AREA
Natowas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plan and Profile
NEMDC West Bank Station 550+00 to Station 559+00
AMERICAN RIVER COMMON FEATURES GRR
Plate
NEMDC W
February 2009
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)

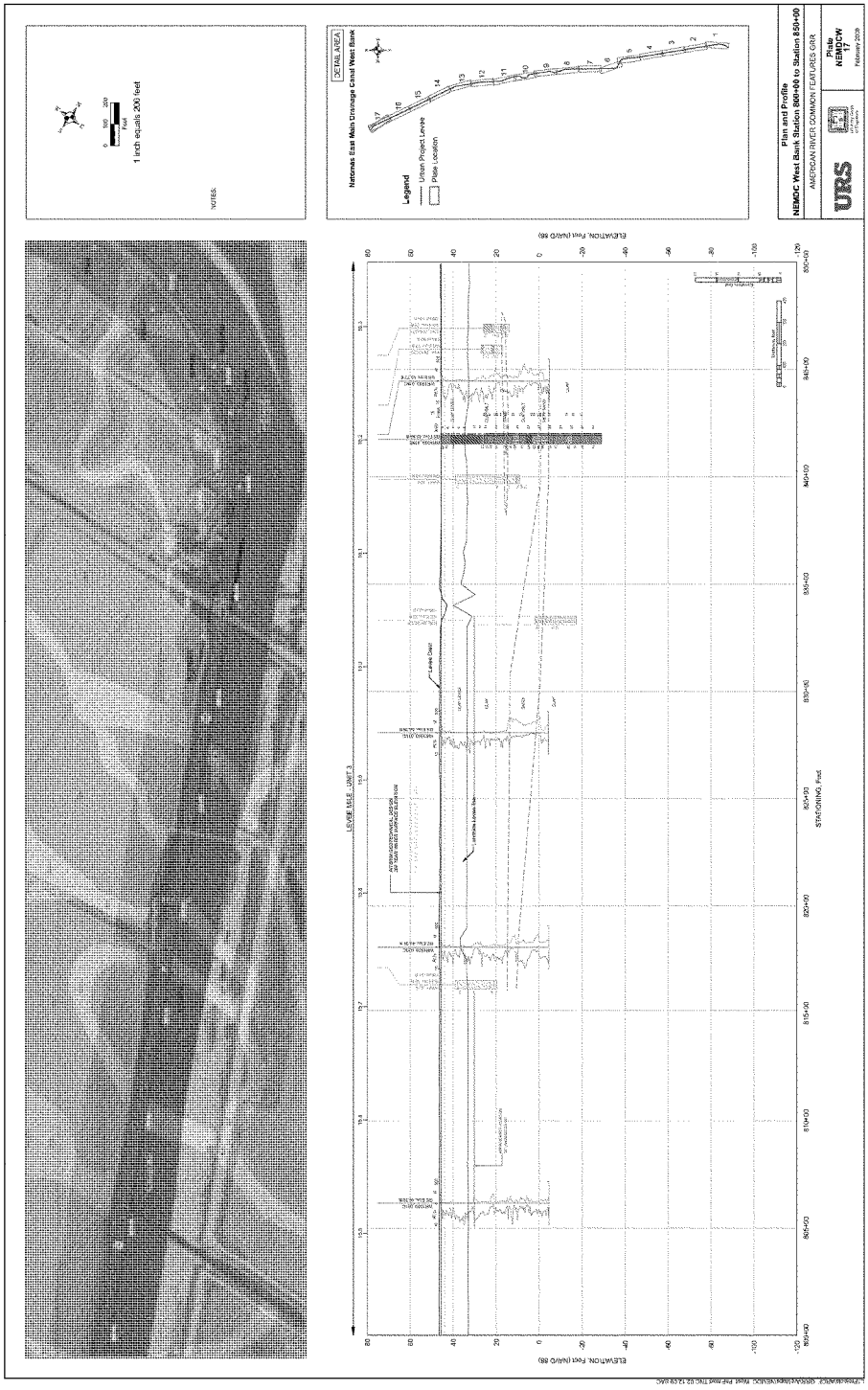

1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Place Location
Plan and Profile
NEMDC West Bank Station 550+00 to Station 600+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NEMDW
12
February 2008
LEVEE MILE - UNIT 3
ELEVATION, Feet (NAVD 88)
STATIONING, Feet

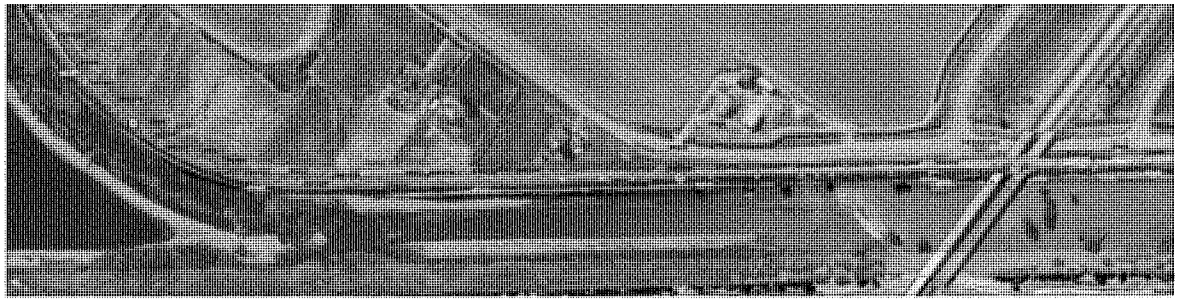
1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plan Location
Plan and Profile
NEMDC West Bank Station 580+00 to Station 659+00
AMERICAN RIVER COMMON FEATURES GRR
Plate
NEMDCW
13
February 2009
URS
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)

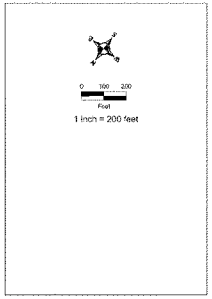
1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plate Location
Plan and Profile
NEMDC West Bank Station 650+00 to Station 700+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NEMDC W
12
February 2009
ELEVATION, Feet (NAVD 88)
LEVEE MILE - UNIT 3
STATIONING, Feet

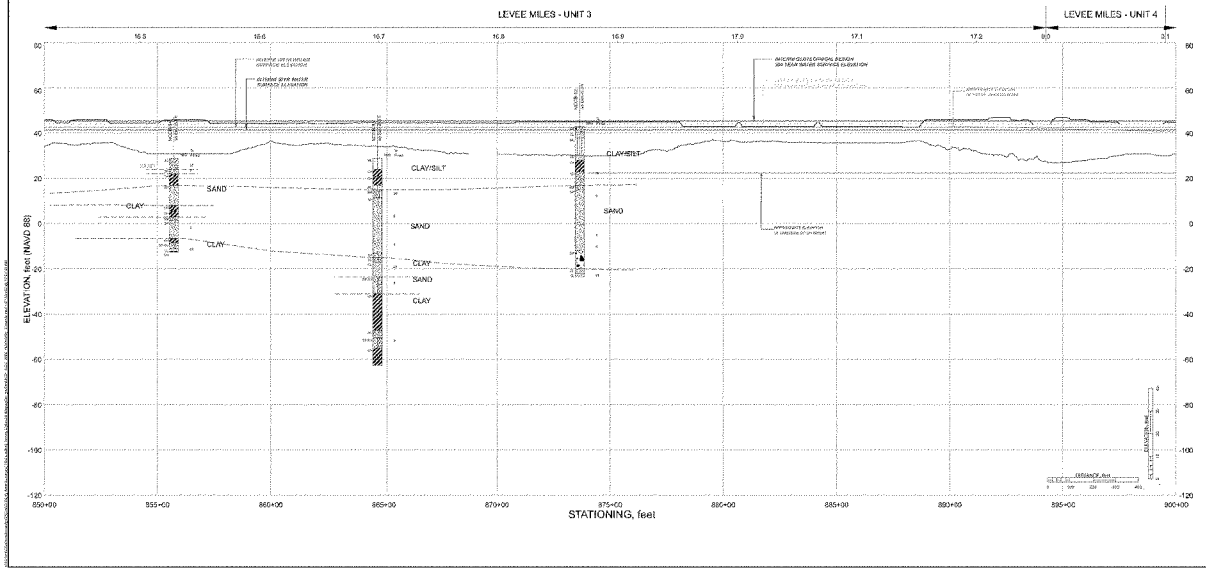

1 inch equals 200 feet
NOTES:
DETAIL AREA
Natoma East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plan Location
Plan and Profile
NEMDC West Bank Station 750+00 to Station 750+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NEMDCW
February 2008
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)

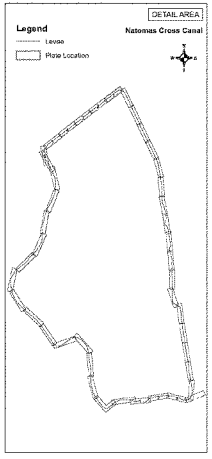
1 inch equals 200 feet
NOTES:
DETAIL AREA
Natowes East Main Drainage Canal West Bank
Legend
Urban Project Levee
Plate Location
Plan and Profile
NEMDC West Bank Station 750+00 to Station 800+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NEMDCW
16
February 2009
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)


1 inch equals 200 feet
NOTES:
DETAIL AREA
Natomas East Main Drainage Canal West Bank
Legend
Urban Project Levee
Place Location
Plan and Profile
NEMDC West Bank Station 804+00 to Station 859+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NEMDC-W
February 2009
LEVEE MILE - UNIT 3
STATIONING, Feet
ELEVATION, Feet (NAVD 88)







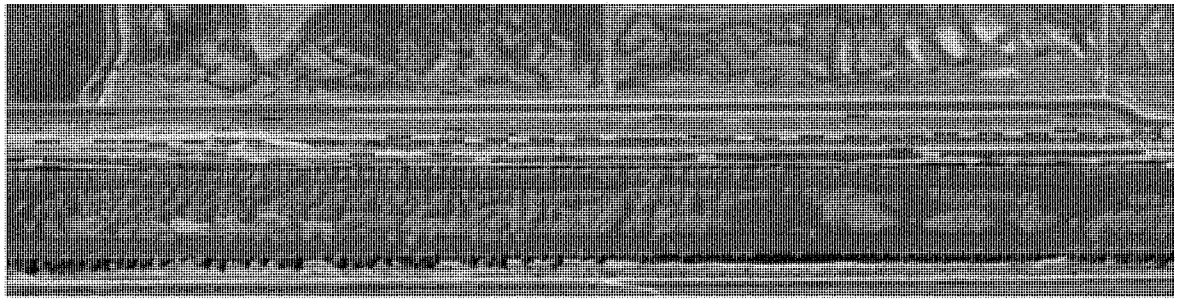


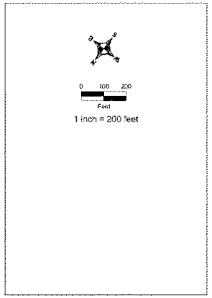
Plan and Profile
Natomas Cross Canal Station 850+00 to Station 900+00
AMERICAN RIVER COMMON FEATURES GRR

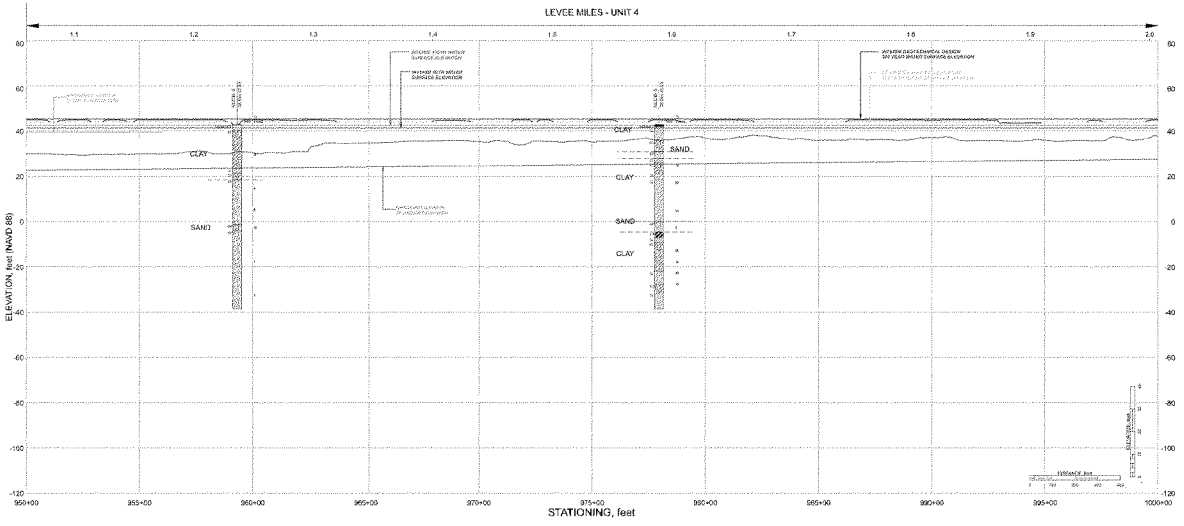
URS

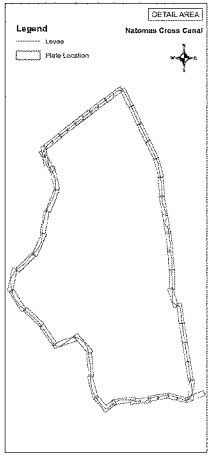
Plate
NCC
1
FEBRUARY 2009

0
100
200
Feet
1 inch = 200 feet
DETAIL AREA
Natomas Cross Canal
Legend
Levee
Plate Location
Plan and Profile
Natomas Cross Canal Station 950+00 to Station 300+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NCC
2
FEBRUARY 2009
LEVEE MILES - UNIT 4
ELEVATION, feet (NAVD 88)
STATIONING, feet
CLAY
SILT
SAND
SILTY CLAY
SANDY SILTY SAND
CLAYEY SILT





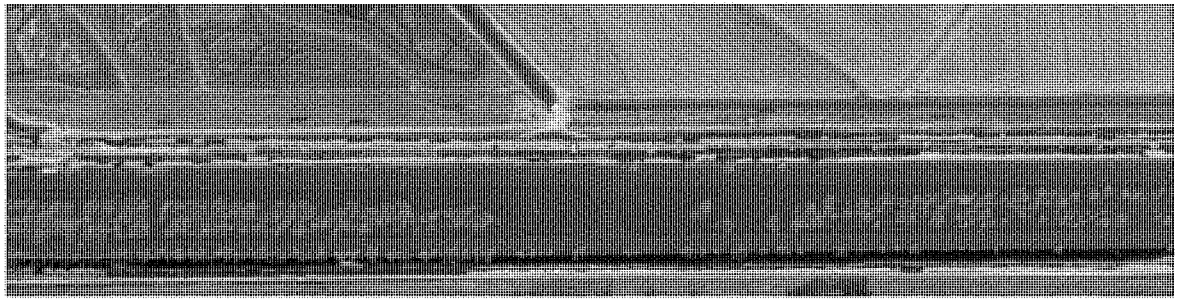


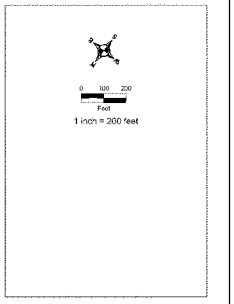


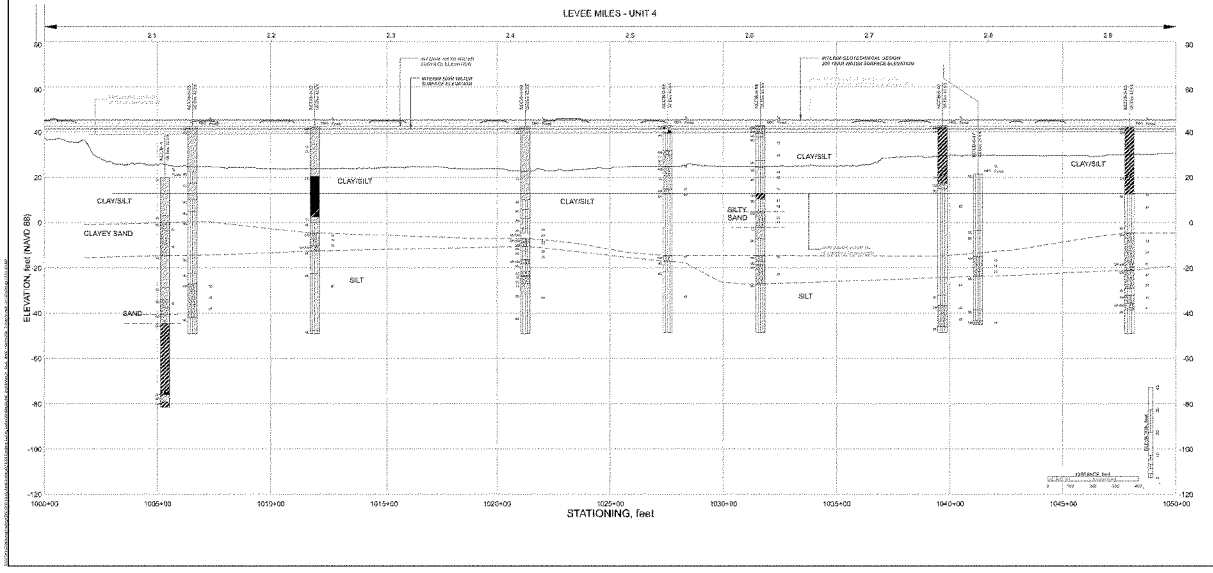
Plan and Profile
Natomas Cross Canal Station 950+00 to Station 1000+00
AMERICAN RIVER COMMON FEATURES GRR

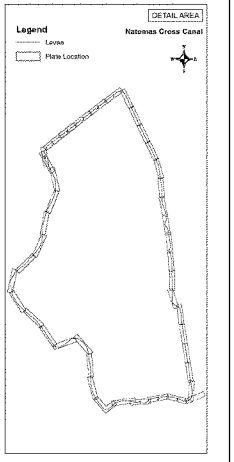
URS

Plate
NCC
3
FEBRUARY 2009





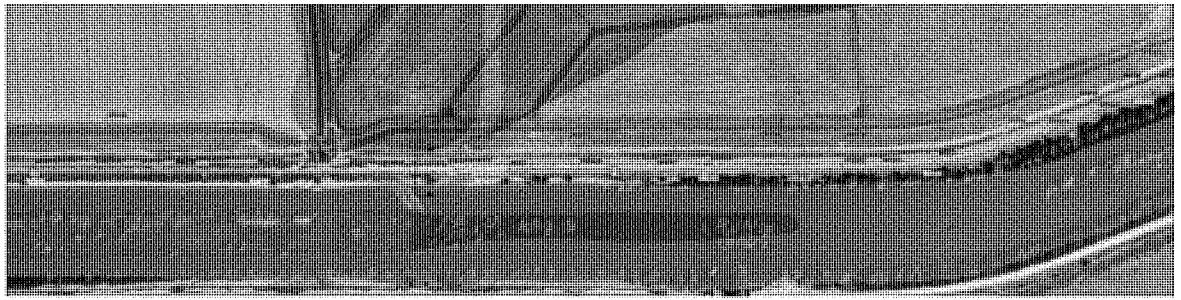


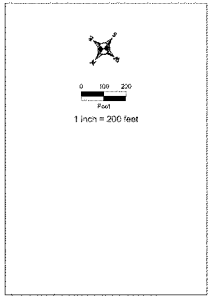


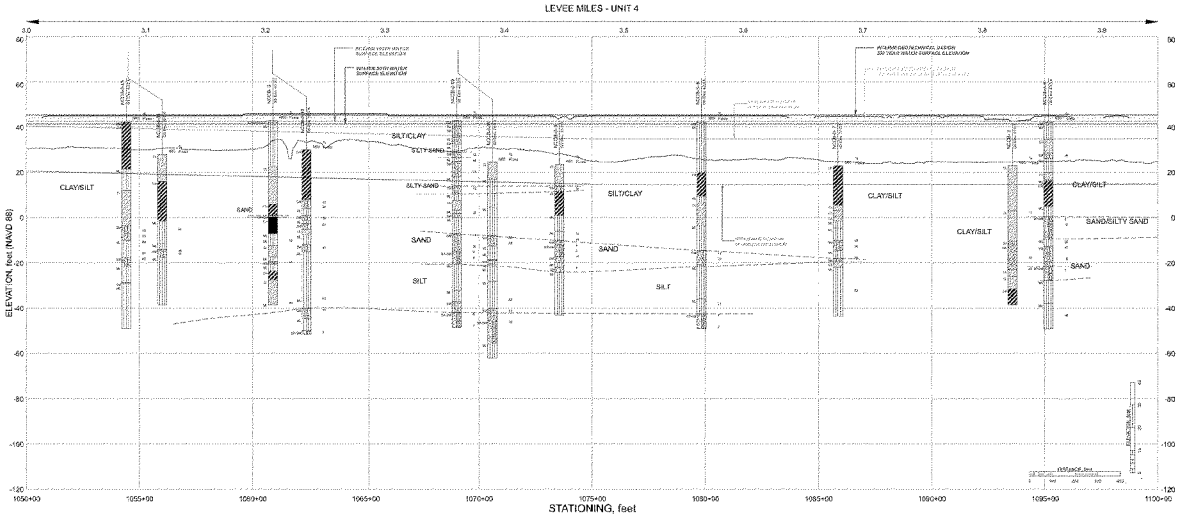
Plan and Profile
Natomas Cross Canal Station 1000+00 to Station 1050+00
AMERICAN RIVER COMMON FEATURES GRR

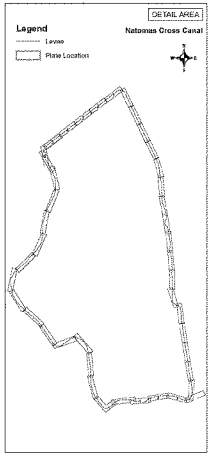
URS

Plate
NCC
4
FEBRUARY 2009





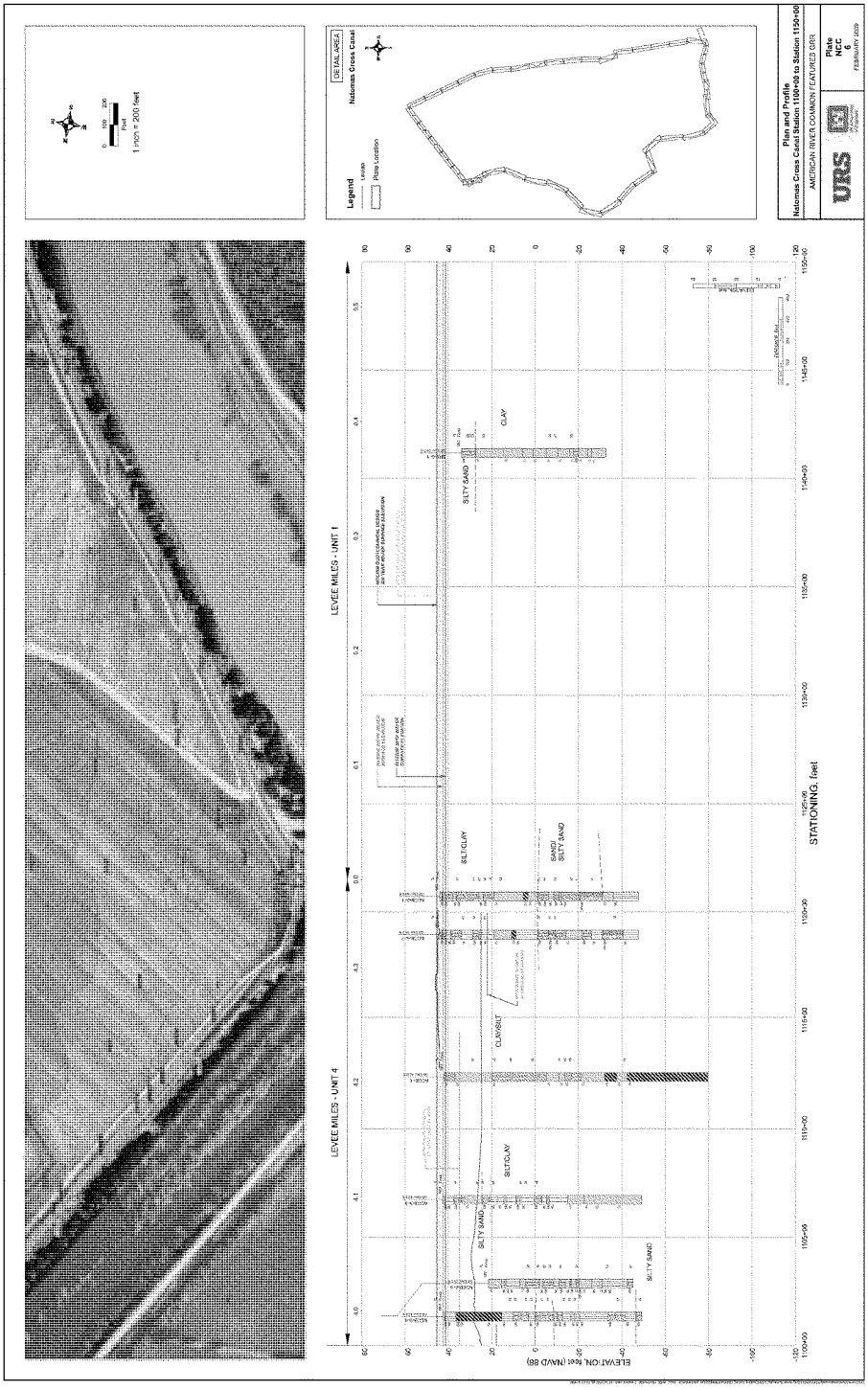




Plan and Profile
Natomas Cross Canal Station 1050+00 to Station 1100+00
AMERICAN RIVER COMMON FEATURES GRR

URS

Plate
NCC
5
FEBRUARY 2009


0
200
400
Feet
1 inch = 200 feet
DETAIL AREA
Natomas Cross Canal
Legend
Levee
Plate Location
Plan and Profile
Natomas Cross Canal Station 1100+00 to Station 1150+00
AMERICAN RIVER COMMON FEATURES GRR
URS
Plate
NCC
6
FEBRUARY 2009
LEVEE MILES - UNIT 4
LEVEE MILES - UNIT 1
SILTY SAND
SILT/CLAY
CLAY/SILT
SILT/CLAY
SILTY SAND
SILTY SAND
SAND/
SILTY SAND
CLAY
SILTY SAND
ELEVATION, feet (NAVD 88)
STATIONING, feet

AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

NATOMAS POST AUTHORIZATION CHANGE REPORT

ENCLOSURE F-1B (Part 1)

KLEINFELDER PLAN AND PROFILES



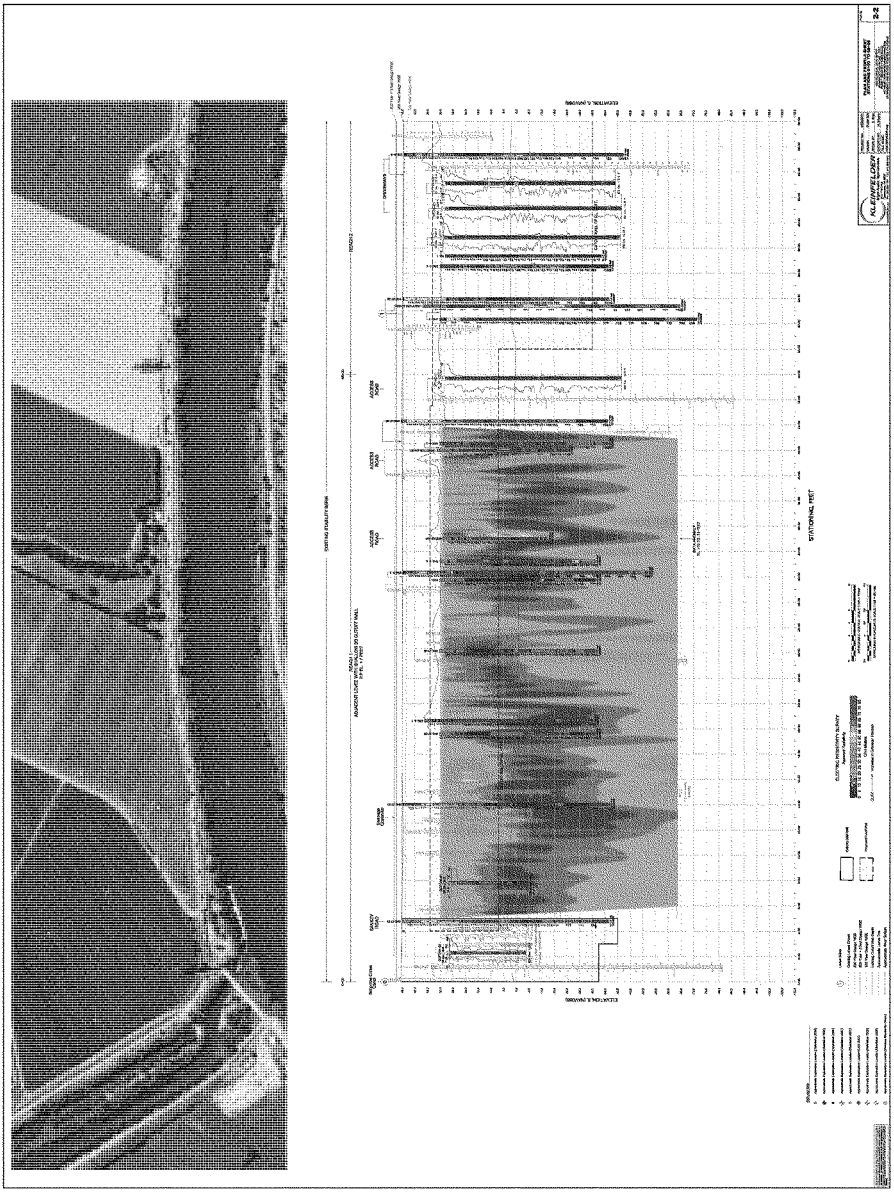


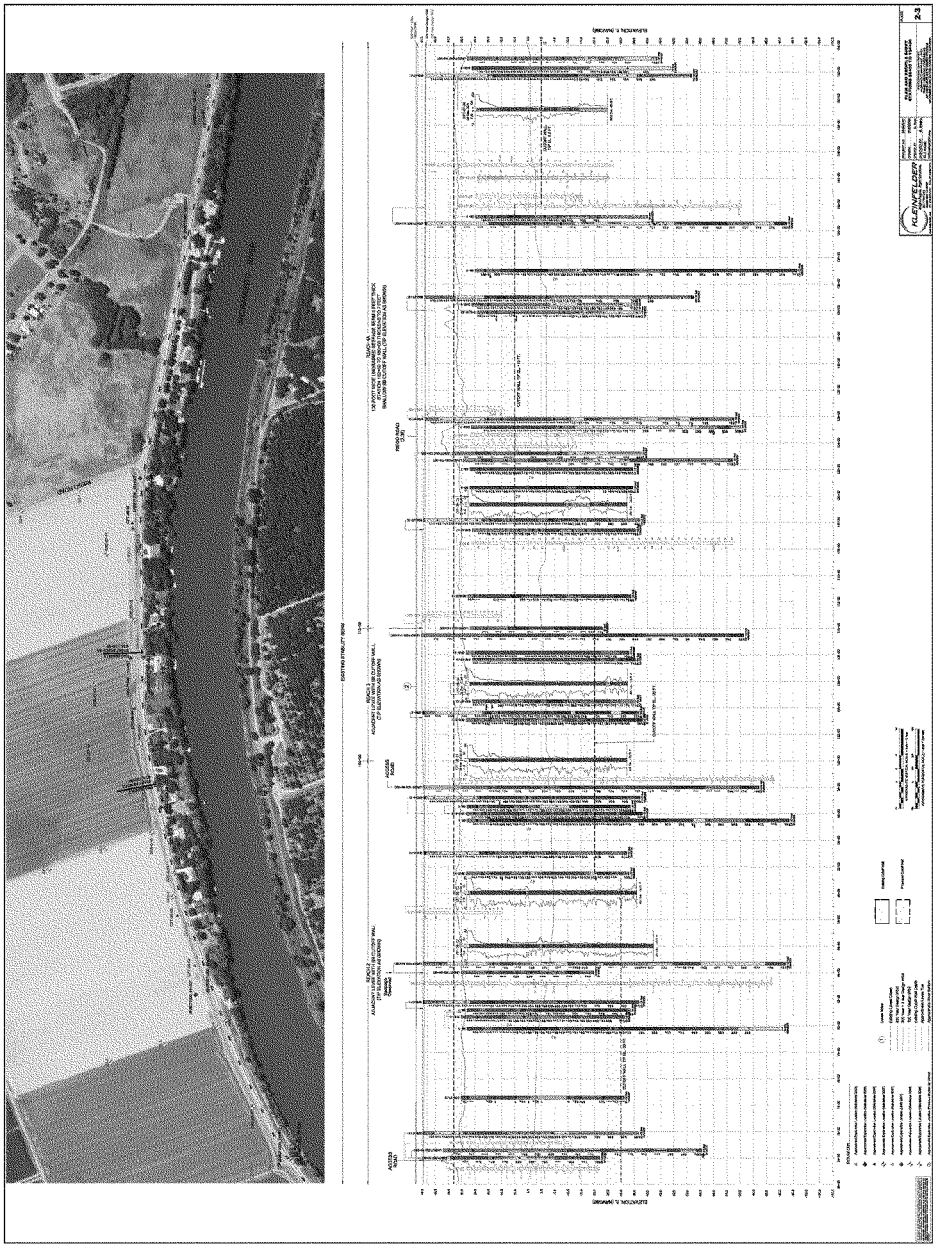
Notes:

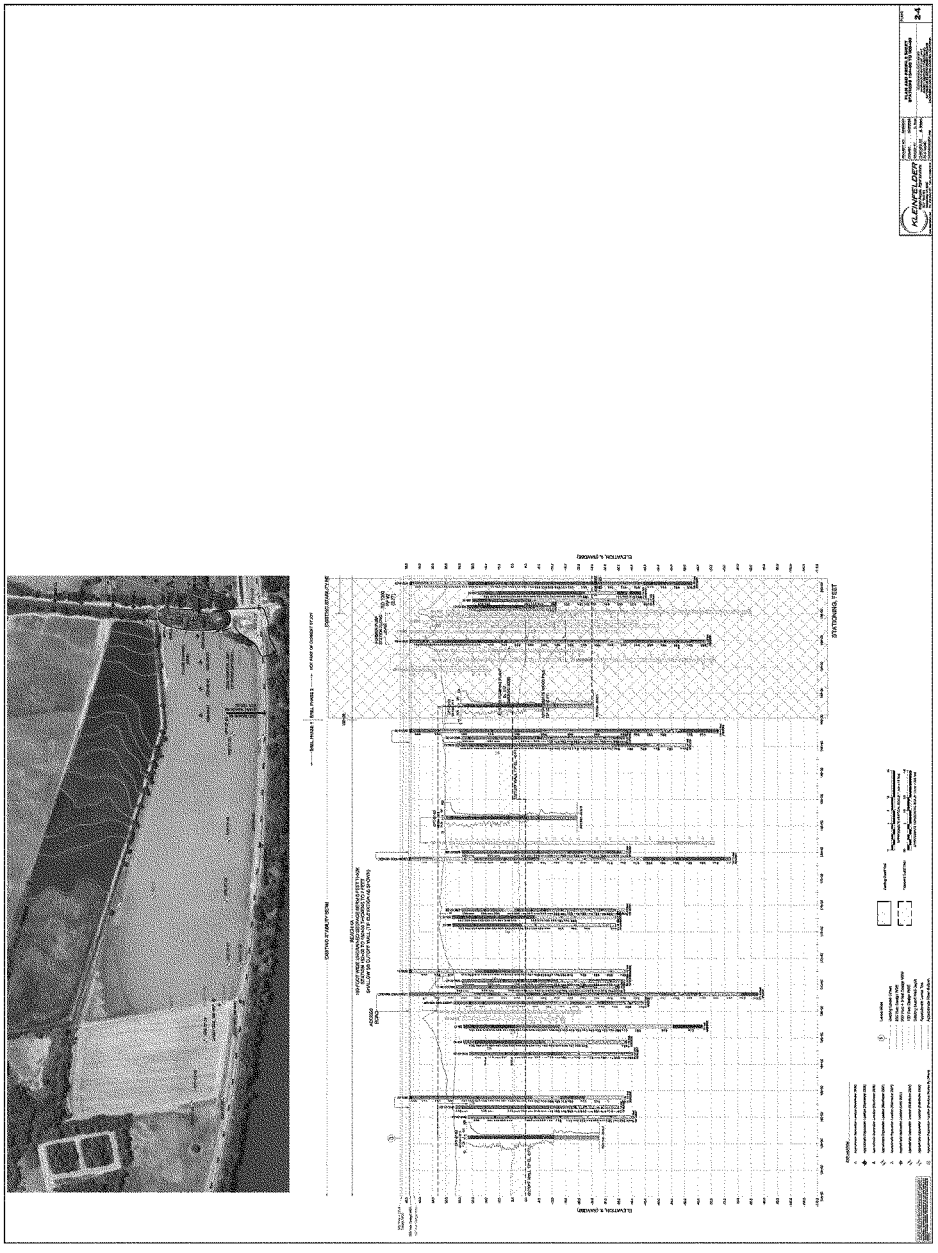
1. Base drawings for the Sacramento River Soil Levee Profile, dated in August, 2020 from the Sacramento District U.S. Army Corps of Engineers (USACE) and used with their permission. Include data logs of previous explorations and notes regarding sewer surcharges and completed levee improvements. Levee crown and toe profiles are based upon existing topographic mapping by the USACE with clarifications conducted by Psomas for the National Levee Improvement Program (NLIP) in 2020. All elevations for data prior to 2017 have been converted from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a +2.3 foot correction factor as determined by Psomas for the NLIP (Psomas, 2020). (0 feet NGVD29 = 2.3 feet NAVD88).
2. Logs of the following explorations were added to the USACE base drawings:
   a. Kleinfelder 2013 borings (S-03-XX);
   b. Kleinfelder 2014 borings and CPTs (S-04-XX, SCPT-04-XX);
   c. Kleinfelder 2006 borings (SWS-XX) and (SS-XX);
   d. Kleinfelder 2024 (SHT-08-XX), SWT (SHW-07-XX), 2008 (SHW-08-XX) borings; Sacramento River CPT-07-XX, CPT-08-XX, CPT-09-XX;
   e. URS 1997 (997-X), URS 2000 (SWS-X) borings;
   f. URS 2001 (SP-01-XX) borings;
   g. URS 2007 borings (USS-07-XXX, XXXX-XXX);
   h. Wallace 1999 (SH-X), Nathan 1997 (SH-X) and Wallace 1999 (SH-X-X) borings.
3. The locations of the explorations shown are approximate. See Plates 2-2 through 2-4 for approximate plan locations.
4. The log beyond shown applies to Kleinfelder 2005 through 2009 borings and CPTs. Caution is advised in using this legend for interpretation of other explorations.
5. Logs represent general site conditions observed at the point of exploration on the date indicated. Refer to Kleinfelder's 2005 report, Kleinfelder's 2005 report and Kleinfelder's 2007 report for more detail on Kleinfelder 2005 borings (SWS-XX), Kleinfelder 2006 borings (SS-X-XX), and Kleinfelder's 2007 borings (SHS-07-XX).
6. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
7. No warranty is provided as to the continuity of soil conditions between individual survey locations.
8. Approximate top of casing elevations for Kleinfelder 2006 borings (SWS-XX), were surveyed using GPS equipment survey. Kleinfelder 2005, 2007, and 2008 borings (SHS-XX, SHF-08-XX) were estimated using contour topographic data provided by Psomas.
9. The 100 and 200 Year design water surface profile shown was provided by MBK Engineers in a report dated Dec. 13, 2006. See report for an explanation of these profiles and conditions.
10. Details regarding completed levee improvements have been added to those already on the USACE levee profile base drawings and were obtained from the USACE. Extents of completed levee improvements shown are approximate and are the same as indicated on the USACE profiles. Refer to USACE as-built drawings for actual extents.
11. Details regarding the 2007 construction of the DSM wall within Reach 1 have been added to the profile and are based upon Sacramento Area Flood Control Agency (SAFCA) construction records.
12. Vertical and lateral extents of the proposed cutoff wall shown are for description purposes only. Actual limits will be defined during final design if a cutoff wall alternative is selected.

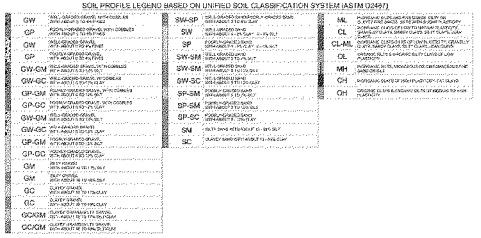
KLEINFELDER

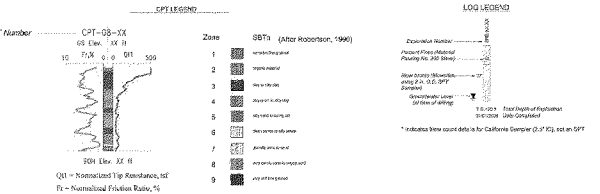
2-1











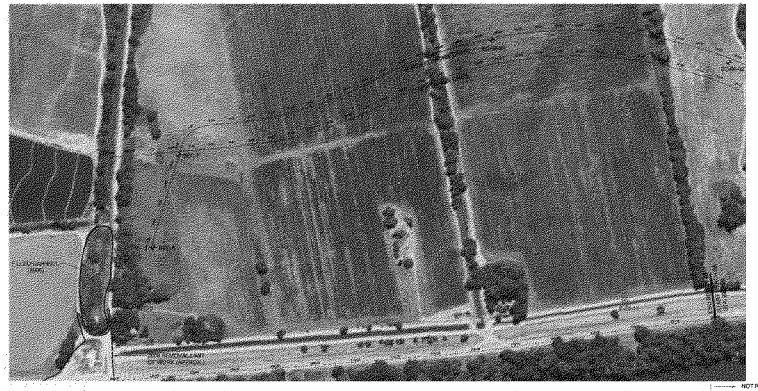
Notes:

1. Base drawings for the Sacramento River East Levee Project contained in August 2005 from the Sacramento District U.S. Army Corps of Engineers (USACE) and used with their permission. Include stock logs of previous explorations and reset regarding levee performance and completed levee improvements. Levee crown and landside toe profiles are based upon existing topographic mapping by the USACE with modifications surveyed by Psomas for the Natomas Levee Improvement Program (NLIP) in 2008. All elevations for data prior to 2007 have been converted from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a -2.29 feet conversion factor as determined by Psomas for the NLIP (Psomas 2007) (e.g. 0 feet NGVD29 = 2.29 feet NAVD88).
2. Logs of the following explorations were added to the USACE base drawings:
   a. Kleinfelder 2004 borings (E-03-XX).
   b. Kleinfelder 2005 borings (SRB-1XX and SB-XX).
   c. Kleinfelder 2006 (SRE-6-XX) borings.
   d. Kleinfelder 2007 setback borings (SC-07-XX).
   e. Kleinfelder 2008 (SRE-08-XX) borings.
   f. Kleinfelder 2008 Elkhorn Deep Borings (SG-08-XX) and (SEC-X), Seepage Berm borings (KSB-08-XX).
   g. John Sandelin & Associates 2008 (CPT-99-XX) CPTs.
   h. LWS 1994 (LWS-X).
   i. LWS 2001 (SP-01-XX) borings.
   j. LWS 2004 borings (LWS 17 HSG XXX+XXA).
   k. Kasner 1996 (CH-X-96).
3. Locations of the following borings shown on the plan view are not in elevation are:
   a. Kleinfelder 2008 Pumping Plant borings (WPS-XX).
   b. Kleinfelder 2008 North Drain borings (BND-XX).
4. The locations of the explorations shown are approximate. See Plates 2-2 through 2-4 for approximate plan location.
5. The log legend shown applies to Kleinfelder 2004 through 2008 borings. Caution is advised in using the legend for interpretation of other explorations.
6. Logs represent general soil conditions observed at the point of exploration on the date indicated. Refer to Kleinfelder's 2005, 2006, and 2007 reports for more detail or Kleinfelder's 2005 borings (SRB-XX and SB-XX), Kleinfelder's 2006 borings (SRE-6-XX), and Kleinfelder's 2007 borings (KB-07-XX).
7. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
8. No warranty is provided as to the continuity of soil conditions between individual sample locations.
9. Approximate top of boring elevations for Kleinfelder 2008 through 2008 borings were estimated using revised topographic data provided by Psomas.
10. The water surface profiles shown were provided by MBK Engineers in a report dated December 2008. See report for an explanation of these profiles and conditions.
11. Details regarding completed levee improvements have been obtained from the USACE and added to the levee profile base drawing. Extents of completed levee improvements shown are approximate and are the same as indicated on the USACE profiles. Refer to USACE as-built drawings for actual extents.

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PLAN AND PROFILE LEGEND AND NOTES

2-1



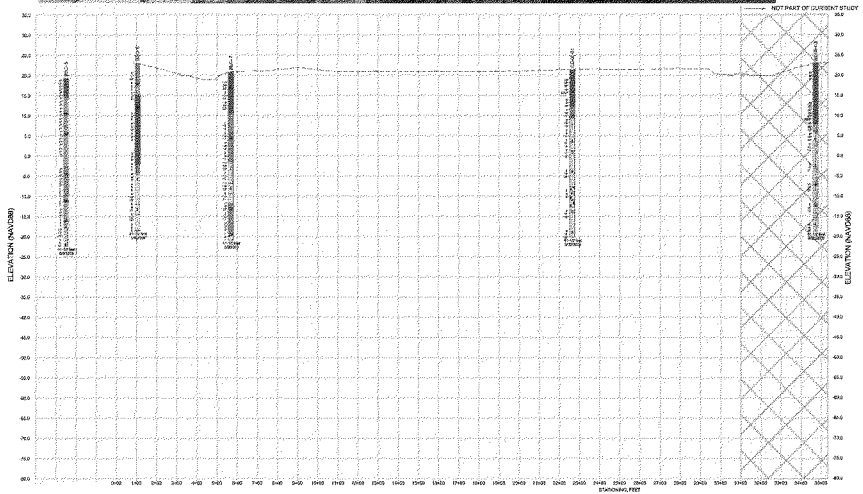
EXPLANATION

- Approximate Exploration Location (Kleinfelder 2008)
- Approximate Exploration Location (Kleinfelder 2007)
- Approximate Exploration Location (Kleinfelder 2005)
- Approximate Exploration Location (URS 2007)
- Approximate Exploration Location (Previous Studies By Others)
- Approximate Proposed Inspection Location
- Approximate Ground Surface Elevation

APPROXIMATE VERTICAL SCALE: 1 inch = 10 feet

APPROXIMATE HORIZONTAL SCALE: 1 inch = 200 feet

NOTE: ELKHORN CANAL STATIONING BEGINS NEAR THE NORTH MAIN DRAINAGE CANAL AND DOES NOT CORRESPOND TO THE SACRAMENTO RIVER EAST LEVEE STATIONING.



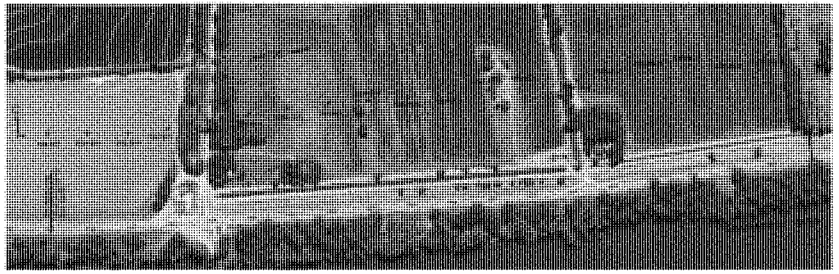
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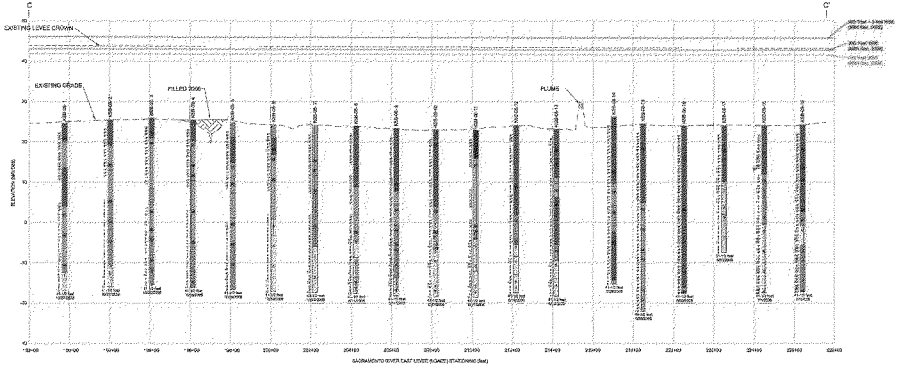
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DRAWN:	02/07/2008
CHANGE BY:	D. Dolan
CHECKED BY:	T. Ryan
FILE NAME:	SHEET1.DWG (Plot)

PLAN AND PROFILE
ELKHORN CANAL
STATIONS 0+00 TO 35+00

DRAFT GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
EVALUATION PROJECT
SACRAMENTO COUNTY, CALIFORNIA
SACRAMENTO AREA FLOOD CONTROL AGENCY

PLATE
2-3





EXPLANATION

- Approximate Excavation Location (Kleinfelder 2006)
- Existing Levee Crown
- 200-Year + 3 feet Design WSE (WSC Dec. 2008)
- 200-Year Design WSE (WSC Dec. 2002)
- 100-Year Design WSE (WSC Dec. 2002)

APPROXIMATE VERTICAL SCALE: 1 inch = 10 feet

APPROXIMATE HORIZONTAL SCALE: 1 inch = 200 feet

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3291 Progress
Roseville, CA 95661
Ph: 916.586.1100 FAX: 916.586.1101

PROJECT NO.	94-00-0018
DRAWN	02/27/2009
CHECKED BY	
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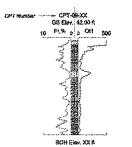
PLAN AND PROFILE
REACH 4B BLANKET SCRAPE
DRAFT GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
FLOOD RISK REDUCTION
NATOMAS BASIN LEVEE IMPROVEMENT PROGRAM
SACRAMENTO RIVER & PRIVATE LEVEE, CALIFORNIA

PLATE
2-4

SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

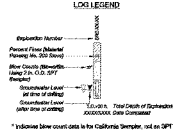
GW	WELL-GRADED GRAVEL WITH COBBLES OR BOULDERS, LITTLE OR NO FINES	SW-SP	WELL-GRADED SAND/POORLY GRADED SAND WITH ABOUT 5 TO 12% CLAY	ML	INORGANIC SILT AND VERY FINE SAND, ROCK FLOUR, SILTY OR CLAYEY FINE SAND OR CLAYEY SILT WITH SLIGHT PLASTICITY
GP	POORLY GRADED GRAVEL WITH COBBLES OR BOULDERS, LITTLE OR NO FINES	SW	WELL-GRADED SAND WITH ABOUT 5 TO 12% CLAY #70-#4.567	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
GW	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES	SP	POORLY GRADED SAND WITH ABOUT 5 TO 12% CLAY #70-#4.567	CL-ML	INORGANIC CLAYEY SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
GP	POORLY GRADED GRAVEL WITH ABOUT 5 TO 12% FINES	SW-SM	WELL-GRADED SAND WITH ABOUT 5 TO 12% 2x7	OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
GW-GM	WELL-GRADED GRAVEL WITH COBBLES OR BOULDERS, WITH ABOUT 5 TO 12% SILT	SW-SM	WELL-GRADED SAND WITH ABOUT 5 TO 12% SILT	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
GW-GC	WELL-GRADED GRAVEL WITH COBBLES OR BOULDERS, WITH ABOUT 5 TO 12% CLAY	SW-SC	WELL-GRADED SAND WITH ABOUT 5 TO 12% CLAY	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
GP-GM	POORLY GRADED GRAVEL WITH COBBLES OR BOULDERS, WITH ABOUT 5 TO 12% SILT	SP-SM	POORLY GRADED SAND WITH ABOUT 5 TO 12% SILT	OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM TO HIGH PLASTICITY
GP-GC	POORLY GRADED GRAVEL WITH COBBLES OR BOULDERS, WITH ABOUT 5 TO 12% CLAY	SP-SM	POORLY GRADED SAND WITH ABOUT 5 TO 12% SILT		
GW-GM	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% SILT	SP-SC	POORLY GRADED SAND WITH ABOUT 5 TO 12% CLAY		
GW-GC	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% CLAY	SM	SILTY SAND WITH ABOUT 5 TO 12% SILT		
GP-GM	POORLY GRADED GRAVEL WITH ABOUT 5 TO 12% SILT	SC	CLAYEY SAND WITH ABOUT 5 TO 12% CLAY		
GP-GC	POORLY GRADED GRAVEL WITH ABOUT 5 TO 12% CLAY	SC-SM	SAND WITH ABOUT 12 TO 40% LEAN PLASTIC FINES THAT DISPERSE AS CLAY		
GM	SILTY GRAVEL WITH ABOUT 5 TO 12% FINES				
GM	SILTY GRAVEL WITH ABOUT 12 TO 40% SILT				
GC	CLAYEY GRAVEL WITH ABOUT 5 TO 12% CLAY				
GC	CLAYEY GRAVEL WITH ABOUT 12 TO 40% CLAY				
GC-GM	CLAYEY/SILTY GRAVEL WITH ABOUT 12 TO 40% SILT AND CLAY				
GC-GM	CLAYEY/SILTY GRAVEL WITH ABOUT 5 TO 12% SILT AND CLAY				

CPT LEGEND



Zone		SBTn (Robertson, 1990)
1		sensitive fine-grained
2		organic material
3		clay to silty clay
4		clayey silt to silty clay
5		silty sand to sandy silt
6		clean sands to silty sands
7		gravelly sand to sand
8		very dense sand to clayey sand
9		very stiff fine-grained

LOG LEGEND



* Indicates blow count data is for California Sampler, not an SPT

NOTES:

1. Base drawings for the Sacramento River East Levee Profile were obtained in August 2006 from the Sacramento District U.S. Army Corps of Engineers (USACE) and used with their permission. Base drawings include stick logs of previous explorations and notes regarding levee performance and completed levee improvements. Levee crown and toe profiles are based upon existing topographic mapping by the USACE with modifications conducted by Psomas for the Natomas Levee Improvement Program (NLIP) in 2008. All elevations for data prior to 2007 have been converted from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a +2.29 feet conversion factor as determined by Psomas for the NLIP (Psomas). (0 feet NGVD29 = +2.29 feet NAVD88).
2. Logs of the following explorations were added to the USACE base drawings:
   a. Kleinfelder 2004 borings (E-03-XX),
   b. Kleinfelder 2005 borings (SR5-8-XX) and (SR-XX),
   c. Kleinfelder 2006 borings (SR5-9-XX), 2008 (SR5-08-XX),
   d. Kleinfelder 2007 canal borings (NS-97-XX),
   e. Kleinfelder 2008 Elkhorn Irrigation Canal borings (EC-09-XX),
   f. Kleinfelder 2009 borings (SR5-JB-XX), and 2009 CPTs (CPT-09-XX),
   g. Kleinfelder 2003 CPTs (CEPT-09-01, -05),
   h. Kleinfelder 2010 CPTs (CPT-10-07, -08, -09, -10, -11),
   i. URS 1997 borings (B97-X), URS 2000 borings (B00-X),
   j. URS 2001 borings (DF-01-XX),
   k. URS 2007 borings (URS 07-0000-XXX-XXX),
   l. Wahler 1986 (SH-2-86), Wahler 1987 (SH-XX), and
   m. Warner 1989 (Elk-XX-X) borings, and
   n. VSI In-Situ Testing CPTs (CPT-X).
3. Locations of the following borings are shown on the plan view but not in profile:
   a. Kleinfelder 2003 boring (B-1),
   b. VSI In-Situ Testing CPTs (CPT-0, -4, -7),
   c. Ninyo&. Fahar & Assoc., Inc. CPTs (CPT-09-01 -03, -03),
   d. Kleinfelder 2008 Elkhorn Irrigation Canal boring (EC-09-01),
   e. Kleinfelder 2009 borings (SR5-JB-26, -27), and
   f. Kleinfelder 2008 CPTs (CPT-08-98, -98, 198, -199, -194, -198, -196, -179, -171, -172).
4. The locations of the explorations shown are approximate.
5. The log legend shown applies to Kleinfelder 2006 through 2009 borings. Caution is advised in using the legend for interpretation of other explorations.
6. Logs represent general soil conditions observed at the point of exploration on the date indicated. Refer to Kleinfelder's 2005 report, Kleinfelder's 2007 report and Kleinfelder's 2007 report for more detail on Kleinfelder 2005 borings (SR5-XX and SB-XX), Kleinfelder 2006 borings (SR5-6-XX), and Kleinfelder's 2007 borings (KB-07-XX).
7. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
8. No warranty is provided as to the continuity of soil conditions between individual sample locations.
9. Approximate top of boring elevations for Kleinfelder 2006 through 2009 borings were estimated using hindcast topographic data provided by Psomas.
10. The water surface profiles shown were provided by MBK Engineers on December 12, 2008.
11. Details regarding completed levee improvements have been added to these drawings by the USACE when profile base drawing and were obtained from the USACE. Extents of completed levee improvements shown are approximate and are the same as indicated on the USACE profiles. Refer to USACE as-built drawings for actual extents.

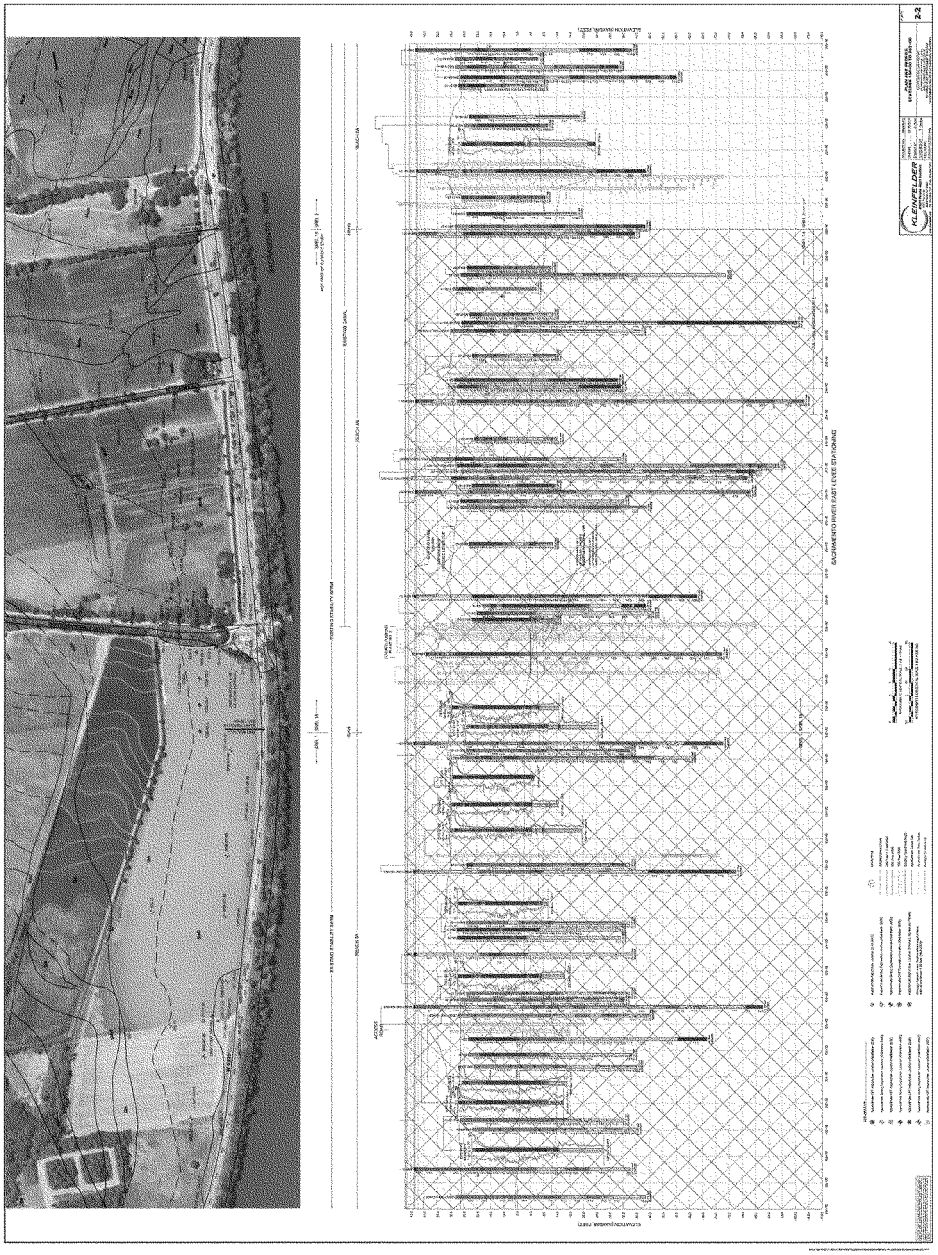
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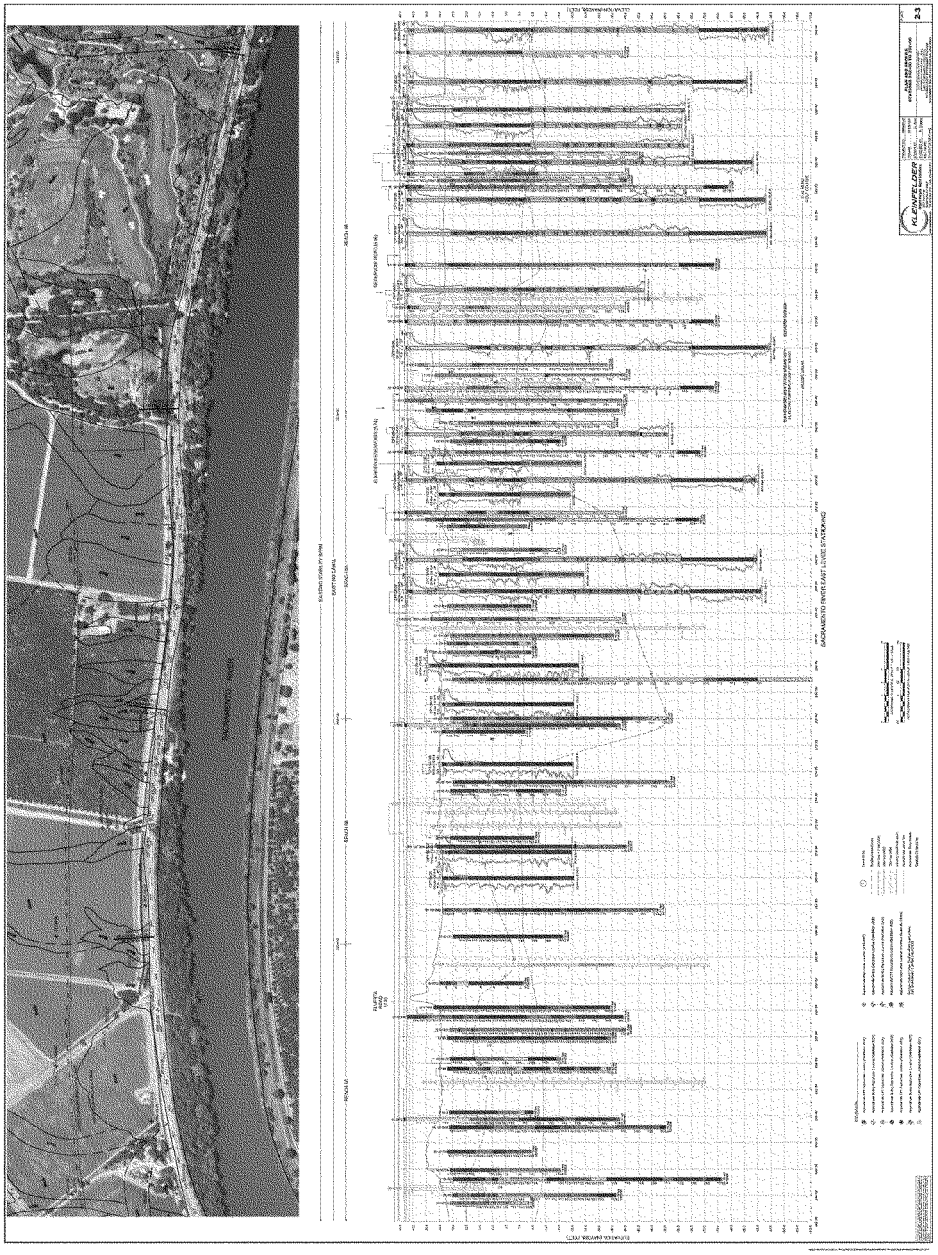
KLEINFELDER
Kleinfelder, Inc.
1351 Response Road, Suite 100
Sacramento, CA 95815
Tel: 916.924.1700 Fax: 916.924.1705

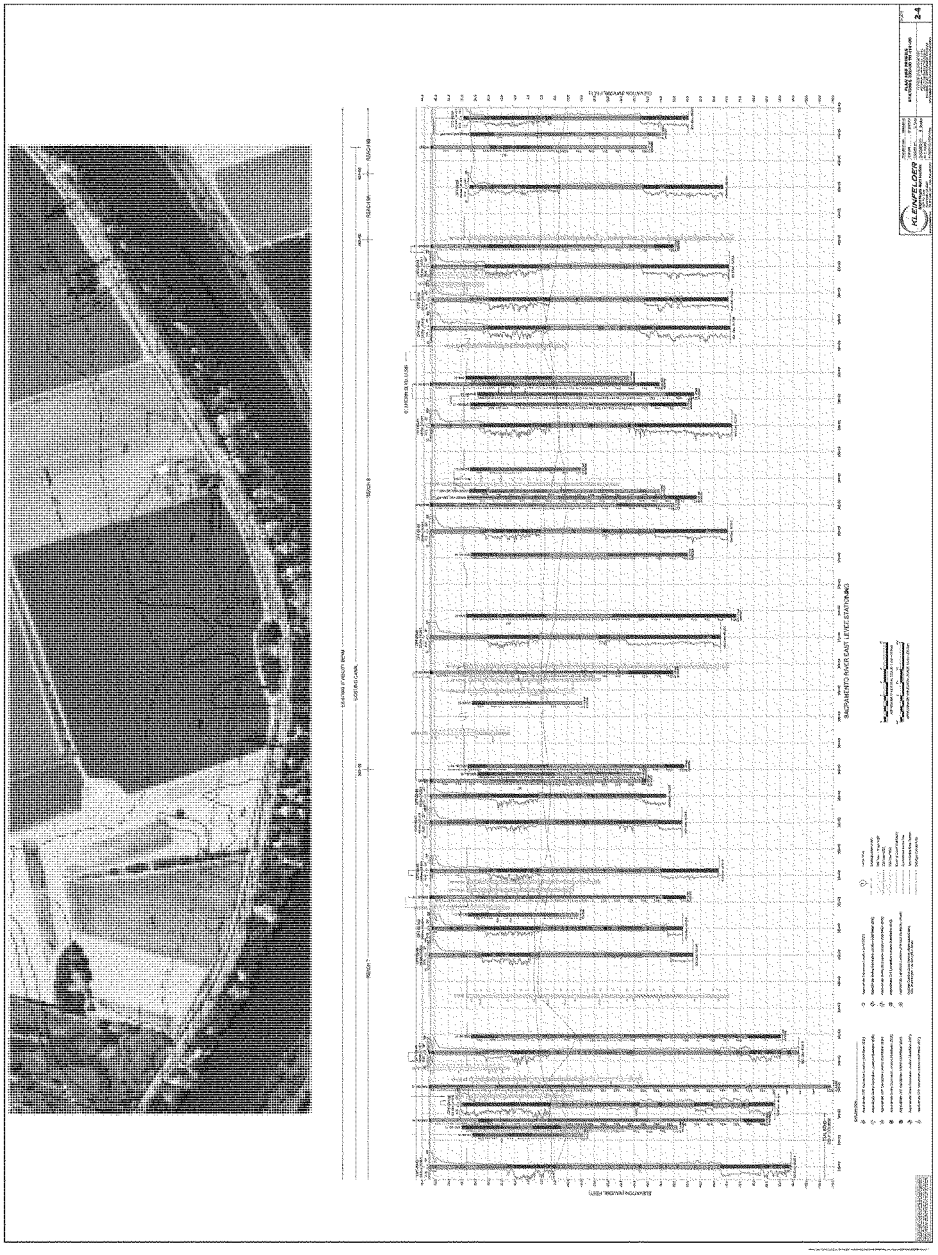
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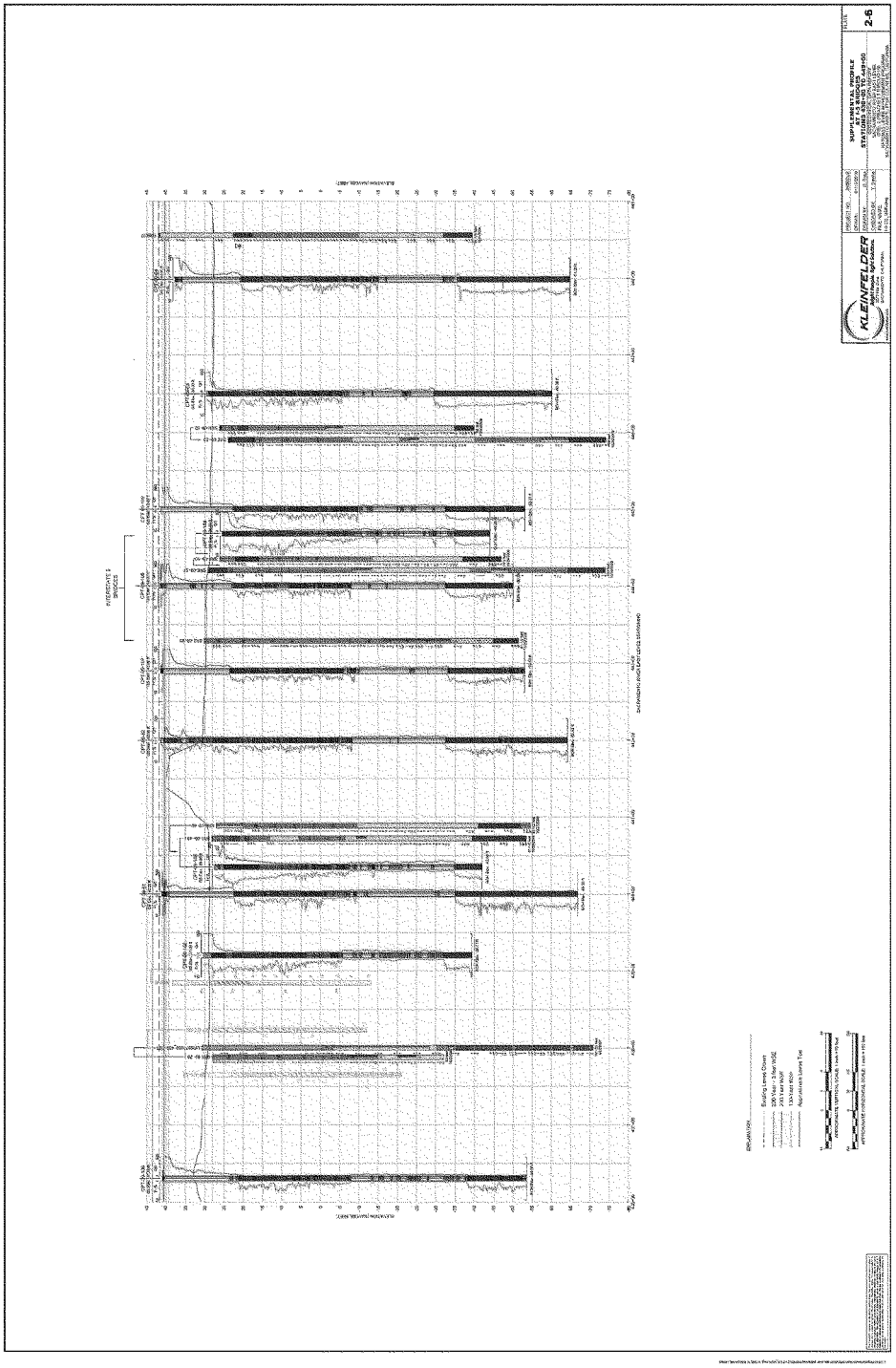
PLAN AND PROFILE
LEVEE AND WATER
LOGS AND LEGEND

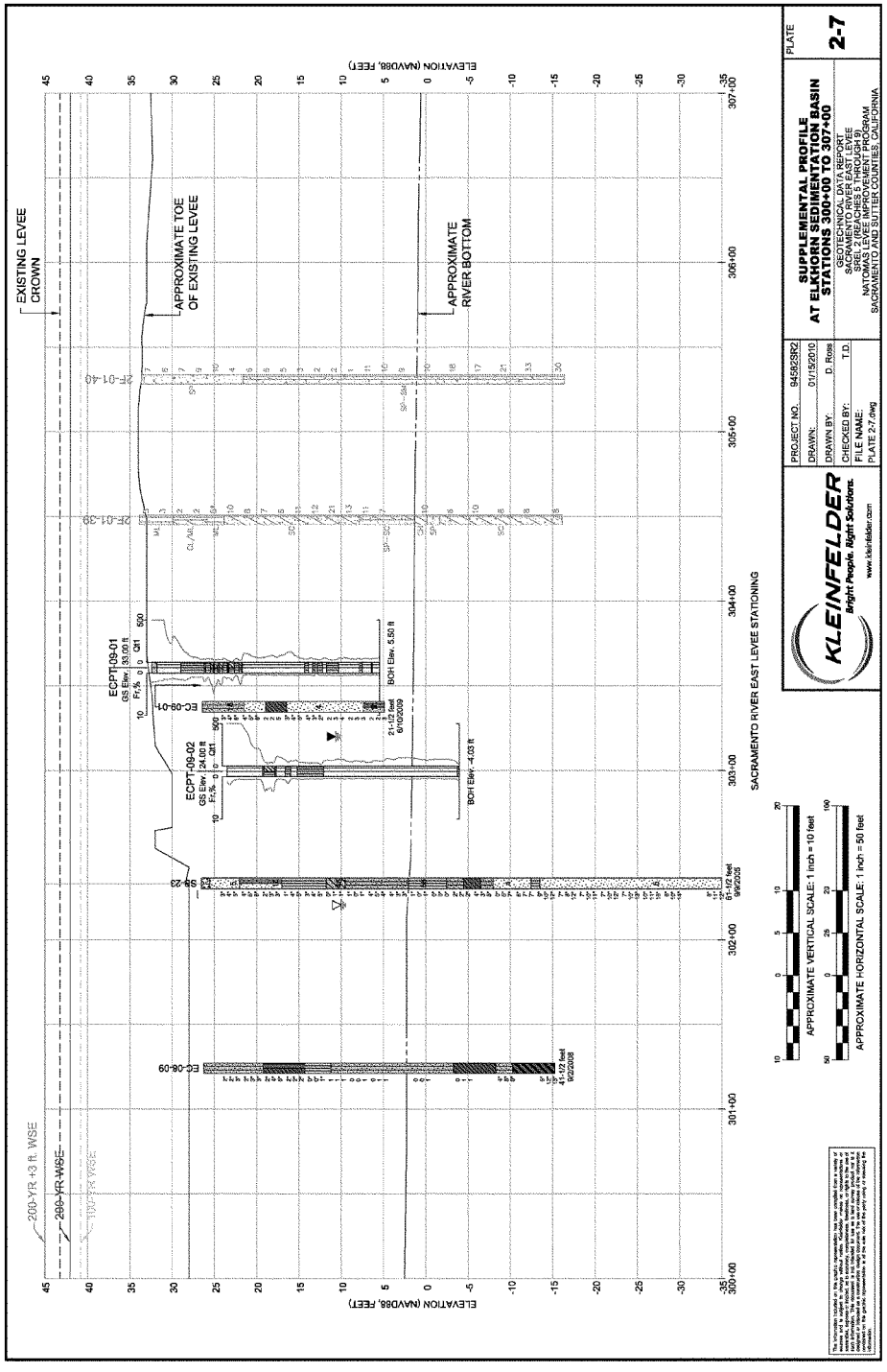
SHEET
2-1

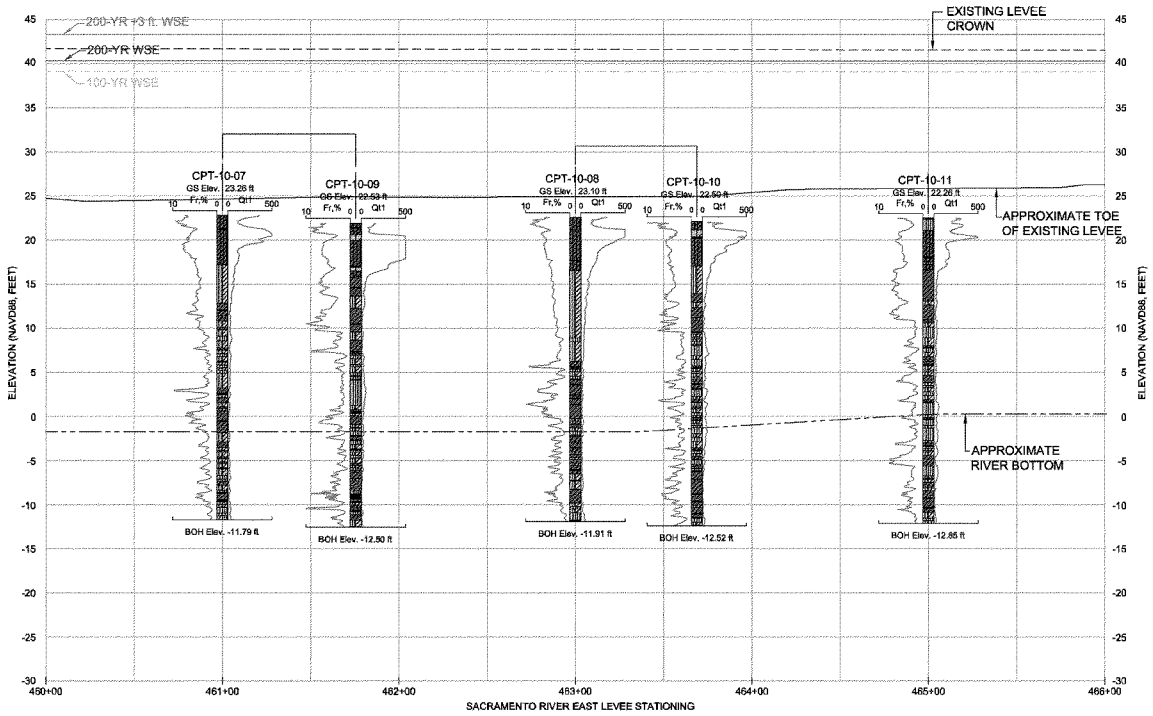









EXISTING LEVEE CROWN
APPROXIMATE TOE OF EXISTING LEVEE
APPROXIMATE RIVER BOTTOM
200-YR +3 ft. WSE
200-YR WSE
RIVER WSE
ELEVATION (NAVD88, FEET)
SACRAMENTO RIVER EAST LEVEE STATIONING
ECPT09-01
ECPT09-02
EC-08-01
EC-08-09
BOH Elev. 5.50 ft
BOH Elev. -4.03 ft
APPROXIMATE VERTICAL SCALE: 1 inch = 10 feet
APPROXIMATE HORIZONTAL SCALE: 1 inch = 50 feet
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PROJECT NO. 94592SR2
DRAWN: 01/15/2010
DRAWN BY: D. Ross
CHECKED BY: T.D.
FILE NAME: PLATE 2-7.dwg
SUPPLEMENTAL PROFILE AT ELKHORN SEDIMENTATION BASIN STATIONS 300+00 TO 307+00
GEOTECHNICAL DATA REPORT SACRAMENTO RIVER EAST LEVEE SEEPAGE CUTOFF WALL PROJECT
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA
PLATE
2-7



APPROXIMATE VERTICAL SCALE: 1 inch = 10 feet

APPROXIMATE HORIZONTAL SCALE: 1 inch = 50 feet

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PROJECT NO.	94582SR2
DRAWN:	01/15/2010
DRAWN BY:	D. Ross
CHECKED BY:	T.D.
FILE NAME:	PLATE 2-8.dwg

SUPPLEMENTAL PROFILE
STATIONS 460+00 TO 466+00

GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 2 (REACHES 5 THROUGH 9)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

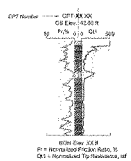
PLATE **2-8**

L:\2010\Projects\94582Gcad\SREL2\2009 soc river plates\GDMS\SREL2PLATE 2-8.dwg, 1/15/2010 8:52:39 AM, DRoss

SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

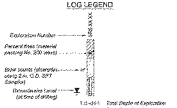
GW	WELL-GRADED GRAVEL; GRAVEL-SAND MIXTURE; LITTLE OR NO FINES	SW-SP	WELL-GRADED SAND WITH GRAVEL; GRAVELLY SAND; LITTLE OR NO FINES	ML	INORGANIC SILT; SILTY OR CLAYEY FINE SAND; CLAYEY SILT WITH SLIGHT PLASTICITY
GP	POORLY-GRADED GRAVEL; GRAVEL-SAND MIXTURE; LITTLE OR NO FINES	SW	WELL-GRADED SAND; GRAVELLY SAND; LITTLE OR NO FINES	CL	INORGANIC CLAY; LOW TO MEDIUM PLASTICITY; GRAVELLY CLAY; SANDY CLAY; SILTY CLAY; LEAN CLAY
GW	WELL-GRADED GRAVEL; GRAVEL-SAND MIXTURE; LITTLE OR NO FINES	SP	POORLY-GRADED SAND; GRAVELLY SAND; LITTLE OR NO FINES	CL-ML	INORGANIC CLAY-SILT; LOW PLASTICITY; GRAVELLY CLAY-SILT; SANDY CLAY-SILT; SILTY CLAY-SILT
GP	POORLY-GRADED GRAVEL; GRAVEL-SAND MIXTURE; LITTLE OR NO FINES	SW-SM	WELL-GRADED SAND; SAND-SILT MIXTURE; LITTLE OR NO FINES	OL	ORGANIC SILT; ORGANIC CLAY; ORGANIC SILT-CLAY
GW-GM	WELL-GRADED GRAVEL; GRAVEL-SAND-SILT MIXTURE; LITTLE OR NO FINES	SW-SM	WELL-GRADED SAND; SAND-SILT MIXTURE; LITTLE OR NO FINES	MH	INORGANIC SILT; MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT	
GW-GC	WELL-GRADED GRAVEL; GRAVEL-SAND-CLAY MIXTURE; LITTLE OR NO FINES	SW-SC	WELL-GRADED SAND; SAND-CLAY MIXTURE; LITTLE OR NO FINES	CH	INORGANIC CLAY OF HIGH PLASTICITY; FAT CLAY	
GP-GM	POORLY-GRADED GRAVEL; GRAVEL-SAND-SILT MIXTURE; LITTLE OR NO FINES	SP-SM	POORLY-GRADED SAND; SAND-SILT MIXTURE; LITTLE OR NO FINES	OH	ORGANIC CLAY OF MEDIUM TO HIGH PLASTICITY	
GP-GC	POORLY-GRADED GRAVEL; GRAVEL-SAND-CLAY MIXTURE; LITTLE OR NO FINES	SP-SM	POORLY-GRADED SAND; SAND-SILT MIXTURE; LITTLE OR NO FINES			
GW-GM	WELL-GRADED GRAVEL; GRAVEL-SAND-SILT MIXTURE; LITTLE OR NO FINES	SP-SC	POORLY-GRADED SAND; SAND-CLAY MIXTURE; LITTLE OR NO FINES			
GW-GC	WELL-GRADED GRAVEL; GRAVEL-SAND-CLAY MIXTURE; LITTLE OR NO FINES	SM	SILTY SAND; SAND-SILT MIXTURE			
GP-GM	POORLY-GRADED GRAVEL; GRAVEL-SAND-SILT MIXTURE; LITTLE OR NO FINES	SC	CLAYEY SAND; SAND-CLAY MIXTURE			
GP-GC	POORLY-GRADED GRAVEL; GRAVEL-SAND-CLAY MIXTURE; LITTLE OR NO FINES	SC-SM	SAND WITH HIGHLY PLASTIC CLAY FINES; SAND-SILT-CLAY MIXTURE			
GM	SILTY GRAVEL; GRAVEL-SAND-SILT MIXTURE					
GM	SILTY GRAVEL; GRAVEL-SAND-SILT MIXTURE					
GC	CLAYEY GRAVEL; GRAVEL-SAND-CLAY MIXTURE					
GC	CLAYEY GRAVEL; GRAVEL-SAND-CLAY MIXTURE					
GC-GM	CLAYEY GRAVEL; GRAVEL-SAND-CLAY-SILT MIXTURE					
GC-GM	CLAYEY GRAVEL; GRAVEL-SAND-CLAY-SILT MIXTURE					

CPT LEGEND



Zone	Soil Behavior (Robertson, 1990)
1	sensitive fine-grained
2	organic material
3	clay to silty clay
4	clayey silt to silty clay
5	silty sand to sandy silt
6	clean sands to silty sands
7	gravelly sand to sand
8	very dense sand to clayey sand
9	very stiff fine-grained

LOG LEGEND



* Indicates blow count data is for California Sampler, not an SPT

Notes:

1. Base drawings for the Sacramento River East Levee Profile, obtained in August 2009 from the Sacramento District U.S. Army Corps of Engineers (USACE) and used with their permission, include alist logs of previous explorations and notes regarding levee performance and completed levee improvements. Levee crown and toe profiles are based upon existing topographic mapping by the USACE with modifications conducted by Psomas for the Natomas Levee Improvements Program (NLIP) in 2008. All elevations for data prior to 2007 have been converted from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a -2.29 feet conversion factor as determined by Psomas for the NLIP (Psomas 2007). (1 feet NGVD29 = 2.29 feet NAVD88).
2. Logs of the following explorations were added to the USACE base drawings:
   a. Kleinfelder 1999 borings (B-X).
   b. Kleinfelder 2005 borings (SRE-XX).
   c. Kleinfelder 2006 borings (SRE-06-XX), 2009 borings (SRE-09-XX).
   d. Kleinfelder 2008 CPTs (CPT-08-XX).
   e. URS 1997 borings (99F-X), URS 2000 borings (B03-X) and (97-06-10of97-X).
   f. URS 2001 (97-01-X) borings.
   g. URS 2007 borings (URS 071020_XXXX-XXA).
   h. Wahler 1999 (DH-XX-99).
   i. Wahler 1997 (DH-XX).
   j. Wahler 1999 (DH-X-X) borings.
   k. Wahler 2007 CPTs (CPT-XXX), and
   l. USACE 2009 CPTs (CPT-09-XX).
3. The locations of the explorations shown are approximate.
4. The log legend shown applies to Kleinfelder 2005 through 2009 borings and CPTs. Caution is advised in using this legend for interpretation of other explorations.
5. Logs represent general soil conditions observed at the point of exploration on the date indicated. Refer to Kleinfelder's 2008 report for more detail on Kleinfelder 2005 borings (SRB-XX) and Kleinfelder's 1999 report for more detail on Kleinfelder 1999 borings (B-X).
6. Lines separating strata on logs represent approximate boundaries only. Actual transition may be gradual.
7. No warranty is provided as to the continuity of soil conditions between individual sample locations.
8. Kleinfelder 2005, 2006 and 2009 borings (SRB-XX, SRE-06-XX, SRE-09-XX) were reinterpreted using revised topographic data provided by Psomas (2008).
9. The 100-Year and 200-Year design water surface profiles shown were provided by MBK Engineers in a report dated Dec. 12, 2008. See report for an explanation of these profiles and conditions.
10. Details regarding completed levee improvements have been added to those already on the USACE base profile base drawing and were obtained from the USACE. Extents of completed levee improvements shown are approximate and are the same as indicated on the USACE profiles. Refer to USACE as-built drawings for actual extents.
11. Vertical and lateral extents of the proposed cutoff walls shown are for description purposes only. Actual limits will be defined during final design if a cutoff wall alternative is selected.

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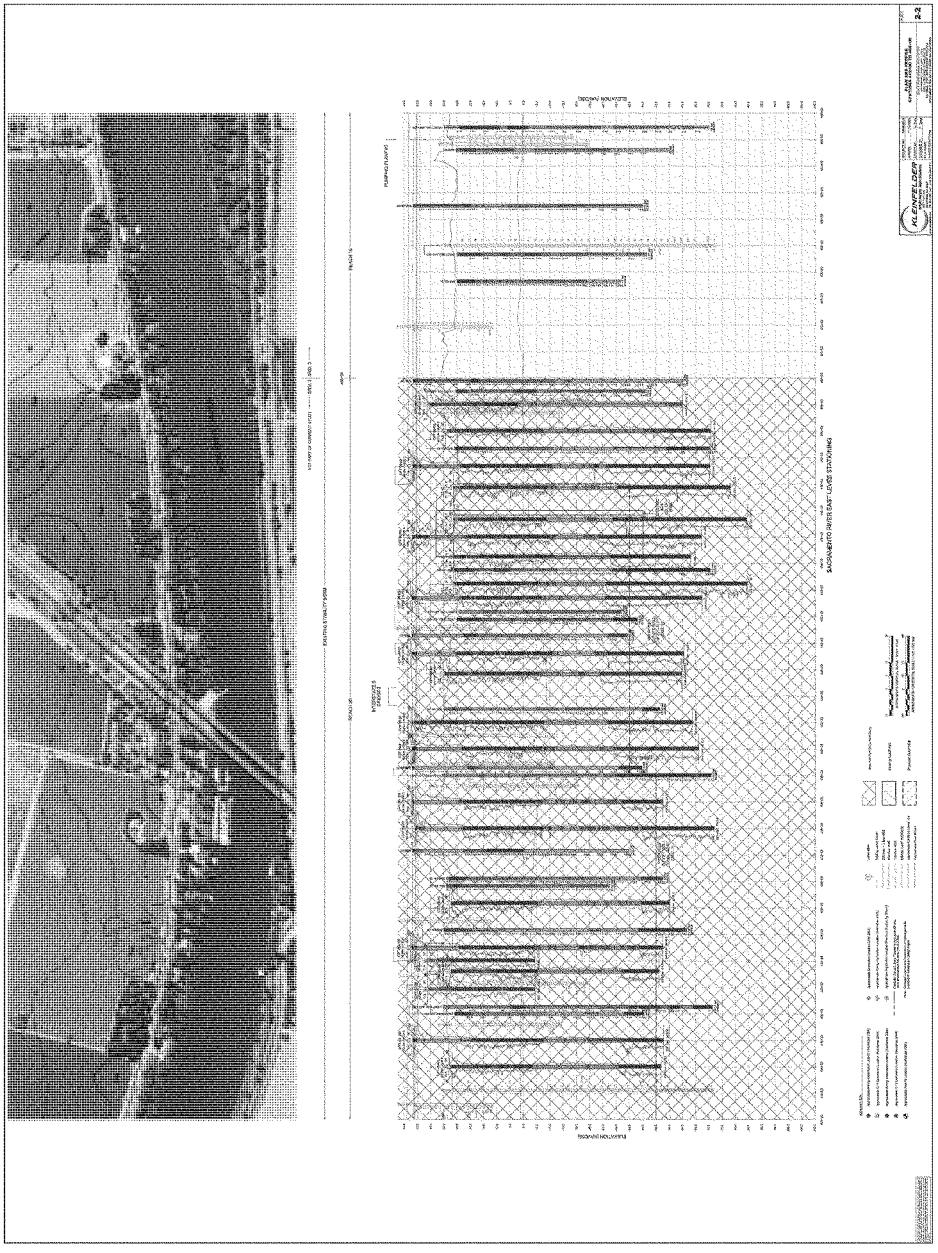
KLEINFELDER
Right People. Right Solutions.
2121 N. California Blvd., Suite 290, Walnut Creek, California 94596
Phone (925) 933-2323 Fax (925) 933-2324

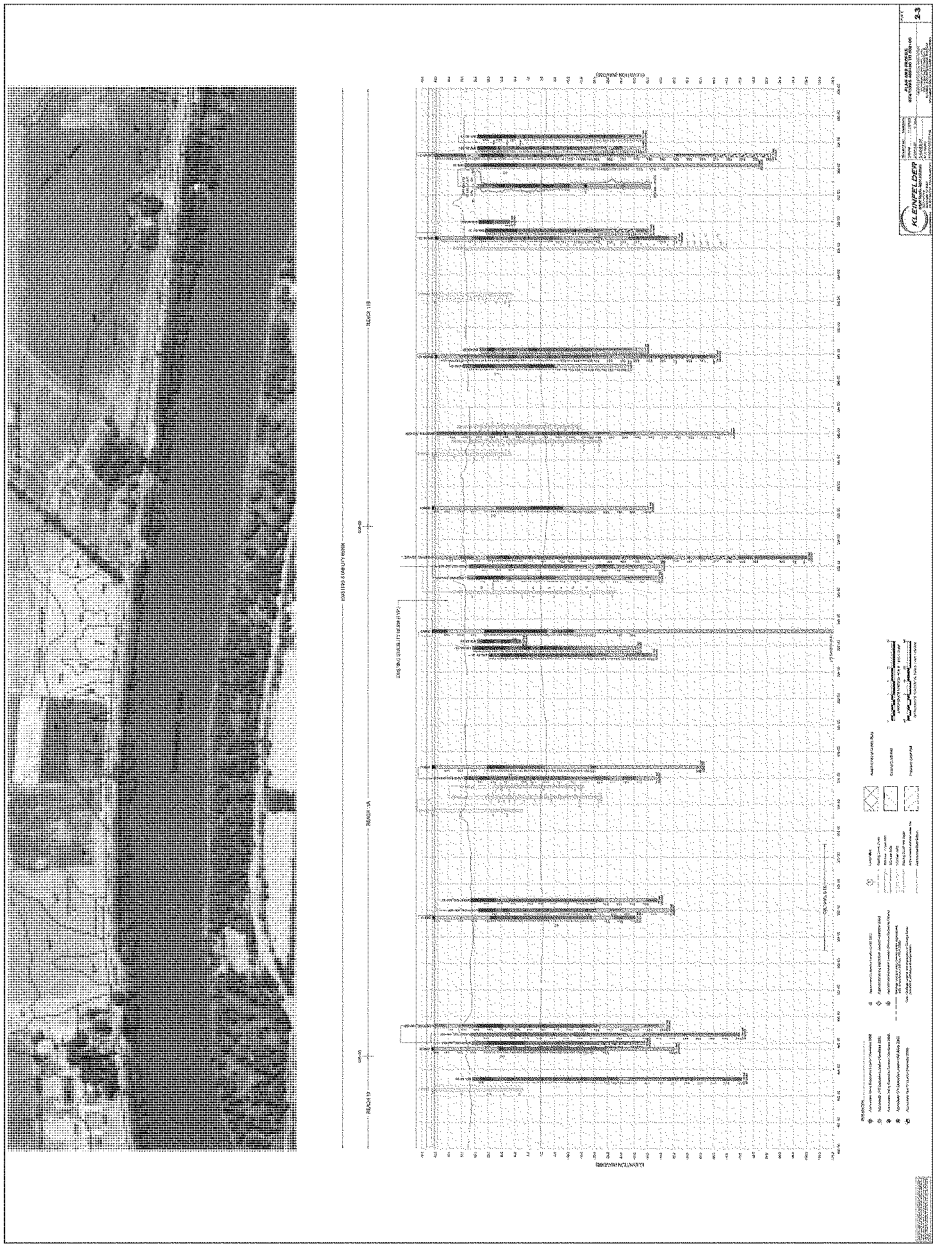
DESIGNED	DATE
DRAWN	DATE
CHECKED	DATE
APPROVED	DATE

FLOOD AND LEVEE EVALUATIONS
LEGEND AND NOTES

PROJECT NO. 20080127.001A
FILE NO. 20080127001A-GN-LEGEND.DWG

SHEET 2-1



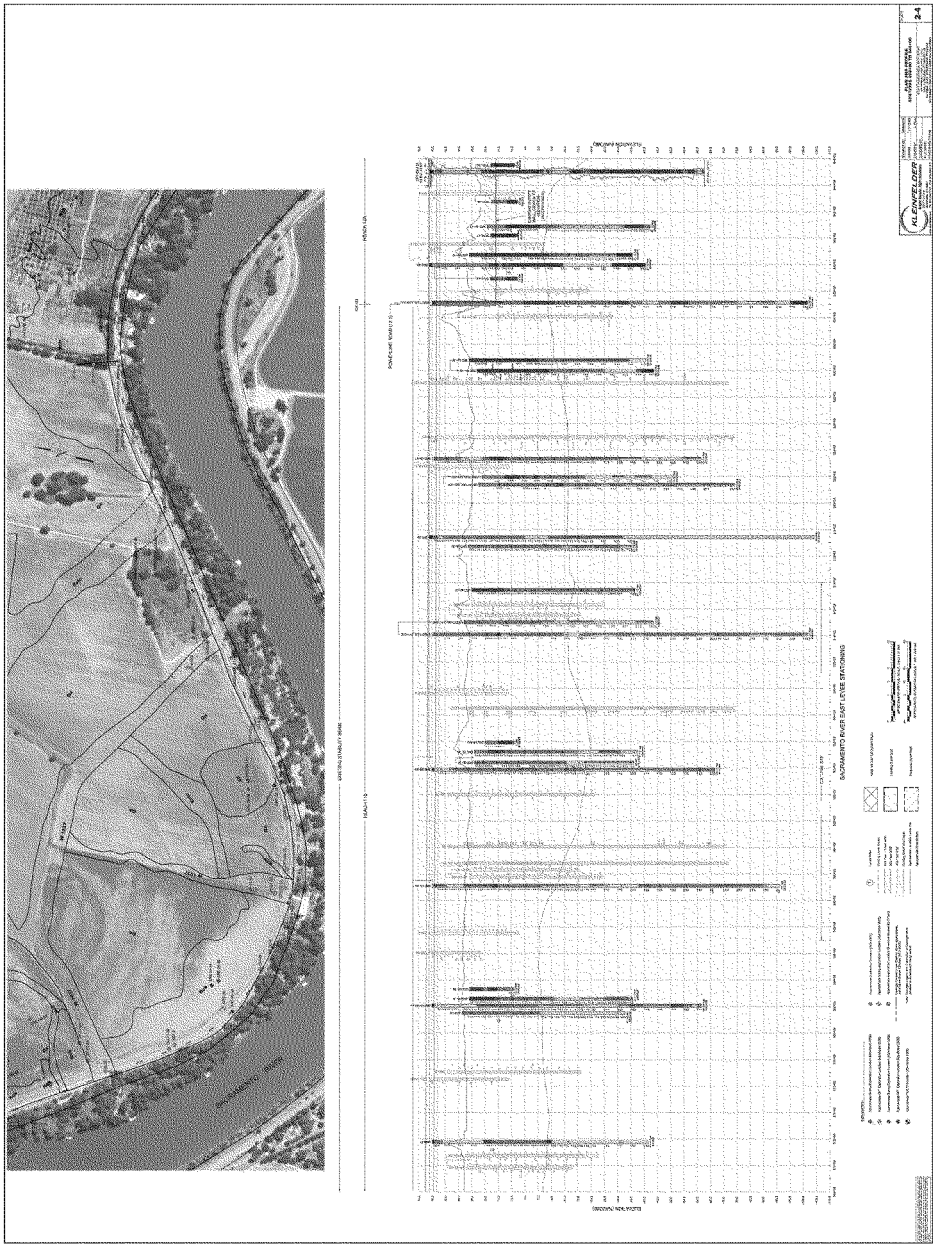


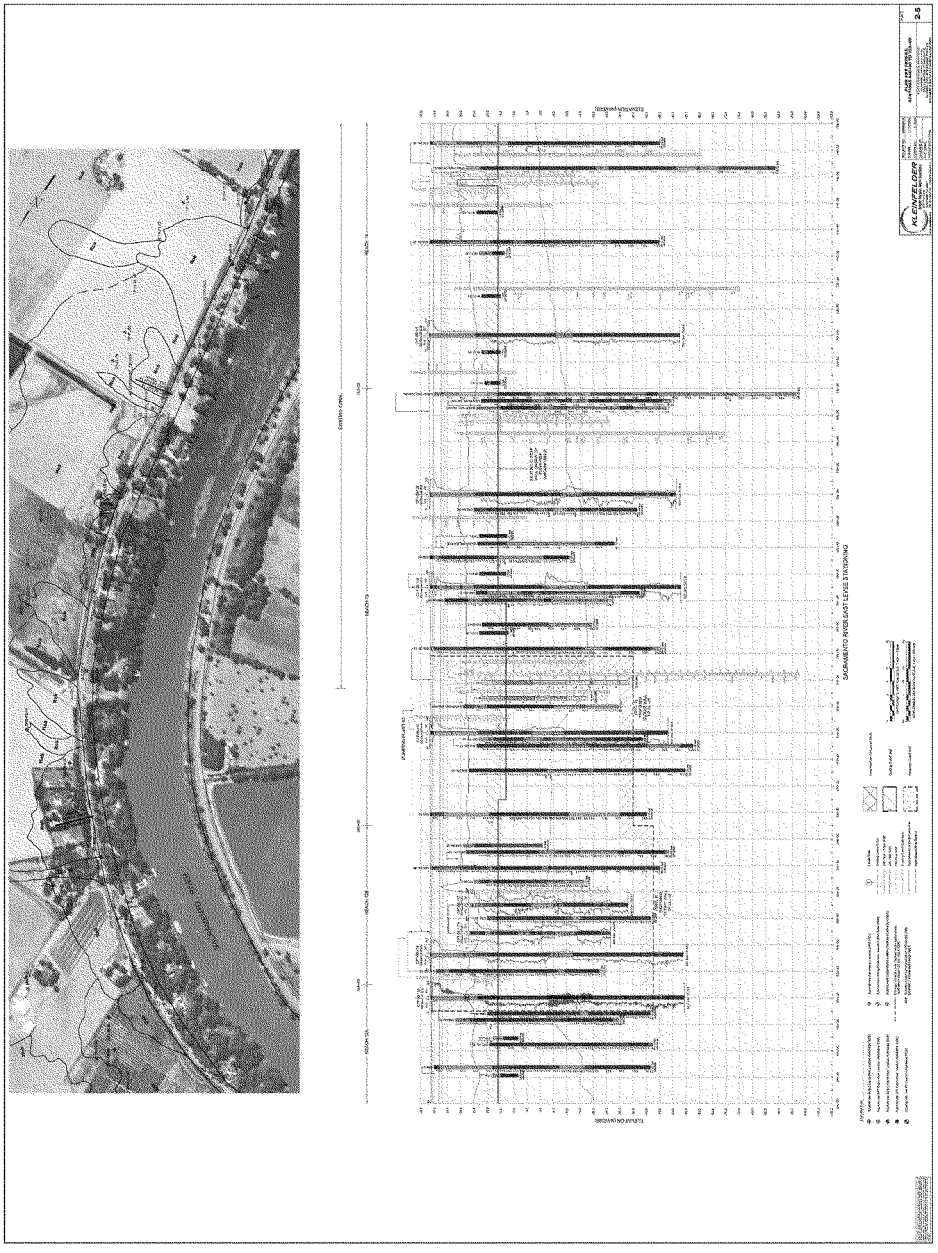
AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

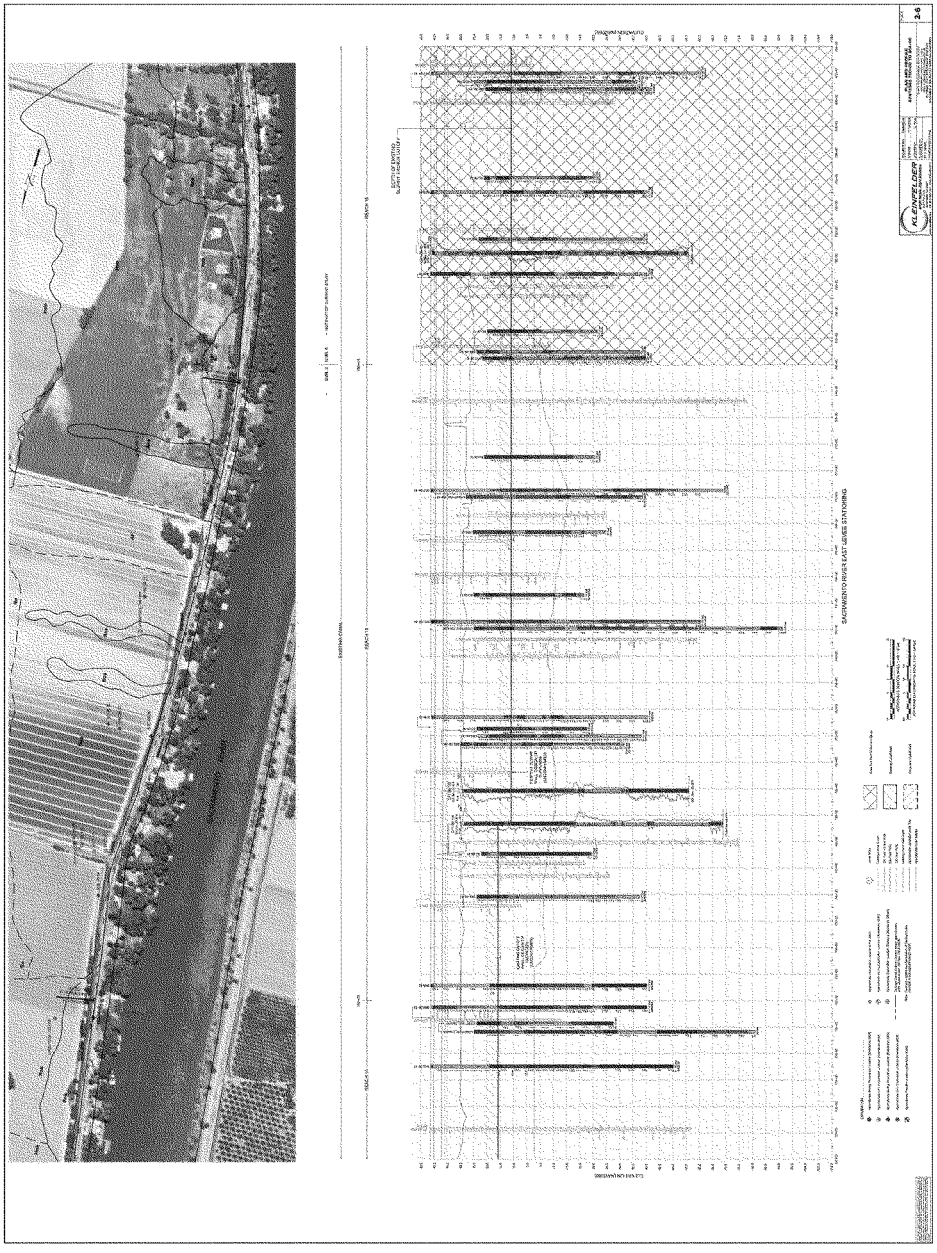
NATOMAS POST AUTHORIZATION CHANGE REPORT

ENCLOSURE F-1B (Part 2)

KLEINFELDER PLAN AND PROFILES







SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

GW	WELL-GRADED GRAVEL WITH OR/AND SAND WITH ABOUT 0 TO 5% FINES
GP	POORLY-GRADED GRAVEL WITH OR/AND SAND WITH ABOUT 0 TO 5% FINES
GW	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GP	POORLY-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GW-GM	WELL-GRADED GRAVEL WITH SILT WITH ABOUT 5 TO 12% SILT
GW-GC	WELL-GRADED GRAVEL WITH CLAY WITH ABOUT 5 TO 12% CLAY
GP-GM	POORLY-GRADED GRAVEL WITH OR/AND SILT WITH ABOUT 5 TO 12% SILT
GP-GC	POORLY-GRADED GRAVEL WITH OR/AND CLAY WITH ABOUT 5 TO 12% CLAY
GW-GM	WELL-GRADED GRAVEL WITH ABOUT 12 TO 50% FINES
GW-GC	WELL-GRADED GRAVEL WITH ABOUT 12 TO 50% CLAY
GP-GM	POORLY-GRADED GRAVEL WITH ABOUT 12 TO 50% SILT
GP-GC	POORLY-GRADED GRAVEL WITH ABOUT 12 TO 50% CLAY
GM	SILTY GRAVEL WITH ABOUT 12 TO 37% SILT
GM	SILTY GRAVEL WITH ABOUT 37 TO 50% SILT
GC	CLAYEY GRAVEL WITH ABOUT 12 TO 37% CLAY
GC	CLAYEY GRAVEL WITH ABOUT 37 TO 50% CLAY
GC-GM	CLAYEY GRAVEL SILTY GRAVEL WITH ABOUT 12 TO 37% SILT AND CLAY
GC-GM	CLAYEY GRAVEL SILTY GRAVEL WITH ABOUT 12 TO 50% SILT AND CLAY

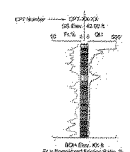
SW-SP	WELL-GRADED SAND WITH/ONLY GRAVEL SAND WITH ABOUT 0 TO 5% FINES
SW	WELL-GRADED SAND WITH ABOUT 5 TO 12% CLAY, 5 TO 12% SILT
SP	POORLY-GRADED SAND WITH ABOUT 5 TO 12% CLAY, 5 TO 12% SILT
SW-SM	WELL-GRADED SAND WITH ABOUT 5 TO 12% SILT
SW-SM	WELL-GRADED SAND WITH ABOUT 12 TO 37% SILT
SW-SC	WELL-GRADED SAND WITH ABOUT 5 TO 12% CLAY
SP-SM	POORLY-GRADED SAND WITH ABOUT 5 TO 12% SILT
SP-SM	POORLY-GRADED SAND WITH ABOUT 12 TO 37% SILT
SP-SC	POORLY-GRADED SAND WITH ABOUT 5 TO 12% CLAY
SM	SILTY SAND WITH ABOUT 12 TO 40% SILT
SC	CLAYEY SAND WITH ABOUT 12 TO 40% CLAY
SC-SM	SAND WITH ABOUT 12 TO 40% FINES WITH MIXED CLAY & SILT (ABOUT 40-60)

ML	INORGANIC SILT AND VERY FINE SAND, ROCK FLOUR, SILTY OR CLAYEY FINE SAND OR CLAYEY SILT WITH SLIGHT PLASTICITY
CL	INORGANIC CLAY OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
CL-ML	INORGANIC CLAYS, SILTS OF LOW PLASTICITY, SLIGHTLY PLASTIC SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM TO HIGH PLASTICITY

Notes:

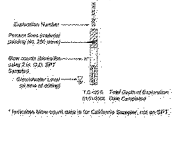
1. Base drawings for the Sacramento River East Levee Profile, obtained in August 2020 from the Sacramento District U.S. Army Corps of Engineers (USACE) and used with their permission, include stick logs of previous explorations and notes regarding levels before/most and completed levee improvements. Levee crown and toe profiles are based upon existing topographic mapping by the USACE with modifications conducted by Psomas for the Natomas Levee Improvement Program (NLIP) in 2016. All elevations for data prior to 2007 have been converted from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a +2.3 feet conversion factor as determined by Psomas for the NLIP (Psomas 2007) (0 feet NGVD29 = 2.3 feet NAVD88).
2. Logs of the following explorations were added to the USACE base drawings:
   a. Woodward 1975 borings (B-X);
   b. Kleinfelder 2002 borings and CPTs (NC-KNC-XX, NCPT-X);
   c. Kleinfelder 2003 (SNB-XX);
   d. Kleinfelder 2008 borings (SR5-08-XX);
   e. Kleinfelder 2008 borings (RC-08-XX);
   f. Kleinfelder 2008 CPTs (CPT-08-XX);
   g. Kleinfelder 2008 borings (SR5-08-XX);
   h. USACE 2008 borings (SF-09-XX);
   i. USACE 2008 borings and CPTs (SF-00-XXX, CPT-00-XCPT-00-XX);
   j. USACE 2007 borings (SF-07-XXX);
   k. URS 1956 borings (SF-BE-X);
   l. URS 1957 borings (SF-SP-X0F-97-XX);
   m. URS 2000 borings (SF-00-XXSPT-X);
   n. URS 2001 borings(SF-01-XX);
   o. URS 2007 borings and CPTs (URS CPT#00_XXX+(AA), (NCPT-X), (CXX);
   p. Wahler 1987 borings (DH-XUH-XX);
   q. Wahler 1988 borings (SH-X-X);
   r. Wahler 2007 CPTs (CPT-NX)
   s. Espana 1994 borings (E-X);
   t. Espana 2002 borings (NW-XX);
   u. Cathrea 1999 borings (B-X/B-XX)
3. The locations of the explorations shown are approximate. See Plates 1-3 through 1-45 for approximate plan locations.
4. The log legend shown applies to Kleinfelder borings and CPTs. Caution is advised in using the legend for interpretation of other explorations.
5. Logs represent general soil conditions observed at the point of exploration on the date indicated. No warranty is provided as to the continuity of soil conditions between individual sample locations.
6. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
7. Boring and CPT elevations were estimated using revised topographic data provided by Psomas (2007).
8. The HDD and 200-Year design water surface elevation profiles shown were provided by MBK Engineers in a report dated Dec. 13, 2008. See report for an explanation of these profiles and conditions.
9. Details regarding completed levee improvements have been added to those already on the USACE levee profile base drawing and were obtained from USACE. Extents of completed levee improvements shown are approximate and are the same as indicated on the USACE profiles. Refer to USACE as-built drawings for actual extents.

CPT LEGEND



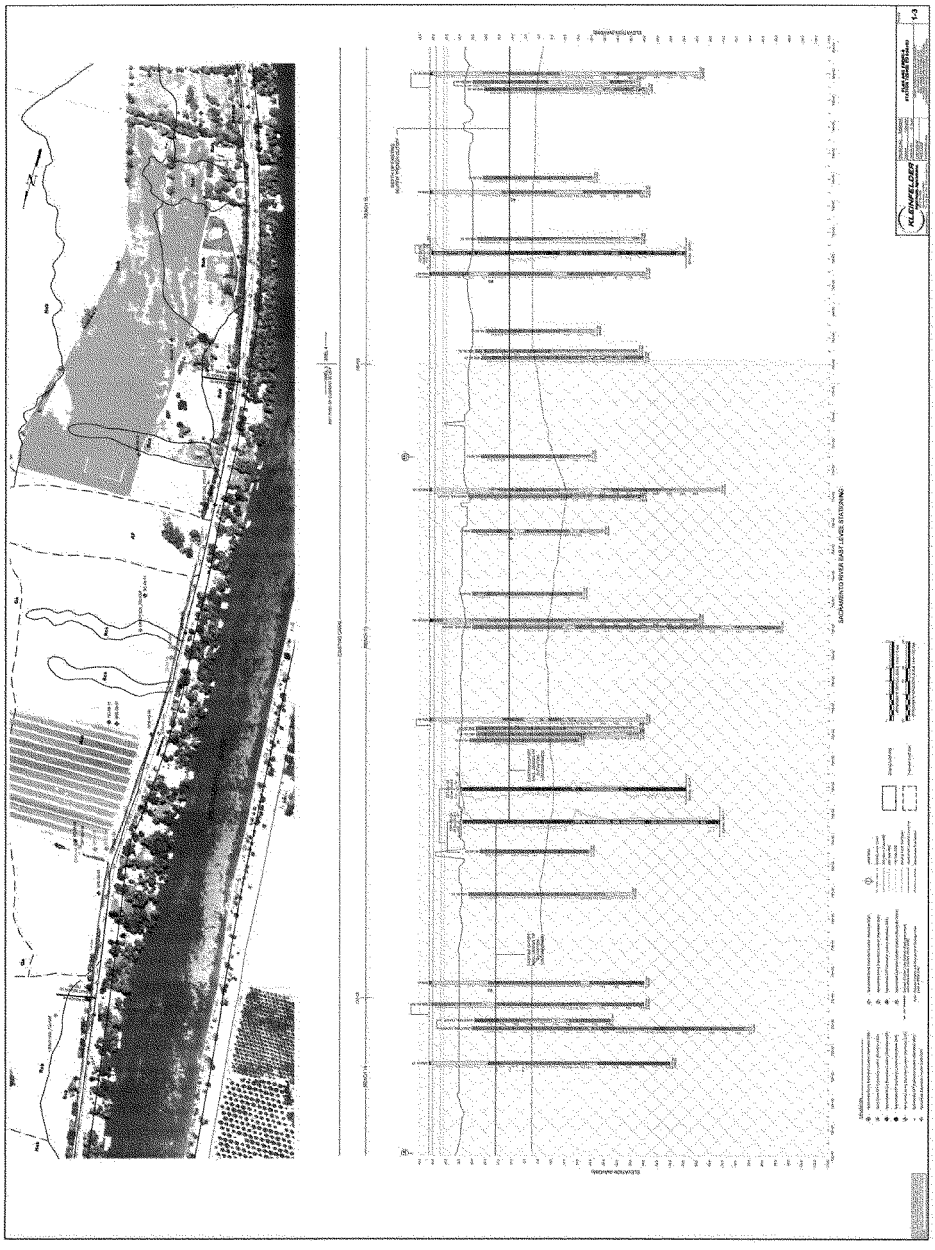
Zone	SBTn (Robertson, 1990)
1	sensitive fine-grained
2	organic material
3	clay to silty clay
4	clayey silt to silty clay
5	silty sand to sandy silt
6	clean sands to silty sands
7	gravelly sand to sand
8	very dense sand to clayey sand
9	very stiff fine-grained

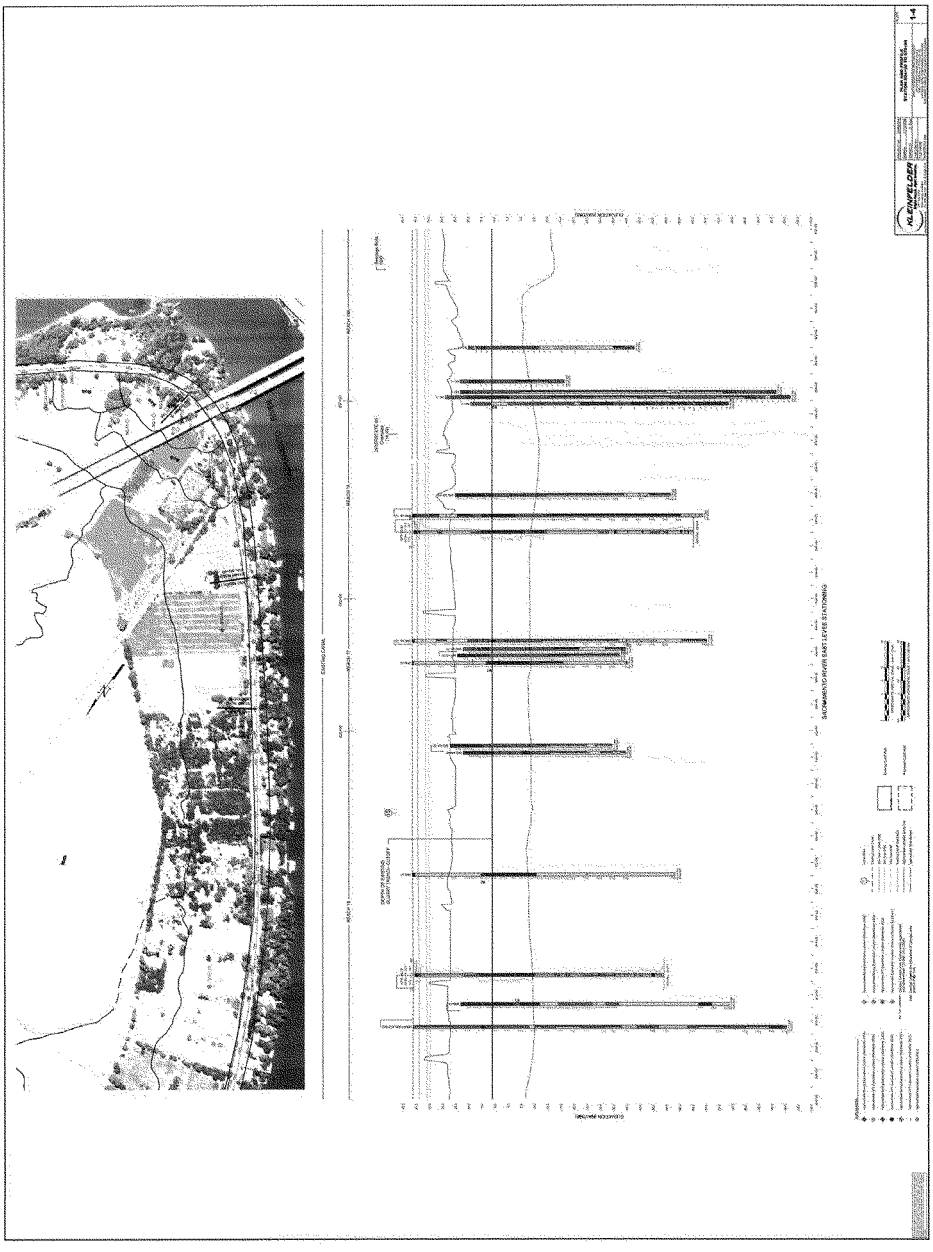
LOG LEGEND

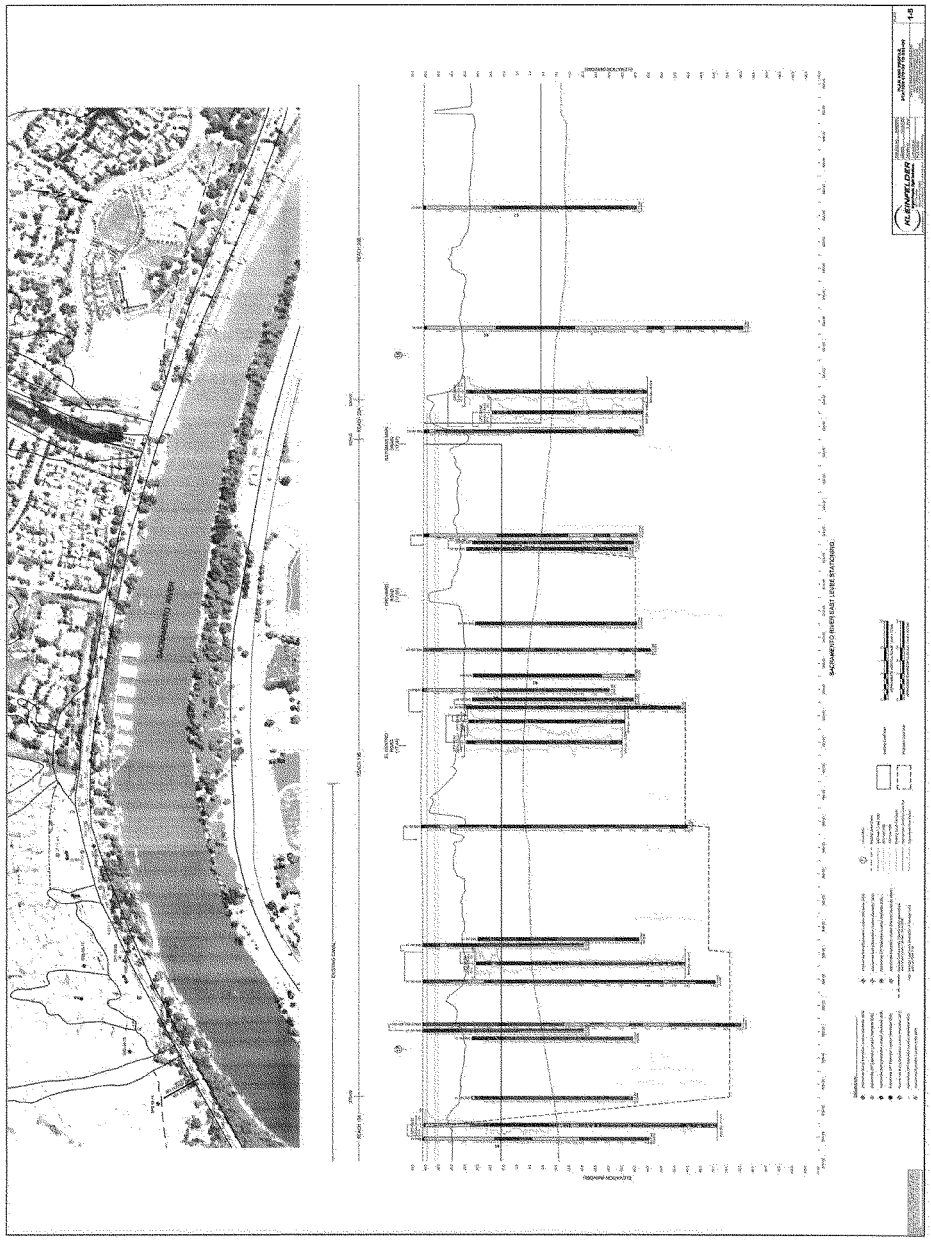


* Penetration blow count data is for California Sampler, not an SPT.

KLEINFELDER
Kleinfelder Western, Inc.
1-2







SACRAMENTO RIVER
ELEVATION (METERS)
KLEINFELDER

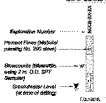
SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

GW	WELL-GRADED GRAVEL WITH OR WITHOUT SAND, LITTLE OR NO FINES WITH ABOUT 0-10% FINES
GP	POORLY-GRADED GRAVEL WITH OR WITHOUT SAND, LITTLE OR NO FINES WITH ABOUT 0-10% FINES
GW	WELL-GRADED GRAVEL WITH ABOUT 0-10% FINES
GP	POORLY-GRADED GRAVEL WITH ABOUT 0-10% FINES
GW-GM	WELL-GRADED GRAVEL WITH OR WITHOUT SAND, WITH OR WITHOUT 0-10% SILT
GW-GC	WELL-GRADED GRAVEL WITH OR WITHOUT SAND, WITH OR WITHOUT 0-10% CLAY
GP-GM	POORLY-GRADED GRAVEL WITH OR WITHOUT SAND, WITH OR WITHOUT 0-10% SILT
GP-GC	POORLY-GRADED GRAVEL WITH OR WITHOUT SAND, WITH OR WITHOUT 0-10% CLAY
GW-GM	WELL-GRADED GRAVEL WITH ABOUT 0-10% SILT
GW-GC	WELL-GRADED GRAVEL WITH ABOUT 0-10% CLAY
GP-GM	POORLY-GRADED GRAVEL WITH OR WITHOUT SAND, WITH ABOUT 0-10% SILT
GP-GC	POORLY-GRADED GRAVEL WITH OR WITHOUT SAND, WITH ABOUT 0-10% CLAY
GM	SILTY GRAVEL WITH ABOUT 0-10% FINES
GM	SILTY GRAVEL WITH ABOUT 10-40% SILT
GC	CLAYEY GRAVEL WITH ABOUT 0-10% CLAY
GC	CLAYEY GRAVEL WITH ABOUT 10-40% CLAY
GC/GM	CLAYEY GRAVEL TO GRAVEL WITH ABOUT 0-10% CLAY TO SILT
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 10-40% SILT/CLAY

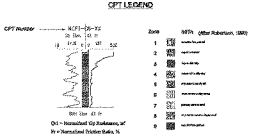
SW-SP	WELL-GRADED SAND TO POORLY-GRADED SAND WITH ABOUT 0-10% CLAY
SW	WELL-GRADED SAND WITH ABOUT 0-10% SILT 0-4% CLAY
SP	POORLY-GRADED SAND WITH ABOUT 0-10% SILT 0-4% CLAY
SW-SM	WELL-GRADED SAND TO SILTY SAND WITH ABOUT 0-10% SILT
SW-SM	WELL-GRADED SAND WITH ABOUT 0-10% SILT
SW-SC	WELL-GRADED SAND WITH ABOUT 0-10% CLAY
SP-SM	POORLY-GRADED SAND WITH ABOUT 0-10% SILT
SP-SM	POORLY-GRADED SAND TO SILTY SAND WITH ABOUT 0-10% SILT
SP-SC	POORLY-GRADED SAND WITH ABOUT 0 - 10% CLAY
SM	SILTY SAND WITH ABOUT 10 - 40% SILT
SC	CLAYEY SAND WITH ABOUT 0 - 10% CLAY

ML	INORGANIC SILTS AND VERY FINE SANDS, SILT OR ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
CL-ML	INORGANIC CLAYS AND SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM TO HIGH PLASTICITY

LOG LEGEND



CPT LEGEND



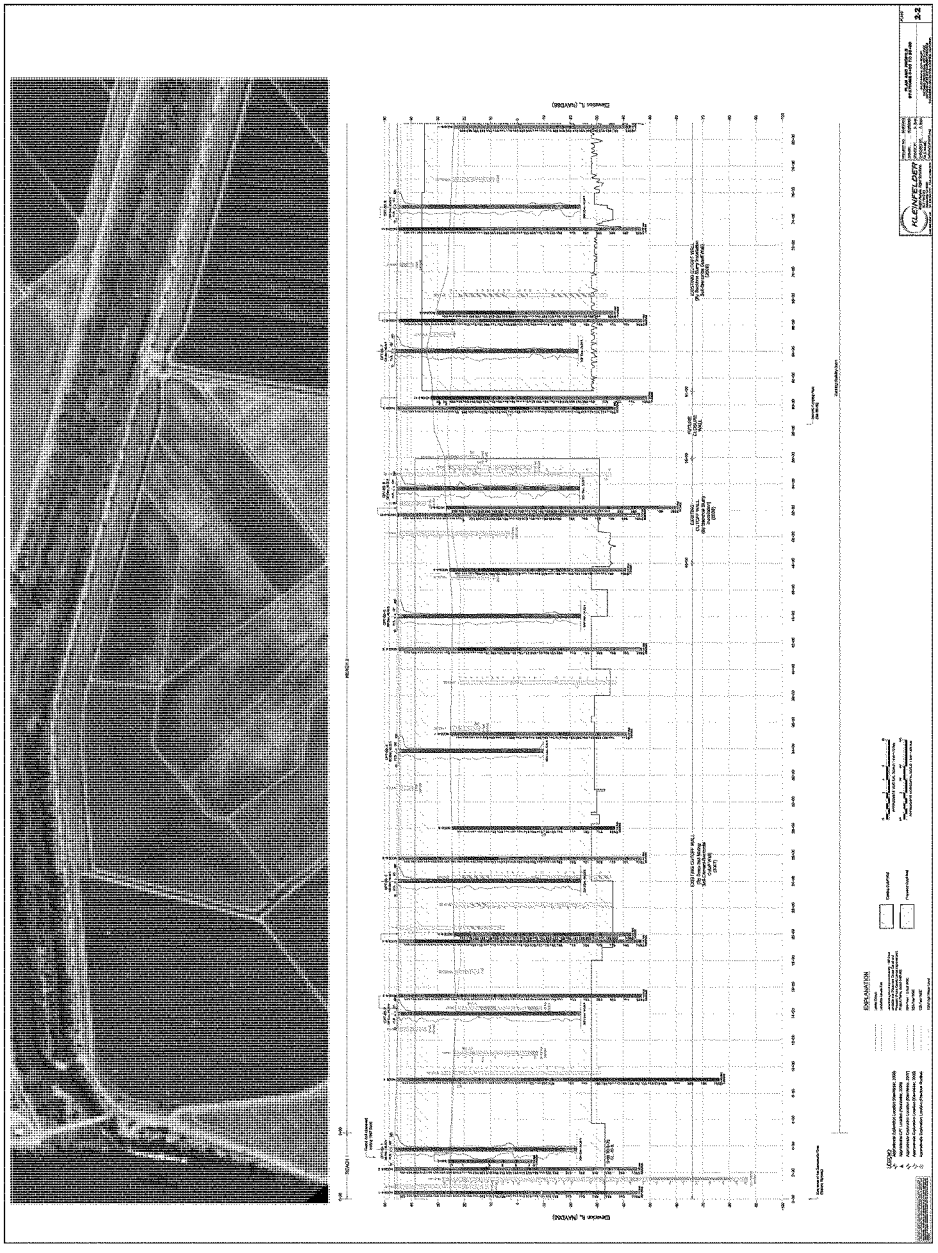
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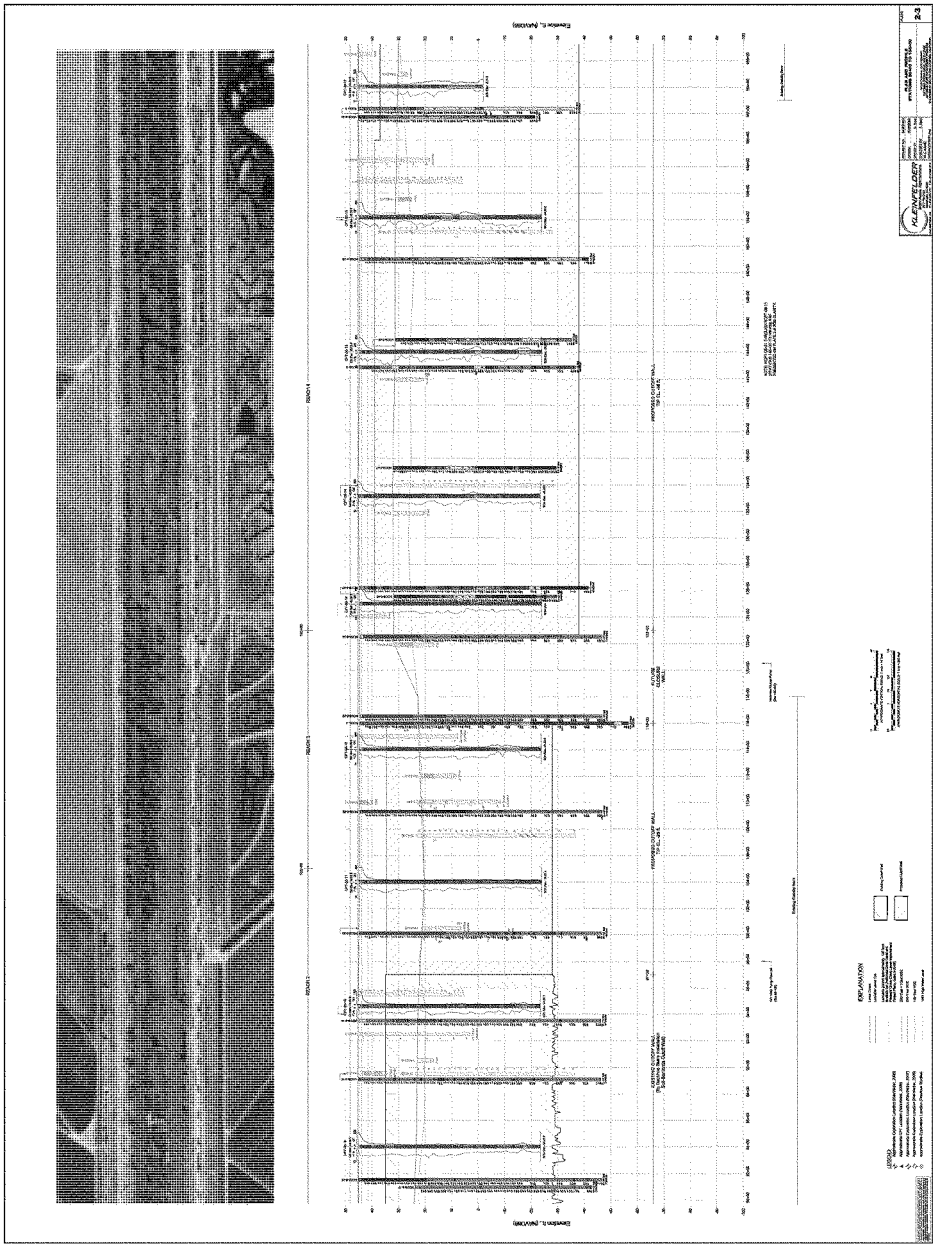
1. Base drawings for these levee profiles, obtained in August 2006 from the Sacramento District U.S. Army Corps of Engineers (USACE) and used with their permission, include stick logs of previous explorations, a levee crown profile, a landside levee toe profile, notes regarding levee performance and completed and planned levee improvements, and elevation scale based on the National Geodetic Vertical Datum 1929 (NGVD29). These drawings were converted to the North American Vertical Datum of 1988 (NAVD88) by adding 2.3 feet to the NGVD29. (If NGVD29 = 2.3' NAVD88).
2. Logs of the following explorations were added to the USACE base drawings: Kleinfelder 2006 borings (NCCD-06-XX) and CPTs (NCPT-06-XX), Kleinfelder 2006 and 2007 borings (NCCB-B-XX); Kleinfelder 2005 borings (NCCB-XX); Kleinfelder 2003/2004 Borings S-03-5, S-03-6, S-03-7, S-04-2, and S-04-6; Kleinfelder 1998 Borings BNCC-##and Test Pits TP-NCC-##. Interpreted Logs of CPTs conducted by USACE (CPT-00-XX) were developed from available hard copies or interpreted data.
3. Kleinfelder drilled 66 borings between stations 57+00 and 278+00 in 2006 designated NCCL-06-XX. These borings were drilled to evaluate reuse of levee degrade material and did not extend through the levee. Therefore these borings have been omitted from the cross sections for clarity.
4. Locations of explorations shown are approximate.
5. The log legend shown applies to Kleinfelder 2006 borings (NCCB-XX), Kleinfelder 2006 and 2007 borings (NCCB-B-XX), and Kleinfelder 2003 borings (NCCB-S5-XX). Caution is advised in using the legend for interpretation of other explorations.
6. The CPT legend shown was applied to USACE CPTs (CPT-00-XX) and Kleinfelder CPTs (NCPT-06-XX). Caution is advised in using the legend for other explorations.
7. Logs represent general soil conditions observed at the point of exploration on the date indicated. Refer to Kleinfelder's 2006 report and Kleinfelder's 2007 report for more detail on Kleinfelder 2006 borings (NCCB-XX) and Kleinfelder 2006 and 2007 borings (NCCB-B-XX), respectively.
8. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
9. No warranty is provided as to the continuity of soil conditions between individual sample locations.
10. Approximate top of boring elevations for Kleinfelder 2006 through 2009 explorations were obtained using GPS equipment/survey; Kleinfelder 2005 borings (NCCB-XX) were estimated using topographic data obtained by USACE 1997.
11. The 100-Year and 200-Year design water surface profiles shown were provided by MBK Engineers on Dec. 12, 2008.
12. Details regarding completed levee improvements have been added based upon data obtained from USACE and are approximate.

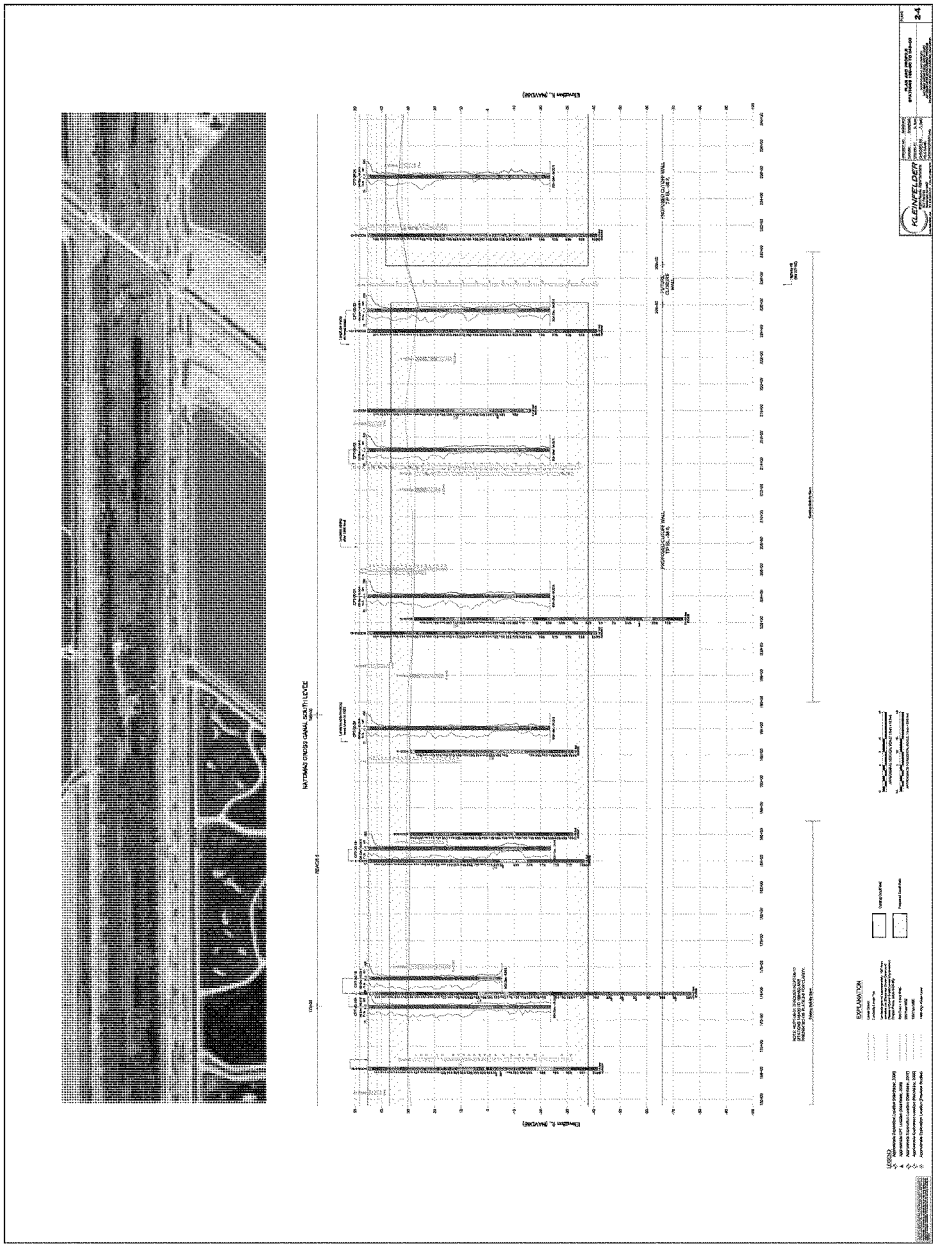
KLEINFELDER

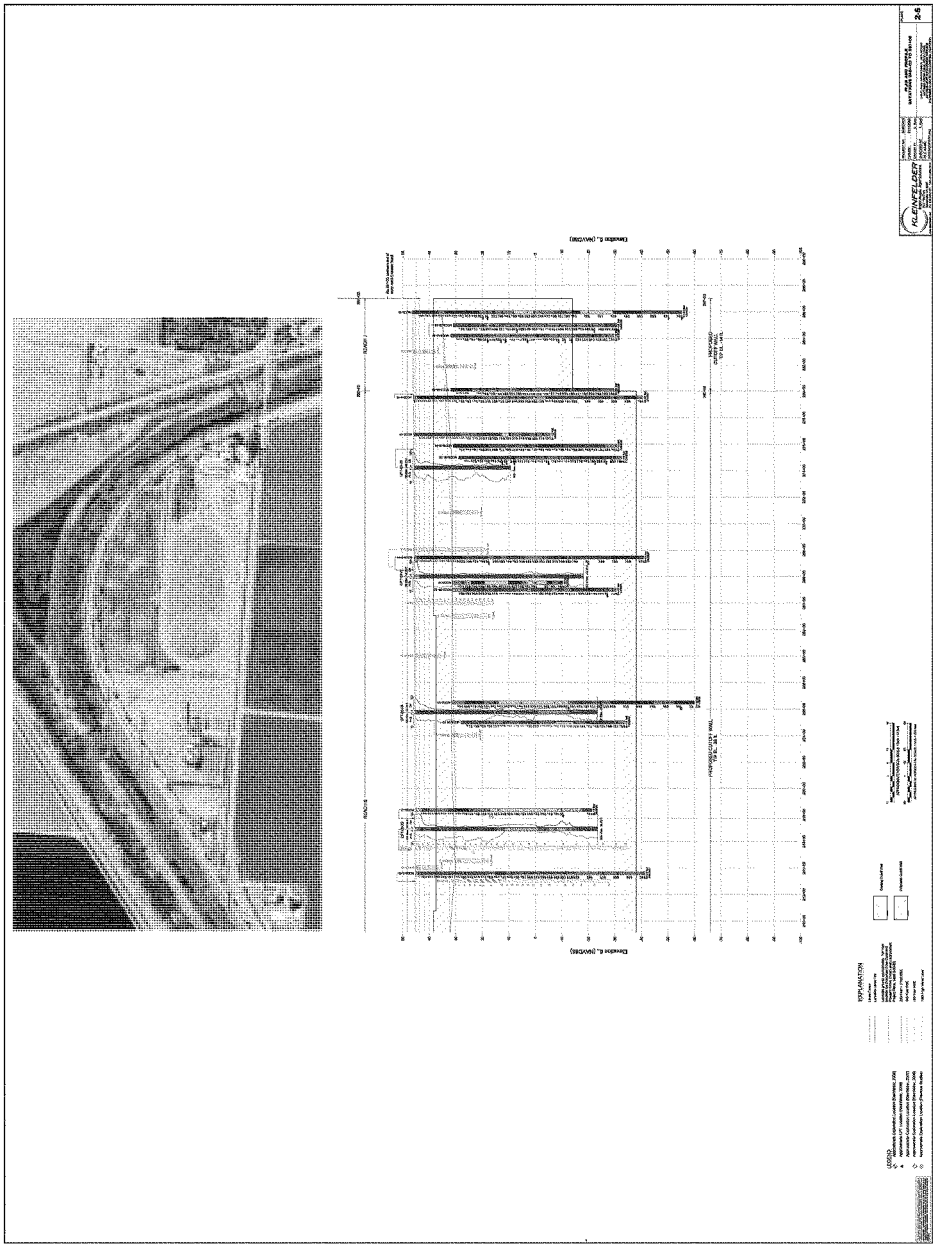
PLAN AND PROFILE SHEET LEGEND AND NOTES

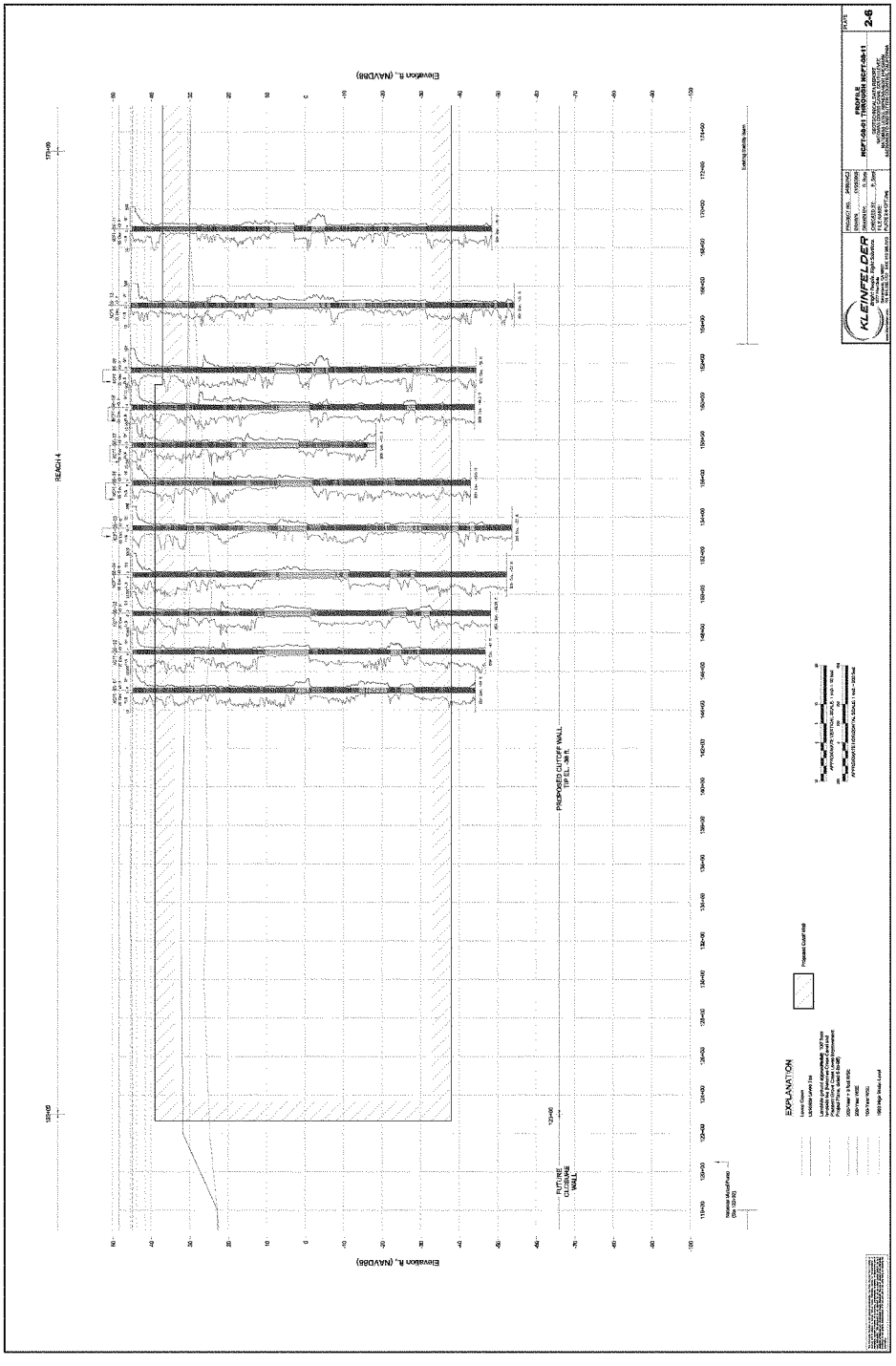
PLATE 2-1










REACH 4
PROPOSED CUTOFF WALL
EXPLANATION
Elevation ft., (NAVD88)

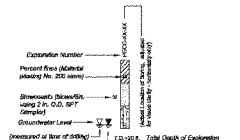
SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

GW	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 0 TO 4% FINES
GP	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 0 TO 4% FINES
GW	WELL-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES
GP	POORLY-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES
GW-GM	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GW-GC	WELL-GRADED GRAVEL W/ COBBLES WITH ABOUT 5 TO 12% FINES
GP-GM	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GP-GC	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GW-GM	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GW-GC	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GP-GM	POORLY-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GP-GC	POORLY-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GM	SILTY GRAVEL WITH ABOUT 12 TO 17% FINES
GM	SILTY GRAVEL WITH ABOUT 18 TO 49% FINES
GC	CLAYEY GRAVEL WITH ABOUT 12 TO 17% FINES
GC	CLAYEY GRAVEL WITH ABOUT 18 TO 49% FINES
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 12 TO 17% FINES
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 18 TO 49% FINES

SW-SP	WELL-GRADED SAND/POORLY GRADED SAND WITH ABOUT 5 TO 4% CLAY
SW	WELL-GRADED SAND WITH ABOUT 0 - 2% CLAY 0 - 4% SILT
SP	POORLY-GRADED SAND WITH ABOUT 0 - 2% CLAY 0 - 4% SILT
SW-SM	WELL-GRADED SAND WITH ABOUT 5 TO 7% SILT
SW-SM	WELL-GRADED SAND WITH ABOUT 5 TO 12% SILT
SW-SC	WELL-GRADED SAND WITH ABOUT 5 TO 12% CLAY
SP-SM	POORLY GRADED SAND WITH ABOUT 5 TO 7% SILT
SP-SM	POORLY-GRADED SAND WITH ABOUT 5 TO 12% SILT
SP-SC	POORLY-GRADED SAND WITH ABOUT 5 - 12% CLAY
SM	SILTY SAND WITH ABOUT 13 - 49% SILT
SC	CLAYEY SAND WITH ABOUT 13 - 49% CLAY
SC-SM	SAND WITH ABOUT 13 TO 49% LOW PLASTIC FINES THAT CLASSIFY AS CL-ML

ML	INORGANIC SILTS AND VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
CL-ML	INORGANIC CLAYS-SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY

LOG LEGEND

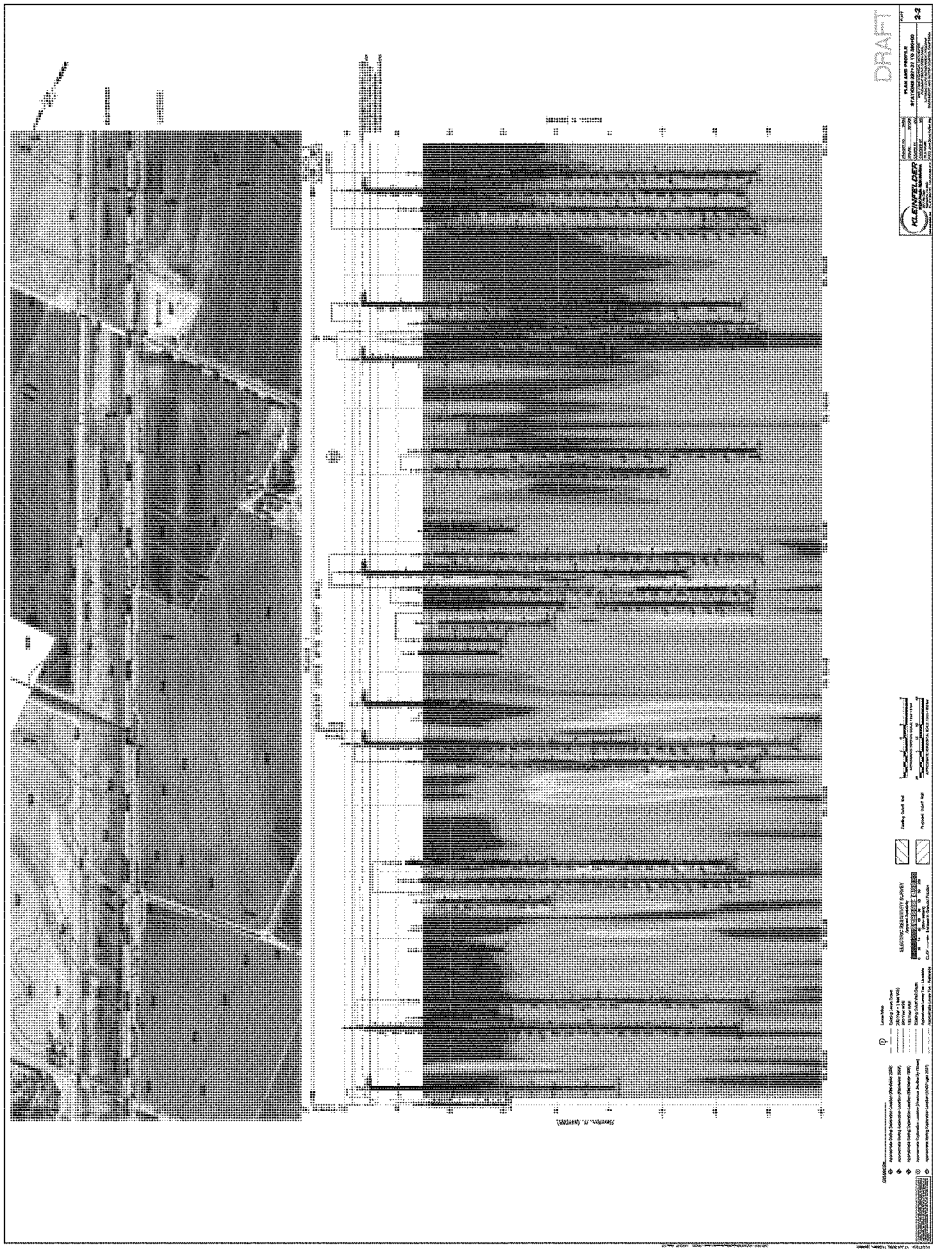


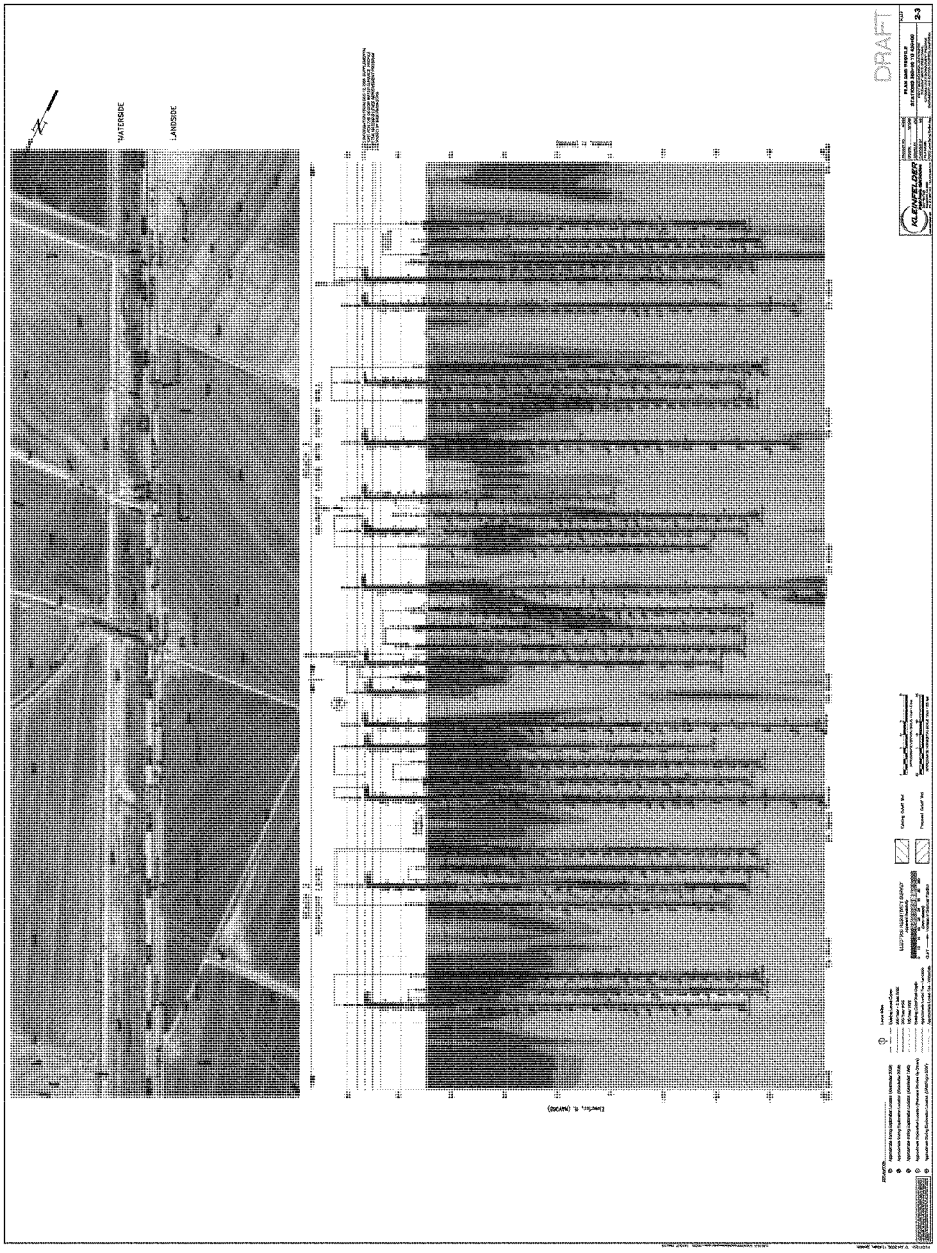
* Indicates blow count data is for California Sampler (2.5" ID), not an SPT.
** Indicates blows per 12" using 2" O.D. SPT Sampler.

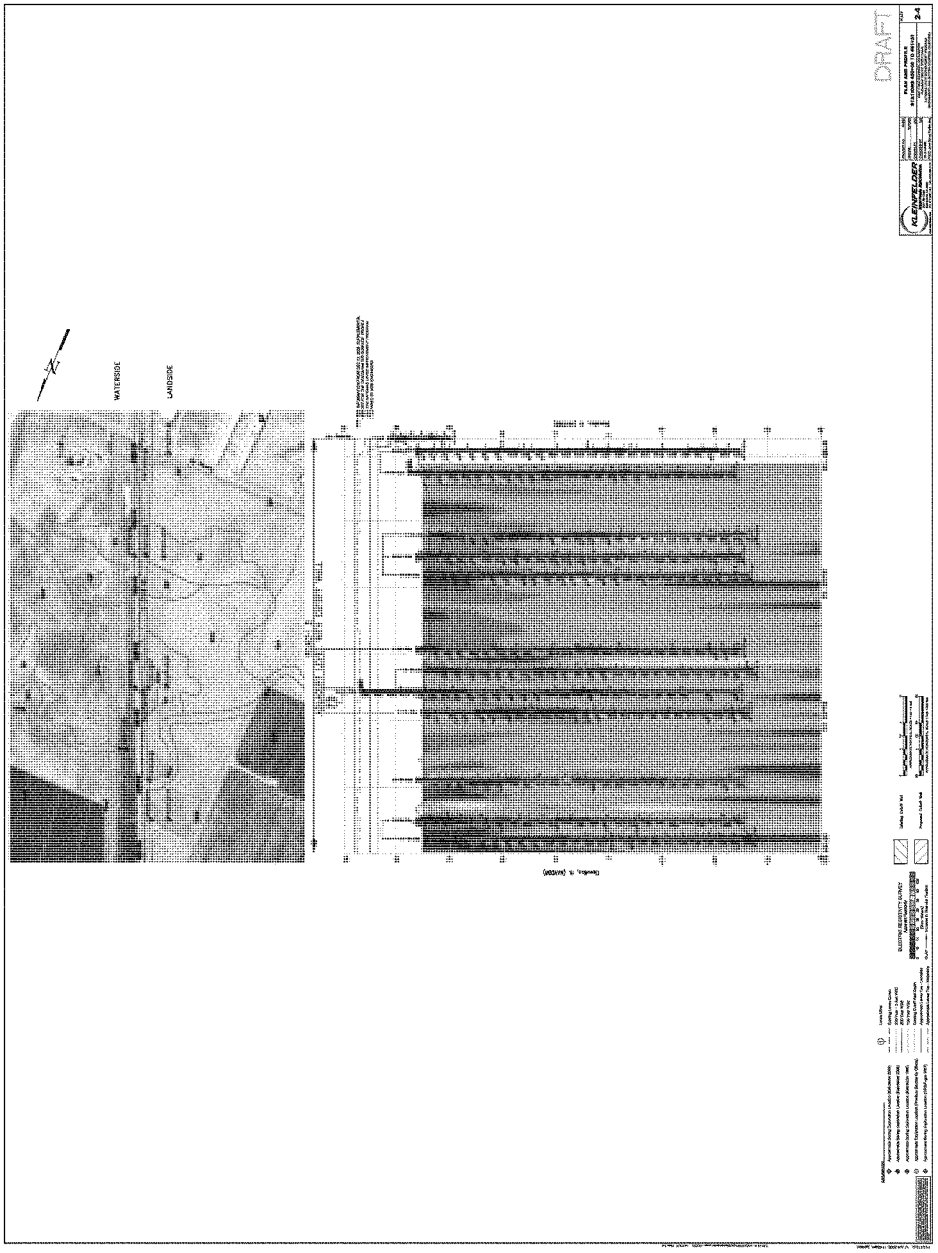
NOTES:

1. Levee crown and toe profiles are based upon existing topographic mapping by Psomas for the Natomas Levee Improvement Program (NLIP) in 2000. All elevations for data prior to 2007 have been converted from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a +2.28 feet conversion factor as determined by Psomas for the NLIP (Psomas 2007) (0 feet NGVD29 = 2.28 feet NAVD88).
2. Logs of the following explorations were added to the USACE base drawings:
   a. Kleinfelder 2000 borings (PGCC-00-XX),
   b. Kleinfelder 2006 borings (PGCC-06-XX),
   c. Kleinfelder 1996 borings (BPGCC-XX,
   d. URS/Fugro 2007 borings (WR1096_2007),
   e. Woodward 1987 borings (DP-XX), and
   f. Beverfoot borings 2006 (B-94-XX).
3. The locations of the explorations shown are approximate. See Plates 2-1 through 2-4 for approximate plan location.
4. The log legend shown applies to Kleinfelder 2006 and 2009 borings . Caution is advised in using this legend for interpretation of other explorations.
5. Logs represent general soil conditions observed at the point of exploration on the date indicated.
6. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
7. No warranty is provided as to the continuity of soil conditions between individual sample locations.
8. Approximate top of boring elevations for Kleinfelder 2006 and 2009 borings were estimated using revised topographic data provided by Psomas.
9. Location of Kleinfelder 1996 borings are approximate.
10. The 100-year and 200-year design water surface profiles shown were provided by MBK Engineers in a report dated Dec. 12, 2008.

DRAFT


DRAFT


WATERSIDE
LANDSIDE
DRAFT


DRAFT
WATERSIDE
LANDSIDE
KLEINFELDER

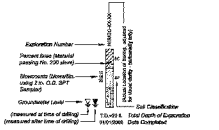
SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

GW	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 0 TO 4% FINES
GP	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 0 TO 4% FINES
GW	WELL-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES
GP	POORLY-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES
GW-GM	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GW-GC	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GP-GM	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GP-GC	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GW-GM	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GW-GC	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GP-GM	POORLY-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GP-GC	POORLY-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GM	SILTY GRAVEL WITH ABOUT 12 TO 17% FINES
GM	SILTY GRAVEL WITH ABOUT 18 TO 49% FINES
GC	CLAYEY GRAVEL WITH ABOUT 12 TO 17% FINES
GC	CLAYEY GRAVEL WITH ABOUT 18 TO 49% FINES
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 12 TO 17% FINES
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 18 TO 49% FINES

SW-SP	WELL-GRADED SAND/POORLY GRADED SAND WITH ABOUT 3 TO 4% CLAY
SW	WELL-GRADED SAND WITH ABOUT 0 - 2% CLAY 0 - 4% SILT
SP	POORLY-GRADED SAND WITH ABOUT 0 - 2% CLAY 0 - 4% SILT
SW-SM	WELL-GRADED SAND WITH ABOUT 5 TO 7% SILT
SW-SM	WELL-GRADED SAND WITH ABOUT 8 TO 12% SILT
SW-SC	WELL-GRADED SAND WITH ABOUT 5 TO 12% CLAY
SP-SM	POORLY-GRADED SAND WITH ABOUT 5 TO 7% SILT
SP-SM	POORLY-GRADED SAND WITH ABOUT 8 TO 12% SILT
SP-SC	POORLY-GRADED SAND WITH ABOUT 5 - 12% CLAY
SM	SILTY SAND WITH ABOUT 13 - 49% SILT
SC	CLAYEY SAND WITH ABOUT 13 - 49% CLAY
SC-SM	SAND WITH ABOUT 13 TO 49% LOW PLASTIC FINES THAT CLASSIFY AS CL-ML

ML	INORGANIC SILTS AND VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
CL-ML	INORGANIC CLAYS-SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY

LOG LEGEND



* Indicates blow count data is for California Sampler (2.5" ID), not an SPT

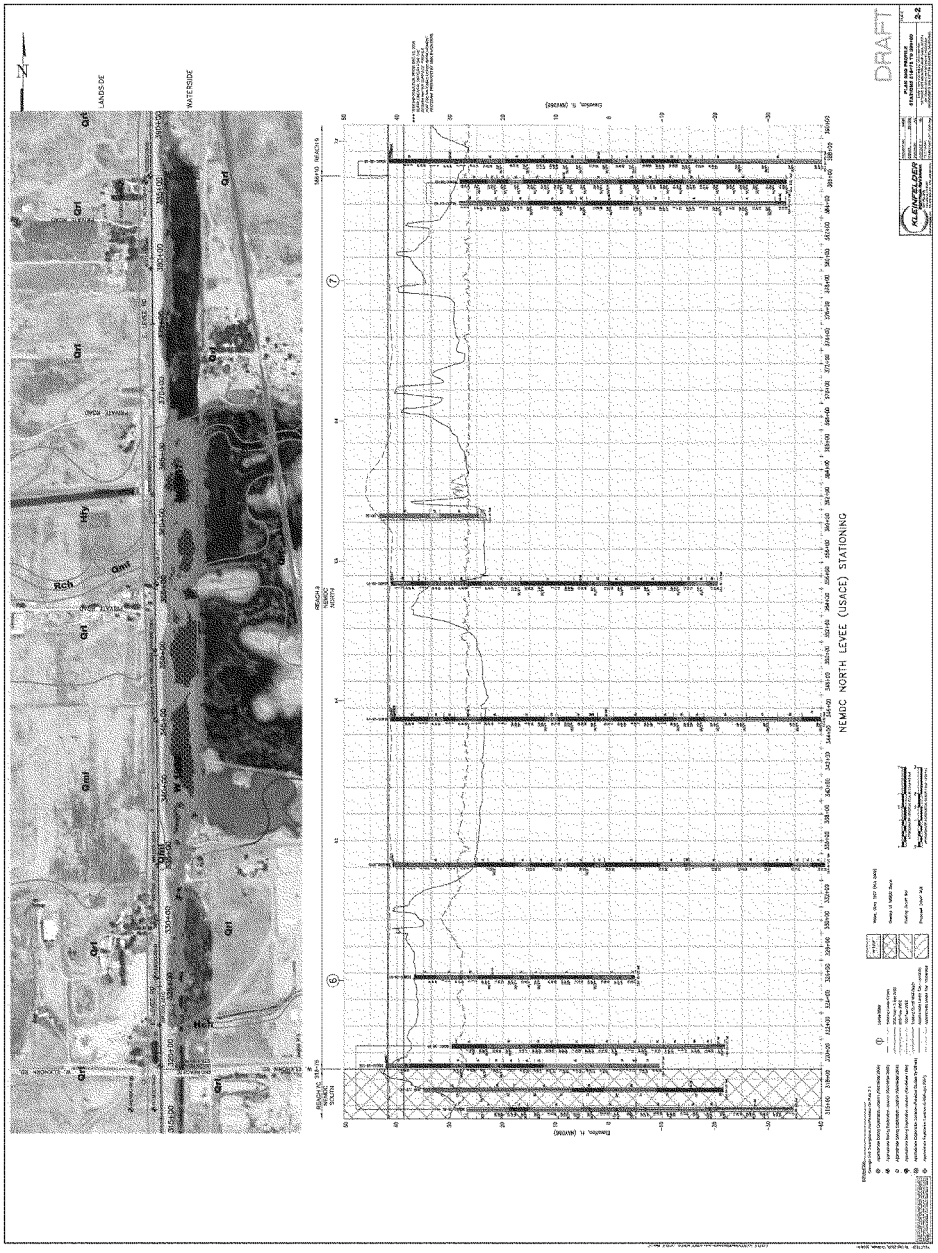
NOTES:

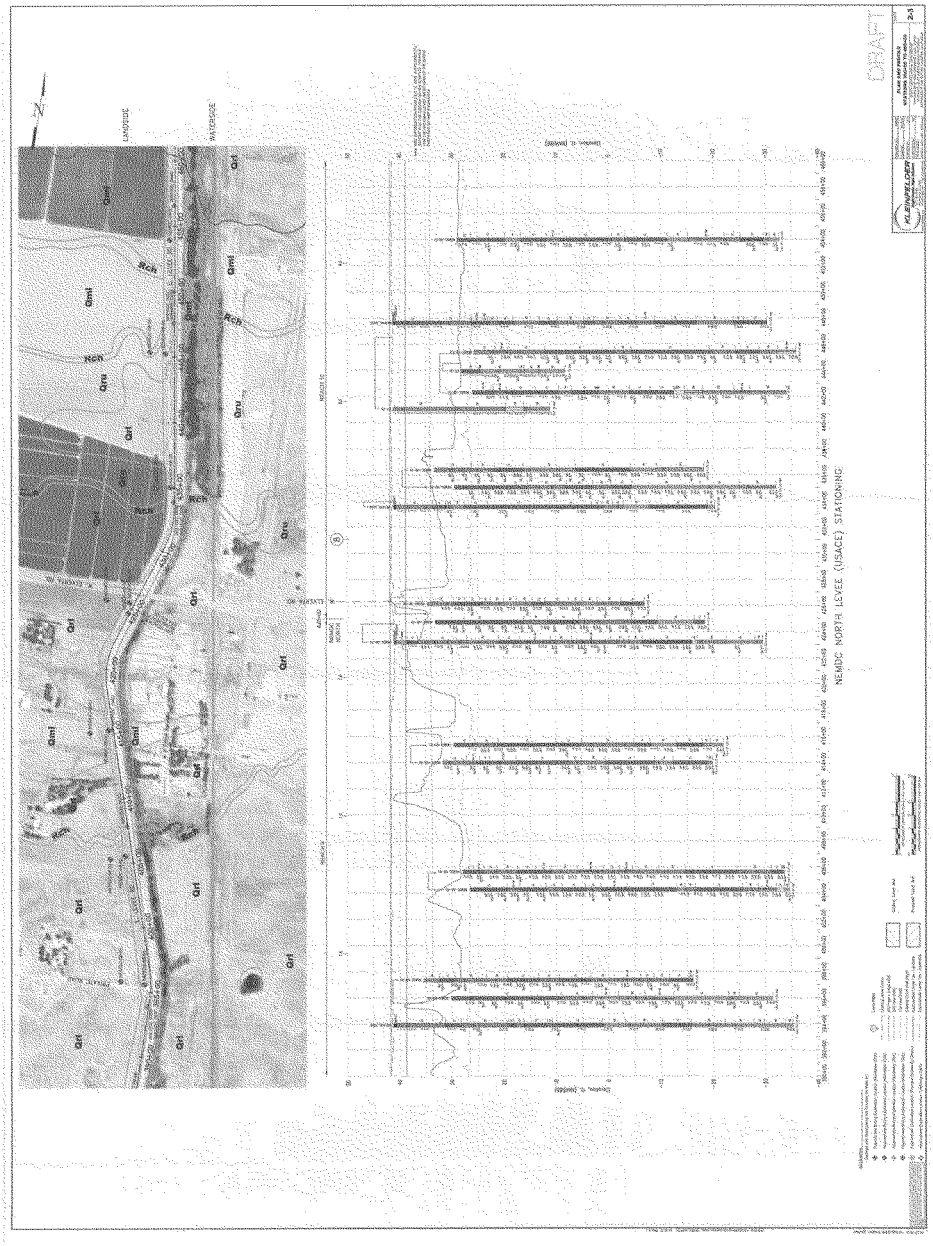
1. Levee crown and toe profiles are based on existing topographic mapping by Pesmes for the Natomas Levee Improvement Program (NLIP) in 2006. All elevations for data prior to 2009 have been converted from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a +2.29 foot conversion factor as determined by Pesmes for the NLIP (Pesmes 2006) (0 feet NGVD29 = 2.29 feet NAVD88).
2. Logs of the following explorations were added to the USACE base drawings:
   a. Kleinfelder 2006 borings (NEMCC-06-XX),
   b. Kleinfelder 2008 borings (NEMCC-08-XX),
   c. Kleinfelder 2004 borings (LWW 2004-10),
   d. Kleinfelder 1998 boring (BP-06C-S),
   e. URS/Fugro 2007 borings (WR1000_XXXS), (WR1000_XXXC), and (WR1000_XXXM). "C" and "M" explorations appear in PlanView, but not on Profile View.
   f. Wahler 1997 borings (GH-XX)
3. The locations of the explorations shown are approximate. See Plates 2-2 through 2-6 for approximate plan location.
4. The log legend shown applies to Kleinfelder 1998, 2004, 2006, and 2008 borings . Caution is advised in using the legend for interpretation of other explorations.
5. Logs represent general soil conditions observed at the point of exploration on the date indicated.
6. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
7. No warranty is provided as to the continuity of soil conditions between individual sample locations.
8. Approximate top of boring elevations for Kleinfelder 1998, 2004, 2006, and 2008 borings were estimated using revised topographic data provided by Pesmes.
9. The 100-year and 200-year design water surface profiles shown were provided by MBK Engineers in a report dated Dec. 12, 2008.
10. Vertical and lateral extents of the proposed cutoff walls shown are for description purposes only. Actual limits will be defined during final design if a cutoff wall alternative is selected.

DRAFT

KLEINFELDER	DESIGNED	DATE	PLAN AND PROFILE LEGEND AND NOTES
	DRAWN	DATE	
	CHECKED	DATE	
	PROJECT MGR	DATE	
	QA/QC	DATE	

PLATE 2-1


LANDSIDE
WATERSIDE
Qrf
Qmf
Rch
Hfy
Qmt
Hmt
NEMDC NORTH LEVEE (USACE) STATIONING
DRAFT

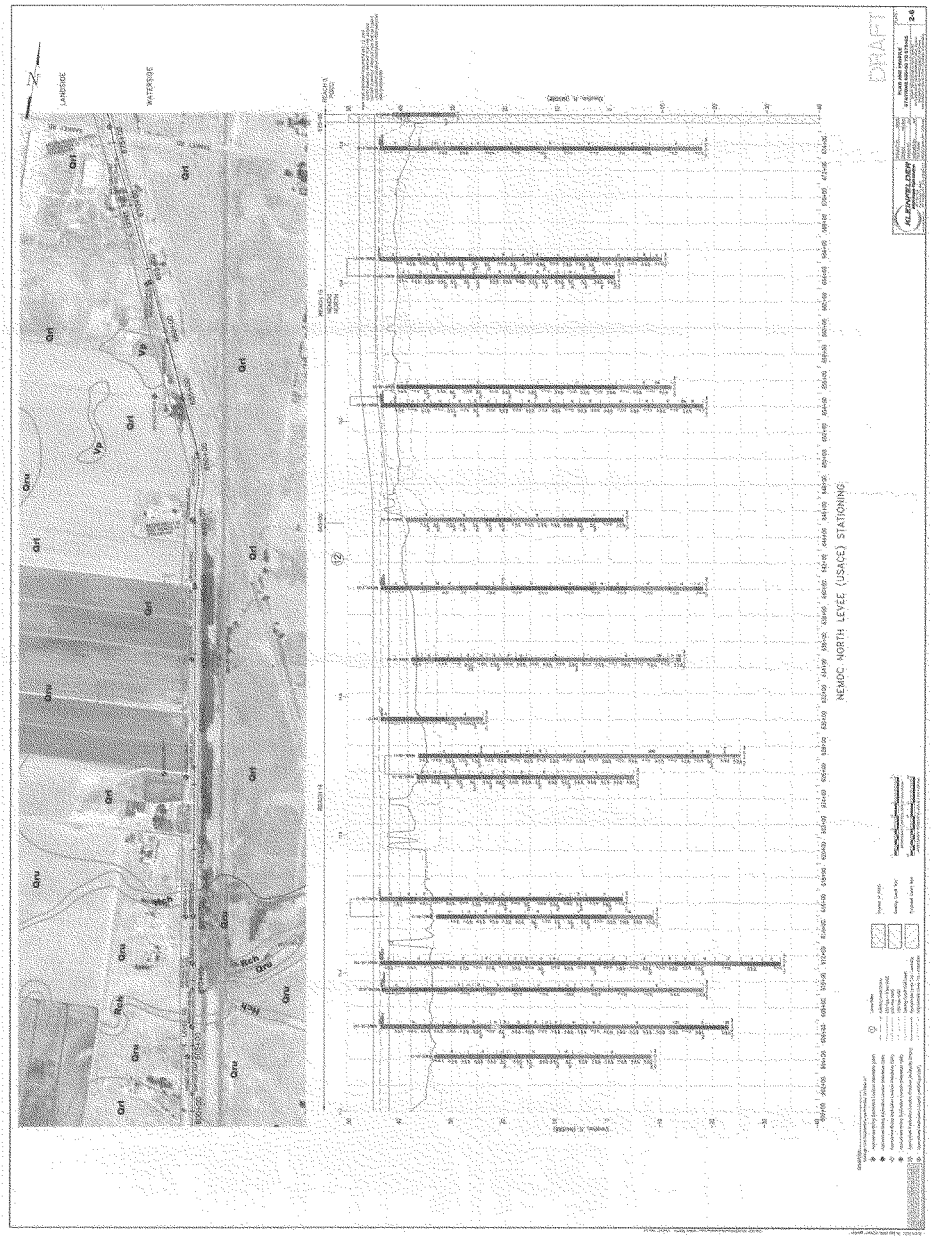

DRAFT
NEMDC NORTH LEVEE (USACE) STATIONING
LANDSIDE
WATERSIDE
KLEINFELDER

AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

NATOMAS POST AUTHORIZATION CHANGE REPORT

ENCLOSURE F-1B (Part 3)

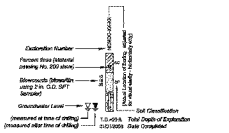
KLEINFELDER PLAN AND PROFILES


LANDSIDE
WATERSIDE
NEMDC NORTH LEVEE (USACE) STATIONING
DRAFT

SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

GW	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 0 TO 4% FINES	SW-SP	WELL-GRADED SAND/POORLY GRADED SAND WITH ABOUT 3 TO 4% CLAY	ML	INORGANIC SILTS AND VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, SILTS WITH SLIGHT PLASTICITY
GP	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 0 TO 4% FINES	SW	WELL-GRADED SAND WITH ABOUT 0 - 2% CLAY 0 - 4% SILT	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
GW	WELL-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES	SP	POORLY-GRADED SAND WITH ABOUT 0 - 2% CLAY 0 - 4% SILT	CL-ML	INORGANIC CLAYS-SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
GP	POORLY-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES	SW-SM	WELL-GRADED SAND WITH ABOUT 5 TO 7% SILT	OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
GW-GM	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES	SW-SM	WELL GRADED SAND WITH ABOUT 6 TO 12% SILT	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
GW-GC	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 6 TO 12% FINES	SW-SC	WELL-GRADED SAND WITH ABOUT 6 TO 12% CLAY	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
GP-GM	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES	SP-SM	POORLY-GRADED SAND WITH ABOUT 5 TO 7% SILT	OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY
GP-GC	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 6 TO 12% FINES	SP-SM	POORLY-GRADED SAND WITH ABOUT 6 TO 12% SILT		
GW-GM	WELL-GRADED GRAVEL WITH ABOUT 6 TO 12% FINES	SP-SC	POORLY-GRADED SAND WITH ABOUT 6 - 12% CLAY		
GW-GC	WELL-GRADED GRAVEL WITH ABOUT 6 TO 12% FINES	SM	SILTY SAND WITH ABOUT 13 - 49% SILT		
GP-GM	POORLY-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES	SC	CLAYEY SAND WITH ABOUT 13 - 40% CLAY		
GP-GC	POORLY-GRADED GRAVEL WITH ABOUT 6 TO 12% FINES	SC-SM	SAND WITH ABOUT 13 TO 45% LOW PLASTIC FINES THAT CLASSIFY AS CL-ML		
GM	SILTY GRAVEL WITH ABOUT 12 TO 17% FINES				
GM	SILTY GRAVEL WITH ABOUT 18 TO 49% FINES				
GC	CLAYEY GRAVEL WITH ABOUT 12 TO 17% FINES				
GC	CLAYEY GRAVEL WITH ABOUT 18 TO 49% FINES				
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 12 TO 17% FINES				
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 18 TO 49% FINES				

LOG LEGEND



* Indicates blow count data is for California Sampler (2.5" ID), not an SPT

NOTES:

1. Levee crown and toe profiles are based on existing topographic mapping by Psomas for the Natomas Levee Improvement Program (NLIP) in 2009. All elevations for data prior to 2009 have been converted from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a +2.28 feet conversion factor as determined by Psomas for the NLIP (Psomas 2009) (0 feet NGVD29 = 2.28 feet NAVD88).
2. Logs of the following explorations were added to the USACE base drawings:
   a. Kleinfelder 2009 borings (NEMDC-09-XX),
   b. Kleinfelder 2008 borings (NEMDC-08-XX),
   c. Kleinfelder 2004 borings (LRVR 03-10),
   d. Kleinfelder 1998 boring (SPDOC-3),
   e. URS/Fugro 2007 borings (WR150D_XXX(R), (WR152E_XXX(C), and (WR150D_XXXM). "C" and "M" explorations appear in PlanView, but not on Profile View.
   f. Woller 1997 borings (GH-XX)
3. The locations of the explorations shown are approximate. See Plates 2.2 through 2.6 for approximate plan location.
4. This log legend shown applies to Kleinfelder 1998, 2004, 2008, and 2009 borings . Caution is advised in using the legend for interpretation of other explorations.
5. Logs represent general soil conditions observed at the point of exploration on the date indicated.
6. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
7. No warranty is provided as to the continuity of soil conditions between individual sample locations.
8. Approximate top of boring elevations for Kleinfelder 1998, 2004, 2008, and 2009 borings were estimated using revised topographic data provided by Psomas.
9. The 100-year and 200-year design water surface profiles shown were provided by MBK Engineers in a report dated Dec. 12, 2008.
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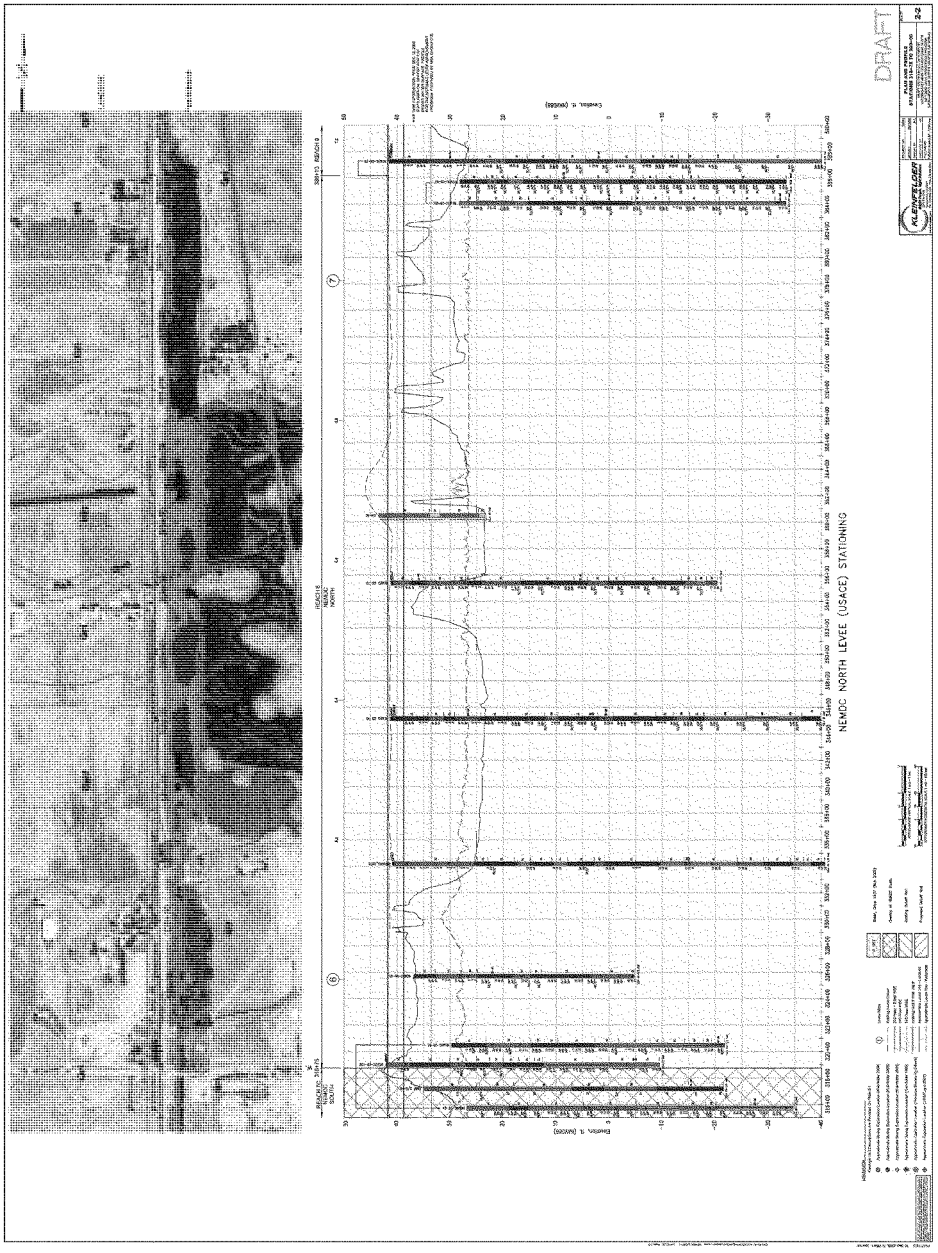
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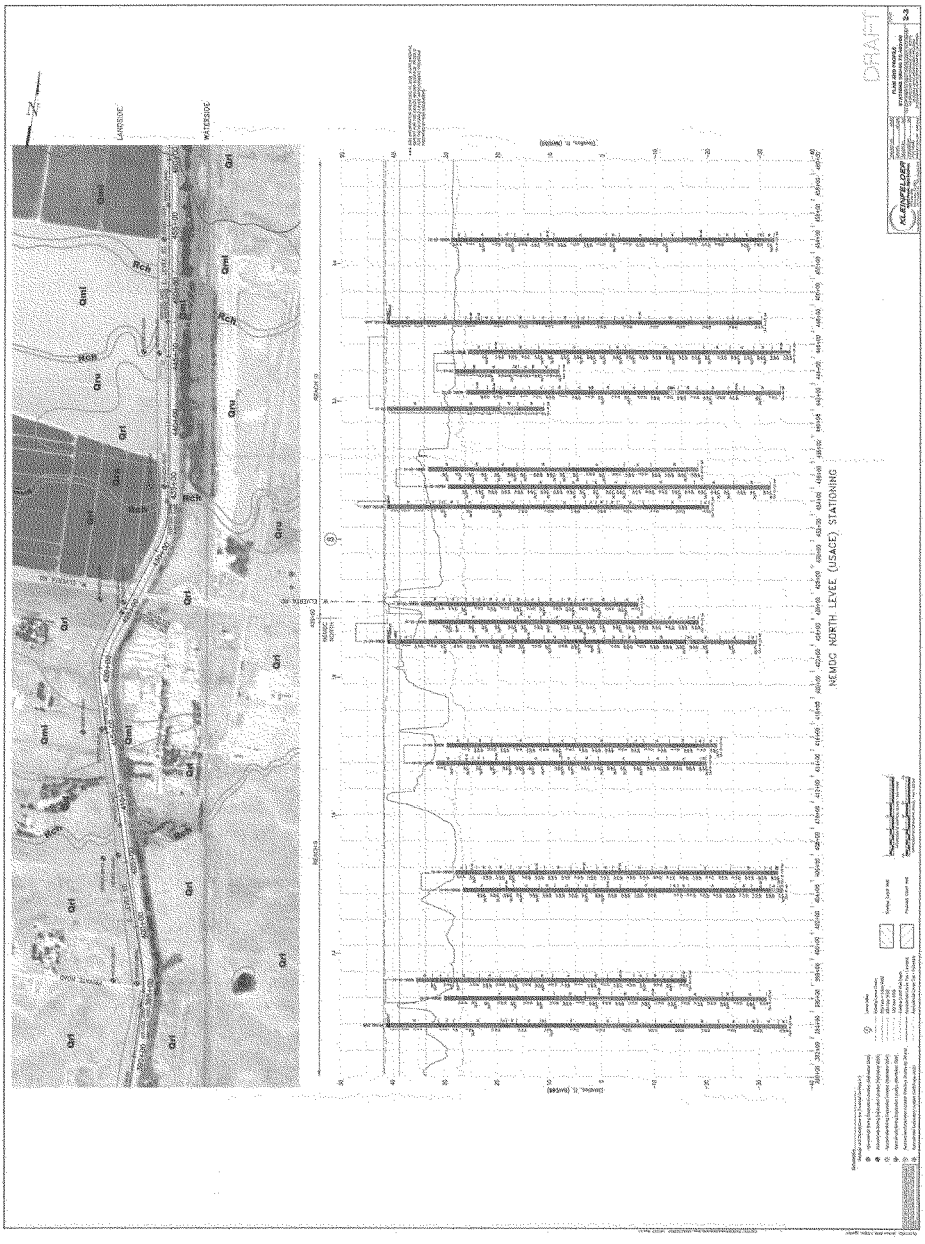
KLEINFELDER

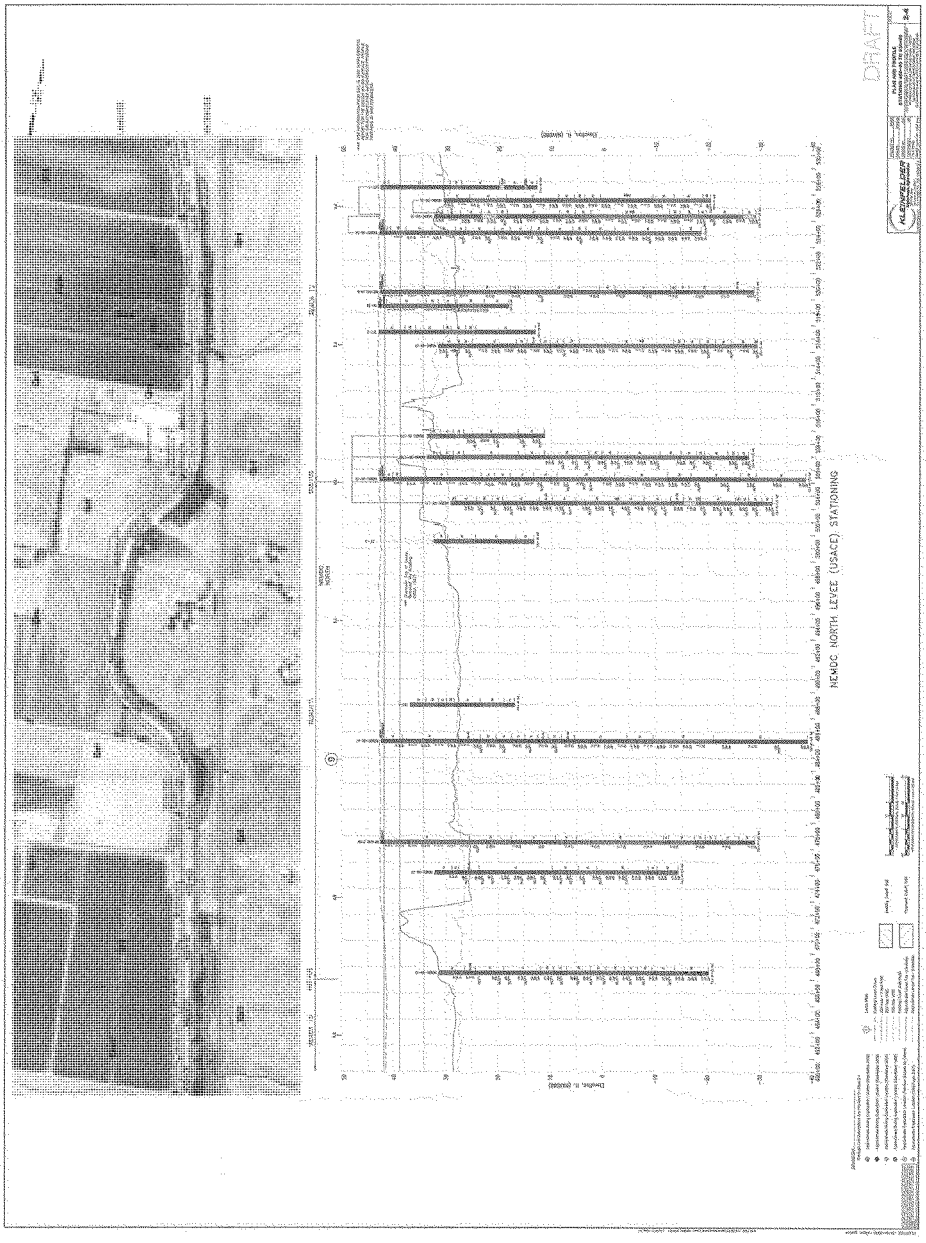
PLAN AND PROFILE
LEGEND AND NOTES

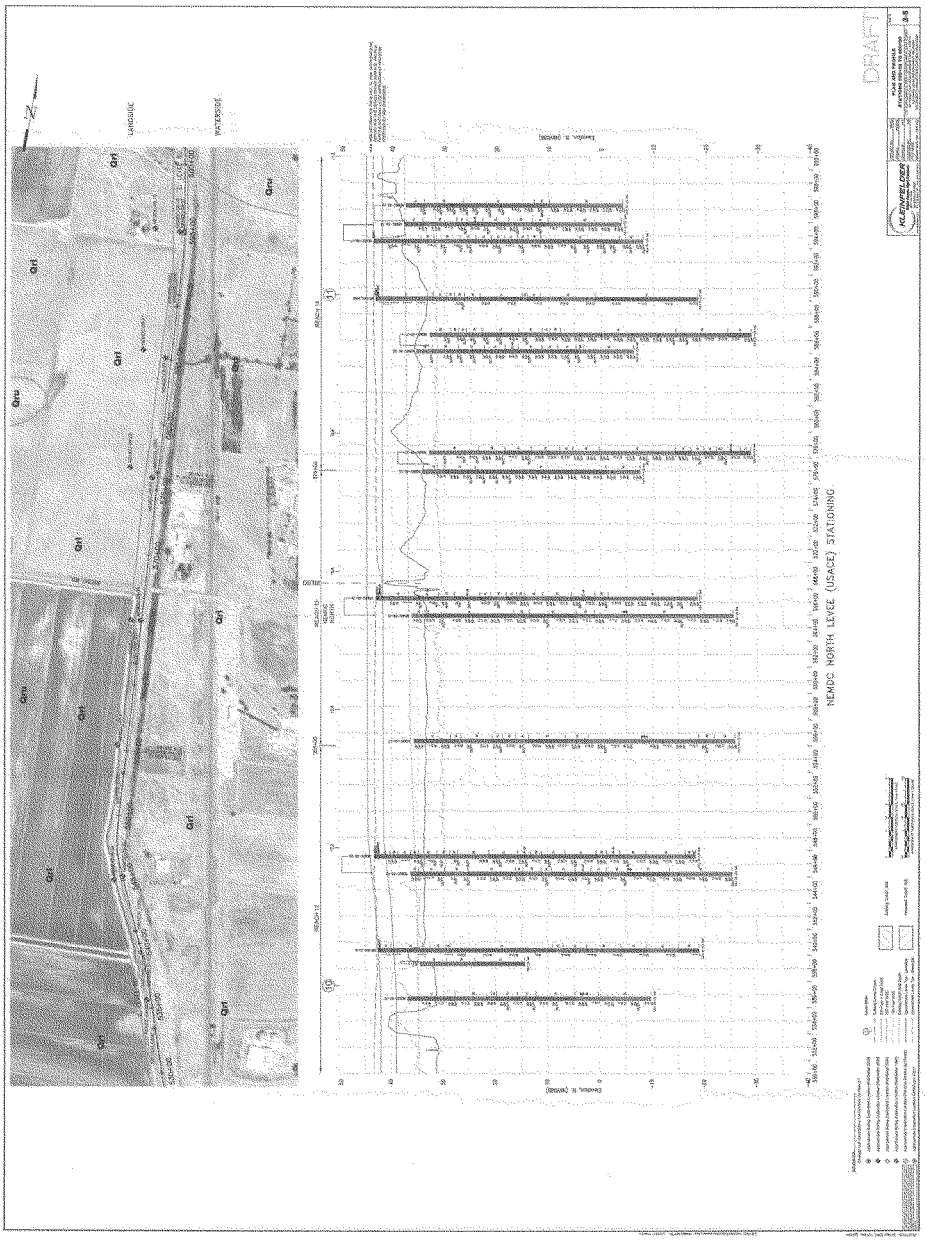
2-1

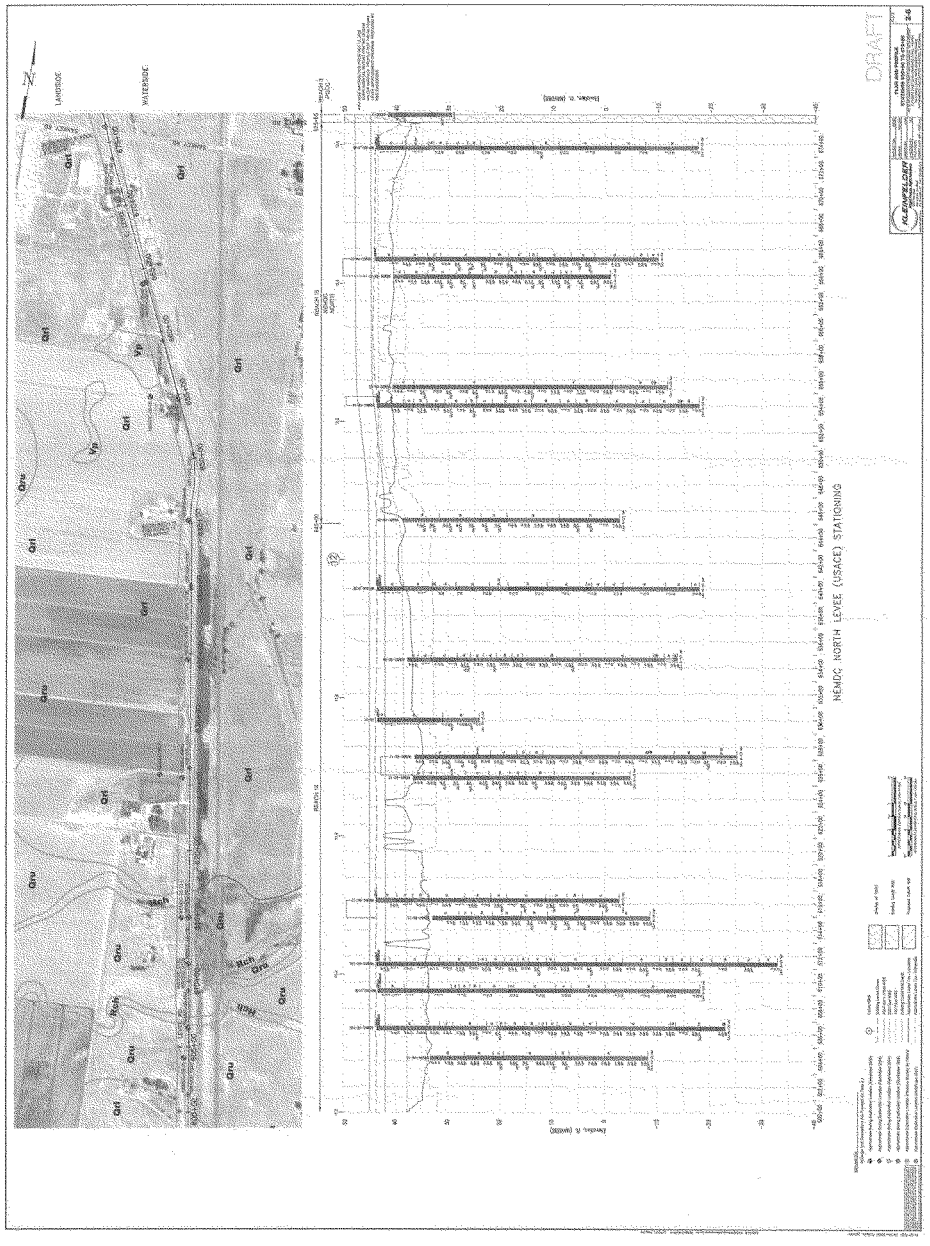
213


DRAFT
NEMDC NORTH LEVEE (USACE) STATIONING
Elevation, ft (NAVD88)
Elevation, ft (NAVD88)


LANDSIDE
WATERSIDE
Qal
Qmf
Qrf
Qrv
Rch
NEMDC NORTH LEVEE (USACE) STATIONING
DRAFT


DRAFT
NEMDC NORTH LEVEE (USACE) STATIONING


NEMDC NORTH LEVEE (USACE) STATIONING
DRAFT
KLEINFELDER


LANDSIDE
WATERSIDE
NEMDC NORTH LEVEE (USACE) STATIONING
DRAFT

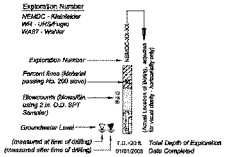
SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

GW	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 0 TO 4% FINES
GP	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 0 TO 4% FINES
GW	WELL-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES
GP	POORLY-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES
GW-GM	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GW-GC	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GP-GM	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GP-GC	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% FINES
GW-GM	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GW-GC	WELL-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GP-GM	POORLY-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GP-GC	POORLY-GRADED GRAVEL WITH ABOUT 5 TO 12% FINES
GM	SILTY GRAVEL WITH ABOUT 12 TO 17% FINES
GM	SILTY GRAVEL WITH ABOUT 18 TO 49% FINES
GC	CLAYEY GRAVEL WITH ABOUT 12 TO 17% FINES
GC	CLAYEY GRAVEL WITH ABOUT 18 TO 49% FINES
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 12 TO 17% FINES
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 18 TO 49% FINES

SW-SP	WELL-GRADED SAND/POORLY GRADED SAND WITH ABOUT 3 TO 4% CLAY
SW	WELL-GRADED SAND WITH ABOUT 0 - 2% CLAY 0 - 4% SILT
SP	POORLY-GRADED SAND WITH ABOUT 0 - 2% CLAY 0 - 4% SILT
SW-SM	WELL-GRADED SAND WITH ABOUT 5 TO 7% SILT
SW-SM	WELL-GRADED SAND WITH ABOUT 6 TO 12% SILT
SW-SC	WELL-GRADED SAND WITH ABOUT 5 TO 12% CLAY
SP-SM	POORLY-GRADED SAND WITH ABOUT 5 TO 7% SILT
SP-SM	POORLY-GRADED SAND WITH ABOUT 6 TO 12% SILT
SP-SC	POORLY-GRADED SAND WITH ABOUT 5 - 12% CLAY
SM	SILTY SAND WITH ABOUT 13 - 49% SILT
SC	CLAYEY SAND WITH ABOUT 13 - 49% CLAY
SC-SM	SAND WITH ABOUT 13 TO 49% LOW PLASTIC FINES THAT CLASSIFY AS CL-ML

ML	INORGANIC SILTS AND VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, SILTS WITH SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
CL-ML	INORGANIC CLAYS-SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY

LOG LEGEND



* Indicates blow count data is for California Sampler (2.5" ID), not an SPT

** Indicates blow count data is for a Modified California Sampler (2.0" ID, 2.5" OD), not an SPT

NOTES:

1. Levee crown and toe profiles are based upon existing topographic mapping by Psomas for the Natomas Levee Improvement Program (NLIP) in 2009. All elevations for data prior to 2009 have been converted from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a +2.29 feet conversion factor as determined by Psomas for the NLIP (Psomas 2009) (1 foot NGVD29 = 2.29 feet NAVD88).
2. Logs of the following explorations were added to the USACE base drawings:
   a. Kleinfelder 2009 borings (NEMDC-09-XX),
   b. Kleinfelder 2008 borings (NEMDC-08-XX),
   c. Kleinfelder 2006 borings (ARB-13),
   d. Kleinfelder 2004 borings (UNW 2/5-10),
   e. Kleinfelder 1995 borings (K95-96-XX),
   f. Kleinfelder 1993 borings (K93-RK-X),
   g. FUGRO 2007 borings (WR1000_XXR) and (WR1000_XXG),
   h. Wallace-Kuhl 2006 borings (WKDS-0XX),
   i. Wallace-Kuhl 2006 borings (WKCAE-0XX)
   j. Winter 1987 borings (WA87-0NXX),
   k. AGS (Parsons Brinckerhoff) 1992 borings (PB B-X),
   l. Parish Consultants 2006 borings (PC-06-B-X),
   m. GeoTrans 2007 borings (B-2-07), and
   n. City of Sacramento borings 1999 (COS-98-B-X).
3. The locations of the explorations shown are approximate. See Plates 2-2 through 2-8 for approximate plan location.
4. The log legend shown applies to Kleinfelder 1993 through 2009 borings . Caution is advised in using the legend for interpretation of other explorations.
5. Logs represent general soil conditions observed at the point of exploration on the date indicated. Refer to Kleinfelder's 1993, 1995, 2004, 2006, and 2009 reports for more detail on Kleinfelder 1993 borings (K93-RK-X), Kleinfelder 1995 borings (K95-96-XX), Kleinfelder 2004 boring (UNW 2/5-10), Kleinfelder 2006 boring (ARB-13), Kleinfelder 2008 borings (NEMDC-08-XX), and Kleinfelder 2009 borings (NEMDC-09-XX).
6. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
7. No warranty is provided as to the continuity of soil conditions between individual sample locations.
8. Approximate top of boring elevations for Kleinfelder 1993, 1995, 2004, 2006, and 2009 borings were estimated using revised topographic data provided by Psomas.
9. The 100-year and 200-year design water surface profiles shown were provided by MBK Engineers in a report dated Dec. 12, 2008. See report for an explanation of these profiles and conditions.
10. Details regarding the 2007 construction of the DSM wall within Reach 1 have been added to the profile and are based upon Sacramento Area Flood Control Agency (SAFCA) construction records.

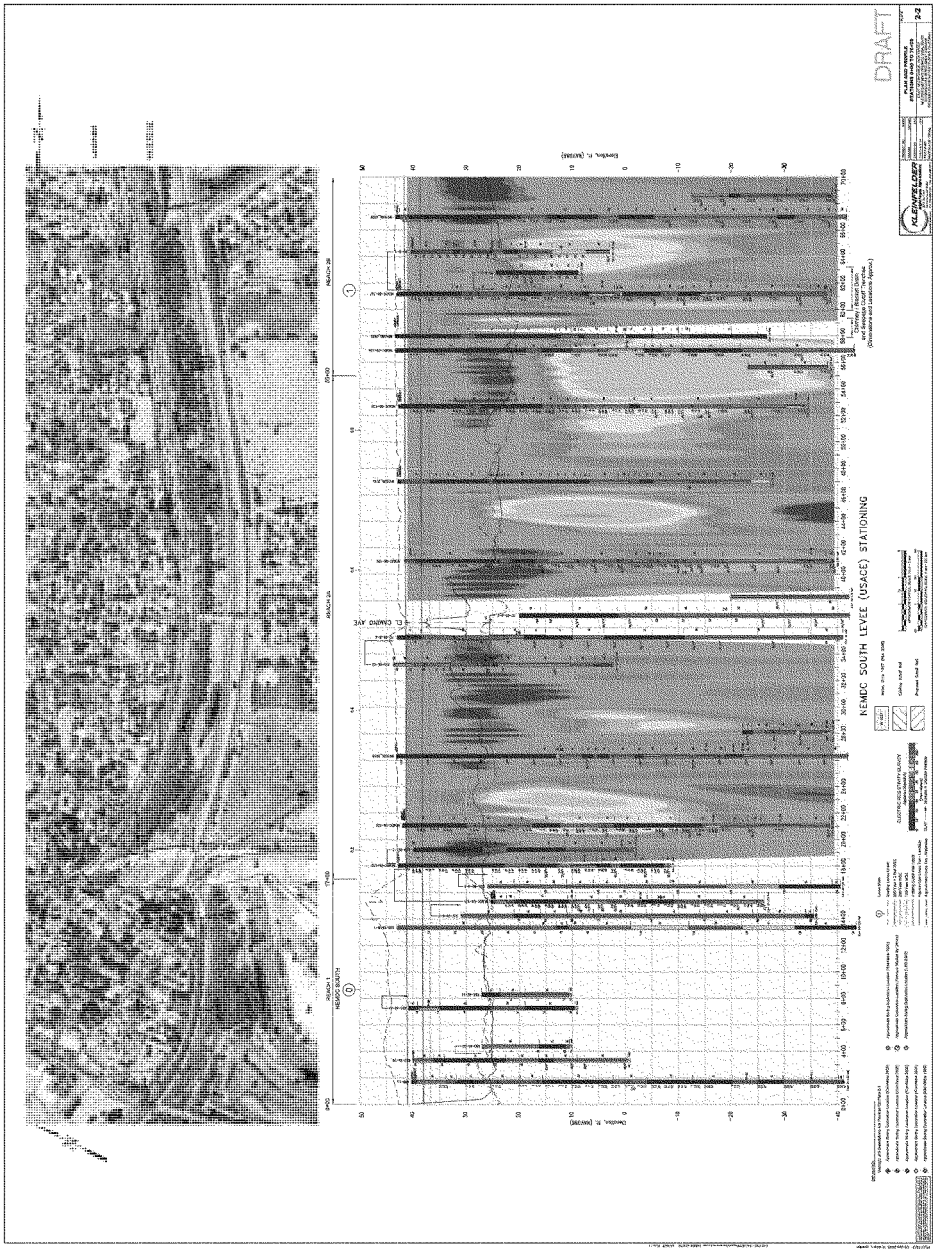
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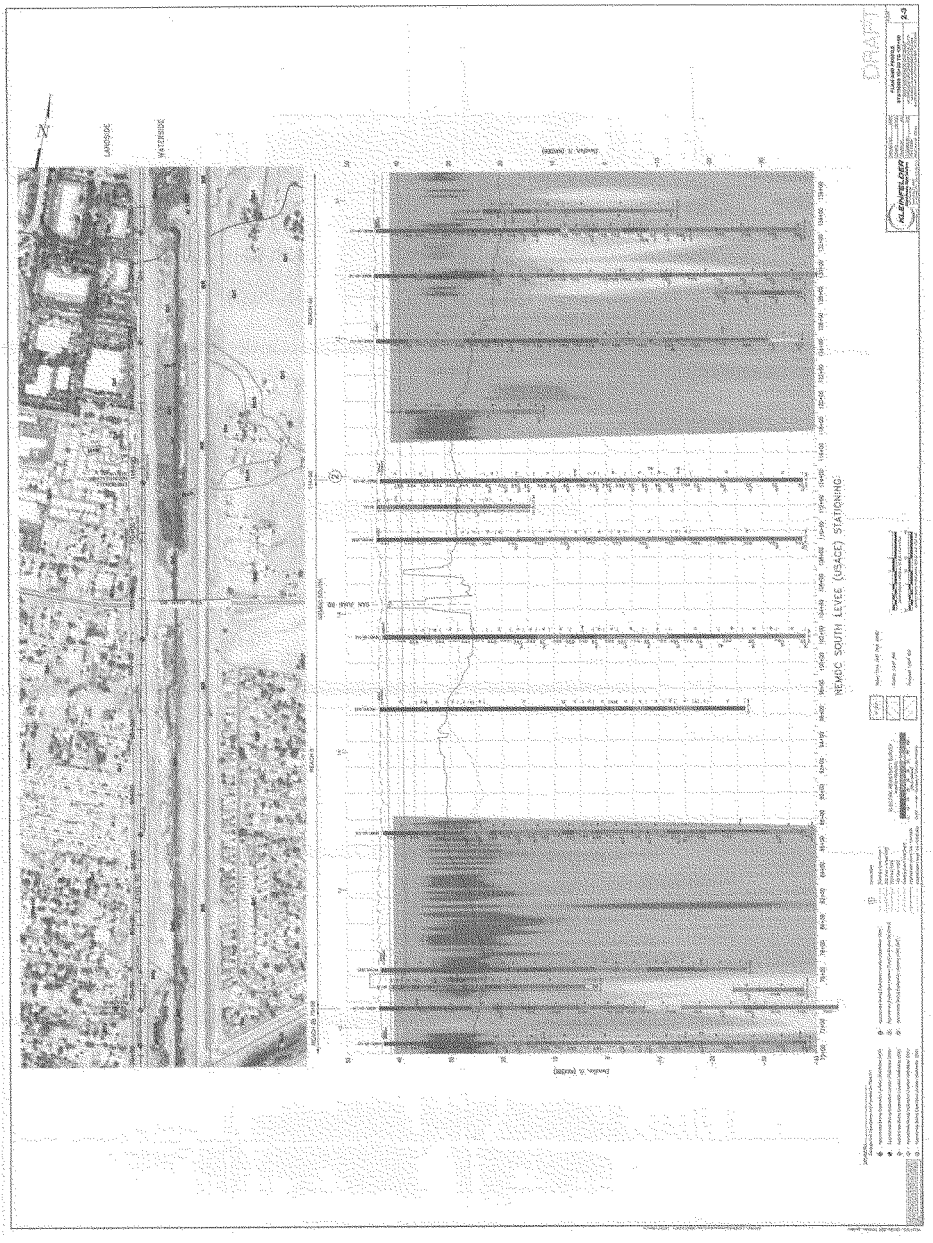
KLEINFELDER

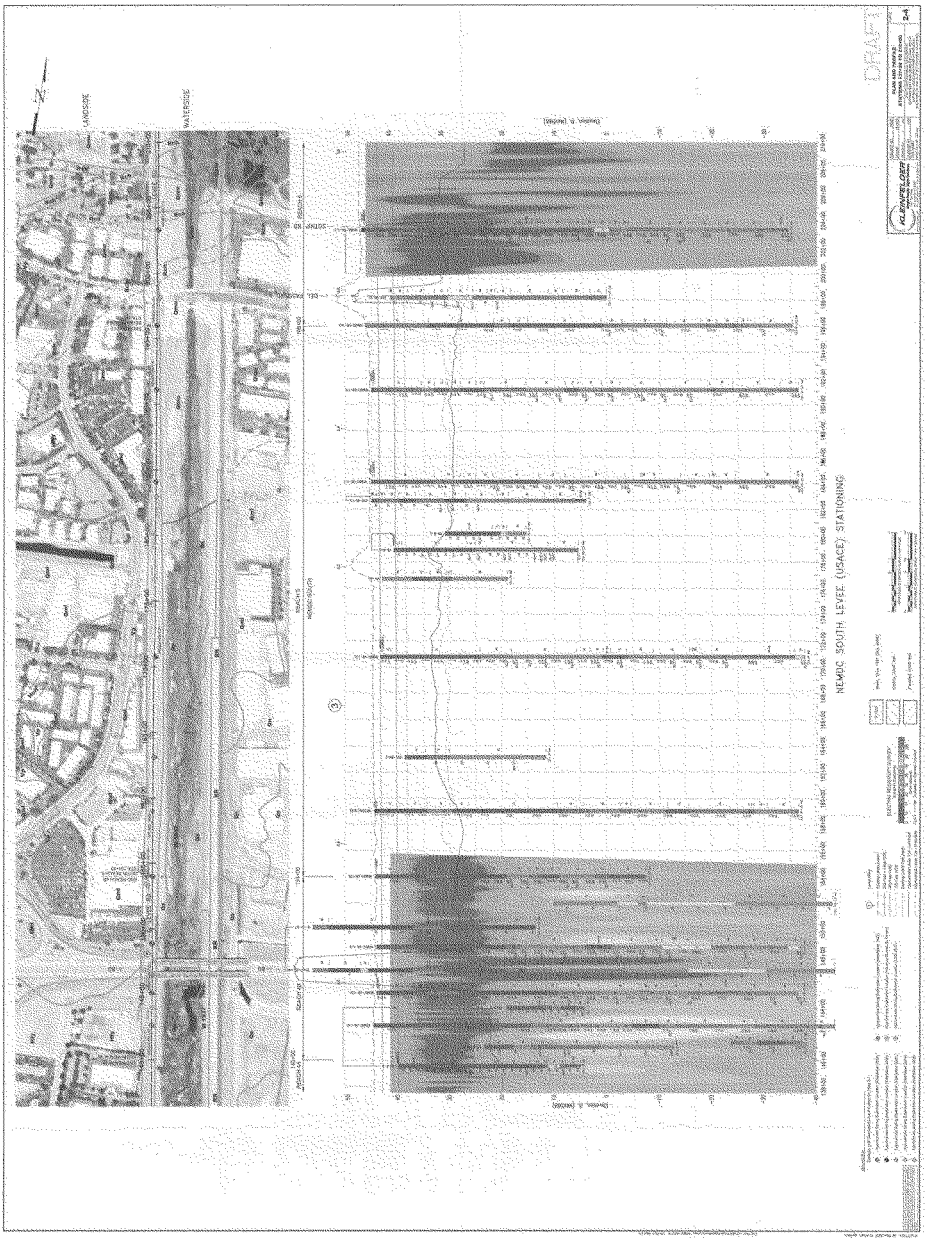
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DRAWN	KDW
CHECKED	JAC
APPROVED	JAC
DATE	12/09

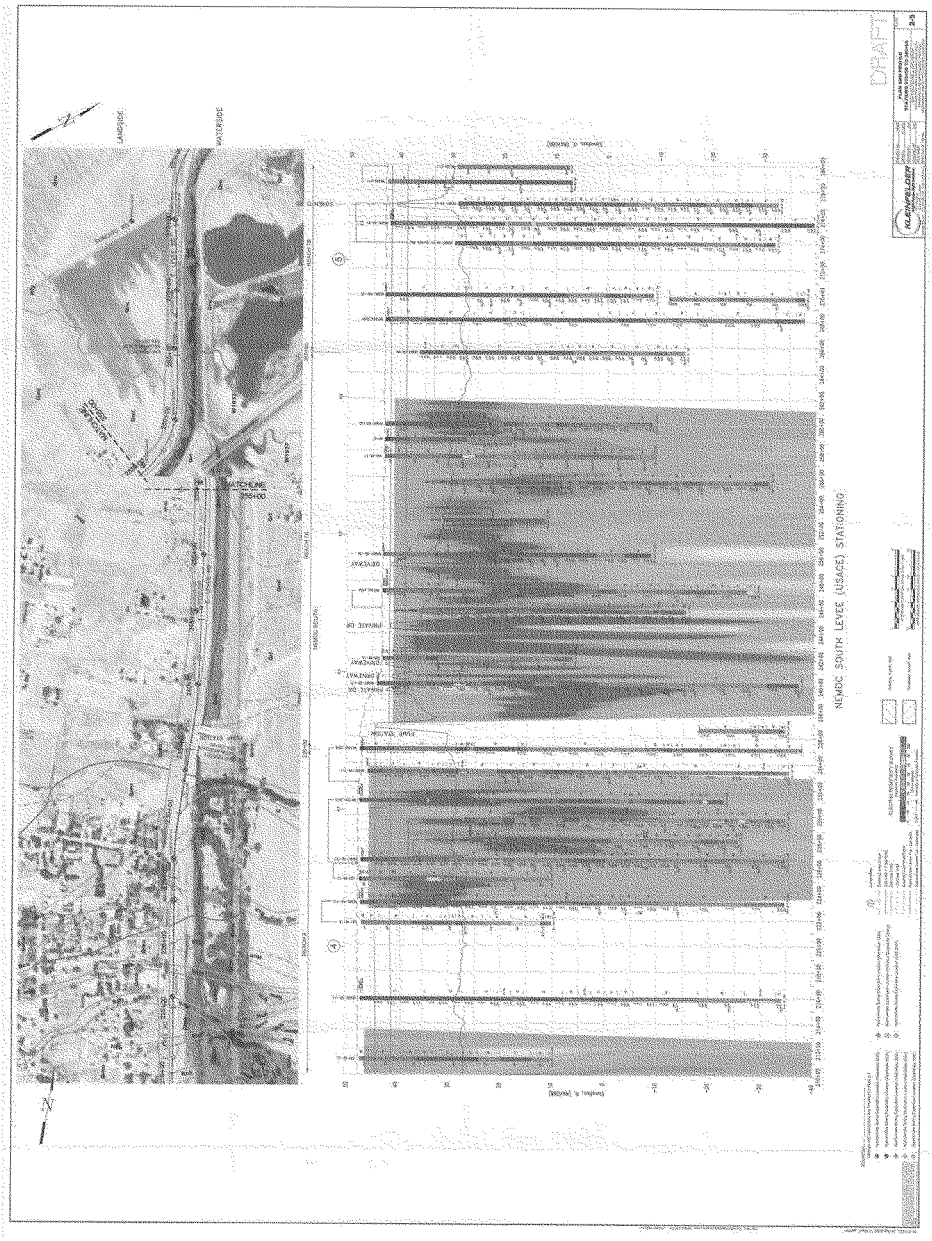
PLAN AND PROFILE
LEGEND AND NOTES

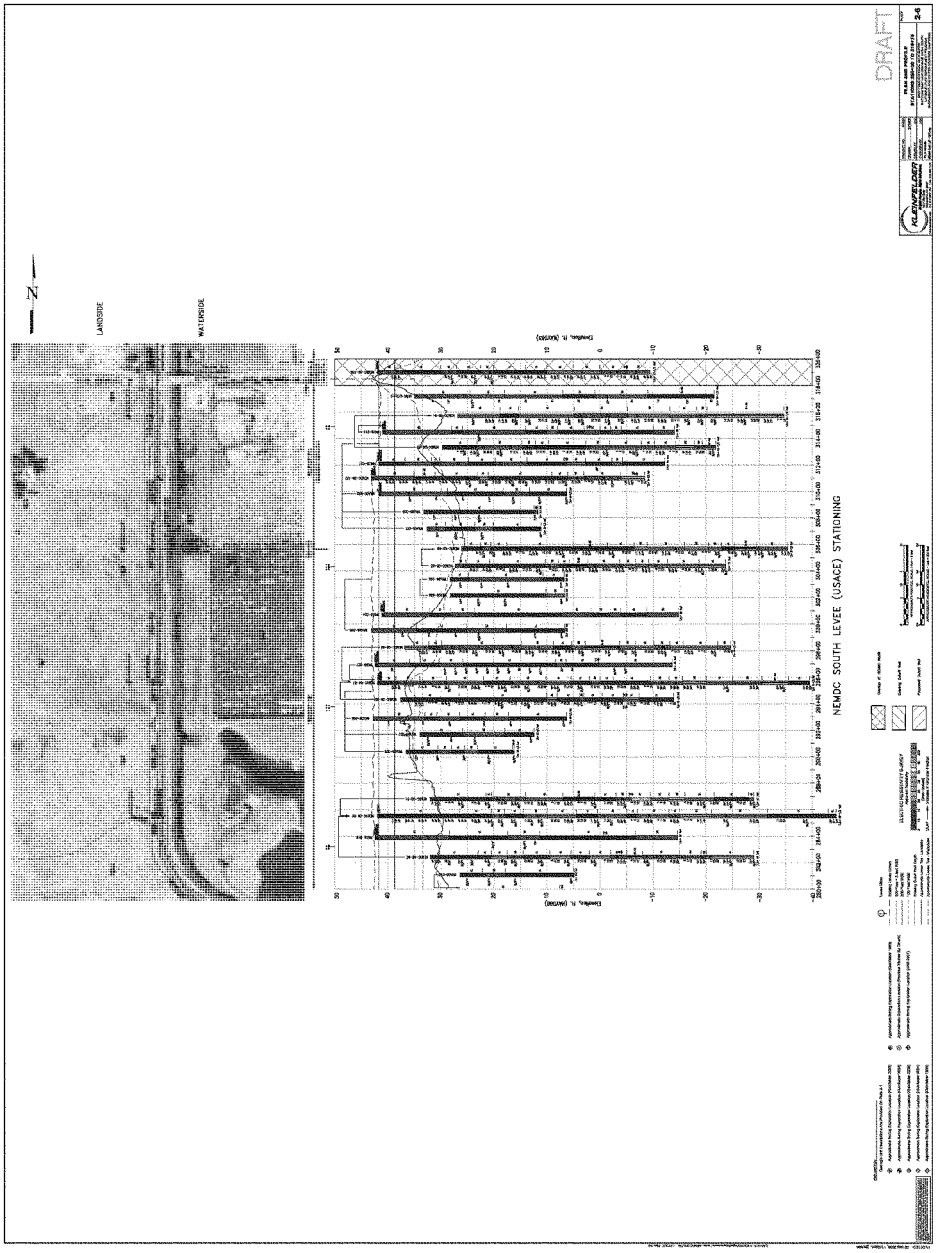
FILE NO. 2-1


DRAFT
KLEINFELDER
KEMDC SOUTH LEVEE (USACE) STATIONING
EL CAMINO AVE
HEGGS BOUNDARY
HEGGS BOUNDARY


N
LANDSIDE
WATERSIDE
NEMDC SOUTH LEVEE (USACE) STATIONING
DRAFT


MEMPHIS SOUTH LEVEE (USACE) STATIONING
DRAFT


DRAFT
NEMDC SOUTH LEVEE (USACE) STATIONING
KLEINFELDER
WATERSIDE
LANDSIDE
CENTERLINE
ALIGNMENT
N


N
LANDSIDE
WATERSIDE
NEMDC SOUTH LEVEE (USACE) STATIONING
DRAFT

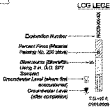
SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

GW	WELL-GRADED GRAVEL, WITH COBBLES AND/OR BOULDERS, LITTLE OR NO FINES
GP	POORLY-GRADED GRAVEL, WITH COBBLES AND/OR BOULDERS, LITTLE OR NO FINES
GW	WELL-GRADED GRAVEL WITH SAND, LITTLE OR NO FINES
GP	POORLY-GRADED GRAVEL WITH SAND, LITTLE OR NO FINES
GW-GM	WELL-GRADED GRAVEL WITH SILT AND SAND
GW-GC	WELL-GRADED GRAVEL WITH CLAY (OR SILTY CLAY) AND SAND
GP-GM	POORLY-GRADED GRAVEL WITH SILT AND SAND
GP-GC	POORLY-GRADED GRAVEL WITH CLAY (OR SILTY CLAY) AND SAND
GW-GM	WELL-GRADED GRAVEL WITH SILT AND SAND
GW-GC	WELL-GRADED GRAVEL WITH CLAY (OR SILTY CLAY) AND SAND
GP-GM	POORLY-GRADED GRAVEL WITH SILT AND SAND
GP-GC	POORLY-GRADED GRAVEL WITH CLAY (OR SILTY CLAY) AND SAND
GM	SILTY GRAVEL
GM	SILTY GRAVEL AND SAND
GC	CLAYEY GRAVEL
GC	CLAYEY GRAVEL AND SAND
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL
GC/GM	CLAYEY GRAVEL/SILTY GRAVEL AND SAND

SW-SP	WELL-GRADED GRAVEL/POORLY GRADED SAND
SW	WELL-GRADED SAND
SP	POORLY-GRADED SAND
SW-SM	WELL-GRADED SAND WITH SILT
SW-SM	WELL-GRADED SAND WITH SILT
SW-SC	WELL-GRADED SAND WITH CLAY (OR SILTY CLAY)
SP-SM	POORLY-GRADED SAND WITH SILT
SP-SM	POORLY-GRADED SAND WITH SILT
SP-SC	POORLY-GRADED SAND WITH CLAY (OR SILTY CLAY)
SM	SILTY SAND
SC	CLAYEY SAND
SC-SM	CLAYEY/SILTY SAND

ML	INORGANIC SILT AND VERY FINE SAND, SILTY OR CLAYEY FINE SAND OR SILTY OR CLAYEY FINE SAND WITH SLIGHT PLASTICITY
CL	INORGANIC CLAY OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAY, SANDY CLAY, SILTY CLAY, LEAN CLAY
CL-ML	INORGANIC CLAY/SILT OF LOW PLASTICITY, GRAVELLY CLAY, SANDY CLAY, SILTY CLAY, LEAN CLAY
OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
CH	ORGANIC CLAYS & SILTS OF MEDIUM TO HIGH PLASTICITY

LOG LEGEND



* Indicates brass count rate is for California Sampler (2.5" ID), not an SPT

NOTE: Borings B-1, B-2, and B-3 undertaken from LCACC Arboleda River Watershed Project Right Bank Levee Profile, 0-1+86.

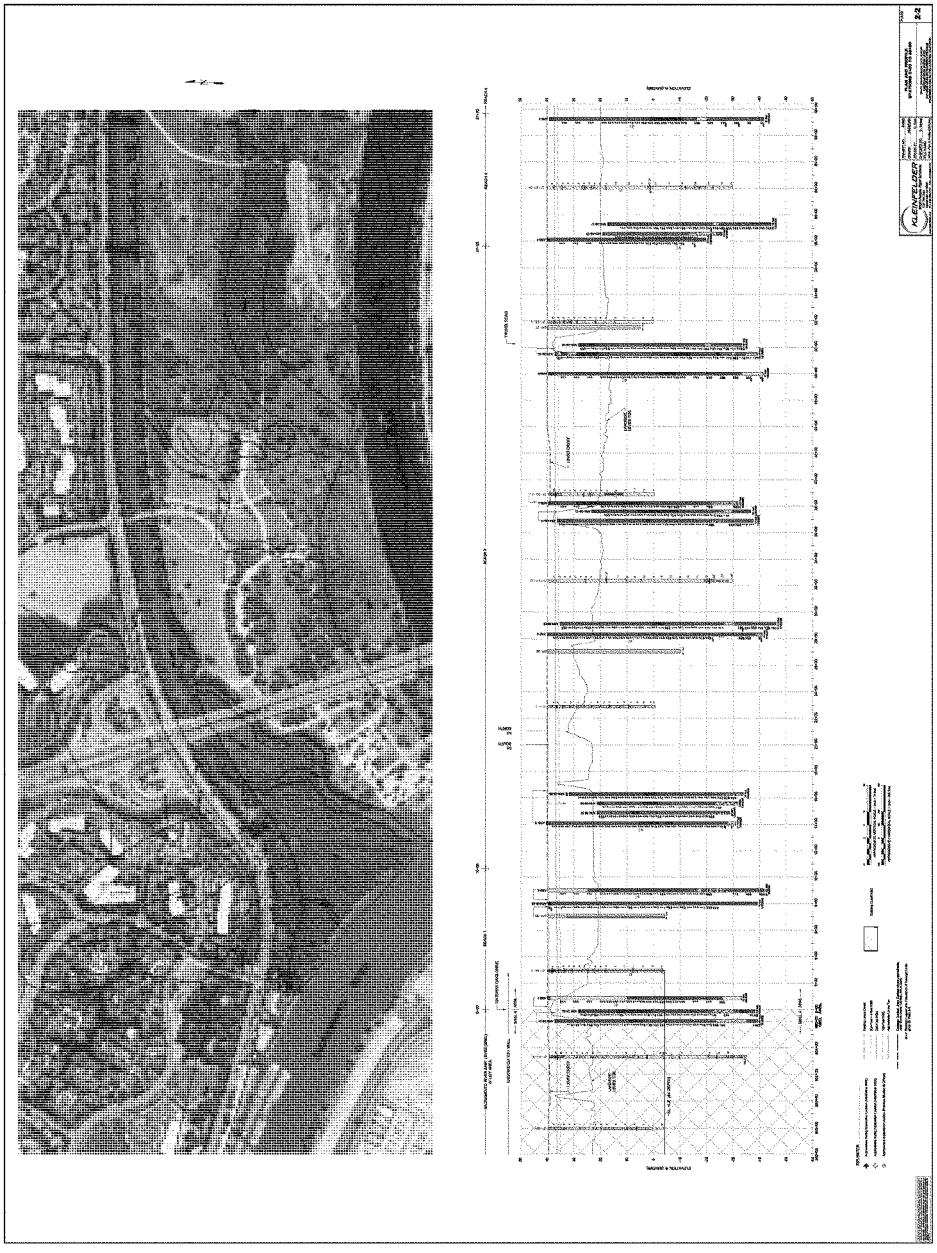
THIS DRAWING AND THE DESIGN AND INFORMATION CONTAINED HEREIN ARE THE PROPERTY OF KLEINFELDER AND SHALL NOT BE REPRODUCED OR USED FOR ANY PURPOSE WITHOUT THE EXPRESS WRITTEN CONSENT OF KLEINFELDER.

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO. 20252
DRAWN BY: DATE
CHECKED BY: DATE
APPROVED BY: DATE
DATE PLOTTED: 01/01/2025

PLATE 2-1

FLOOD AND DRAINAGE CONTROL AND WATER CONSERVATION DISTRICT
LOS ANGELES COUNTY PUBLIC WORKS



SOIL PROFILE LEGEND BASED ON UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2487)

GW	WELL-GRADED GRAVEL, WITH COBBLES WITH ABOUT 0 TO 4% FINES	SW-SP	WELL-GRADED SAND/POORLY GRADED SAND WITH ABOUT 3 TO 4% CLAY	ML	INORGANIC SILTS AND VERY FINE SANDS, SILTS WITH SLIGHT PLASTICITY
GP	POORLY-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES	SW	WELL-GRADED SAND WITH ABOUT 0 TO 2% CLAY 0 TO 4% SILT	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
GW	WELL-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES	SP	POORLY-GRADED SAND WITH ABOUT 0 TO 2% CLAY 0 TO 4% SILT	CL-ML	INORGANIC CLAYS SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
GP	POORLY-GRADED GRAVEL WITH ABOUT 0 TO 4% FINES	SW-SM	WELL-GRADED SAND WITH ABOUT 3 TO 7% SILT	OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
GW-GM	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 3 TO 10% SILT	SW-SM	WELL-GRADED SAND WITH ABOUT 3 TO 10% SILT	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
GW-GC	WELL-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 10% CLAY	SW-SC	WELL-GRADED SAND WITH ABOUT 3 TO 10% CLAY	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
GP-GM	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 3 TO 12% SILT	SP-SM	POORLY GRADED SAND WITH ABOUT 3 TO 7% SILT	OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM TO HIGH PLASTICITY
GP-GC	POORLY-GRADED GRAVEL WITH COBBLES WITH ABOUT 5 TO 12% CLAY	SP-SM	POORLY-GRADED SAND WITH ABOUT 3 TO 10% SILT		
GW-GM	WELL-GRADED GRAVEL WITH ABOUT 3 TO 10% SILT	SP-SC	POORLY-GRADED SAND WITH ABOUT 3 TO 10% CLAY		
GW-GC	WELL-GRADED GRAVEL WITH ABOUT 5 TO 10% CLAY	SM	SILTY SAND WITH ABOUT 13 TO 49% SILT		
GP-GM	POORLY-GRADED GRAVEL WITH ABOUT 3 TO 10% SILT	SC	CLAYEY SAND WITH ABOUT 13 TO 49% CLAY		
GP-GC	POORLY-GRADED GRAVEL WITH ABOUT 5 TO 10% CLAY	SC-SM	SAND WITH ABOUT 13 TO 49% LOW PLASTIC FINES THAT CLASSIFY AS CL-ML		
GM	SILTY GRAVEL WITH ABOUT 13 TO 27% SILT				
GM	SILTY GRAVEL WITH ABOUT 13 TO 49% SILT				
GC	CLAYEY GRAVEL WITH ABOUT 13 TO 27% CLAY				
GC	CLAYEY GRAVEL WITH ABOUT 13 TO 49% CLAY				
GC-GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 13 TO 7% SILT/CLAY				
GC-GM	CLAYEY GRAVEL/SILTY GRAVEL WITH ABOUT 13 TO 49% SILT/CLAY				

ELECTRIC RESISTIVITY SURVEY

Apparent Resistivity

0 2 4 10 15 20 30 39 49 55 60 120 200 400

Ohm-meters

CLAY ——— Increase in Granular Fraction

CPT LEGEND

CPT Number → CPT-08-XX

GS Elev. : XX ft

10 Fr,% 0 | 0 Qt1 500

BOH Elev. XX ft

Qt1 = Normalized Tip Resistance, tsf

Fr = Normalized Friction Ratio, %

Zone		SBTn (After Robertson, 1990)
1		sensitive fine grained
2		organic material
3		clay to silty clay
4		clayey silt to silty clay
5		silty sand to sandy silt
6		clean sands to silty sands
7		gravelly sand to sand
8		very dense sand to clayey sand
9		very stiff fine grained

LOG LEGEND

XXXX-XXXX

Exploration Number

Percent Fines (Material Passing No. 230 Sieve) ——— %

Blow counts (Uncorrected, Using 2 in. O.D. SPT Sampler) ——— N*

Groundwater Level ———

(measured at time of drilling) T.D. +93 ft. Total Depth of Exploration

(measured after time of drilling) XX/XX/XXXX Date Completed

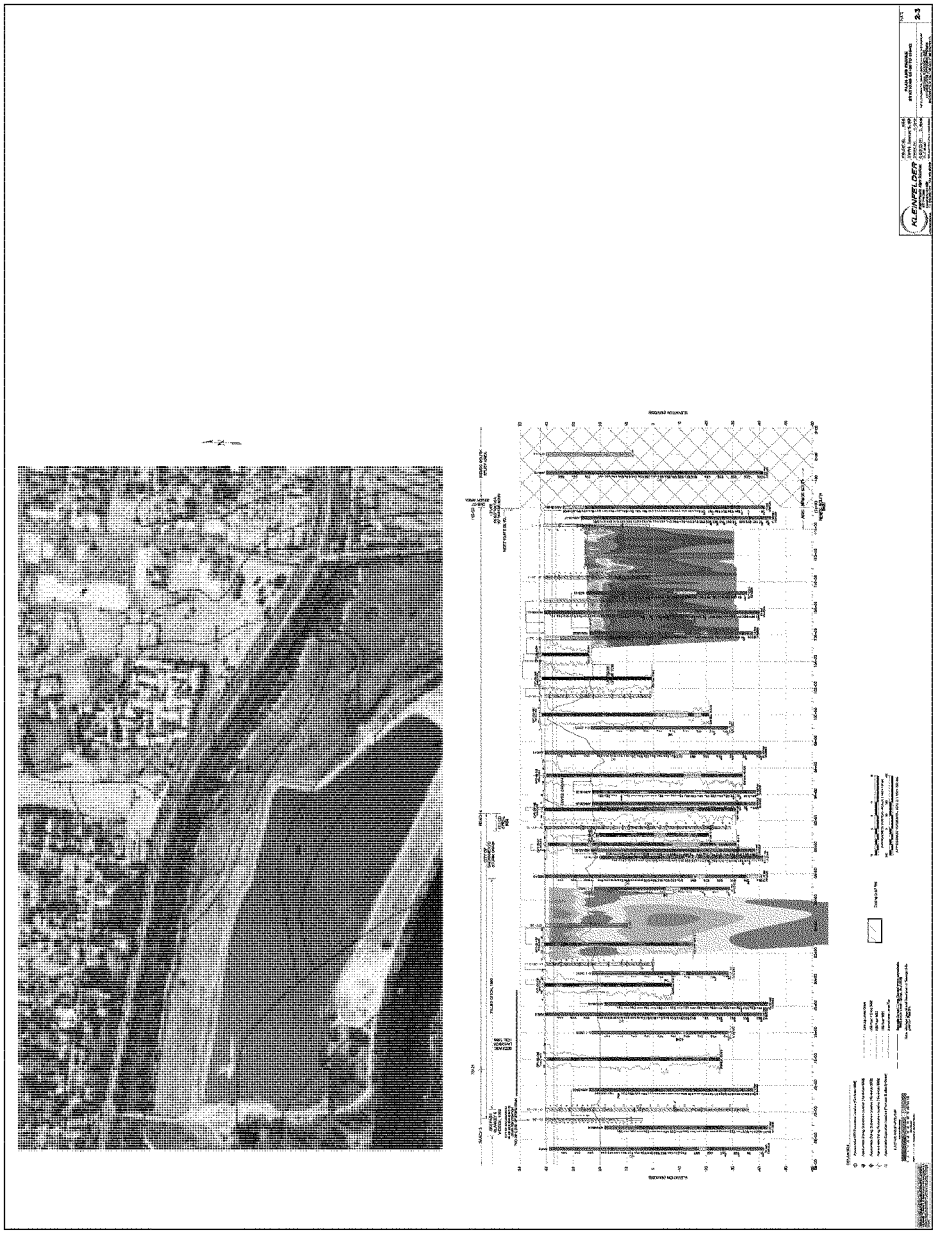
* Indicates blow count data is for California Sampler, not an SPT

Notes:

1. Base drawings for the American River North Levee Profile, obtained in August 2008 from the Sacramento District U.S. Army Corps of Engineers (USACE) and used with their permission, include stick logs of previous explorations and notes regarding levee performance and completed levee improvements. Levee crown and toe profiles are based upon existing topographic mapping by the USACE with modifications conducted by Psomas for the Natomas Levee Improvement Program (NLIP) in 2008. All elevations for data prior to 2007 have been surveyed from the National Geodetic Vertical Datum 1929 (NGVD29) to the North American Vertical Datum 1988 (NAVD88) by applying a +2.23 foot conversion factor as determined by Psomas for the NLIP (Psomas 2007) (0 feet NGVD29 = +2.23 feet NAVD88).
2. Borings B-1, B-2, and B-3 elevations are from USACE American River Watershed Project Right Bank Levee Profile, (USACE 1958b). No associated boring logs are available.
3. Logs of the following explorations were added to the USACE base drawings:
   a. Kleinfelder 1994 CPTs (CPT-XX).
   b. Kleinfelder 2002 borings (B-X (2002)).
   c. Kleinfelder 2006 borings (ARR-X)
   d. Kleinfelder 2008 borings (ARN-08-XX)
   e. Kleinfelder 2009 borings (ARN-09-XX)
   f. Kleinfelder 2008 CPTs (CPT-08-XX)
   g. Woller 1997 (DH-XX)
   h. Caltrans 1964 borings (B-X (1964))
4. The locations of the explorations shown are approximate.
5. The log legend shown applies to Kleinfelder 2002 through 2009 borings and CPTs. Caution is advised in using the legend for interpretation of other explorations.
6. Logs represent general soil conditions observed at the point of exploration on the date indicated. Refer to Kleinfelder's 2008 report for more detail on Kleinfelder 2006 borings (ARR-XX).
7. Lines separating strata on logs represent approximate boundaries only. Actual transitions may be gradual.
8. No warranty is provided as to the continuity of soil conditions between individual sample locations.
9. Kleinfelder 2002, 2008 and 2009 borings (ARR-XX, ARN-08-XX, ARN-09-XX) were estimated using revised topographic data provided by Psomas (2007).
10. The 100-Year and 200-Year design water surface profiles shown were provided by MBK Engineers in a report dated Dec. 12, 2006. See report for an explanation of these profiles and conditions.
11. Details regarding completed levee improvements have been added to those already on the USACE levee profile base drawing and were obtained from the USACE. Details of completed levee improvements shown are approximate and are the same as indicated on the USACE profiles. Refer to USACE as-built drawings for actual details.

KLEINFELDER

PAGE 2-1



AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

NATOMAS POST AUTHORIZATION CHANGE REPORT

ENCLOSURE F2

GEOTECHNICAL ANALYSIS CALCULATION PACKAGE

REACH A (LM 19.60 - 15.50)
SACRAMENTO RIVER EAST LEVEE
ANALYSIS CROSS-SECTION: LM 16.70

	Existing Levee Conditions			Alt 1: Waterside Hanging Cutoff Wall to Tip Elev -68.5 (103.5 ft Deep)			Alt 1: Levee Crest Raise with Keyed in Cutoff Wall (Waterside of Existing Cutoff Wall and within Levee Crest) to Tip Elev. -85.0 (120.0 ft Deep)		
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe/Berm Toe	Average Vertical Exit Gradient at Toe/Berm Toe	Landside SS FOS	Point Gradient at toe	Average Vertical Exit Gradient at Toe	Landside SS FOS
40.75	0.90	0.69	1.38	NA	NA	NA	NA	NA	NA
39.92	0.86	0.66	1.43	0.27	0.10	1.62	0.10	0.11	1.61
36.73	0.74	0.53	1.62	0.58	0.47	1.62	0.39	0.48	1.56
34.70	0.65	0.45	1.72	NA	NA	NA	NA	NA	NA
34.60	0.62	0.43	1.76	NA	NA	NA	NA	NA	NA
33.45	0.60	0.41	1.79	0.53	0.39	1.70	0.33	0.41	1.65
31.29	0.51	0.32	1.90	NA	NA	NA	NA	NA	NA

REACH B (LM 15.50 - 9.60)
SACRAMENTO RIVER EAST LEVEE
ANALYSIS CROSS-SECTION: LM 14.30

	Existing Levee Conditions			Alt 1: Adjacent Levee with Keyed in SB Cutoff Wall TE = -4.0ft			Alt 1: 500yr Raise Adjacent Levee with Keyed in SB Cutoff Wall TE = -4.0ft			Alt 2: Drained Seepage Berm (60ft wide with varied thickness)			Alt 2: 500yr Raise Drained Seepage Berm (60ft wide with varied thickness)			Alt 3: Waterside Keyed in SCB Cutoff Wall TE Varies			Alt 3: 500yr Raise Waterside Keyed in SCB Cutoff Wall TE Varies		
Water Level (Aug. 09 H&H)	Point Gradient at Ditch/Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe/Berm Toe	Average Vertical Exit Gradient at Toe/Berm Toe	Landside SS FOS	Point Gradient at Toe/Berm Toe	Average Vertical Exit Gradient at Toe/Berm Toe	Landside SS FOS	Point Gradient at Ditch/Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at toe	Average Vertical Exit Gradient at Toe	Landside SS FOS
40.56	0.24/0.46	0.73	1.59	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
39.99	0.23/0.44	0.70	1.72	0.10	0.19	1.67	0.10	0.19	1.69	0.08/0.44	0.23/0.33	1.88	0.31/0.36	0.23/0.24	1.84	0.14	0.23	2.18	0.14	0.23	2.07
36.82	0.18/0.35	0.55	1.91	<0.1	0.14	1.80	<0.1	0.14	1.81	0.05/0.39	0.14/0.26	1.96	0.28/0.32	0.34/0.18	1.71	0.11	0.18	2.21	0.11	0.18	2.11
34.99	0.13/0.29	0.45	2.03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
34.27	0.12/0.27	0.42	2.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
33.75	0.11/0.26	0.39	2.10	<0.1	0.10	1.92	<0.1	0.10	1.90	0.02/0.31	0.09/0.19	2.01	0.15/0.28	0.11/0.14	1.96	0.08	0.12	2.25	0.08	0.12	2.16
31.97	0.07/0.20	0.30	2.20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

REACH B (LM 15.50 - 5.00)
SACRAMENTO RIVER EAST LEVEE
ANALYSIS CROSS-SECTION: LM 8.50

	Existing Levee Conditions			Alt 8: Adjacent Levee with Hanging Cutoff Wall to Tip Elev. -84.0 (120.0 ft deep) and 100 ft wide by 7.5 ft thick Drained Seepage Berm			Alt 8: Adjacent Levee Crest Raise with Hanging Cutoff Wall to Tip Elev. -84.0 (120.0 ft deep) and 100 ft wide by 7.5 ft thick Drained Seepage Berm			Alt 8: Adjacent Levee with Hanging Cutoff Wall to Tip Elev. -39.0 (75.0 ft deep) and 300 ft wide by 7.5 ft thick Drained Seepage Berm			Alt 8: Adjacent Levee Crest Raise with Hanging Cutoff Wall to Tip Elev. -39.0 (75.0 ft deep) and 300 ft wide by 7.5 ft thick Drained Seepage Berm		
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at Berm Toe	Landside SS FOS	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at Berm Toe	Landside SS	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at Berm Toe	Landside SS FOS	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at Berm Toe	Landside SS FOS
42.37	1.39	1.89	0.78	0.34	0.77	1.91	NA	NA	NA	0.26	0.71	2.22	NA	NA	NA
42.40	NA*	NA*	NA*	NA	NA	NA	0.32	0.78	2.19	NA	NA	NA	0.28	0.72	1.61
41.35	1.29	1.76	0.97	0.32	0.72	2.04	0.28	0.73	2.29	0.24	0.67	2.45	0.24	0.67	1.75
38.86	1.16	1.58	1.22	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
38.97	1.08	1.48	1.40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
38.31	1.02	1.40	1.56	0.25	0.58	2.42	0.23	0.60	2.58	0.19	0.54	3.14	NA	NA	NA
36.06	0.82	1.14	1.96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: NA = Not Analyzed

REACH C (LM 6.00 - 0.00)															
SACRAMENTO RIVER EAST LEVEE															
ANALYSIS CROSS-SECTION: LM 4.00															
	Existing Levee Conditions			Alt. 1: Hanging Cutoff Wall to Tip Elev. -40.0 (75.0 ft deep) with 90 ft wide 5 ft thick Drained Seepage Berm			Alternative 1: Levee Crest Raise with Hanging Cutoff Wall to Tip Elev. -40.0 (75.0 ft deep) with 90 ft wide 5 ft thick Drained Seepage Berm			Alternative 2: Adjacent Levee with Hanging Cutoff Wall to tip elev. -37.0 (75.0 ft deep).			Alternative 2: Adjacent Levee Crest Raise with Hanging Cutoff Wall to tip elev. -37.0 (75.0 ft deep).		
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at Berm Toe	Landside SS FOS	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at Berm Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS
42.81	0.93	0.95	0.53	0.16	0.21	2.14	NA	NA	NA	0.55	0.33	1.49	NA	NA	NA
43.11	NA*	NA*	NA*	NA	NA	NA	0.14	0.21	2.28	NA	NA	NA	0.58	0.33	1.60
42.24	0.91	0.94	0.55	0.16	0.20	2.16	0.16	0.20	2.32	0.53	0.32	1.72	0.54	0.31	1.64
40.86	0.84	0.87	0.98	NA	NA	NA	NA	NA	NA	0.46	0.29	1.94	NA	NA	NA
39.95	0.79	0.81	1.06	NA	NA	NA	NA	NA	NA	0.44	0.28	1.80	NA	NA	NA
39.26	0.75	0.77	1.12	0.22	0.20	2.24	<0.1	0.10	NA	0.42	0.23	1.87	0.49	0.24	1.84
37.08	0.62	0.61	1.22	NA	NA	NA	NA	NA	NA	0.33	0.19	2.10	NA	NA	NA

REACH C (LM 6.00 - 0.00)																				
SACRAMENTO RIVER EAST LEVEE																				
ANALYSIS CROSS-SECTION: LM 1.20																				
	Existing Levee Conditions			Alternative 3: Hanging Cutoff Wall to tip elev. -19.0 (56.0 ft deep) with 90 ft Drained Seepage Berm.			Alternative 3: Levee Crest Raise with Hanging Cutoff Wall to tip elev. -19.0 (56.0 ft deep) with 90 ft Drained Seepage Berm.			Alternative 4: Hanging Cutoff Wall to tip elev. -39.0 (75.0 ft deep).			Alternative 4: Levee Crest Raise with Hanging Cutoff Wall to tip elev. -39.0 (75.0 ft deep)			Alternative 5: Adjacent Levee with Hanging Cutoff Wall to tip elev. -39.0 (75.0 ft deep)			Alternative 5: Adjacent Levee Crest Raise with Hanging Cutoff Wall to tip elev. -39.0 (75.0 ft deep)		
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at Berm Toe	Landside SS FOS	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at Berm Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Levee Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Levee Toe	Average Vertical Exit Gradient at Berm Toe	Landside SS FOS	Point Gradient at Levee Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS
44.49	1.77	1.46	0.39	0.30	0.45	2.28	NA	NA	NA	0.31	0.38	1.56	NA	NA	NA	0.28	0.30	1.47	NA	NA	NA
44.44	NA*	NA*	NA*	NA	NA	NA	0.46	0.68	2.15	NA	NA	NA	0.48	0.42	1.46	NA	NA	NA	0.49	0.50	1.36
43.59	1.69	1.39	0.40	0.28	0.43	2.29	0.44	0.65	2.18	0.29	0.24	1.57	0.46	0.40	1.48	0.27	0.28	1.51	0.47	0.48	1.40
42.21	1.55	1.27	0.45	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
41.26	1.47	1.20	0.54	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
40.55	1.39	1.15	0.60	0.23	0.35	2.40	0.35	0.53	NA	0.27	0.22	1.58	0.38	0.32	1.51	0.22	0.22	1.61	0.37	0.39	1.53
39.43	1.17	0.99	0.79	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

REACH D (LM 4.36 - 0.00)										
NATOMAS CROSS CANAL SOUTH LEVEE										
ANALYSIS CROSS-SECTION: LM 3.92										
	Existing Levee Conditions			Alternative 1: Hanging Cutoff Wall to tip elev. -38.0 (75.0 ft deep).				Alternative 1: Levee Crest Raise with Hanging Cutoff Wall to tip elev. -38.0 (75.0 ft deep).			
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe (Ditch Empty)	Average Vertical Exit Gradient at Toe (Ditch Empty)	Average Vertical Exit Gradient at Ditch Toe (Ditch Empty)	Landside SS FOS (Ditch Empty)	Point Gradient at Toe (Ditch Empty)	Average Vertical Exit Gradient at Toe (Ditch Empty)	Average Vertical Exit Gradient at Ditch Toe (Ditch Empty)	Landside SS FOS (Ditch Empty)
44.62	0.80	0.76	0.99	0.17	0.13	0.44	1.70	NA	NA	NA	NA
45.13	NA	NA	NA	NA	NA	NA	NA	0.29	0.16	0.45	1.55
44.16	0.78	0.74	1.02	0.16	0.14	0.45	1.71	0.23	0.12	0.44	1.59
42.76	0.69	0.66	1.11	NA	NA	NA	NA	NA	NA	NA	NA
41.80	0.64	0.60	1.18	NA	NA	NA	NA	NA	NA	NA	NA
41.07	0.57	0.56	1.25	0.03	<0.1	0.39	1.80	0.04	<0.1	0.40	1.68
38.97	0.45	0.43	1.43	NA	NA	NA	NA	NA	NA	NA	NA

Note: NA = Not Analyzed

REACH D (LM 4.56 - 0.00)
NATOMAS CROSS CANAL SOUTH LEVEE
ANALYSIS CROSS-SECTION: LM 1.47

	Existing Levee Conditions			Alternative 1: Hanging Cutoff Wall to tip elev. -18.0 (55.0 ft deep).					Alternative 1: Levee Crest Raise with Hanging Cutoff Wall to tip elev. -38.0 (75.0 ft deep).				
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe at Levee Toe	Point Gradient at Toe at LS Cut Toe	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at LS Cut Toe	Landside SS FOS	Point Gradient at Levee Toe	Point Gradient at Toe at LS Cut Toe	Average Vertical Exit Gradient at Levee Toe	Average Vertical Exit Gradient at LS Cut Toe	Landside SS FOS
44.89	0.72	0.60	1.54	0.06	0.45	<0.1	0.45	2.12	NA	NA	NA	NA	NA
45.16	NA*	NA*	NA*	NA	NA	NA	NA	NA	0.49	NA	0.50	NA	1.51
44.23	0.71	0.59	1.57	0.05	0.44	<0.1	0.44	2.14	0.45	NA	0.45	NA	1.52
42.84	0.65	0.53	1.68	NA	NA	NA	NA	NA	NA	NA	0.44	NA	NA
41.86	0.61	0.49	1.72	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
41.11	0.58	0.47	1.77	0.02	0.37	<0.1	0.35	2.22	0.35	NA	0.35	NA	1.63
39.00	0.49	0.39	1.59	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

REACH E (LM 18.08 - 12.60)
PLEASANT GROVE CREEK CANAL WEST LEVEE
ANALYSIS CROSS-SECTION: LM 15.70

	Existing Levee Conditions			Alternative 1: Keyed in Cutoff Wall to tip elev. -6.0 (49.9ft deep)			Alternative 1: Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -6.0 (49.9ft deep)		
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS
46.20	1.00	1.94	1.36	0.03	<0.1	1.65	0.17	0.24	1.84
47.19	NA*	NA*	NA*	NA*	NA*	NA*	0.19	0.26	1.83
46.69	NA*	NA*	NA*	NA*	NA*	NA*	0.18	0.25	1.83
46.17	1.00	1.94	1.36	0.03	<0.1	1.65	0.17	0.24	1.84
45.40	0.92	1.81	1.43	0.02	<0.1	1.65	0.16	0.21	1.84
44.28	0.81	1.63	1.48	0.01	<0.1	1.65	0.13	0.19	1.85
42.59	0.62	1.29	1.54	0.006	<0.1	1.65	0.10	0.13	1.87

REACH F (LM 12.60 - 7.38)
NATOMAS EAST MAIN DRAINAGE CANAL WEST LEVEE
ANALYSIS CROSS-SECTION: LM 8.38

	Existing Levee Conditions			Alternative 1: Drained Stability Berm			Alternative 1: Levee Crest Raise with Drained Stability Berm			Alternative 2: Flattened Landside Levee Slope (5H:1V)			Alternative 2: Levee Crest Raise with Flattened Landside Levee Slope (5H:1V)		
Water Level (Dec. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS
41.42	0.35	0.38	1.12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
43.03	NA*	NA*	NA*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
39.76	0.32	0.34	1.16	NA	NA	NA	0.23	0.33	1.84	NA	NA	NA	0.79	0.44	2.05
38.97	0.30	0.32	1.18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
38.19	0.27	0.29	1.21	0.16	0.23	1.87	NA	NA	NA	0.56	0.39	2.07	NA	NA	NA
37.24	0.24	0.26	1.24	0.15	0.21	1.89	NA	NA	NA	0.50	0.35	2.13	NA	NA	NA
35.62	0.19	0.21	1.29	0.13	0.17	1.91	NA	NA	NA	0.38	0.28	2.23	NA	NA	NA

Note: NA = Not Analyzed

REACH G (LM 7.99 - 4.25)									
NATOMAS EAST MAIN DRAINAGE CANAL WEST LEVEE									
ANALYSIS CROSS-SECTION: LM 6.45									
	Existing Levee Conditions			Alternative 1: Keyed in Cutoff Wall to tip elev. -6.8 (38.8ft deep)			Alternative 1: Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -6.6 (39.0ft deep)		
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS
40.89	1.29	1.27	0.98	0.15	~0.1	1.67	NA	NA	NA
46.45	NA*	NA*	NA*	NA*	NA*	NA*	0.24	0.24	1.84
44.46	NA*	NA*	NA*	NA*	NA*	NA*	0.21	0.20	1.84
43.17	NA*	NA*	NA*	NA*	NA*	NA*	0.18	0.18	1.85
41.78	NA*	NA*	NA*	NA*	NA*	NA*	NA	NA	NA
40.50	1.26	1.24	1.00	0.15	~0.1	1.68	0.16	0.14	1.88
38.57	1.11	1.09	1.18	0.13	~0.1	1.89	NA	NA	NA

REACH H (LM 4.25 - 0.00)									
NATOMAS EAST MAIN DRAINAGE CANAL WEST LEVEE									
ANALYSIS CROSS-SECTION: LM 1.00									
	Existing Levee Conditions				Alternative 1: Keyed in Cutoff Wall to tip elev. -5.0 (38.8ft deep)			Alternative 1: Levee Crest Raise with Hanging Cutoff Wall to tip elev. -40.0 (75.0ft		
Water Level (Aug. 09 H&H)	Point Gradient at Road/Toe	Average Vertical Exit Gradient Road/Toe	Landside SS FOS	Water Level (Dec. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Road/Toe	Average Vertical Exit Gradient Road/Toe	Landside SS FOS
43.17	1.41/1.11	1.38/0.98	0.55	43.17	NA*	NA*	NA*	NA	NA	NA
44.87	NA*	NA*	NA*	44.37	NA*	NA*	NA*	1.12	0.50	1.60
38.77	1.14/0.94	1.11/0.74	1.11	39.07	0.31	0.30	1.78	0.77	0.35	1.75
37.51	1.06/0.79	1.06/0.69	1.19	37.53	0.26	0.25	1.78	NA	NA	NA
35.99	0.97/0.65	0.94/0.59	1.34	35.98	0.23	0.21	1.82	NA	NA	NA
34.67	0.90/0.62	0.88/0.54	1.41	34.93	0.21	0.18	1.85	NA	NA	NA
33.21	0.79/0.51	0.77/0.43	1.60	32.55	0.12	0.11	1.91	NA	NA	NA

REACH I (LM 2.33 - 0.00)									
AMERICAN RIVER NORTH LEVEE									
ANALYSIS CROSS-SECTION: LM 1.30									
	Existing Levee Conditions			Alternative 1: Keyed in Cutoff Wall to tip elev. -6.5 (37.4ft deep)			Alt 1: 500yr Raise with Keyed in SB Cutoff Wall TE = 6.9ft		
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS
41.34	1.45	1.06	0.68	0.54	0.33	1.41	NA	NA	NA
43.95	NA*	NA*	NA*	NA*	NA*	NA*	0.30	0.45	1.53
38.79	1.25	0.90	0.83	0.49	0.30	1.43	0.21	0.38	1.60
35.66	1.12	0.79	0.92	NA	NA	NA	NA	NA	NA
35.06	1.09	0.76	0.95	NA	NA	NA	NA	NA	NA
34.60	1.06	0.73	1.02	NA	NA	NA	NA	NA	NA
31.24	0.88	0.57	1.12	NA	NA	NA	NA	NA	NA

REACH I (LM 2.33 - 0.00)									
AMERICAN RIVER NORTH LEVEE									
ANALYSIS CROSS-SECTION: LM 1.30 - ALTERNATE									
	Existing Levee Conditions			Alternative 1: Keyed in Cutoff Wall to tip elev. -6.5 (37.4ft deep)			Alt 1: 500yr Raise with Keyed in SB Cutoff Wall TE = 6.9ft		
Water Level (Aug. 09 H&H)	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS	Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Landside SS FOS
41.34	0.97	0.58	1.38	0.41	0.25	1.52	NA	NA	NA
43.95	NA*	NA*	NA*	NA*	NA*	NA*	0.31	0.17	1.66
38.79	0.86	0.50	1.12	0.36	0.23	1.51	0.23	0.12	1.73
35.66	0.77	0.44	1.24	NA	NA	NA	NA	NA	NA
35.06	0.75	0.43	1.28	NA	NA	NA	NA	NA	NA
34.60	0.73	0.42	1.28	0.31	0.20	1.67	0.17	0.09	1.77
31.24	0.59	0.33	1.34	NA	NA	NA	NA	NA	NA

Note: NA = Not Analyzed



Material Parameters Summary						
Material Type	Hydraulic Conductivity			Effective Strength Parameters		
	Horizontal kh (kx) cm/sec	kh/kv	Horizontal kh (kx) ft/day	Φ'	C' (psf)	γ (pcf)
Clay Fill	10^{-6}	4	0.0028	28	50	115
Cutoff Wall	10^{-6}	1	0.0028	0	50	85
Random Fill	$2x10^{-4}$	4	0.567	32	0	120
Drainage Gravel	10^{-2}	10	28.35	35	0	135
Drainage Sand	$5x10^{-3}$	10	14.18	35	0	130
Clayey Sand (SC), Silty Clay (CL-ML)	$4x10^{-5}$ or $7x10^{-5}$	4	0.11 or 0.2	28-32	50	120
Lean Clay (CL), Fat Clay (CH)	10^{-5}	4 or 10	0.028	24-30	50 or 150	115
Elastic Silt (MH)	$4x10^{-5}$ to 10^{-5}	4	0.11 or 0.028	28-30	50	120
Silt (ML)	$2x10^{-4}$	4	0.567	28-32	0	120
Silty Sand (SM)	10^{-3} or $5x10^{-3}$	4	2.835 or 14.18	30-35	0	125
Poorly-Graded Sand (SP), Well-Graded Sand (SW)	10^{-2}	10	28.35	32-35	0	135
Poorly-Graded Sand w/ Silt (SP-SM), Well-Graded Sand w/ Silt (SW-SM)	10^{-2} or $5x10^{-3}$	10	14.18 or 28.35	32-35	0	130

Note: Material properties based on DWR NWS TRM (2008), DWR NEMDC-West P1GER (2009), USACE F3 CF-GRR (2009), SAFCA NEMDC-South PIR (2009)

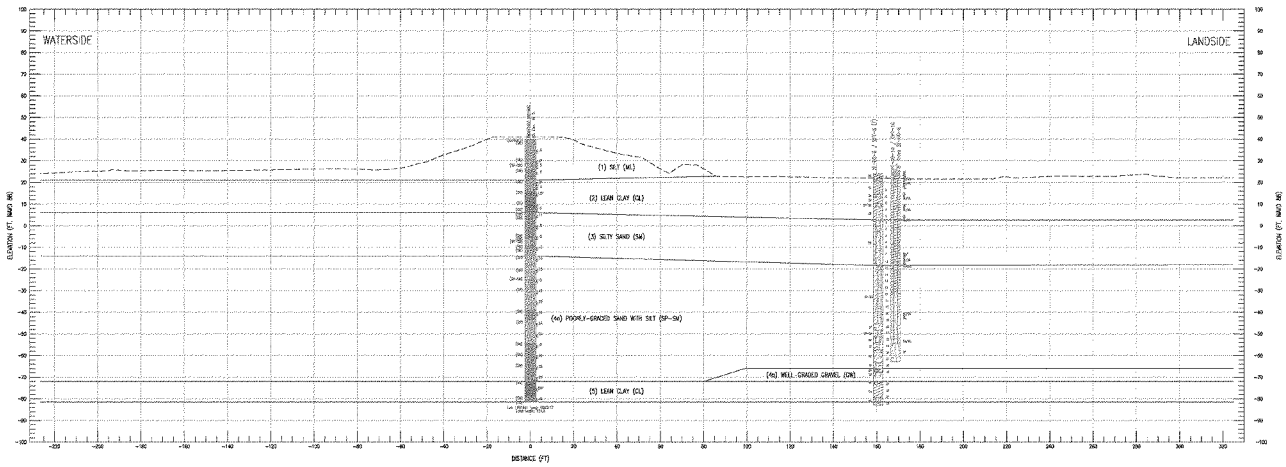
REACH A

CALCULATION PACKAGE

SACRAMENTO RIVER EAST LEVEE

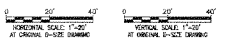
(SREL)

LM 18.60 – 15.50



REACH B (LK 16.00 - LK 30)
SACRAMENTO RIVER EAST LEVEE
ANALYSIS CROSS-SECTION: LK 16.70

Boring	Layer ID	Material Classification	Horizontal k_h (cm/sec)	k_h/k_v	Vertical k_v (cm/sec)	Anisotropic k_h (ft/day)	Vertical k_v (ft/day)	Effective Strength Parameters ϕ'	C' (psf)	γ (pcf)
USBR1001	1	Silt (ML)	2.0E-04	4	5.0E-05	0.567	0.142	30	0	124
960+60L	2	Lean Clay (CL)	1.1E-05	4	2.7E-06	0.0249	0.00599	28	150	115
JP-BANK	3	Silty Sand (SM)	1.7E-03	4	4.2E-04	3.84	0.936	32	0	125
CP1401-03	4a	Poorly Graded Sand w/ Silt (SP-SM)	5.4E-03	16	3.4E-04	14.16	0.918	33	0	126
	4b	Well-Graded Gravel (GW)	1.1E-02	16	3.0E-03	28.35	2.601	35	0	131
	5	Lean Clay (CL)	1.1E-05	16	7.1E-06	0.0284	0.00284	28	150	115



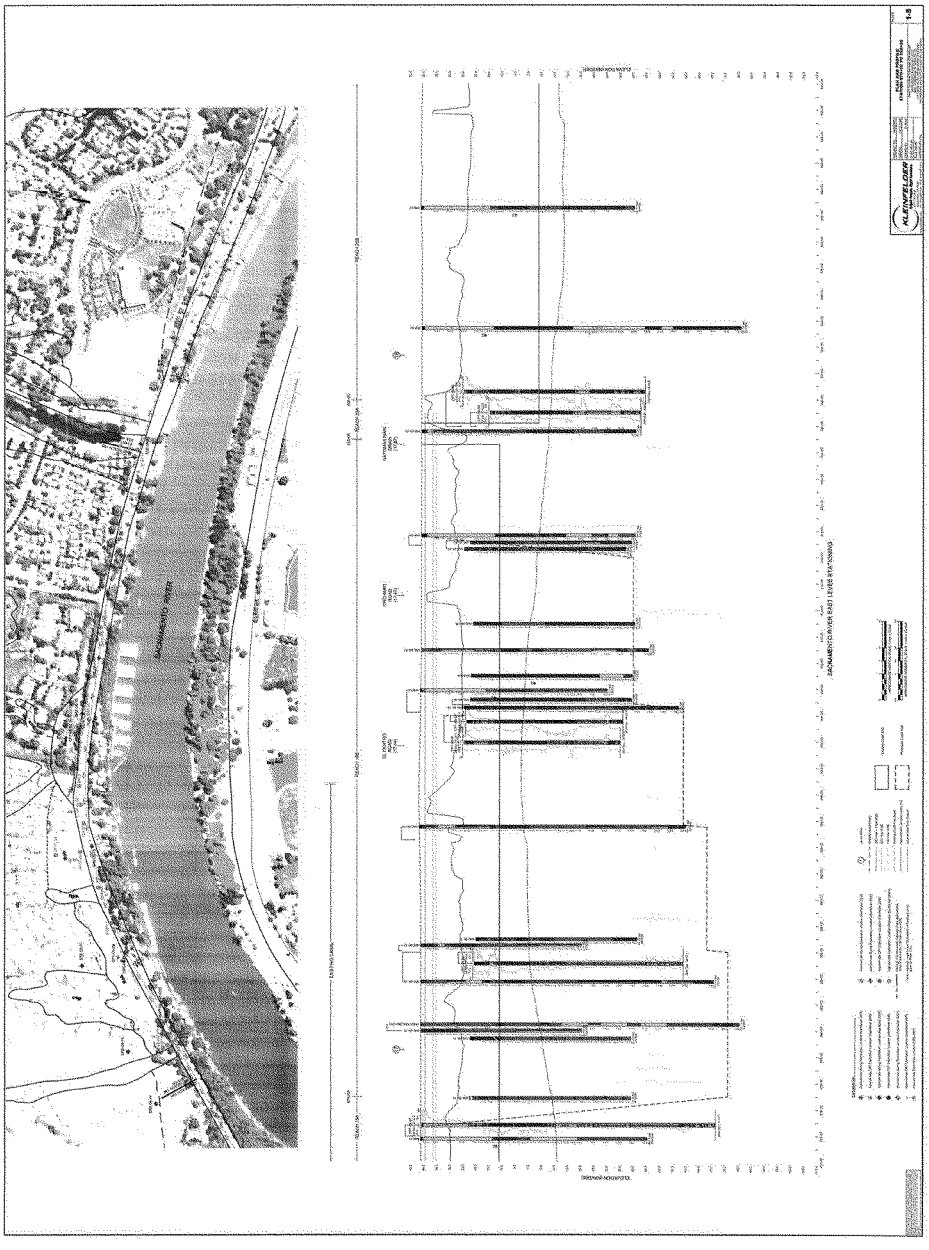
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO — CALIFORNIA

COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
SACRAMENTO RIVER EAST LEVEE
REACH A - LEVEE MILE 16.70

DATE:	SCALE:	SHEET NO.
29-JAN-2010	AS SHOWN	F.2.1

PLOT BY: LSOLOMAK — Jan 29, 2010 — 11:13:15am
DRAWING: N:\SEA\Common Features (DWR)\Plot\ Geotech Attachments\3-3 - Geo Analysis\Cross Section Picture\SREL Lat 16.7.dwg



Boring Designation URS071000_880+00C

DRILLING LOG	DIVISION: South Pacific	INSTALLATION: Sacramento District	SHEET 1 OF 8 SHEETS
1. PROJECT: Natomas GRR 2007		9. COORDINATE SYSTEM: State Plane CA Zone 4	HORIZONTAL: NAD 83 / VERTICAL:
		10. SIZE AND TYPE OF BIT: 3 inch drag bit	
2. HOLE NUMBER / LOCATION COORDINATES		11. MANUFACTURER'S DESIGNATION OF DRILL	
3. DRILLING AGENCY: PC Exploration		12. TOTAL SAMPLES / DISTURBED / UNDISTURBED	
4. NAME OF DRILLER: Bob Wharff		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED / DEG FROM VERTICAL: --- / BEARING		14. DEPTH GROUND WATER	
		15. DATE BORING: STARTED 3/28/07 / COMPLETED 4/2/07	
6. THICKNESS OF OVERBURDEN		16. ELEVATION TOP OF BORING	
7. DEPTH DRILLED INTO ROCK		17. TOTAL CORE RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 121.5		18. SIGNATURE AND TITLE OF INSPECTOR	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
	0.5															Driller used 3" blade bit, 4" NJW rods, 4" casing. Casing set to 50' bgs. Archeologist cleared to 35' bgs.
		2 2 4	6			Sandy silt (ML); dry; light olive brown (2.5Y 5/3) light olive brown; 60% low dry strength, slow dilatancy, no toughness fines; 40% sand.	100	S1								S01A_005_007S
	9.0															
		1 2 4	6			Sandy silt (ML); dry; grayish brown (2.5Y 5/2) grayish brown; 55% low dry strength, slow dilatancy, no toughness fines; 45% sand.	80	M2								S02A_010_012M
	11.5															
		1 2 3	5			Sandy silt (ML); dry; grayish brown (2.5Y 5/2) grayish brown; 60% low dry strength, slow dilatancy, no toughness fines; 40% sand.	100	S3								S03A_012_014S

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_880+00C SHEET 1 of 8

Boring Designation URS071000_880+00C

DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 2
	Sacramento District	OF 8 SHEETS
PROJECT	COORDINATE SYSTEM	HORIZONTAL / VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC.	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Sandy silt (ML); dry; grayish brown (2.5Y 5/2) grayish brown; 60% low dry strength, slow dilatancy, no toughness fines; 40% sand. *(continued)*											
		1 1 2	3				100	S4								S04A_015_017S
	19.0					Sandy silt (ML); dry; grayish brown (2.5Y 5/2) grayish brown; 60% low dry strength, slow dilatancy, no toughness fines; 40% sand.										
		1 1 2	3				100	M5								S05A_020_022M
																S06A_022_024S
		1 2 2	4				100	S6								
	24.0					Clayey sand (SC); moist; grayish brown (2.5Y 5/2) grayish brown grades to dark greenish gray (10Y 4/1) dark greenish gray; 60% sand; 40% fines; vertically grades to clayey sand with less sand like neopoliatan ice cream. Interbedded silty sand swirled with clayey sand at 28' bgs..										
		5 6 7	13				100	M7								S07A_025_027S
																S08A_027_029S
	29.0					Sandy lean clay (CL); moist; dark greenish gray (10Y 4/1) dark greenish gray mottled w/ dark grayish brown (2.5Y 4/2) dark grayish brown; 60% medium dry strength, slow dilatancy, low toughness fines; 40% sand.										
																S09A_030_032T, may be disturbed

15.0 17.5 20.0 22.5 25.0 27.5 30.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_880+00C

DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 3
	Sacramento District	OF 8 SHEETS
PROJECT	COORDINATE SYSTEM	HORIZONTAL / VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
							100	T9								
	32.0															
		2				Clayey sand (SC); moist; olive gray (5Y 4/2) olive gray mottled w/ dark grayish brown (2.5Y 4/2) dark grayish brown; 65% sand; 35% fines; blocky; cemented nodules.	100	S10								S10A_032_034S
		2														
		4	6													
	34.0															
						Silty sand (SM); wet; very dark grayish brown (2.5Y 3/2) very dark grayish brown; 75% sand; 25% fines.											
		3														S11A_035_037S, driller reported water at 35' bgs. End on 3/28/07. Resume on 3/29/07.
	35.8	5					100	S11								
		6	11			Silty sand (SM); very moist; very dark greenish gray (10Y 3/1) very dark greenish gray mottled w/ very dark grayish brown (2.5Y 3/2) very dark grayish brown; 70% sand; 30% fines.											
		1														S12A_040_042S. Driller reported lost drilling mud to formation, may be a void at 40' bgs.
		2					100	S12								
		6	8													
	44.0															
						Silty sand (SM); wet; very dark greenish gray (10Y 3/1) very dark greenish gray; 85% sand; 15% fines; interbed of fine grained silty sand at 45.5-46 bgs. Increase in silts at 46-46.5 bgs..											
	45.5	2														S13A_045_047S
	46.0	3				Silty sand (SM); moist; very dark greenish gray (10Y 3/1) very dark greenish gray; 55% sand; 45% fines.	100	S13								
		6	9			Silty sand (SM); moist; very dark greenish gray (10Y 3/1) very dark greenish gray; 70% sand; 30% fines; micaceous.										

32.5 35.0 37.5 40.0 42.5 45.0 47.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_880+00C SHEET 3 of 8

Boring Designation URS071000_880+00C

DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 4
	Sacramento District	OF 8 SHEETS
PROJECT	COORDINATE SYSTEM	HORIZONTAL / VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
	49.0															
		5				Silty sand (SM); moist; olive gray (5Y 4/2) olive gray; 80% sand; 20% fines; fines to a sandy silt at 50.75-51.5 bgs..											S14A_050_052S. Casing set to 50' bgs.
	50.8	6	13			Sandy silt (ML); moist; (10Y 3/2); 60% low dry strength, slow dilatancy, low toughness fines; 40% sand.	80	S14								
		7														
	54.0					Poorly graded sand with silt (SP-SM); moist; dark grayish brown (2.5Y 4/2) dark grayish brown; 90% sand; 10% fines; micaceous, subangular to rounded.										S15A_055_057
		5														
		6	14				20	S15								
		8														
	59.0					Silty sand (SM); wet; dark grayish brown (2.5Y 4/2) dark grayish brown; 75% sand; 25% fines; micaceous.										
		7														S16A_060_062S
		8	18				87	S16								
		10														
	64.0					Poorly graded sand with silt (SP-SM); wet; (10Y 3/2); 90% sand; 10% fines.										

50.0 52.5 55.0 57.5 60.0 62.5 65.0

Boring Designation URS071000_880+00C

DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 5
	Sacramento District	OF 8 SHEETS
PROJECT	COORDINATE SYSTEM	HORIZONTAL / VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		10 10 11	21			Poorly graded sand with silt (SP-SM); wet; (10Y 3/2); 90% sand; 10% fines. *(continued)*	67	S17								S17A_065_067S
		6 8 11	19				67	S18								S18A_070_072S
		8 10 15	25				67	S19								S19A_075_077S
	79.0					Silty sand (SM); very moist; very dark greenish gray (10Y 3/1) very dark greenish gray; 80% sand; 20% fines.										
		8 8 8	16				67	S20								S20A_080_082S

65.0 67.5 70.0 72.5 75.0 77.5 80.0

Boring Designation URS071000_880+00C

DRILLING LOG (Cont Sheet)	INSTALLATION		SHEET 6 OF 8 SHEETS
	Sacramento District		
PROJECT	COORDINATE SYSTEM	HORIZONTAL	VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83	
LOCATION COORDINATES	ELEVATION TOP OF BORING		

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Silty sand (SM); very moist; very dark greenish gray (10Y 3/1) very dark greenish gray; 80% sand; 20% fines. *(continued)*										
	84.0															
		8				Poorly graded sand with silt (SP-SM); very moist; very dark greenish gray (10Y 3/1) very dark greenish gray; 90% sand; 10% fines.										S21A_080_082S
		11														
		13	24				80	S21								
		11														S22A_090_092S
		11														
		13	24				67	S22								
	94.0															
						Silty sand (SM); very moist; very dark greenish gray (10Y 3/1) very dark greenish gray; 80% sand; 20% fines.										
		13														S23A_095_097S
		15														
		16	31				67	S23								
	99.0															

82.5 85.0 87.5 90.0 92.5 95.0 97.5

Boring Designation URS071000_880+00C

DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 7
	Sacramento District	OF 8 SHEETS
PROJECT	COORDINATE SYSTEM	HORIZONTAL / VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Silty sand (SM); very moist; very dark greenish gray (10Y 3/1) very dark greenish gray; 70% sand; 30% fines; subrounded to rounded.										
		17														S24A_100_102S
		19	40				73	S24								
		21														
	104.0															
						Silty sand (SM); very moist; very dark greenish gray (10Y 3/1) very dark greenish gray; 80% sand; 20% fines; subrounded to rounded.										
		11														S25A_105_107S
		11	26				67	S25								
		15														
		9														S26A_110_112S
		13	26				53	S26								
		13														
	112.0															
						Lean clay (CL); moist; greenish gray (5G 5/1) greenish gray; 100% high dry strength, no dilatancy, medium toughness fines.											Driller reported gravel lense at 112-113' bgs and clay from 113 to bgs
		24														S27A_115_117S. End on 3/30/07. Resume on 4/2/07.
		34					133	M27								

100.0 102.5 105.0 107.5 110.0 112.5 115.0

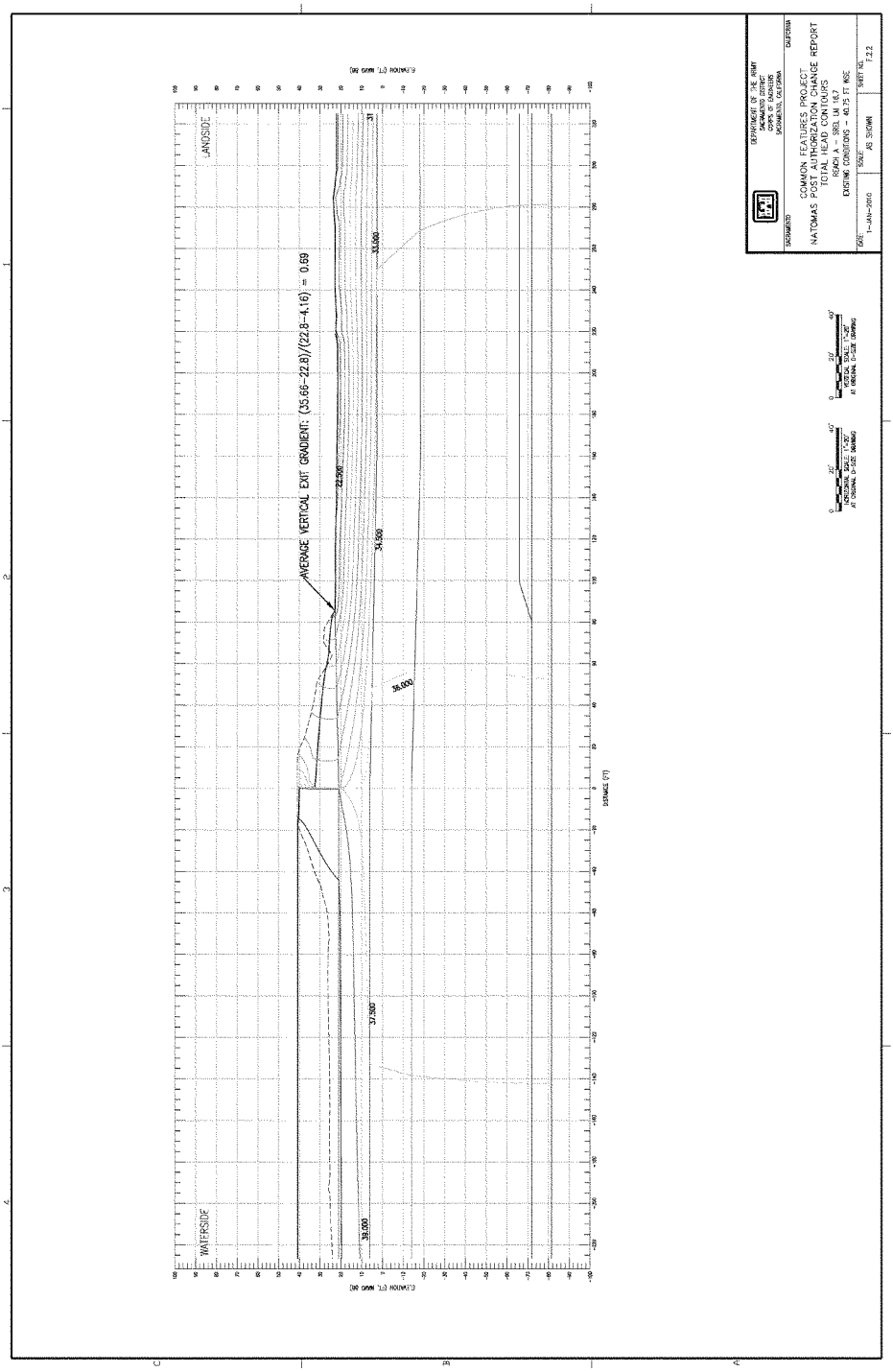
SPK FORM 1836-A
SEP 05

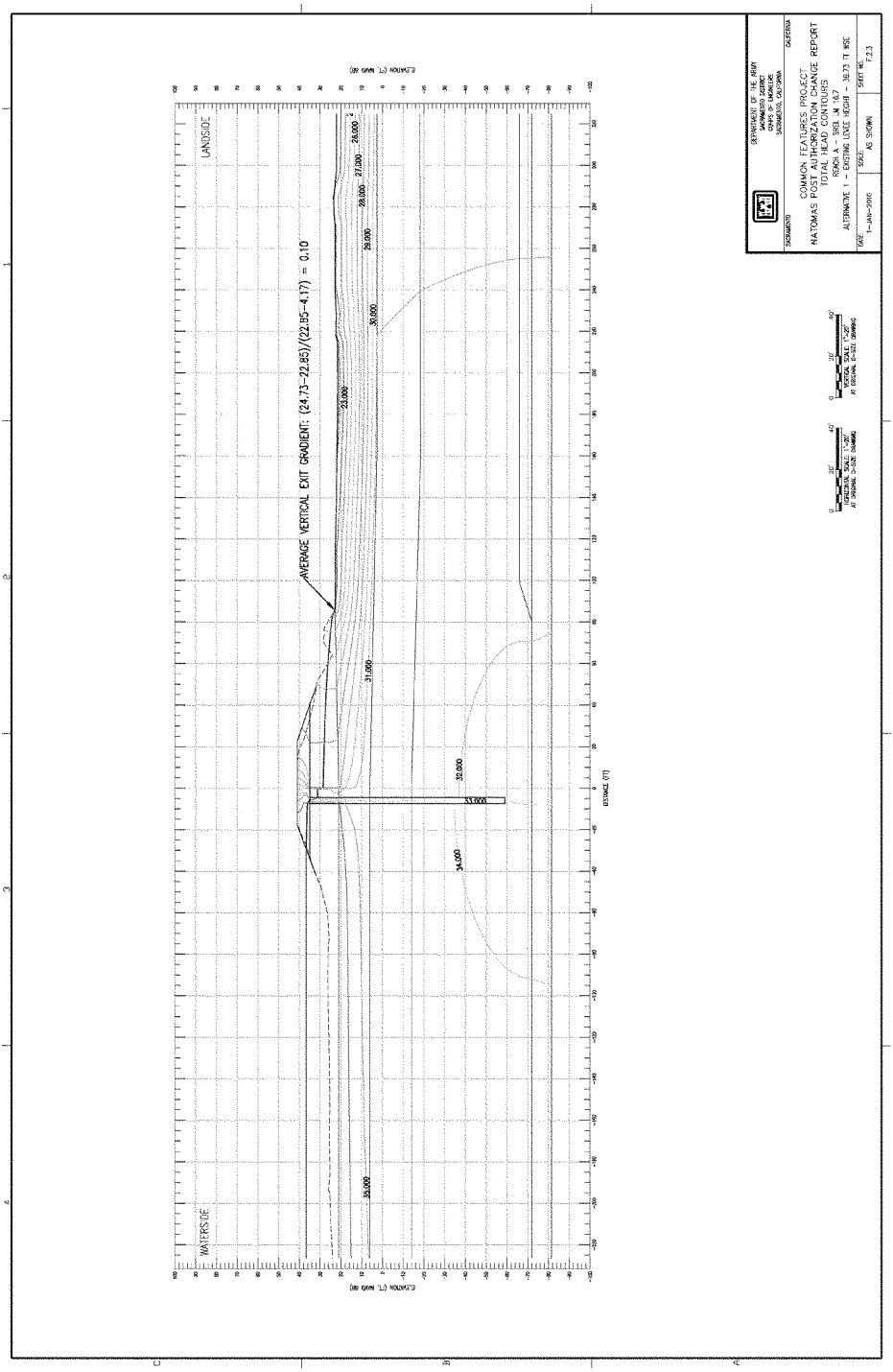
Boring Designation URS071000_880+00C SHEET 7 of 8

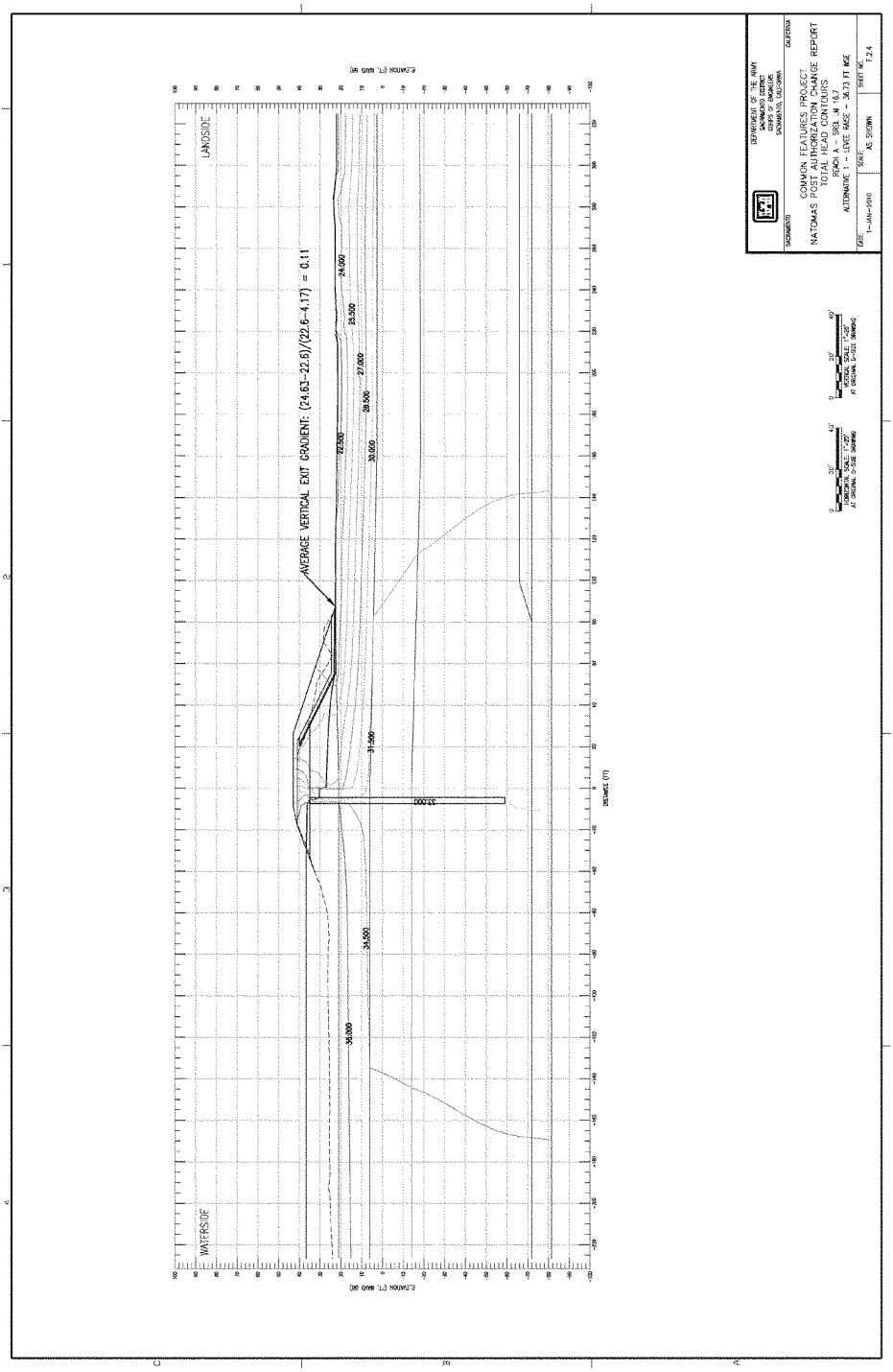
Boring Designation URS071000_880+00C

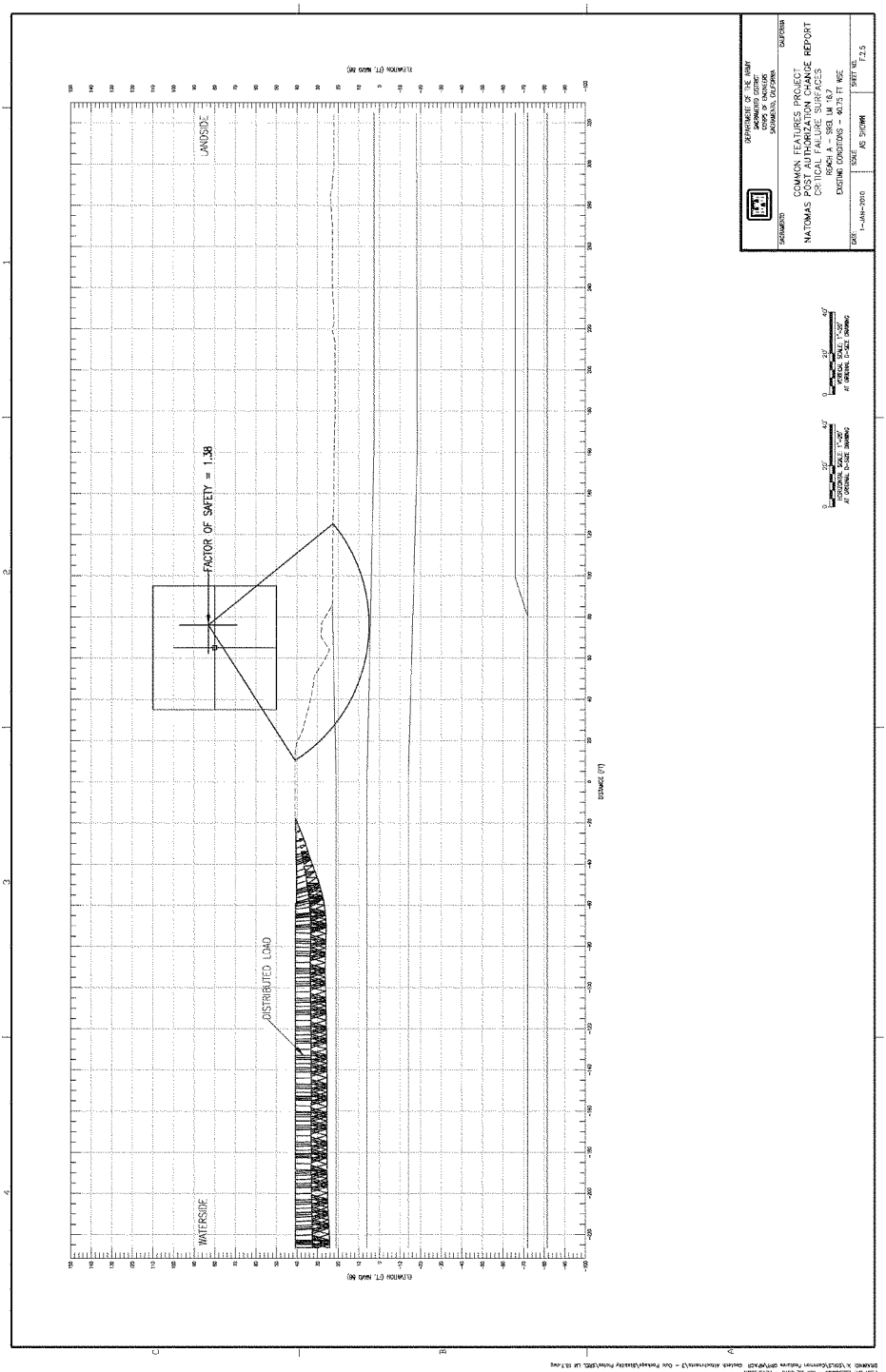
DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 8
	Sacramento District	OF 8 SHEETS
PROJECT	COORDINATE SYSTEM	HORIZONTAL / VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83
LOCATION COORDINATES	ELEVATION TOP OF BORING	

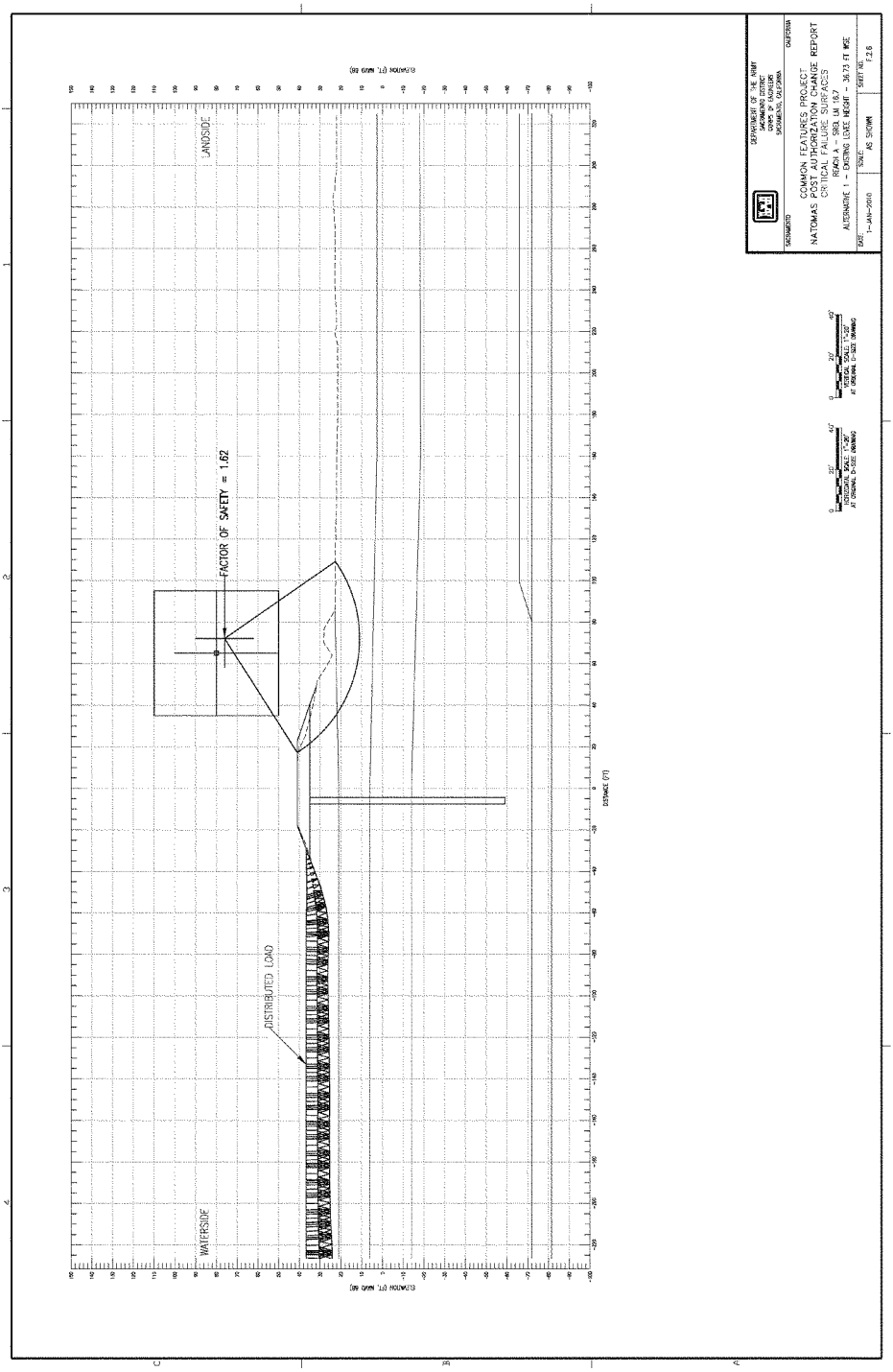
ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		26	60			Lean clay (CL); moist; greenish gray (5G 5/1) greenish gray; 100% high dry strength, no dilatancy, medium toughness fines. *(continued)*										
	119.0															117.5
		15				Silty sand (SM); moist; dark greenish gray (10GY 4/1) dark greenish gray; 80% sand; 20% fines; cemented nodules.										S28A_120_122S
	121.0	23	46				100	S28								120.0
	121.5	23				Clayey sand (SC); moist; dark greenish gray (10GY 4/1) dark greenish gray; 60% sand; 40% fines; cemented nodules.										

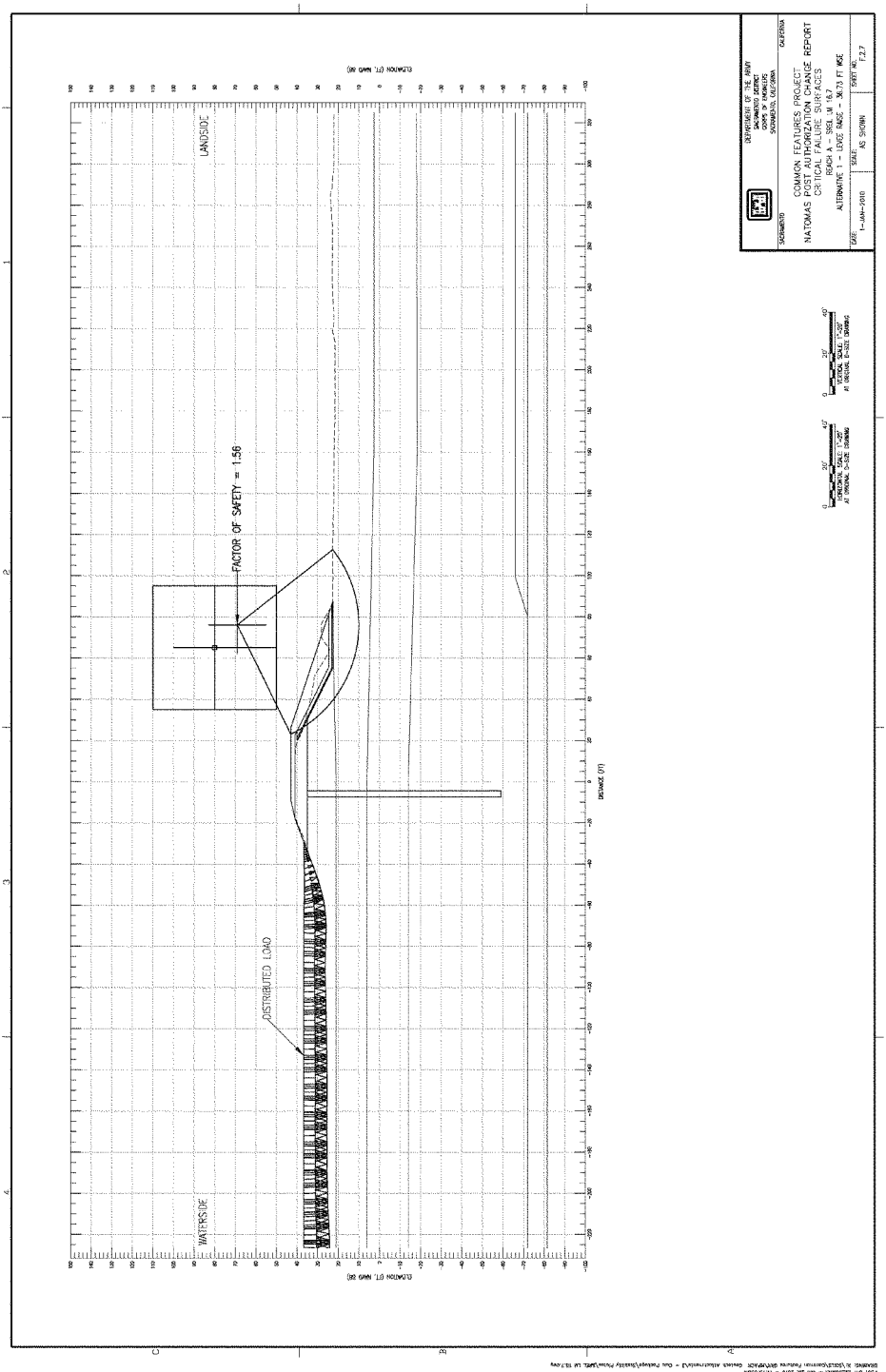

AVERAGE VERTICAL EXIT GRADIENT: (35.66-22.8)/(22.8-4.16) = 0.69
LANDSIDE
WATERSIDE
ELEVATION (FT NAVD 88)
DISTANCE (FT)
39.000
37.380
36.000
34.500
33.000
31
22.800
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A, STA 38+00
EXISTING CONDITIONS - 40.25 FT WSE
DATE: 1-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.2
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING


AVERAGE VERTICAL EXIT GRADIENT: (24.73-22.85)/(22.95-4.17) = 0.10
WATERSIDE
LANDSIDE
ELEVATION (FT NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A, STA 1+00
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 38.73 FT WSE
DATE: 1-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.3


AVERAGE VERTICAL EXIT GRADIENT: (24.63-22.6)/(22.6-4.17) = 0.11
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A, STA 3+00
ALTERNATIVE 1 - LEVEE RAISE - 38.73 FT MSE
DATE: 1-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.4


FACTOR OF SAFETY = 1.36
WATERSIDE
LANDSIDE
DISTRIBUTED LOAD
ELEVATION (FT, NGVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, STATION 0+00 TO 46+25 FT WSE
EXISTING CONDITIONS
DATE: 1-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.5


FACTOR OF SAFETY = 1.62
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, STA 1+00
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 36.73 FT WSE
DATE: 1-JAN-2010
SCALE: AS SHOWN
SHEET NO.: F.2.6


FACTOR OF SAFETY = 1.56
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, SEG 1 & 2
ALTERNATIVE 1 - LEVEE RAISE - 36.73 FT MSE
DATE: 1-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.7

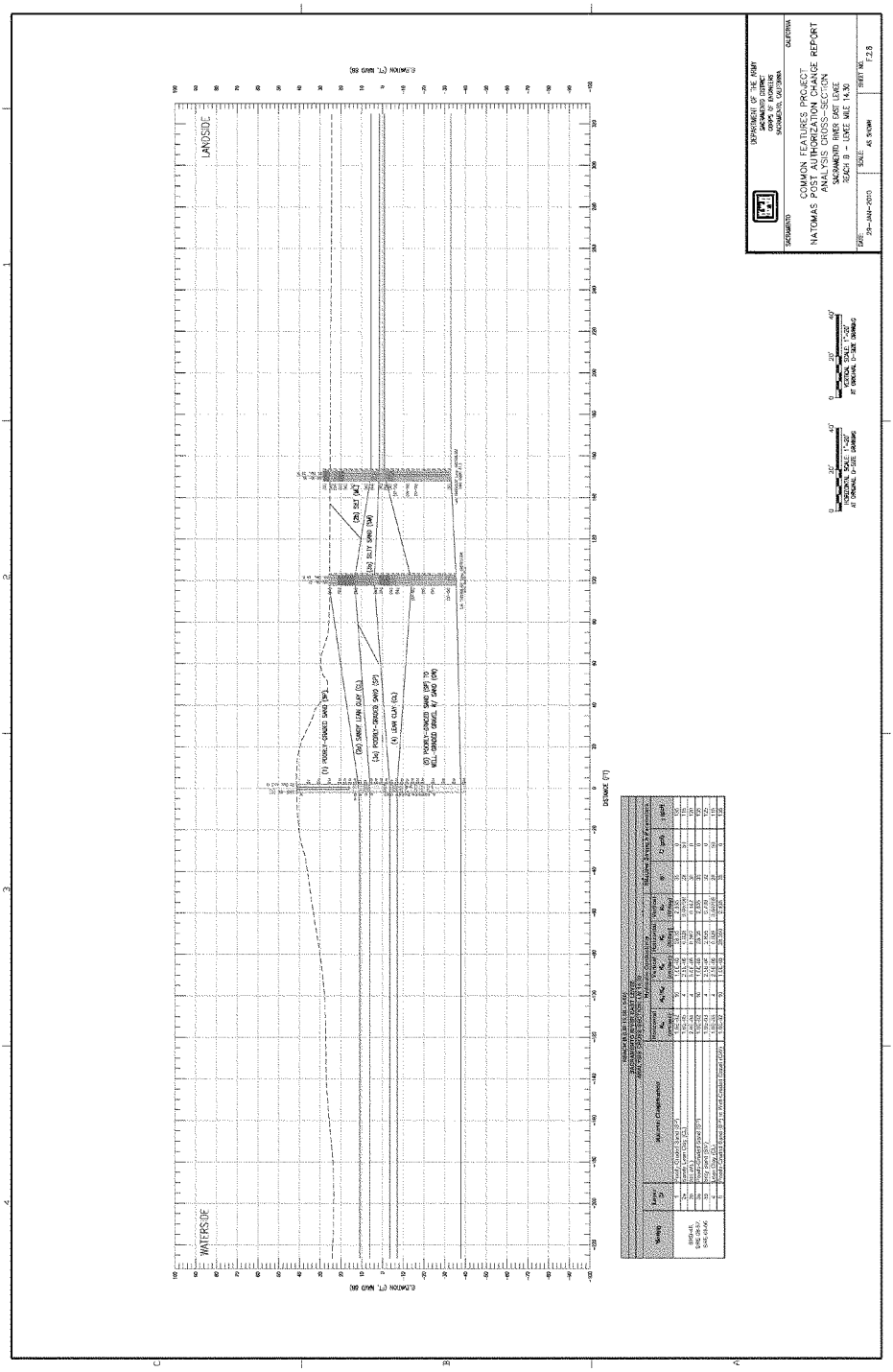
REACH B

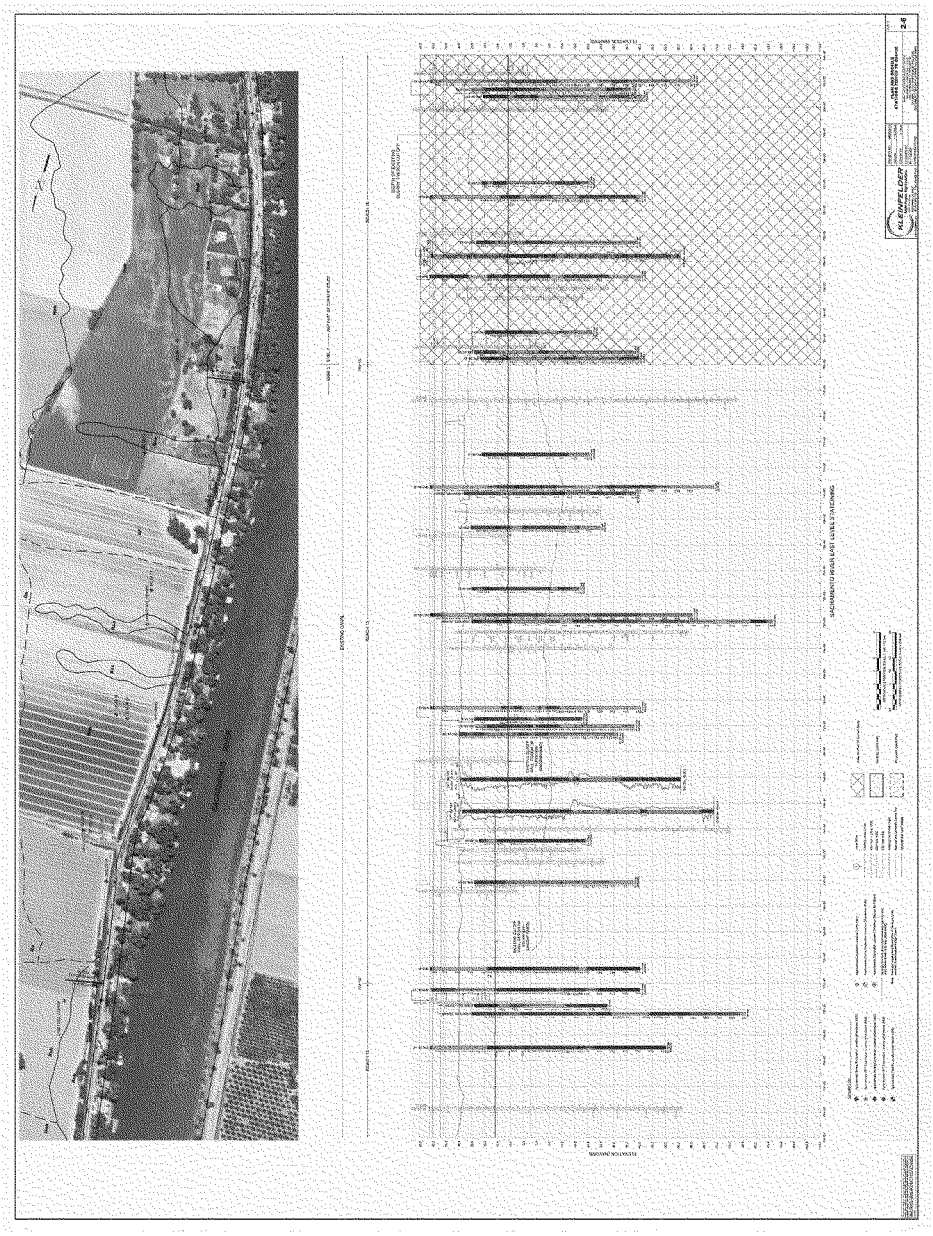
CALCULATION PACKAGE

SACRAMENTO RIVER EAST LEVEE

(SREL)

LM 15.50 – 5.00


WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
(1) POORLY-GRADED SAND (SP)
(2a) SANDY LEAN CLAY (CL)
(2b) POORLY-GRADED SAND (SP)
(4) LEAN CLAY (CL)
(5) POORLY-GRADED SAND (SP) TO WELL-GRADED GRAVEL W/ SAND (GW)
(2c) SILTY SAND (SM)
(2d) SILT (ML)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
NATOMAS MAIN AND NORTH LEVEE
REACH B - LOWER MILE 14.50
DATE: 29-JAN-2013
SCALE: AS SHOWN
SHEET NO. F2.8



Surface Conditions: Garden Highway on levee crown.

Groundwater: Groundwater initially encountered at a depth of about 32.5 feet below existing site grade.

Method: Hollow Stem Auger/Mud Rotary

Equipment: CME 75

Date Completed: 9/8/2005

Logged By: Ginger Zhang

Total Depth: 81-1/2 feet

Boring Diameter: 8 inch and 4 inch

Approximate Elevation: 39 feet (NGVD29*)
Approximate Northing: 1989562.79 feet
Approximate Easting: 6687278.04 feet

Elevation (ft., msl)	Depth (feet)	FIELD: Sample Type	FIELD: Sample No.	FIELD: Blows/6 inches	FIELD: Pocket Penetrometer (tsf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphic Log	DESCRIPTION
														ASPHALT CONCRETE: Not measured
														AGGREGATE BASE: Not measured
														Poorly Graded SAND (SP): Brown and white, moist, fine to medium grained, (FILL)
34	5		1b	5										
			1a	3										
				4										
29	10		2b	6										Trace coarse sand
			2a	6										
				5										
24	15		3b	6										
			3a	7										
				7										
19	20		4b	4										
			4a	5										
				5										
			5b	6										Brown
			5a	8										
14	25			8										
			6b	7										
			6a	6										
				7										
			7b	6										
			7a	7										
				8						100	10	Sieve; see Plate B-3		**Poorly Graded SAND With Silt** (SP-SM): Brown, moist, fine grained, about 10% silt, trace mica

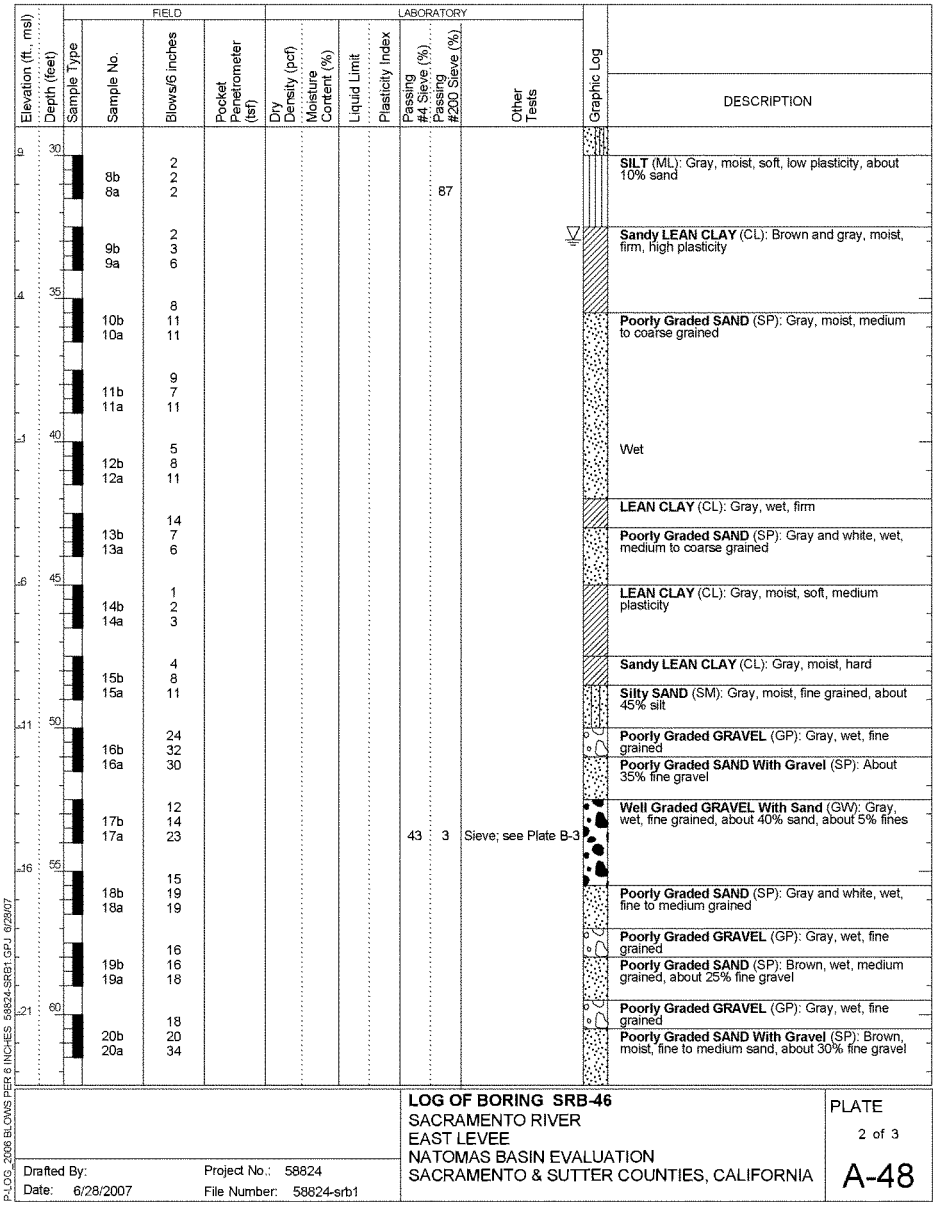
PLOG_2006 BLOWS PER 6 INCHES 58824-SRB1.GPJ 6/28/07

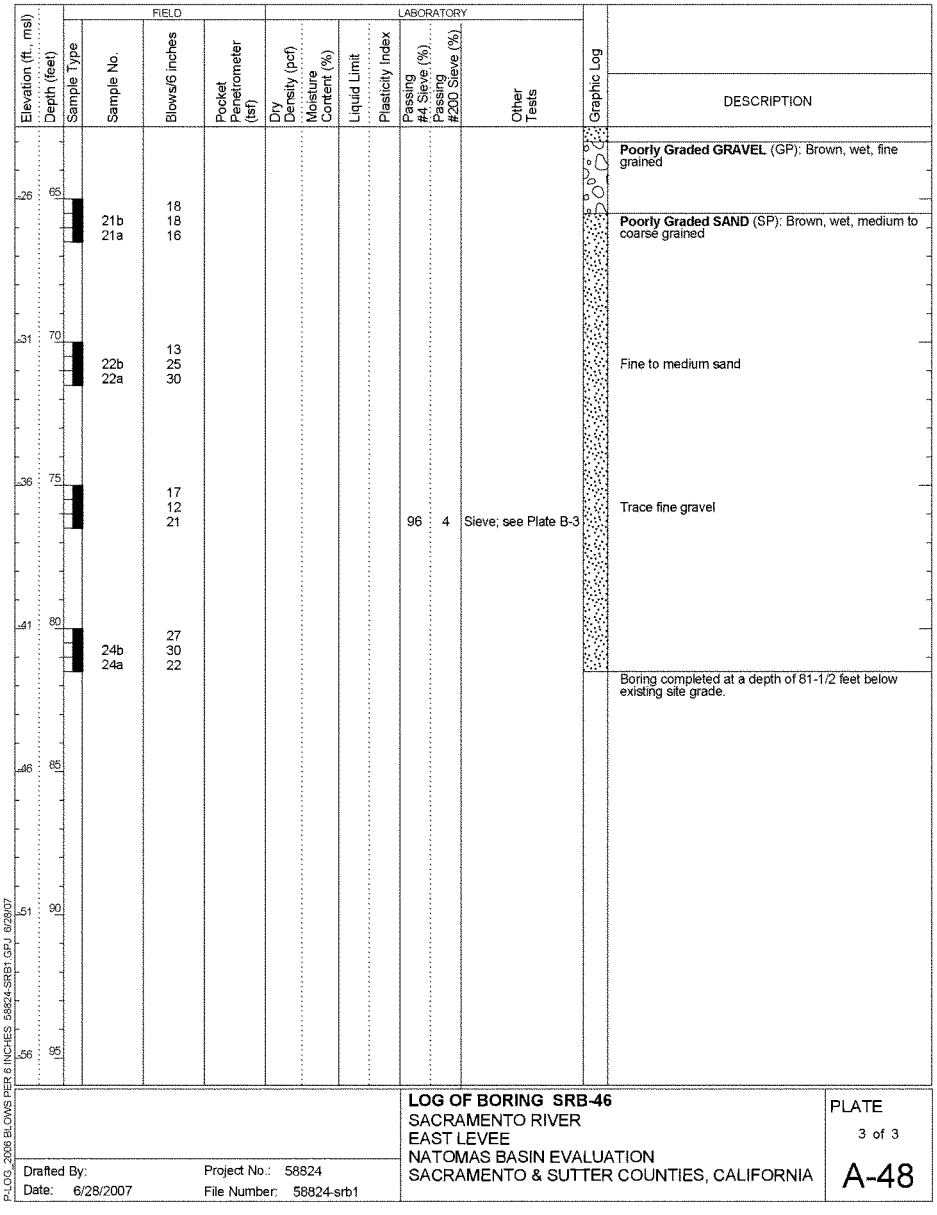
Drafted By:
Date: 6/28/2007

Project No.: 58824
File Number: 58824-srb1

LOG OF BORING SRB-46
SACRAMENTO RIVER
EAST LEVEE
NATOMAS BASIN EVALUATION
SACRAMENTO & SUTTER COUNTIES, CALIFORNIA

PLATE
1 of 3
A-48


FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
0
30
8b 2
8a 2
87
SILT (ML): Gray, moist, soft, low plasticity, about 10% sand
9b 2
9a 6
Sandy LEAN CLAY (CL): Brown and gray, moist, firm, high plasticity
4
35
8
10b 11
10a 11
Poorly Graded SAND (SP): Gray, moist, medium to coarse grained
11b 9
11a 7
11
Wet
-1
40
5
12b 8
12a 11
LEAN CLAY (CL): Gray, wet, firm
14
13b 7
13a 6
Poorly Graded SAND (SP): Gray and white, wet, medium to coarse grained
-6
45
1
14b 2
14a 3
LEAN CLAY (CL): Gray, moist, soft, medium plasticity
4
15b 8
15a 11
Sandy LEAN CLAY (CL): Gray, moist, hard
Silty SAND (SM): Gray, moist, fine grained, about 45% silt
-11
50
24
16b 32
16a 30
Poorly Graded GRAVEL (GP): Gray, wet, fine grained
Poorly Graded SAND With Gravel (SP): About 35% fine gravel
12
17b 14
17a 23
43 3 Sieve; see Plate B-3
Well Graded GRAVEL With Sand (GW): Gray, wet, fine grained, about 40% sand, about 5% fines
-16
55
15
18b 19
18a 19
Poorly Graded SAND (SP): Gray and white, wet, fine to medium grained
Poorly Graded GRAVEL (GP): Gray, wet, fine grained
16
19b 16
19a 18
Poorly Graded SAND (SP): Brown, wet, medium grained, about 25% fine gravel
-21
60
Poorly Graded GRAVEL (GP): Gray, wet, fine grained
18
20b 20
20a 34
Poorly Graded SAND With Gravel (SP): Brown, moist, fine to medium sand, about 30% fine gravel
PLOG_2006 BLOWS PER 6 INCHES 58824-SRB1.GPJ 6/28/07
LOG OF BORING SRB-46
SACRAMENTO RIVER
EAST LEVEE
NATOMAS BASIN EVALUATION
SACRAMENTO & SUTTER COUNTIES, CALIFORNIA
PLATE
2 of 3
A-48
Drafted By:
Date: 6/28/2007
Project No.: 58824
File Number: 58824-srb1


FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
26
65
21b
21a
18
18
16
Poorly Graded GRAVEL (GP): Brown, wet, fine grained
Poorly Graded SAND (SP): Brown, wet, medium to coarse grained
31
70
22b
22a
13
25
30
Fine to medium sand
36
75
17
12
21
96
4
Sieve; see Plate B-3
Trace fine gravel
41
80
24b
24a
27
30
22
Boring completed at a depth of 81-1/2 feet below existing site grade.
46
85
51
90
56
95
PLOG_2006 BLOWS PER 6 INCHES 58824-SRB1.GPJ 6/28/07
Drafted By:
Date: 6/28/2007
Project No.: 58824
File Number: 58824-srb1
LOG OF BORING SRB-46
SACRAMENTO RIVER
EAST LEVEE
NATOMAS BASIN EVALUATION
SACRAMENTO & SUTTER COUNTIES, CALIFORNIA
PLATE
3 of 3
A-48

Boring Location/ Surface Conditions: Existing landside levee toe, seasonal weeds
Groundwater: Groundwater not measured due to drilling method.
Method: Mud Rotary
Equipment: CME 75 with 140 lb. Automatic Hammer

Date Completed: 3/27/2008
Logged By: E. Ortakci
Reviewed By: M. Briseno
Total Depth: 61-1/2 feet
Boring Diameter: 4 inch

Approximate Elevation: 30 feet (NAVD88)
Approximate Northing: 1989593 feet
Approximate Easting: 6687339 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
				4										
			1b	4										
			1a	5	4.5	101	19	36	15					**LEAN CLAY** (CL): Brown, dry, firm, low to medium plasticity
				5										Moist
			2b	5										
			2a	6	2.25						81	Hydrometer		**SILT With Sand** (ML): Brown, moist, firm, low plasticity, fine to medium sand
25	5			6										
			3b	6										**Silty SAND** (SM): Brown, moist, fine to medium sand
			3a	8	3.75						49			
				3										
			4b	3	1.5									**LEAN CLAY** (CL): Brown, moist, soft, low to medium plasticity
			4a	4	2.0			37	15					
20	10			2										
			5b	2										**SILT With Sand** (ML): Brown, moist, soft, low plasticity, fine sand
			5a	4							76			
				2										
			6b	2	0.25									
			6a	2										**SILT** (ML): Blue gray, moist, very soft, low plasticity, fine sand
15	15			2										
			7b	2										
			7a	2	<0.25			41	11		93			
				1										Soft
			8b	2										
			8a	3	0.25			45	17					
10	20			1										
			9b	3										**Sandy SILT** (ML): Gray, moist, soft, low plasticity, fine sand
			9a	2							53			
				3										
			10b	2										**Silty SAND** (SM): Brown, moist, fine sand
			10a	3							44			
5	25			3										
			10c	4										
				4										
				3										
			11	3							74			**SILT With Sand** (ML): Brown, moist, low plasticity, fine sand
				3										

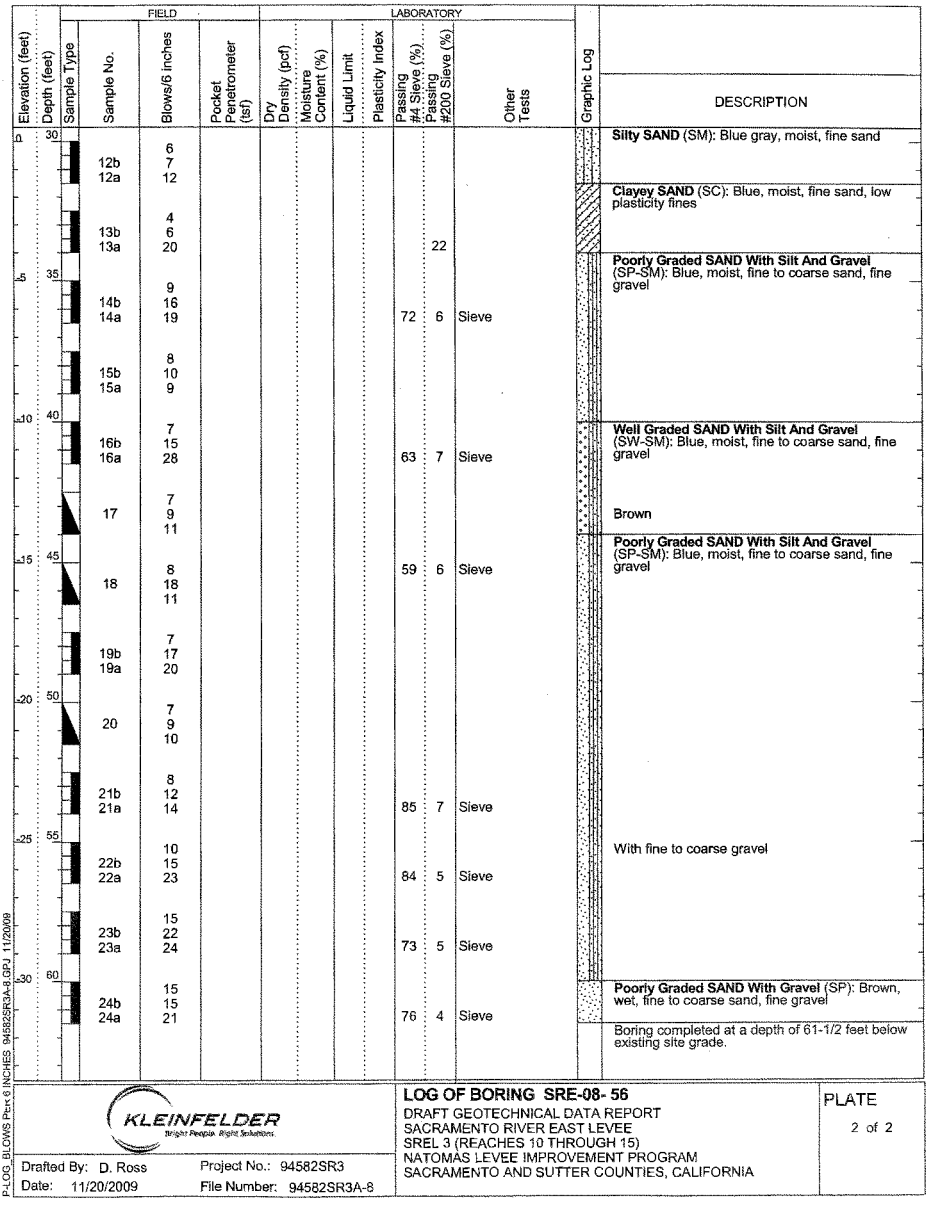
P:\LOG_BLOWS Per 6 INCHES_94582SR3A-8.GPJ 11/20/09

KLEINFELDER
Bright People. Right Solutions.

Drafted By: D. Ross
Date: 11/20/2009
Project No.: 94582SR3
File Number: 94582SR3A-8

LOG OF BORING SRE-08- 56
DRAFT GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 3 (REACHES 10 THROUGH 15)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
1 of 2



Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
0	30			6										**Silty SAND** (SM): Blue gray, moist, fine sand
			12b	7										
			12a	12										
				4										**Clayey SAND** (SC): Blue, moist, fine sand, low plasticity fines
			13b	6										
			13a	20							22			
-5	35			9										**Poorly Graded SAND With Silt And Gravel** (SP-SM): Blue, moist, fine to coarse sand, fine gravel
			14b	16										
			14a	19						72	6	Sieve		
				8										
			15b	10										
			15a	9										
-10	40			7										**Well Graded SAND With Silt And Gravel** (SW-SM): Blue, moist, fine to coarse sand, fine gravel
			16b	15										
			16a	28						63	7	Sieve		
				7										
			17	9										Brown
				11										
-15	45			8										**Poorly Graded SAND With Silt And Gravel** (SP-SM): Blue, moist, fine to coarse sand, fine gravel
			18	18						59	6	Sieve		
				11										
				7										
			19b	17										
			19a	20										
-20	50			7										
			20	9										
				10										
				8										
			21b	12										
			21a	14						85	7	Sieve		
-25	55			10										With fine to coarse gravel
			22b	15										
			22a	23						84	5	Sieve		
				15										
			23b	22										
			23a	24						73	5	Sieve		
-30	60			15										**Poorly Graded SAND With Gravel** (SP): Brown, wet, fine to coarse sand, fine gravel
			24b	15										
			24a	21						76	4	Sieve		
														Boring completed at a depth of 61-1/2 feet below existing site grade.

P:\LOG_BLOWS Plot 6 INCHES 94582SR3A-8.GPJ 11/20/09

KLEINFELDER
Bright People. Right Solutions.

Drafted By: D. Ross
Date: 11/20/2009
Project No.: 94582SR3
File Number: 94582SR3A-8

LOG OF BORING SRE-08- 56
DRAFT GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 3 (REACHES 10 THROUGH 15)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
2 of 2

Boring Location/ Surface Conditions: Landside field boring

Groundwater: Groundwater not measured due to drilling method.

Method: Mud Rotary

Equipment: CME 75 with 140 lb. Automatic Hammer

Date Completed: 3/27/2008

Logged By: E. Ortakci

Reviewed By: M. Briseno

Total Depth: 61-1/2 feet

Boring Diameter: 4 inch

Approximate Elevation: 24 feet (NAVD88)
Approximate Northing: 1989585 feet
Approximate Easting: 6687614 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
				4										
			1b	4										**Sandy SILT** (ML): Brown, moist, firm, low plasticity, fine sand
			1a	7										
				5										
			2b	5							62			
			2a	4	2.5									
19	5			3										**LEAN CLAY** (CL): Dark brown, moist, soft, low to medium plasticity
			3b	3				36	14					
			3a	5	0.75									
				9										
			4b	19										Very hard
			4a	32	>4.5									
14	10			4										
			5b	5										
			5a	6				25	9					Firm, low plasticity
				3										**Silty SAND** (SM): Dark brown, moist, fine sand
			6b	2										
			6a	2							46			
9	15			3										
			7b	4										
			7a	4							19			
				5										
			8b	4										
			8a	4										
4	20			3										
			9b	3							28			
			9a	5										
				3										**Sandy SILT** (ML): Dark brown, moist, firm, low plasticity, fine sand
			10b	3										
			10a	5							50			
-1	25			2										**LEAN CLAY With Sand** (CL): Dark brown, moist, very soft, low plasticity, fine sand
			11b	2										
			11a	2				31	10					
				2										
			12b	2										
			12a	2										

P:\LOG_BLOWS PER 6 INCHES 94582SR3A-8.GPJ 11/20/09

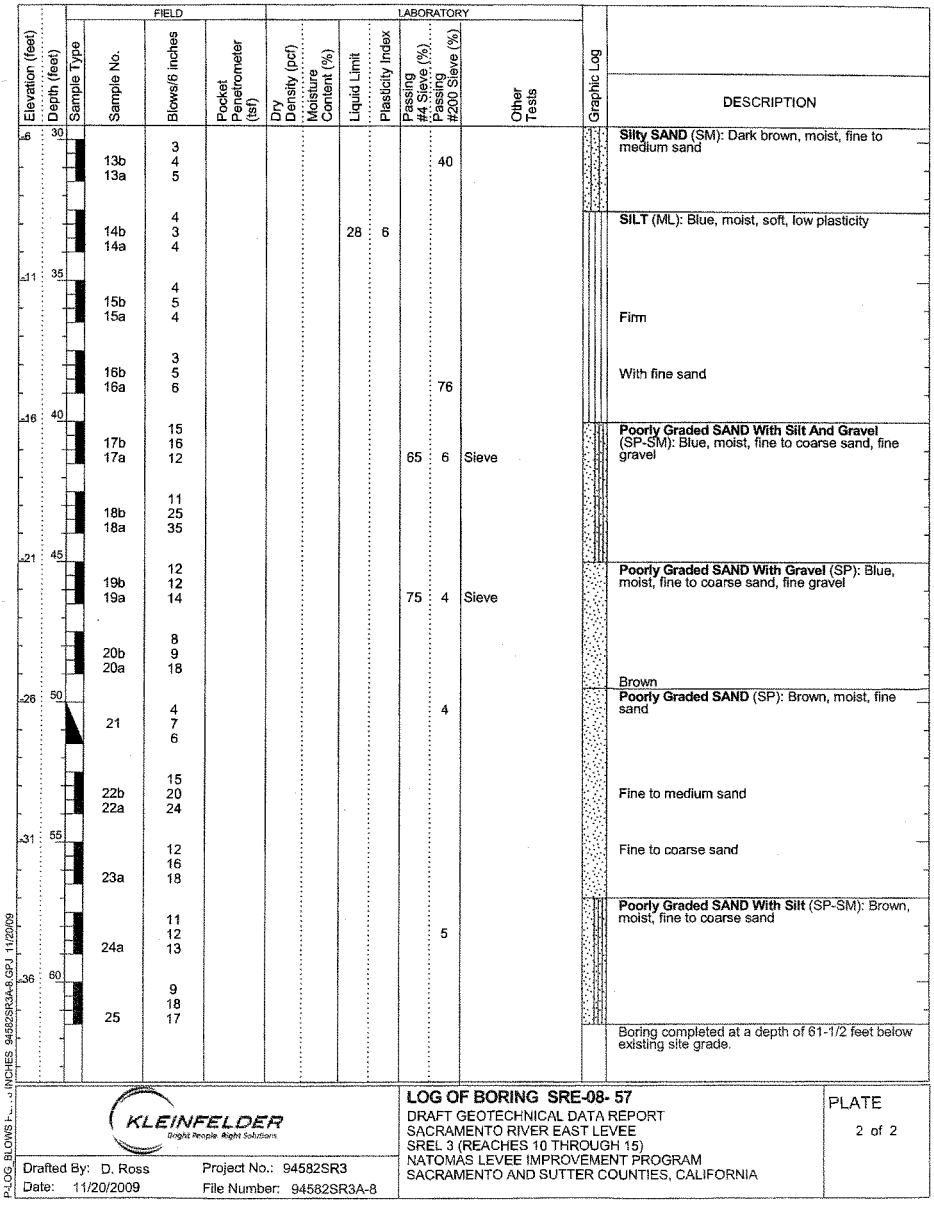
KLEINFELDER
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Drafted By: D. Ross
Date: 11/20/2009

Project No.: 94582SR3
File Number: 94582SR3A-8

LOG OF BORING SRE-08- 57
DRAFT GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 3 (REACHES 10 THROUGH 15)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
1 of 2



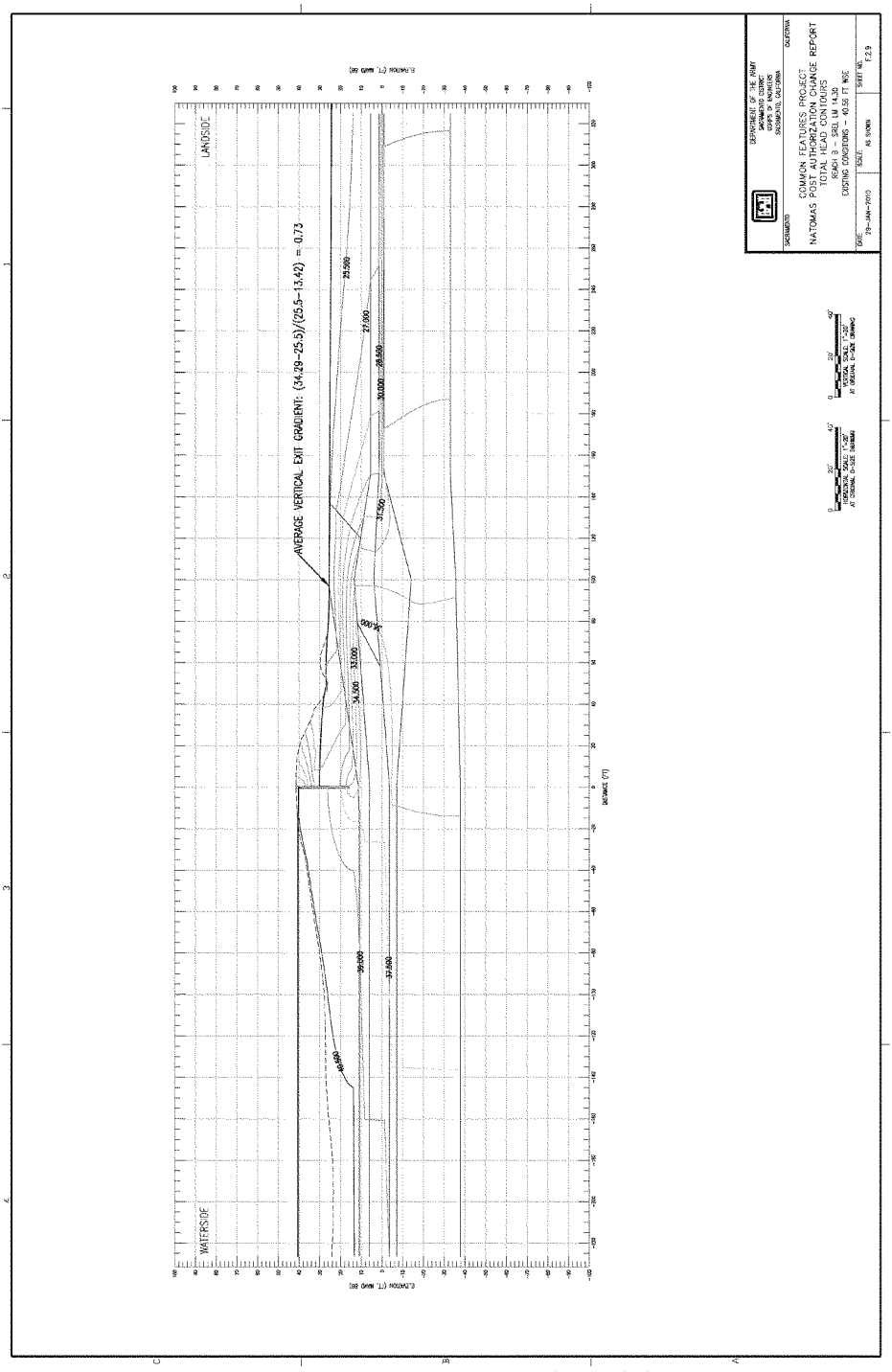
KLEINFELDER
Bright People. Right Solutions.

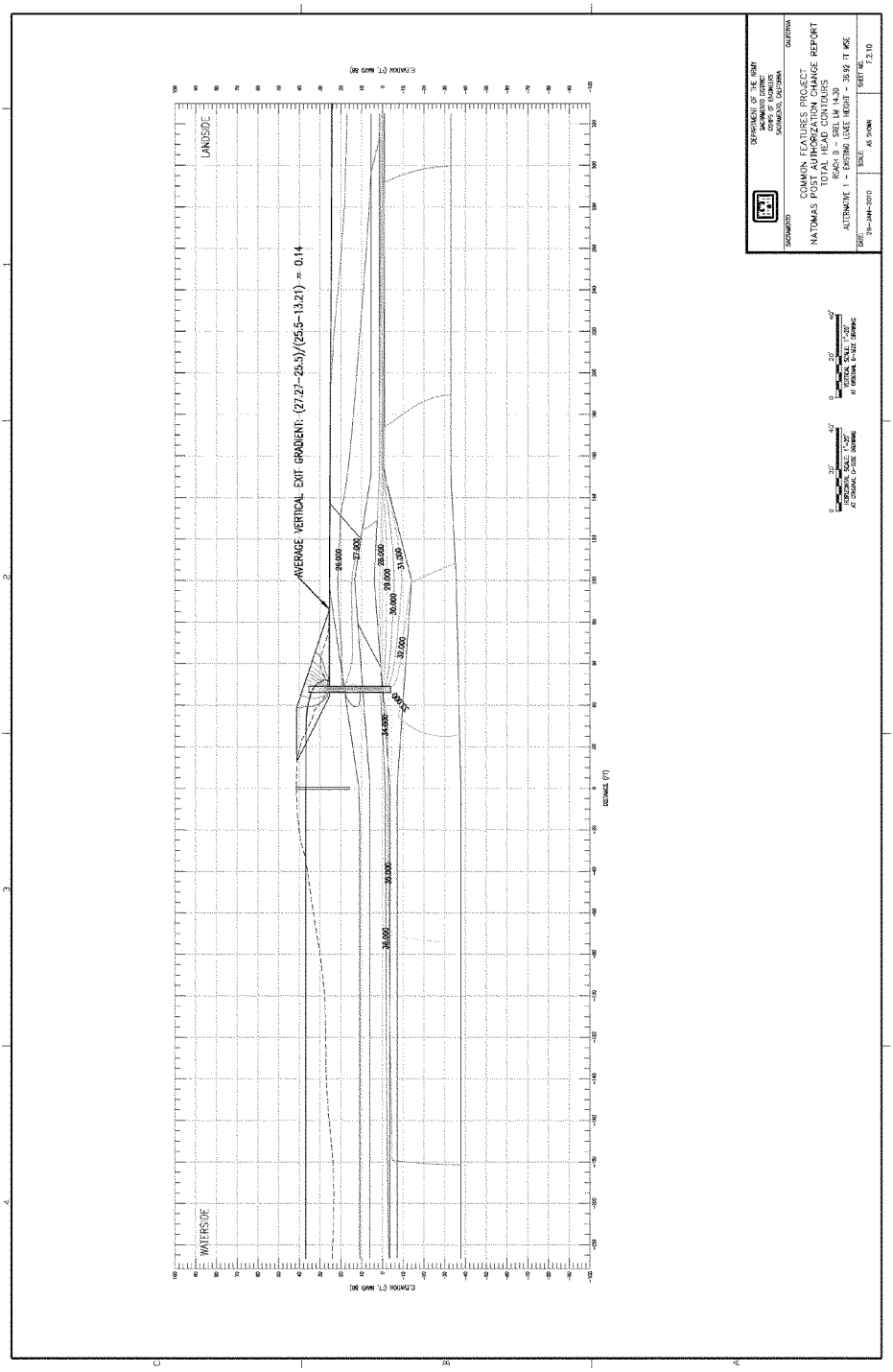
Drafted By: D. Ross
Date: 11/20/2009

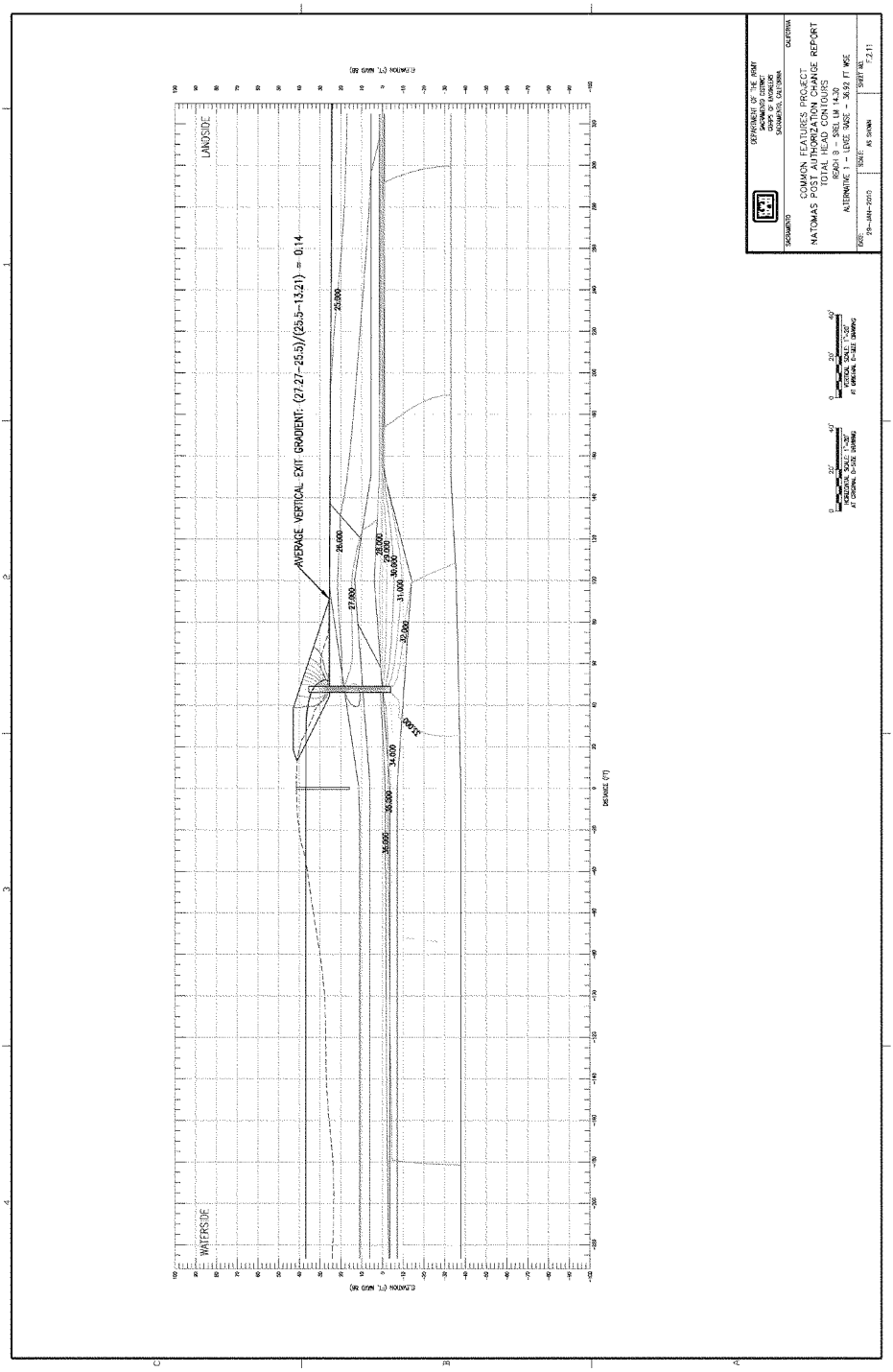
Project No.: 94582SR3
File Number: 94582SR3A-8

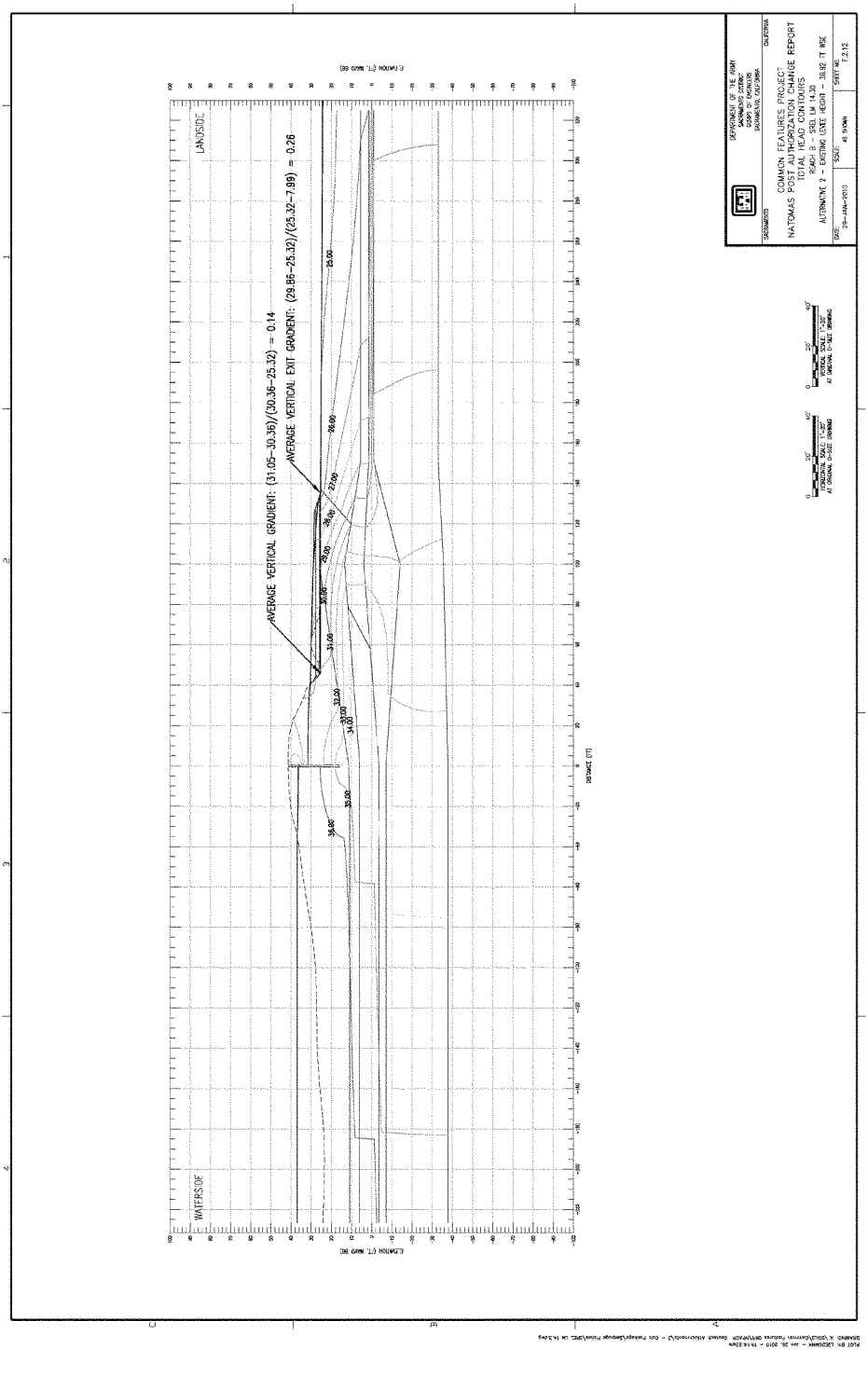
LOG OF BORING SRE-08- 57
DRAFT GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 3 (REACHES 10 THROUGH 15)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

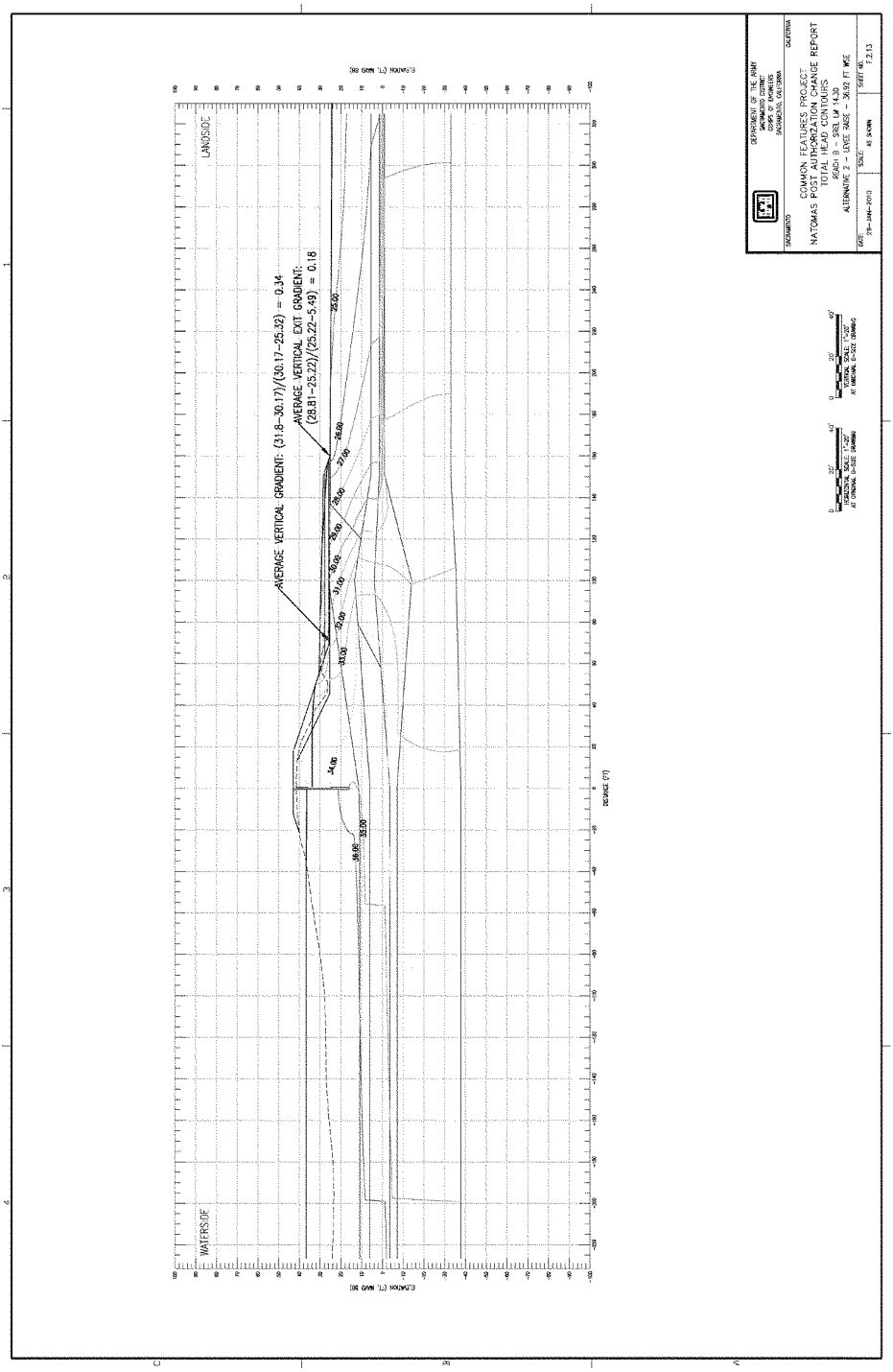
PLATE
2 of 2

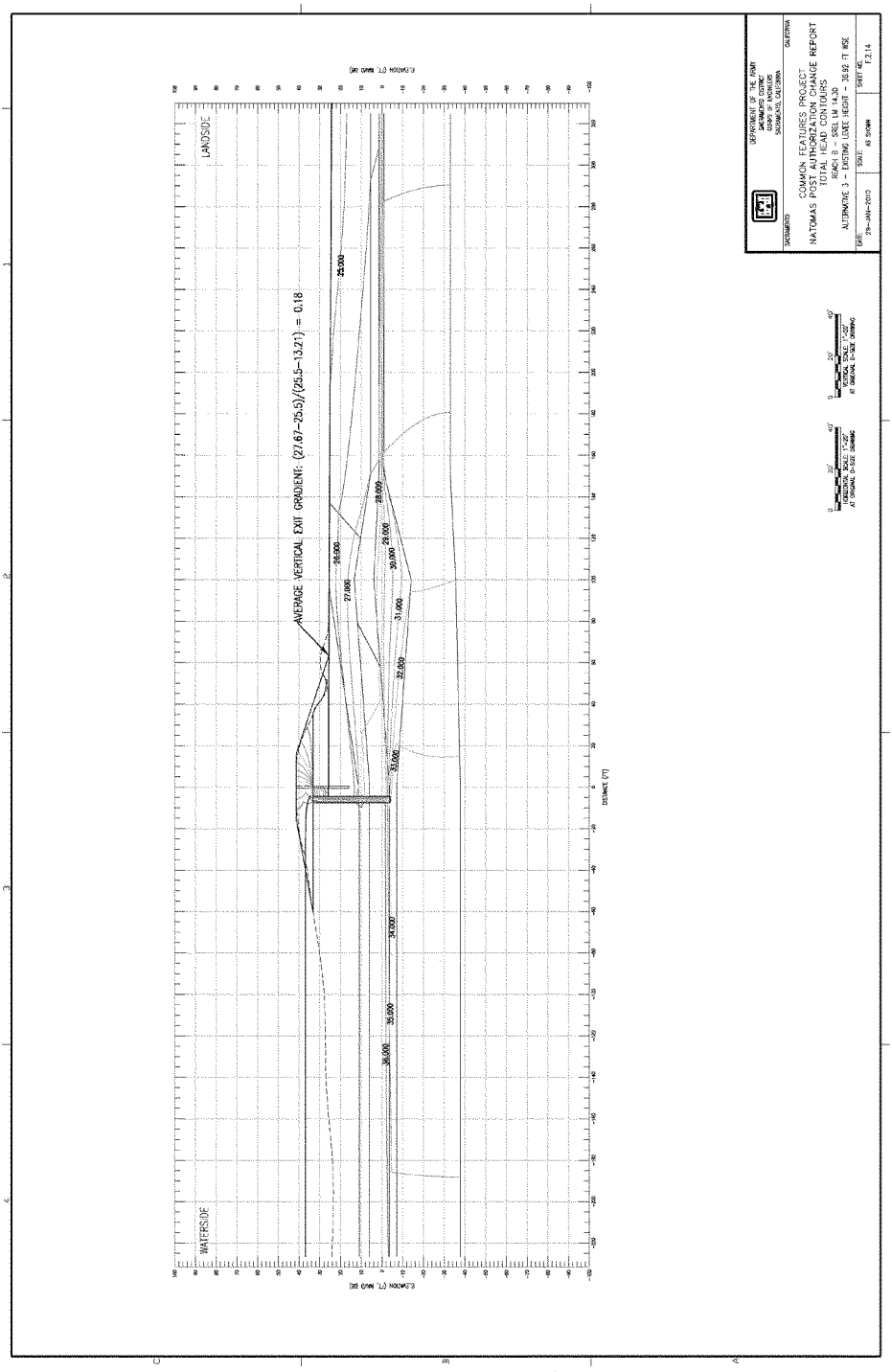

AVERAGE VERTICAL EXIT GRADIENT: (34.29-25.5)/(25.5-13.42) = 0.73
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A, STA 34+00
EXISTING CONDITIONS - 40,500 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.9

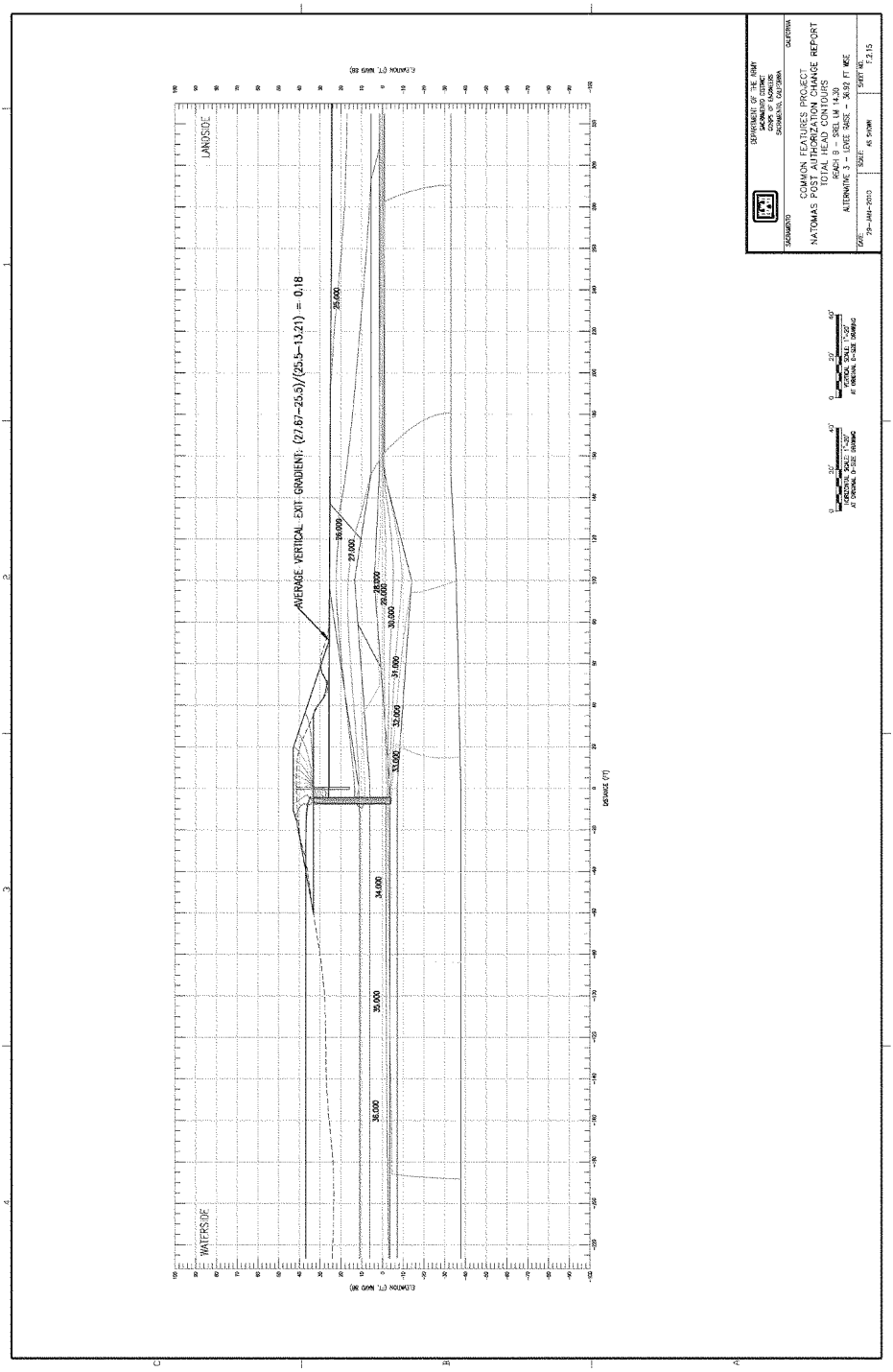

AVERAGE VERTICAL EXIT GRADIENT: (27.27-25.5)/(25.5-13.21) = 0.14
LANDSIDE
WATERSIDE
ELEVATION (FT NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
TOTAL HEAD CONTOURS
REACH B SEEPAGE
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT - 38.92 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.10

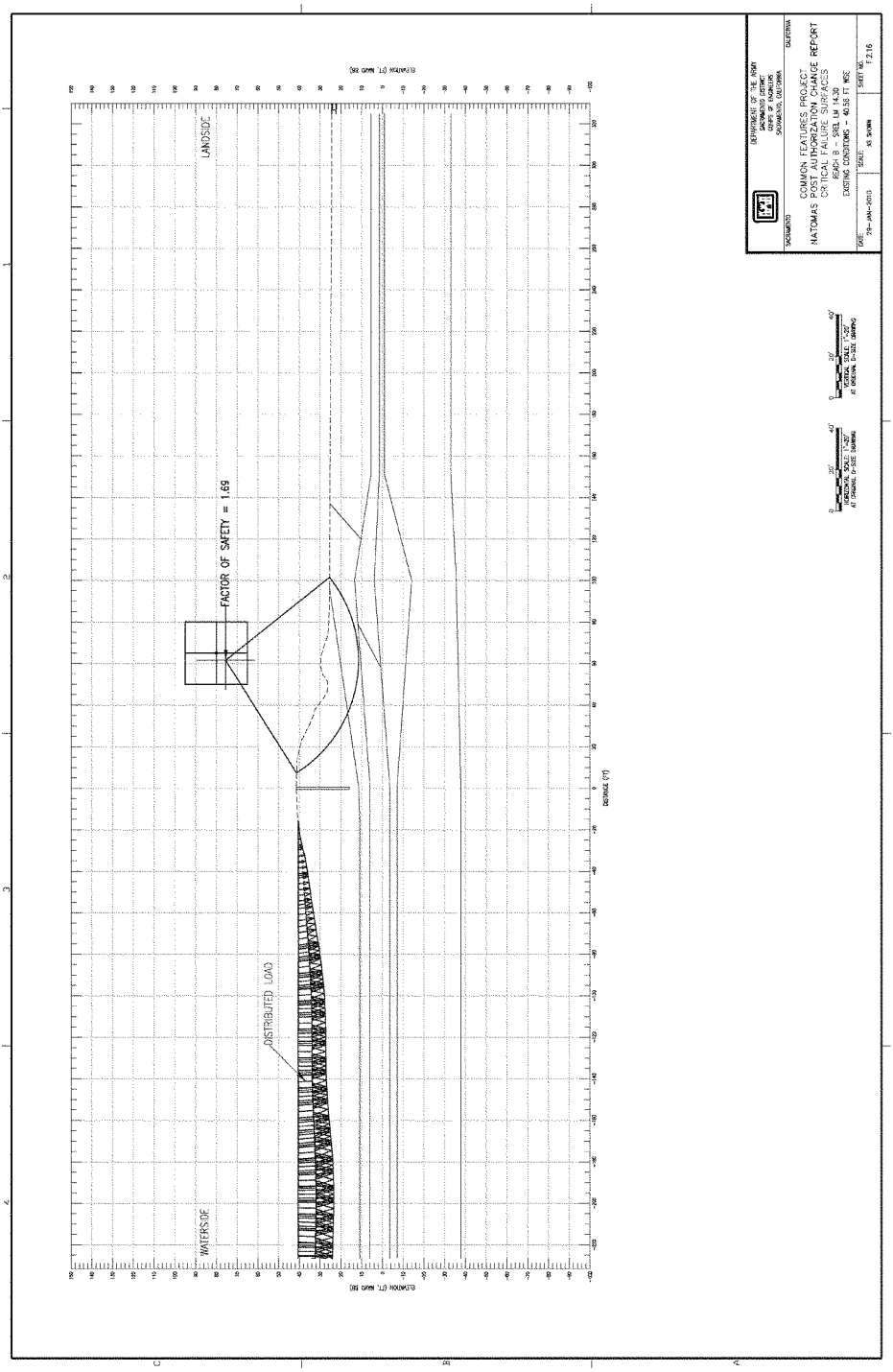

AVERAGE VERTICAL EXIT GRADIENT: (27.27-25.5)/(25.5-13.21) = 0.14
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
TOTAL HEAD CONTOURS
REACH A, STA 1+34
ALTERNATIVE 1 - LEVEE RAISE - 36.92 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.11

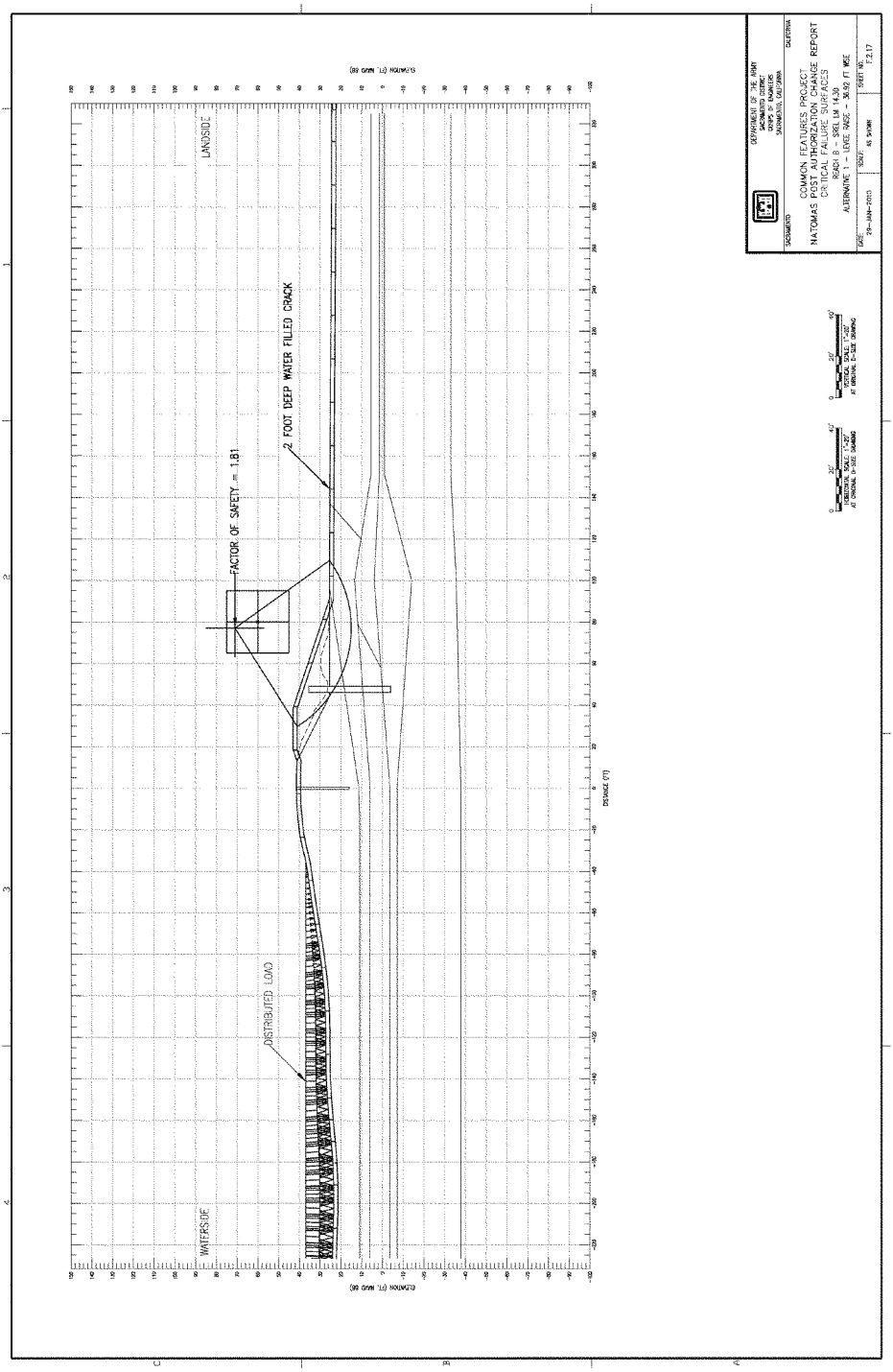

AVERAGE VERTICAL GRADIENT: (31.05-30.36)/(30.36-25.32) = 0.14
AVERAGE VERTICAL EXIT GRADIENT: (29.86-25.32)/(25.32-7.99) = 0.26
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A - STA 14+35
ALTERNATIVE 2 - EXISTING LEVEE HEIGHT - 38.92' FT MSE
DATE: 28-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.12

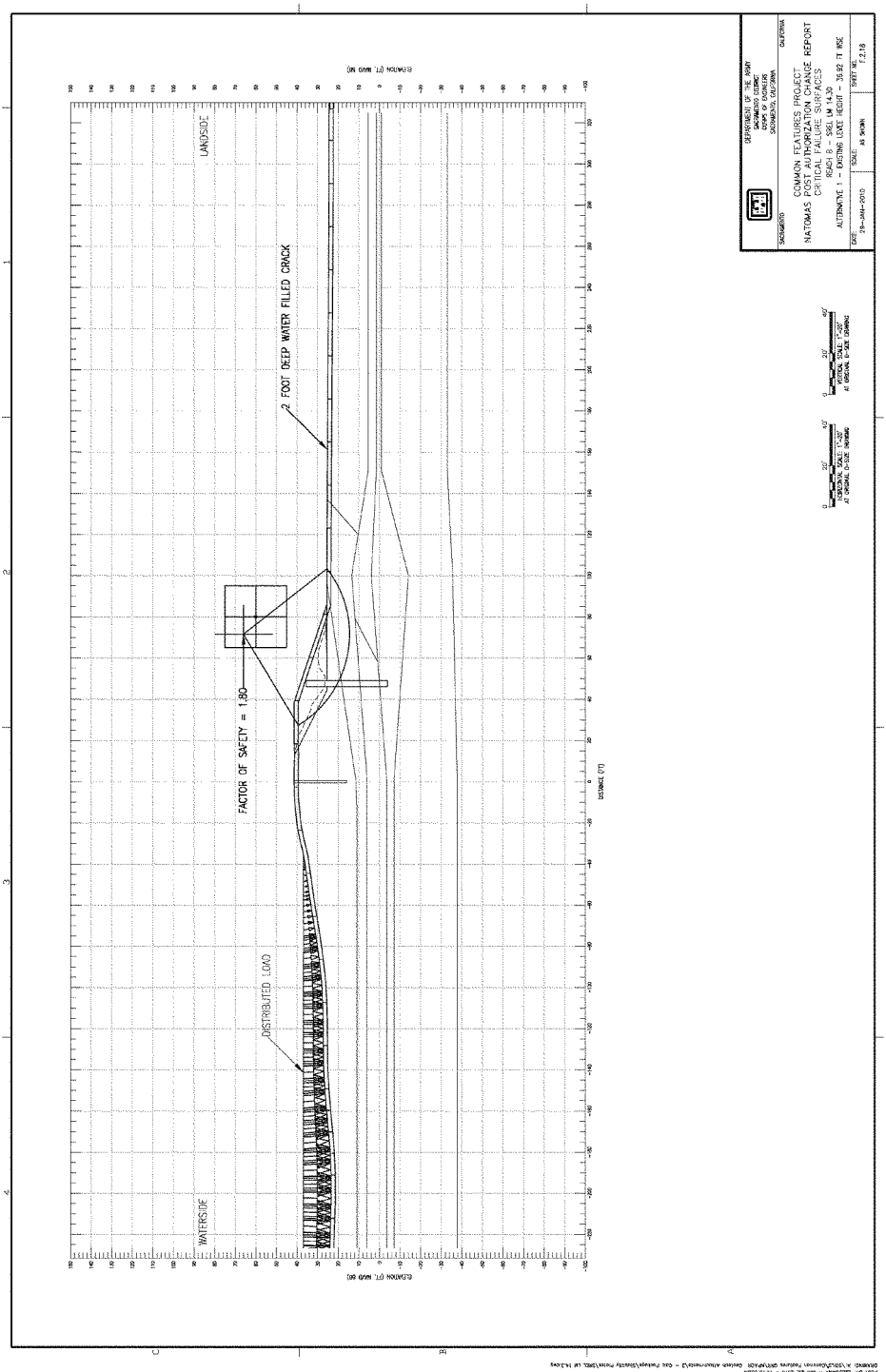

AVERAGE VERTICAL GRADIENT: (31.8-30.17)/(30.17-25.32) = 0.34
AVERAGE VERTICAL EXIT GRADIENT: (28.81-25.22)/(25.22-5.49) = 0.18
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A, STA 1+00
ALTERNATIVE 2 - LEVEE RAISE - 36.92 FT MSE
DATE: 29-JAN-2013
SCALE: AS SHOWN
SHEET NO. F.2.13

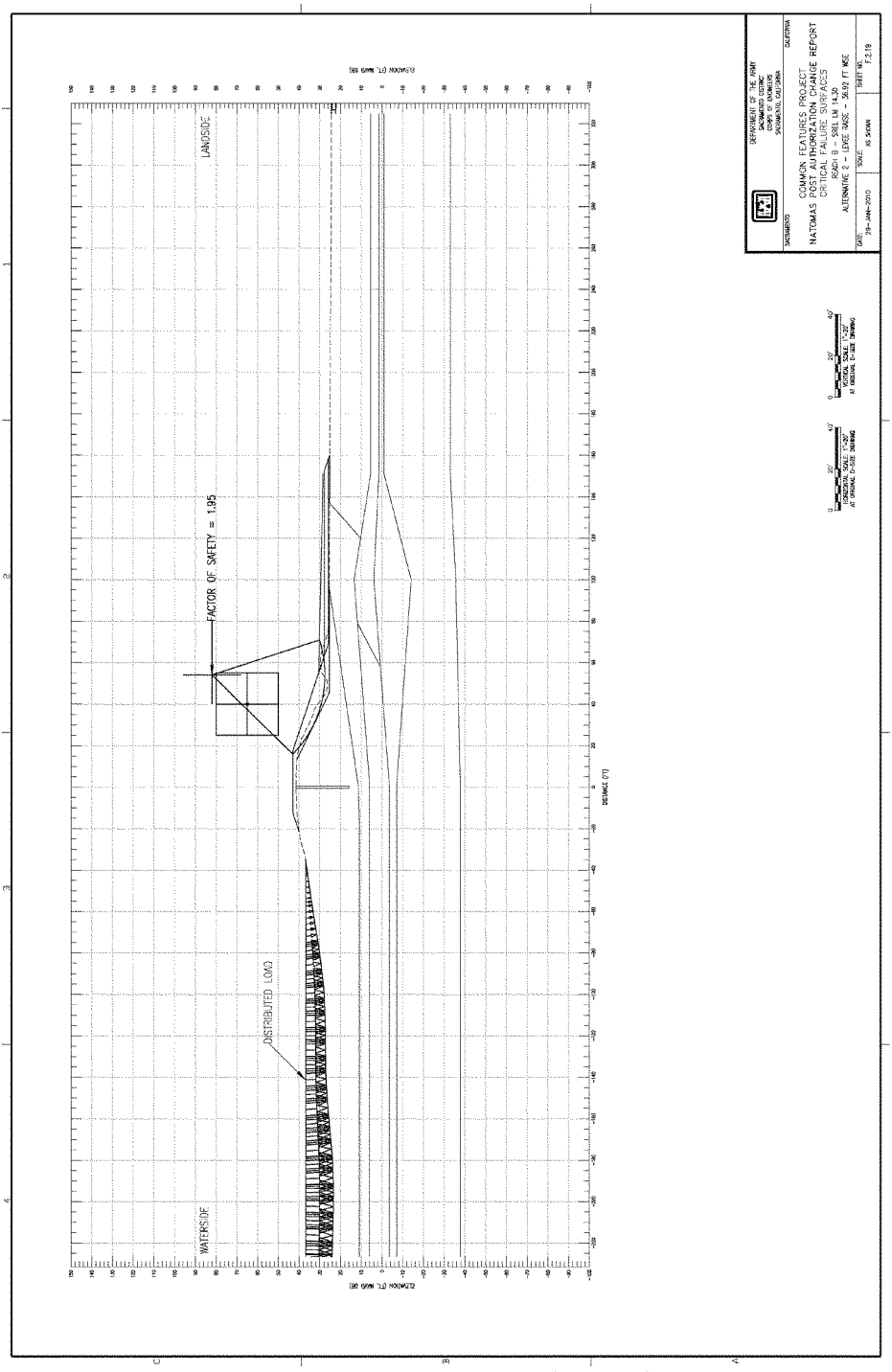

AVERAGE VERTICAL EXIT GRADIENT: (27.67-25.5)/(25.5-13.27) = 0.18
LANDSIDE
WATERSIDE
ELEVATION (FT NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A - STA 14+00
ALTERNATIVE 3 - EXISTING LEVEE HEIGHT + 38.92 FT WSE
DATE:
29-JAN-2013
SCALE:
AS SHOWN
SHEET NO.
F2.14

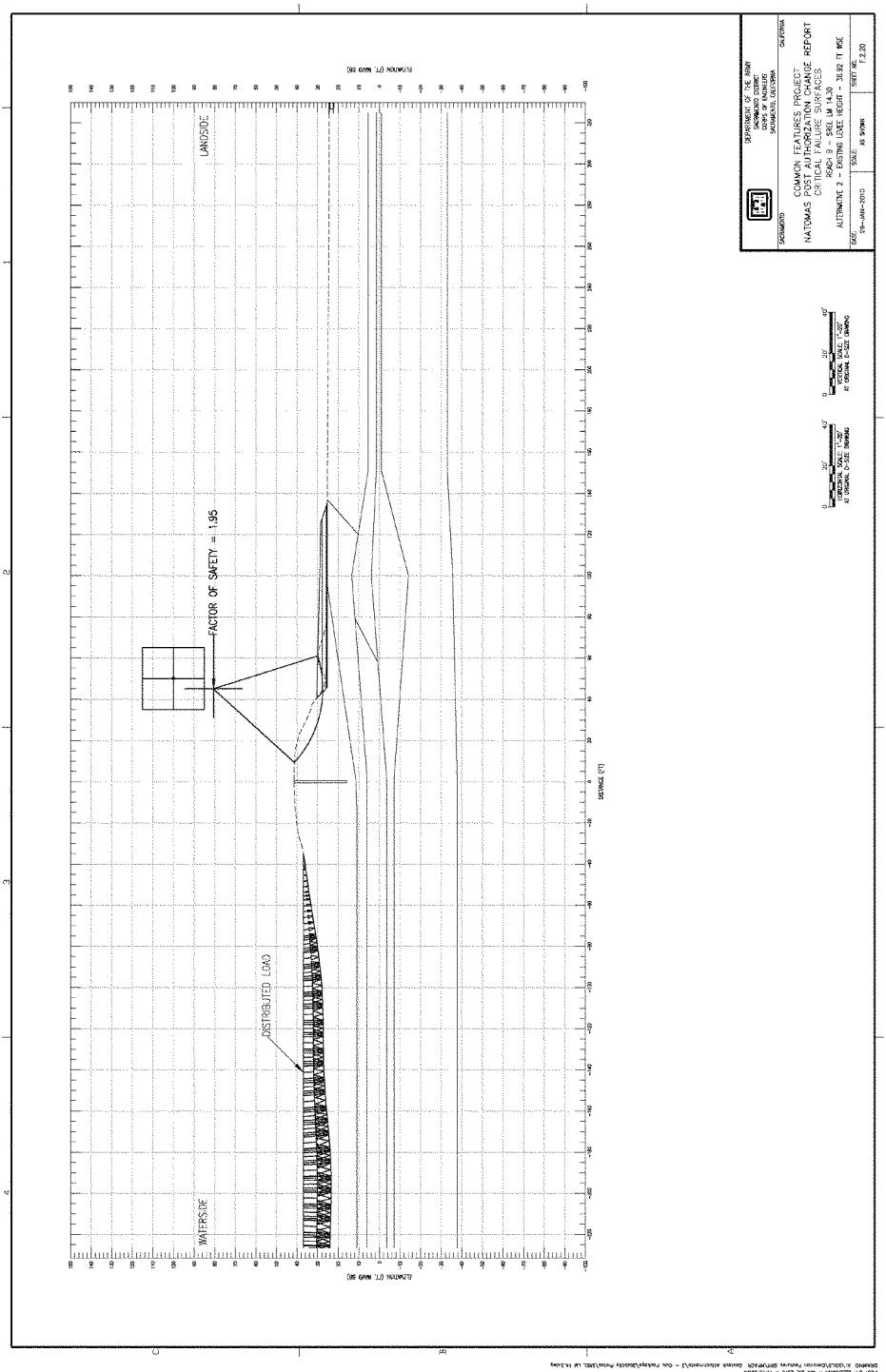

AVERAGE VERTICAL EXIT GRADIENT: (27.67-25.5)/(25.5-13.21) = 0.18
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
TOTAL HEAD CONTOURS
REACH B - SEEP/STABILITY
ALTERNATIVE 3 - LOWE SAGE - 36.90 FT MSE
DATE:
29-JAN-2013
SCALE:
AS SHOWN
SHEET NO.
F.2.15

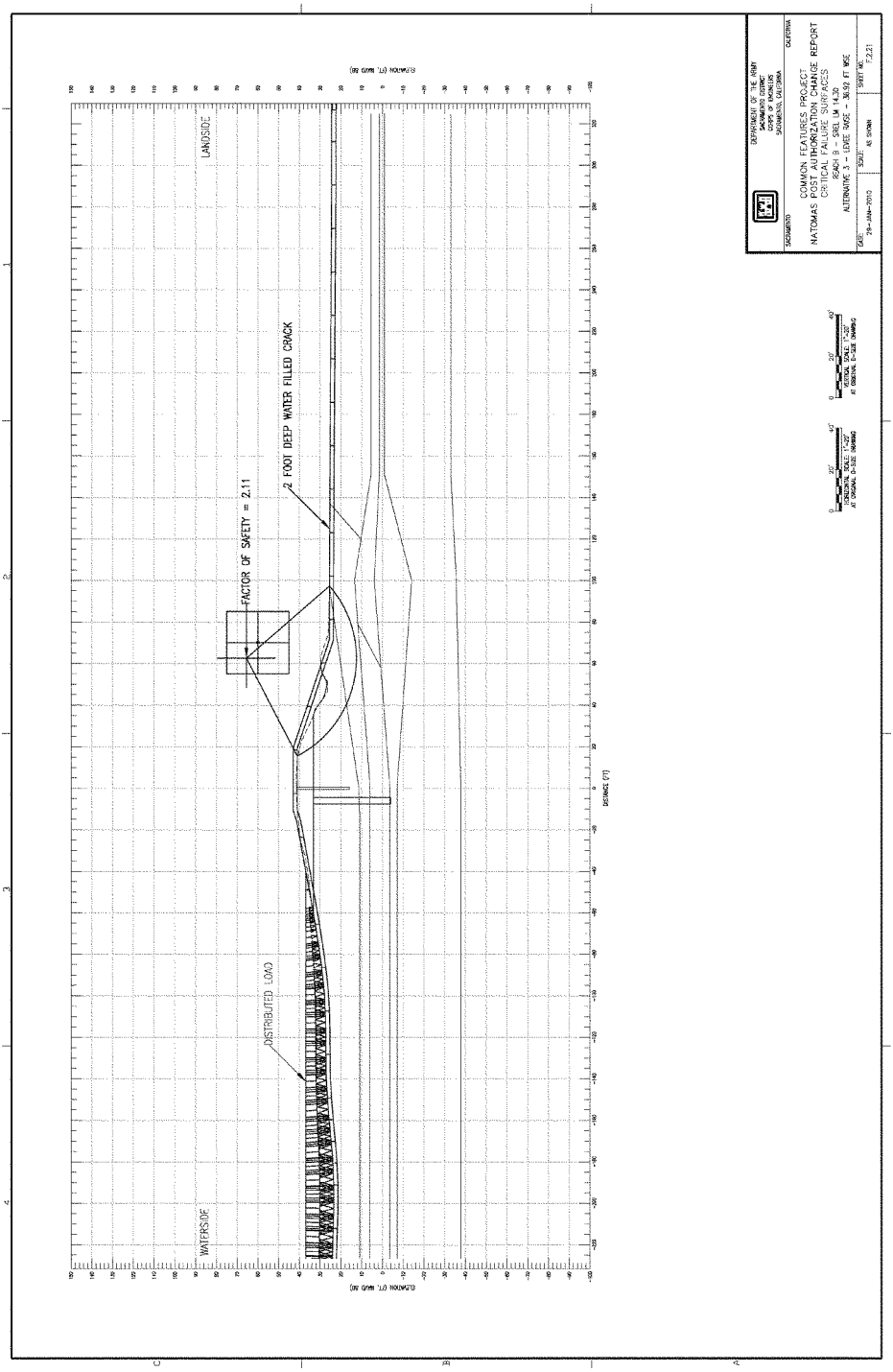

FACTOR OF SAFETY = 1.69
LANDSIDE
WATERSIDE
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH B, STA 1+00 TO STA 14+00
EXISTING CONDITIONS - 40.50 FT WSE
DATE: 29-JAN-2013
SCALE: AS SHOWN
SHEET NO. F.2.16

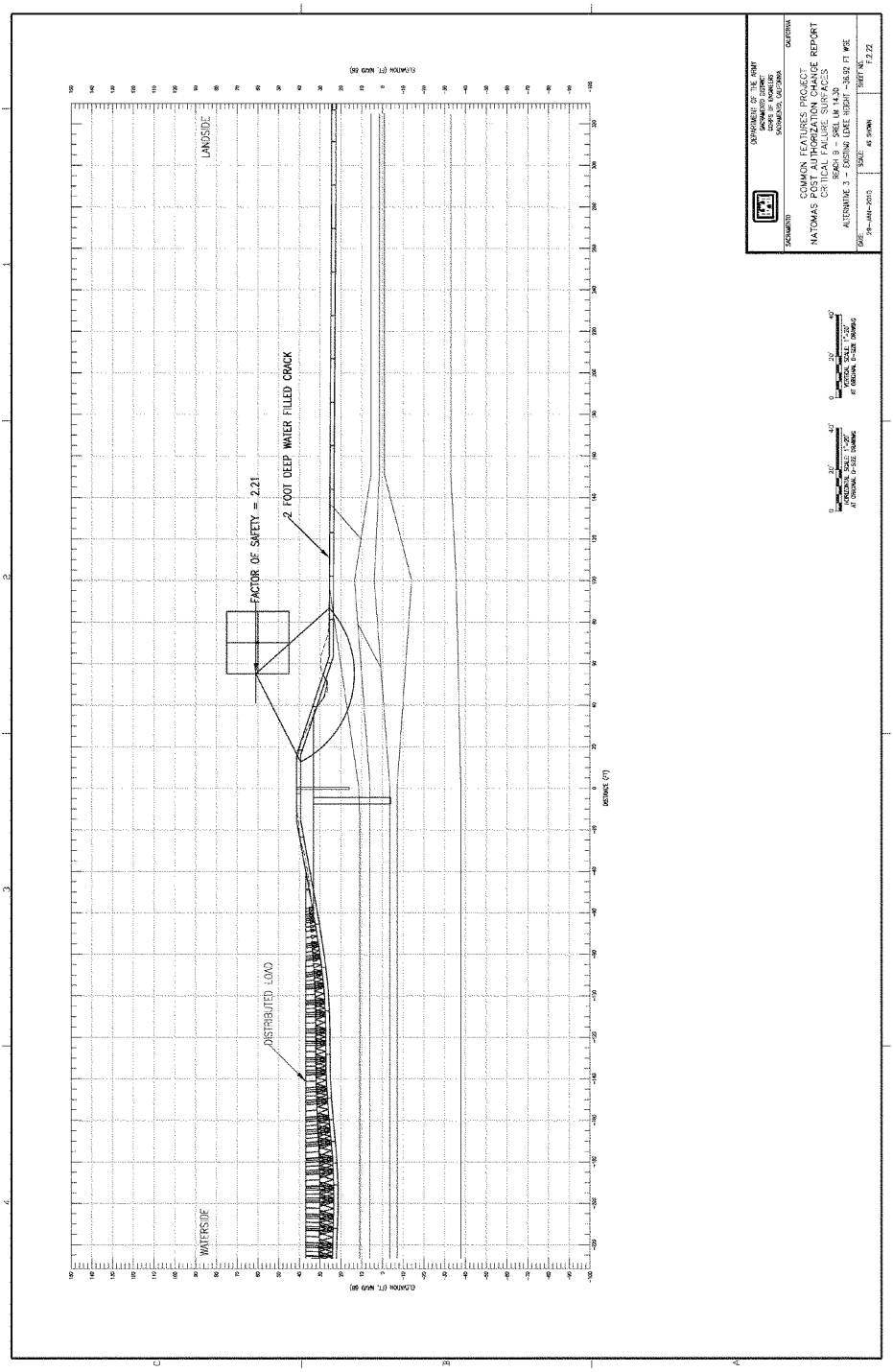

FACTOR OF SAFETY = 1.81
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
CRITICAL FAILURE SURFACES
REACH 3, SECTION 3
ALTERNATIVE 1 - LEVEE RAISE - 36.90 FT MSE
DATE: 29-JAN-2013
SCALE: AS SHOWN
SHEET NO. F.2.17

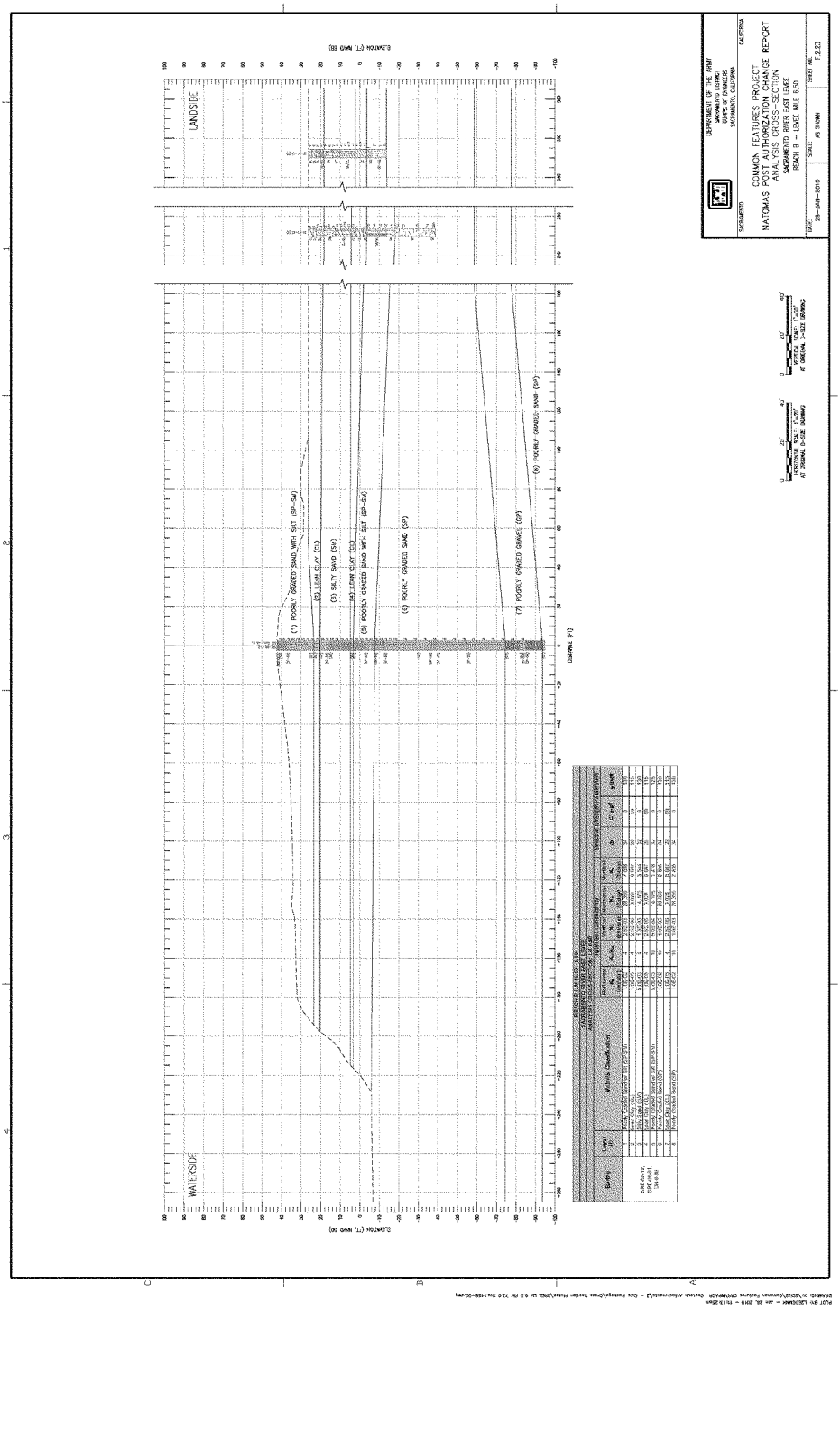

2 FOOT DEEP WATER FILLED CRACK
FACTOR OF SAFETY = 1.80
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT MSL NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A - SHEET 1 OF 3
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT - 35.92 FT MSE
DATE: 28-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.18

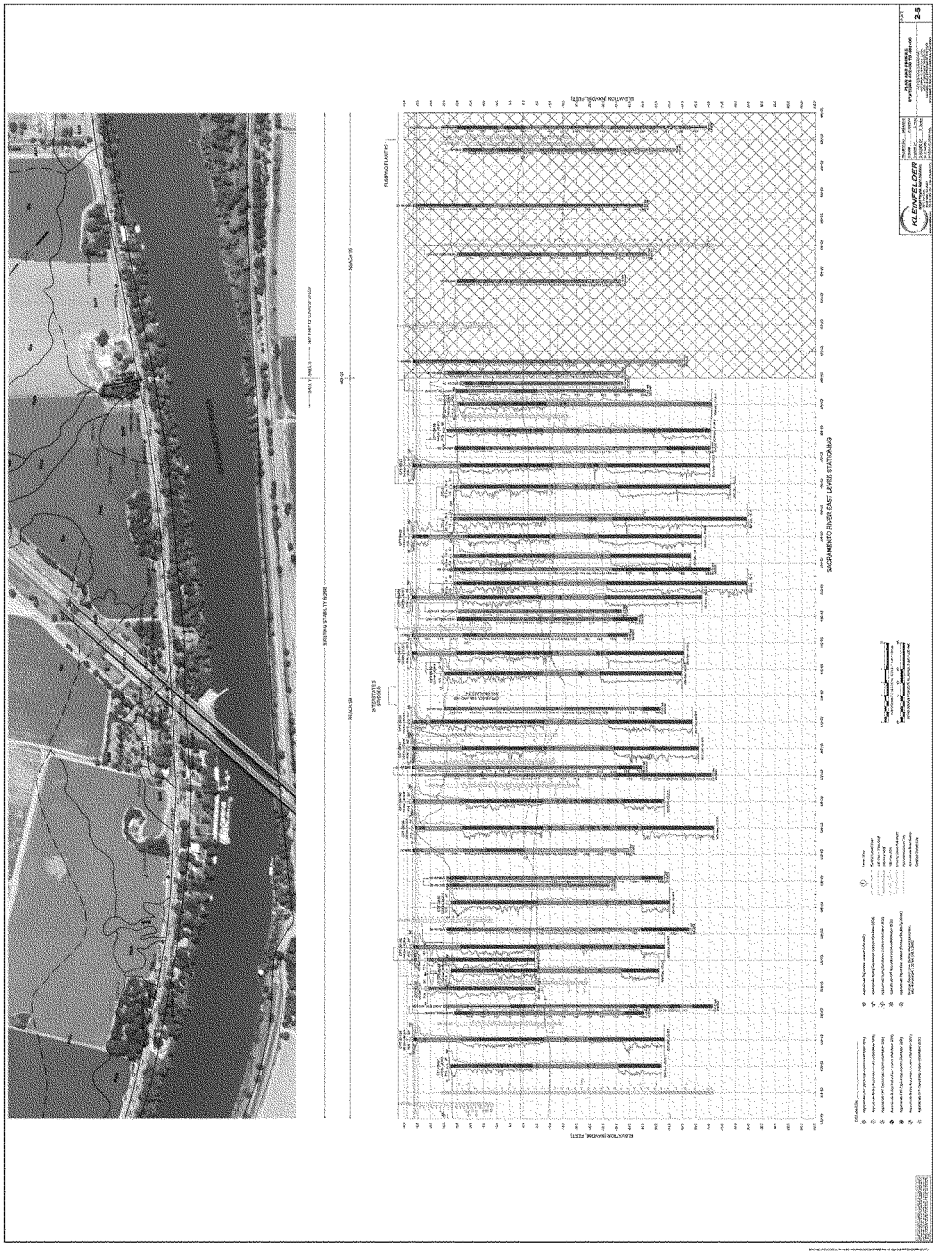

FACTOR OF SAFETY = 1.95
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH 3, SOUTH NATOMAS
ALTERNATIVE 2 - LEVEE RAISE - 36.00 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.19


LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 1.95
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH 2 - SHEET 1 OF 3
ALTERNATIVE 2 - EXISTING LEVEE HEIGHT + 36.92 FT MSL
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.20


FACTOR OF SAFETY = 2.11
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT MSL)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
CRITICAL FAILURE SURFACES
ALTERNATIVE 3 - LEVEE RAISE - 36.50 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.21


FACTOR OF SAFETY = 2.21
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
CRITICAL FAILURE SURFACES
REACH A, REACH B, REACH C
ALTERNATIVE 3 – EXISTING LEVEE HEIGHT – +36.92 FT NAVD
DATE: 28-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.22


DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
SACRAMENTO RIVER LEVEE
REACH B - LEVEE MILE 8.30
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 7.2.23
HORIZONTAL SCALE 1"=20'
AT ORIGINAL D-SIZE DRAWING
HORIZONTAL SCALE 1"=40'
AT ORIGINAL D-SIZE DRAWING
WATERSIDE
LANDSIDE
(1) POORLY GRADED SAND WITH SILT (SP-SM)
(2) LEAN CLAY (CL)
(3) SILTY SAND (SM)
(4) LEAN CLAY (CL)
(5) POORLY GRADED SAND WITH SILT (SP-SM)
(6) POORLY GRADED SAND (SP)
(7) POORLY GRADED GRAVEL (GP)
(8) POORLY GRADED SAND (SP)
ELEVATION (FT, NAVD 88)
DISTANCE (FT)



Boring Location/ Surface Conditions: Levee crown, asphalt concrete

Groundwater: Groundwater not measured due to drilling method.

Method: Hollow Stem Auger (20 ft.)/Mud Rotary

Equipment: CME 75 with 140 lb. Automatic Hammer

Date Completed: 3/13/2008

Logged By: B. Maddy

Reviewed By: M. Briseno

Total Depth: 151-1/2 feet

Boring Diameter: 8 inch/4 inch

Approximate Elevation: 42 feet (NAVD88)
Approximate Northing: 2016614 feet
Approximate Easting: 6668216 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														ASPHALT CONCRETE: About 10 inches
			1b	5										**Silty SAND With Gravel** (SM): Brown, moist, fine sand and gravel, (Levee)
			1a	6 7		107	18							
			2	3 6 4							12			
37	5		3b	5 4										**Poorly Graded SAND With Silt** (SP-SM): Brown, moist, fine sand, (Levee)
			3a	4										
			4	3 2 3							6			
32	10		5b	7 4										
			5a	5										
			6	4 4 4						99	6	HYD		
27	15		7b	9 7										
			7a	8		96	5							**Poorly Graded SAND** (SP): Gray brown, moist, fine sand, (Levee)
			8	2 2 3							0			
22	20		9b	6 6										**SILT** (ML): Gray brown, moist, soft, low plasticity, (Native)
			9a	11										Firm
			10	5 5 7							0			**Poorly Graded SAND** (SP): Brown, moist, fine sand
17	25		11b	5 6										**Poorly Graded SAND With Silt** (SP-SM): Brown, moist, fine sand
			11a	9							10			
			12	2 3 3							20			**Silty SAND** (SM): Brown, moist, fine sand

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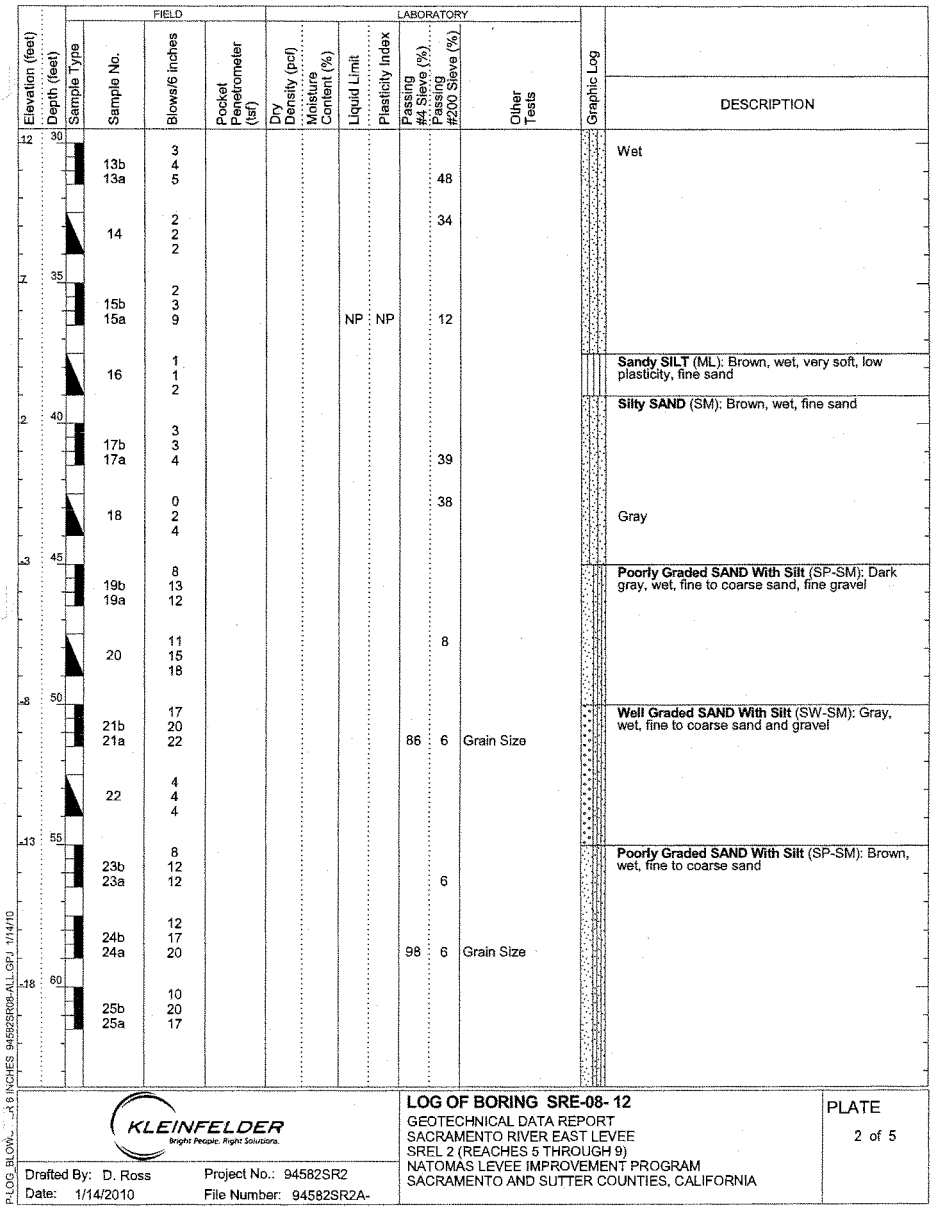
Drafted By: D. Ross
Date: 1/14/2010

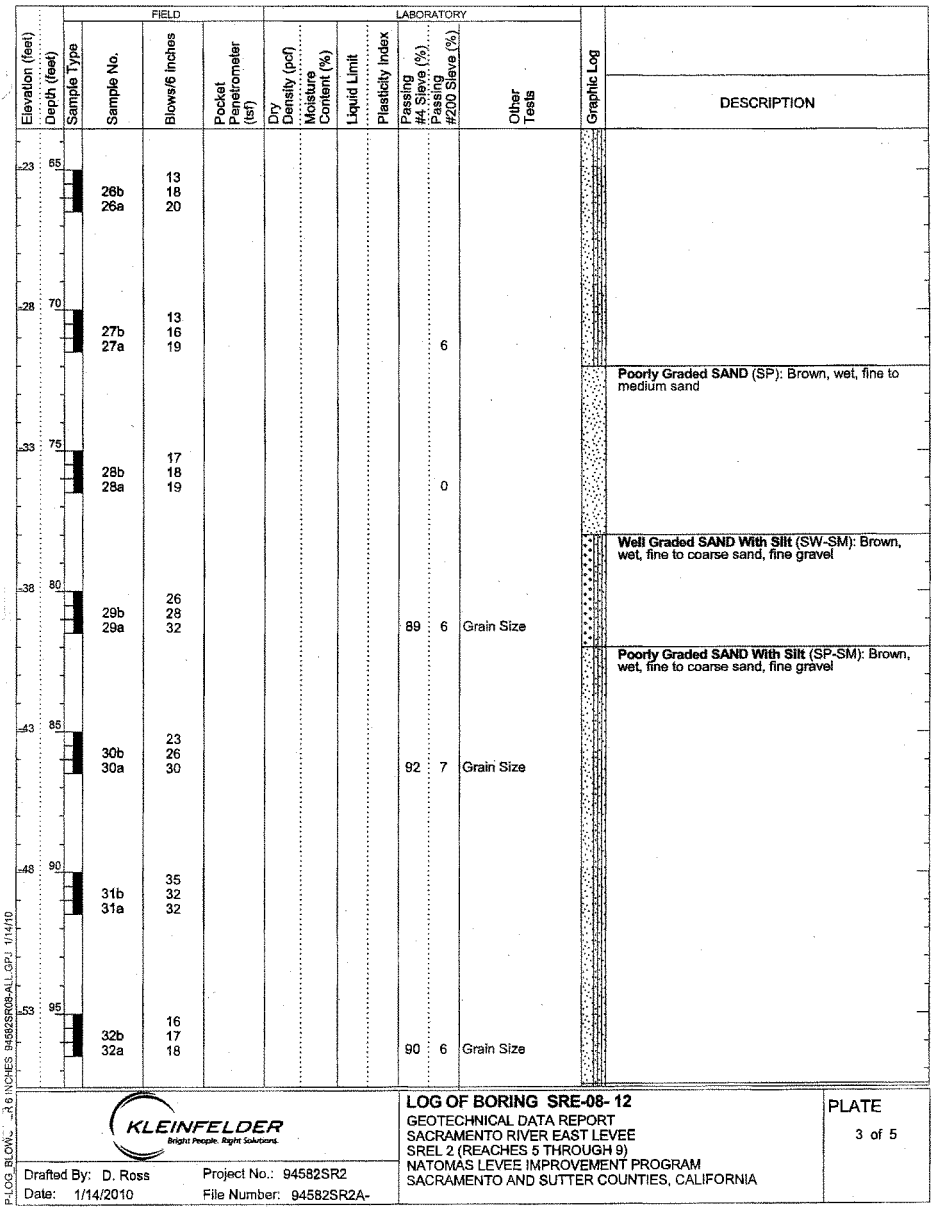
Project No.: 94582SR2
File Number: 94582SR2A-

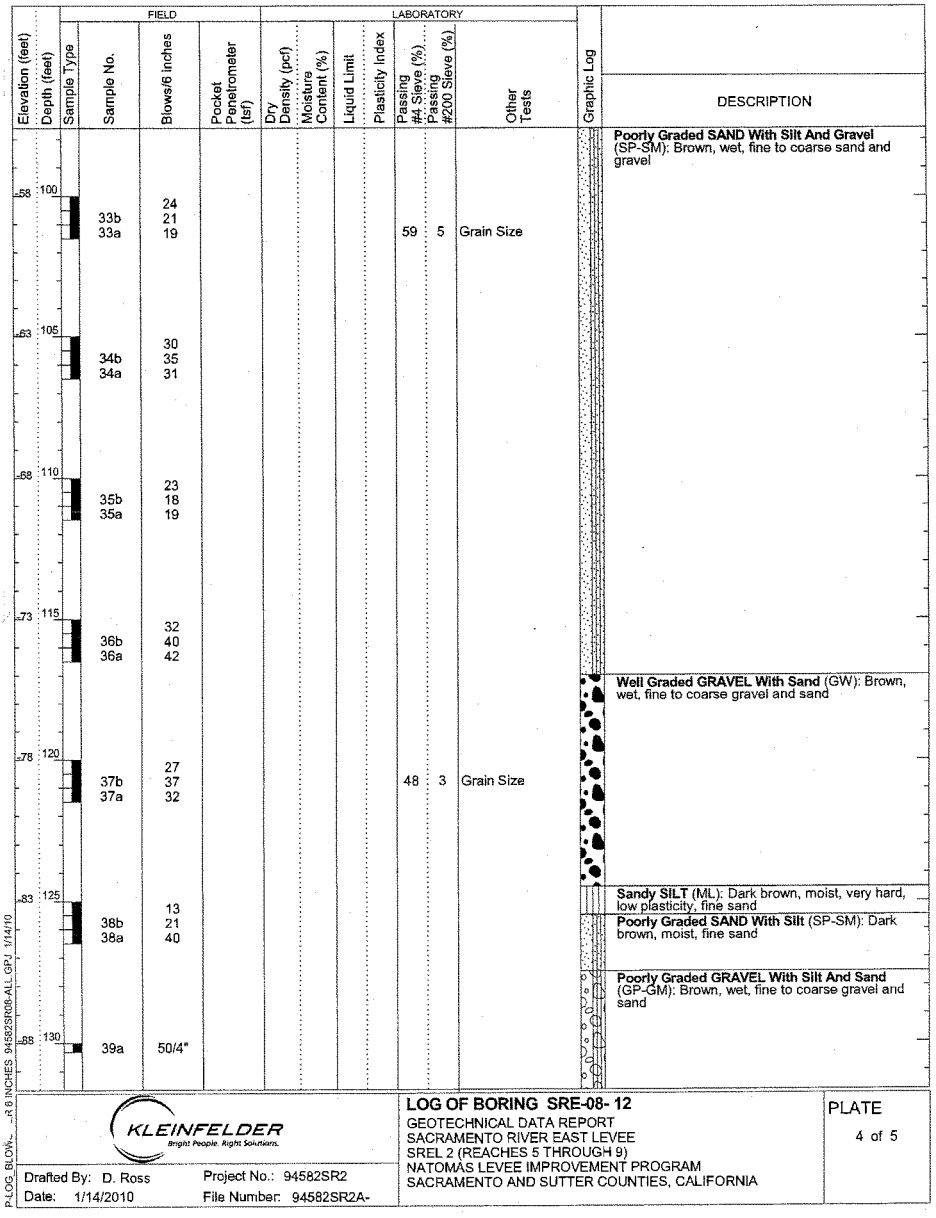
LOG OF BORING SRE-08- 12
GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 2 (REACHES 5 THROUGH 9)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

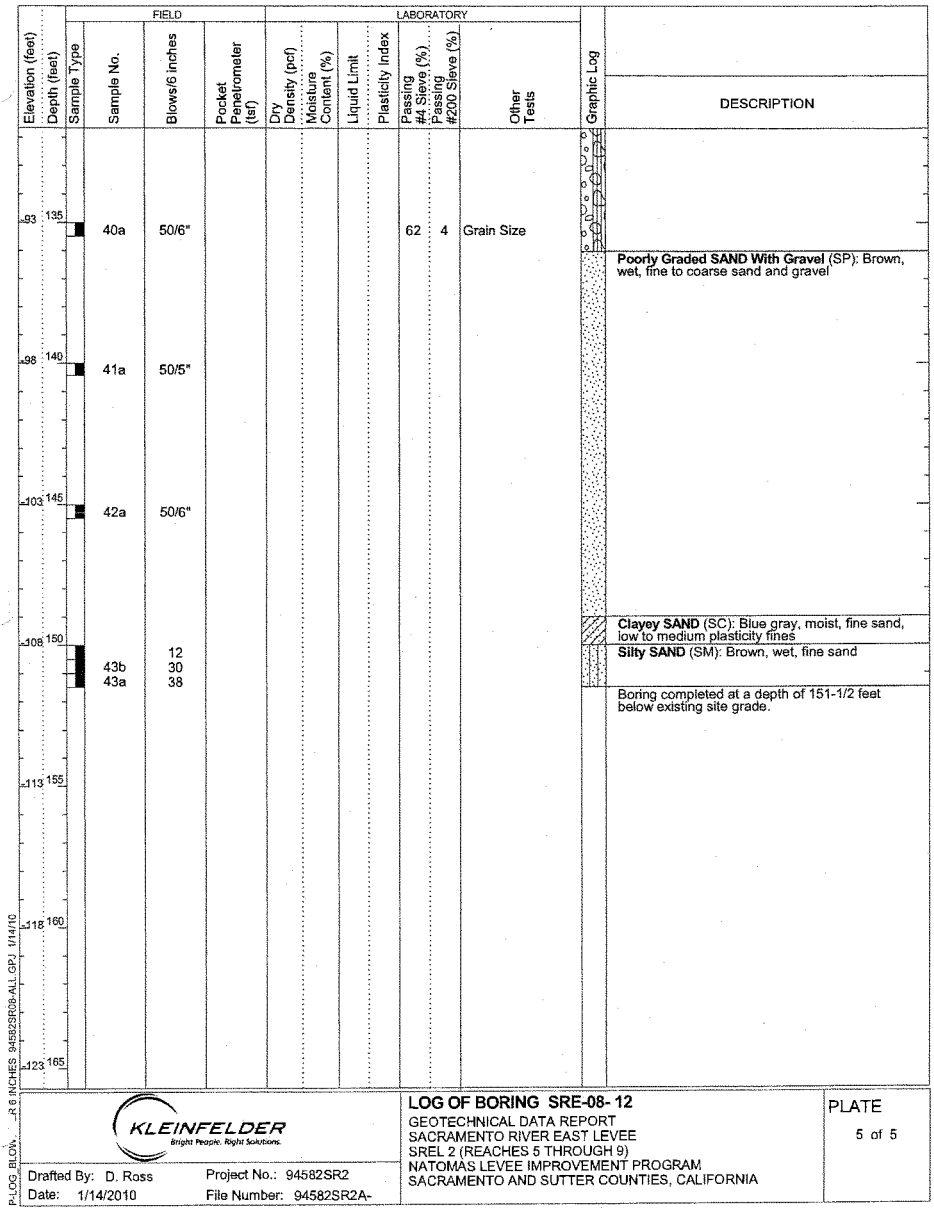
PLATE
1 of 5

P:\LOG_BLOW_R 6 INCHES 94582SR08-ALL.GPJ 1/14/10


FIELD
LABORATORY
Elevation (feet)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
12 30
13b 3
13a 4 5 48
14 2 2 2 34
35
15b 2
15a 3 9 NP NP 12
16 1 1 2
Sandy SILT (ML): Brown, wet, very soft, low plasticity, fine sand
2 40
17b 3
17a 3 4 39
18 0 2 4 38
Silty SAND (SM): Brown, wet, fine sand
Gray
3 45
19b 8
19a 13 12
20 11 15 18 8
Poorly Graded SAND With Silt (SP-SM): Dark gray, wet, fine to coarse sand, fine gravel
8 50
21b 17
21a 20 22 86 6 Grain Size
22 4 4 4
Well Graded SAND With Silt (SW-SM): Gray, wet, fine to coarse sand and gravel
13 55
23b 8
23a 12 12 6
24b 12 17
24a 20 98 6 Grain Size
Poorly Graded SAND With Silt (SP-SM): Brown, wet, fine to coarse sand
18 60
25b 10
25a 20 17
P:\LOG_BLOW\...R 6 INCHES 94582SR08-ALL.GPJ 1/14/10
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Drafted By: D. Ross
Date: 1/14/2010
Project No.: 94582SR2
File Number: 94582SR2A-
LOG OF BORING SRE-08- 12
GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 2 (REACHES 5 THROUGH 9)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA
PLATE
2 of 5


FIELD
LABORATORY
Elevation (feet)
Depth (feet)
Sample Type
Sample No.
Blows/6 Inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
23 65 26b 13
26a 18
20
28 70 27b 13
27a 16
19
6
Poorly Graded SAND (SP): Brown, wet, fine to medium sand
33 75 28b 17
28a 18
19
0
Well Graded SAND With Silt (SW-SM): Brown, wet, fine to coarse sand, fine gravel
38 80 29b 26
29a 28
32
89 6 Grain Size
Poorly Graded SAND With Silt (SP-SM): Brown, wet, fine to coarse sand, fine gravel
43 85 30b 23
30a 26
30
92 7 Grain Size
48 90 31b 35
31a 32
32
53 95 32b 16
32a 17
18
90 6 Grain Size
PLOG_BLOWS_IN6 INCHES 94582SR09-ALL.GPJ 1/14/10
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Drafted By: D. Ross
Date: 1/14/2010
Project No.: 94582SR2
File Number: 94582SR2A-
LOG OF BORING SRE-08- 12
GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 2 (REACHES 5 THROUGH 9)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA
PLATE
3 of 5


FIELD
LABORATORY
Elevation (feet)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
100
105
110
115
120
125
130
58
53
68
73
78
83
88
33b
33a
24
21
19
59
5
Grain Size
34b
34a
30
35
31
35b
35a
23
18
19
36b
36a
32
40
42
37b
37a
27
37
32
48
3
Grain Size
38b
38a
13
21
40
39a
50/4"
Poorly Graded SAND With Silt And Gravel (SP-SM): Brown, wet, fine to coarse sand and gravel
Well Graded GRAVEL With Sand (GW): Brown, wet, fine to coarse gravel and sand
Sandy SILT (ML): Dark brown, moist, very hard, low plasticity, fine sand
Poorly Graded SAND With Silt (SP-SM): Dark brown, moist, fine sand
Poorly Graded GRAVEL With Silt And Sand (GP-GM): Brown, wet, fine to coarse gravel and sand
P:\LOG_BLOWS_...R 6 INCHES 94582SR6B-ALL.GPJ 1/14/10
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Drafted By: D. Ross
Date: 1/14/2010
Project No.: 94582SR2
File Number: 94582SR2A-
LOG OF BORING SRE-08- 12
GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 2 (REACHES 5 THROUGH 9)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA
PLATE
4 of 5


FIELD
LABORATORY
Elevation (feet)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
93 135
40a
50/6"
62
4
Grain Size
Poorly Graded SAND With Gravel (SP): Brown, wet, fine to coarse sand and gravel
98 140
41a
50/5"
103 145
42a
50/6"
Clayey SAND (SC): Blue gray, moist, fine sand, low to medium plasticity fines
108 150
12
43b
30
43a
38
Silty SAND (SM): Brown, wet, fine sand
Boring completed at a depth of 151-1/2 feet below existing site grade.
113 155
118 160
123 165
P-LOG_BLOW_...R6 INCHES 94582SR08-ALL.GPJ 1/14/10
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Drafted By: D. Ross
Date: 1/14/2010
Project No.: 94582SR2
File Number: 94582SR2A-
LOG OF BORING SRE-08- 12
GEOTECHNICAL DATA REPORT
SACRAMENTO RIVER EAST LEVEE
SREL 2 (REACHES 5 THROUGH 9)
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA
PLATE
5 of 5

Project: Natomas Levee North of Powerline Road
Project Location: Sacramento County, California
Project Number: 51971138NA.00

Log of Boring 2F-01-42

Sheet 1 of 2

Date(s) Drilled	1 - 2 August 2001	Logged By	R.L. McCune	Checked By	D. Simpson
Drilling Method	Rotary Wash	Drill Bit Size/Type	4-inch-OD open drag bit	Total Depth of Borehole	65.0 feet
Drill Rig Type	Mobile B-61	Drilling Contractor	Westex (S. Dockery)	Surface Elevation	24.65 feet MSL
Groundwater Level(s)	14 feet bgs ATD	Sampler Type(s)	SPT, Modified California, Shelby Tube	Hammer Data	Automatic (80% efficiency), 140 lbs, 30-inch drop
Borehole Completion	Backfilled with grout to ground surface			Location	N 2,016,494 E 6,668,288

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / Foot	N_{60}	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	% Gravel	% Sand	% Fines	Liquid Limit	Plasticity Index	Moisture, %	REMARKS AND OTHER TESTS
	0														
			FS1	8	11	100		LEAN CLAY WITH SAND, CL: Firm; moist; brown (10YR 5/3); ~80% medium plasticity, medium toughness fines; ~20% fine sand; trace of hard, subrounded gravel to 3/4 in. dia.; slow dilatancy; trace of iron oxide staining; sandy lean clay seam from 2-2.5 ft				30	10		Begin drilling on 8/1/01 at 0730. Using hammer with 80% efficiency. Easy drilling.
			FS2	5	7	100		LEAN CLAY, CL: Firm; moist; dark gray (10YR 4/1); ~90% medium plasticity, medium toughness fines; ~10% fine sand; no dilatancy							
-20	5		FS3	10	13	100		SANDY SILT, ML: Loose; moist; dark gray (10YR 4/1); ~70% low to very low plasticity fines; ~30% fine sand; slow dilatancy; saturated from 5-5.5 ft							
			FS4	6	8	80		At 6 ft, as above except brown (10YR 4/3); very low plasticity to nonplastic fines				23	1		
			FS5	6	8	100		SILTY SAND, SM: Loose; moist; brown (10YR 4/3); ~60% to 70% fine sand; ~30% to 40% nonplastic fines; rapid dilatancy	0	64	36				
-15	10		FS6	7	6	80		At 10 ft, as above except wet; dark grayish brown (10YR 4/2)							
			FS7	5	7	80		At 12 ft, as above except moist							
-10	15		FS8	<1	<1	100		SILTY CLAY WITH SAND, CL-ML: Very soft; wet to saturated; grayish brown (10YR 5/2); ~85% low plasticity, medium toughness fines; ~15% fine sand						35	Very easy drilling; samplers advance 18 in. with one hammer blow through 24 ft.
			FS9	<1	<1	100								30	
			FS10	<1	<1	100		At 18 ft, as above except saturated							
-5	20		FS11	<1	<1	100						25	4		
			FS12	<1	<1	100		SANDY LEAN CLAY, CL: Very soft; saturated; dark grayish brown (10YR 4/2); ~70% medium plasticity, medium toughness fines; ~30% fine sand							
0	25		FS13A FS13B	1	1	100		LEAN CLAY WITH SAND, CL: Very soft; very moist; dark grayish brown (10YR 4/2); ~85% medium plasticity, medium toughness fines; ~15% fine sand; abundant iron oxide staining							Less than 100 psi down pressure.
			T1			95								25	TRIAX R-Bar: c' =1210 psf ϕ'=24.3°
-5	30		FS14	1	1	100		SANDY LEAN CLAY, CL: Very soft; saturated; grayish brown (10YR 5/2); ~70% medium plasticity, medium toughness fines; ~30% fine sand							

Report: GEO_10B1SW_OAKCOE; File: NATURSNP.GPJ; 2/28/2002 C2F-01-42

URS

Figure A-41

Project: Natomas Levee North of Powerline Road
Project Location: Sacramento County, California
Project Number: 51971138NA.00

Log of Boring 2F-01-42

Sheet 2 of 2

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / Foot	N_{60}	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	% Gravel	% Sand	% Fines	Liquid Limit	Plasticity Index	Moisture, %	REMARKS AND OTHER TESTS
	30		FS15	10	13	66		SILTY SAND / SANDY SILT, SM/ML: Loose; wet; grayish brown (10YR 5/2); ~50% fine sand with trace of medium grains; ~50% non-plastic fines	0	52	48				Easy drilling.
			FS16	14	19	66		At 33 ft, as above except firm							
-10	35		FS17	12	16	66		At 36 ft, as above except sand grades fine to medium with trace of coarse grains							Driller states it feels like gravel. Blow a hydraulic fine on hammer.
-15	40		FS18A FS18B	12	16	80		SILTY SAND, SM: Firm; wet; very dark gray (5Y 3/1); ~85% fine sand with trace of coarse grains; ~15% nonplastic fines; trace of wood at 40.4 ft							
			FS19	15	20	100									
-20	45		FS20	14	19	100		POORLY GRADED SAND, SP: Firm; wet; grayish brown (2.5Y 5/2); ~95% fine to medium sand with trace of coarse grains; ~5% non-plastic fines	0	96	4				
			FS21	17	23	100									
-25	50														
-30	55		FS22	15	20	80		At 55 ft, as above except trace of fine, subrounded gravel							
-35	60		FS23	14	19	NA									
-40	65		FS24	36	32	100		POORLY GRADED SAND WITH GRAVEL, SP: Very firm; wet; grayish brown (2.5Y 5/2); ~60% fine to coarse, subangular to subrounded sand; ~35% subrounded gravel to 1 in. dia; ~5% nonplastic fines Bottom of boring at 66.0 feet							Slightly rough drilling at 62 ft due to gravel, possible cobbles. No brass liners in Mod Cal sampler.

Report: GED_10B1SW_OAKCOE; File: NATURSNP.GPJ; 2/28/2002 C2F-01-42

URS

Figure A-41

Project: Natomas Levee North of Powerline Road
Project Location: Sacramento County, California
Project Number: 51971138NA.00

Log of Boring 2F-01-43

Sheet 1 of 2

Date(s) Drilled	2 - 3 August 2001	Logged By	R.L. McCune	Checked By	D. Simpson
Drilling Method	Rotary Wash	Drill Bit Size/Type	4-inch-OD open drag bit	Total Depth of Borehole	40.0 feet
Drill Rig Type	Mobile B-61	Drilling Contractor	Westex (S. Dockery)	Surface Elevation	23.93 feet MSL
Groundwater Level(s)	14.4 feet bgs ATD	Sampler Type(s)	SPT, Modified California	Hammer Data	Automatic (80% efficiency), 140 lbs, 30-inch drop
Borehole Completion	Backfilled with grout to ground surface			Location	N 2,016,425 E 6,668,403

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / Foot	N_{60}	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	% Gravel	% Sand	% Fines	Liquid Limit	Plasticity Index	Moisture, %	REMARKS AND OTHER TESTS
	0														
			FS1	4	5	100		SANDY SILT, ML: Very loose; moist; brown (10YR 5/3); ~70% low plasticity, low toughness fines; ~30% fine sand; small amount of iron oxide staining throughout							Begin drilling on 8/2/01 at 1130. Using hammer with 80% efficiency. Easy drilling.
			FS2	6	8	80		LEAN CLAY, CL: Firm; moist; very dark grayish brown (10YR 3/2); ~90% medium plasticity, medium toughness fines; ~10% fine sand; trace of charcoal							
20															
	5		FS3	5	7	100		LEAN CLAY WITH SAND, CL: Firm; very moist; very dark grayish brown (10YR 3/2); ~80% medium plasticity, medium toughness fines; ~20% fine sand						36	
			FS4	4	5	100		SANDY LEAN CLAY / CLAYEY SAND, CL/SC: Soft / very loose; moist; dark yellowish brown (10YR 4/4); ~50% medium plasticity, medium toughness fines; ~50% fine sand	0	48	52				
15			FS5	* 7	6	80		SILTY SAND, SM: Loose; very moist; grayish brown (10YR 5/2); ~80% fine sand; ~20% nonplastic fines							
	10		FS6	8	11	NA		At 10 ft, as above except moist; dark yellowish brown (10YR 4/4)	0	80	20				
			FS7A					At 12 ft, as above except very loose							
			FS7B	2	3	NA		CLAYEY SAND, SC: Very loose; very moist to slightly wet; dark yellowish brown (10YR 4/4); ~60% to 80% fine sand; ~20% to 40% medium plasticity fines							
10								At 14 ft, as above except wet to saturated ▽							
	15		FS8	<1	<1	100									Very easy drilling; samplers driven from 14-30 ft advance 18 in. with one hammer blow.
			FS9	<1	<1	100		SILT / LEAN CLAY WITH SAND, ML/CL: Very loose / very soft; saturated; dark yellowish brown (10YR 4/4); ~85% medium plasticity, medium toughness fines; ~15% fine sand; trace of charcoal at 16.1 ft						31	
			FS10	<1	<1	100								38	
5	20		FS11	* <1	<1	100						37	12		
			FS12	<1	<1	100									
0															
	25		FS13	<1	<1	100		LEAN CLAY, CL: Very soft; saturated; grayish brown (10YR 5/2); ~90% medium plasticity, medium toughness fines; ~10% fine sand							
			FS14	* <1	<1	100									
-5			FS15	<1	<1	100		At 28 ft, as above except very dark grayish brown (2.5Y 3/2)							
	30														

Report: GEO_10B1SW_OAKCOE, File: NATURSNP.GPJ; 2/28/2002 C2F-01-43

URS

Figure A-42

Project: Natomas Levee North of Powerline Road
Project Location: Sacramento County, California
Project Number: 51971138NA.00

Log of Boring 2F-01-43

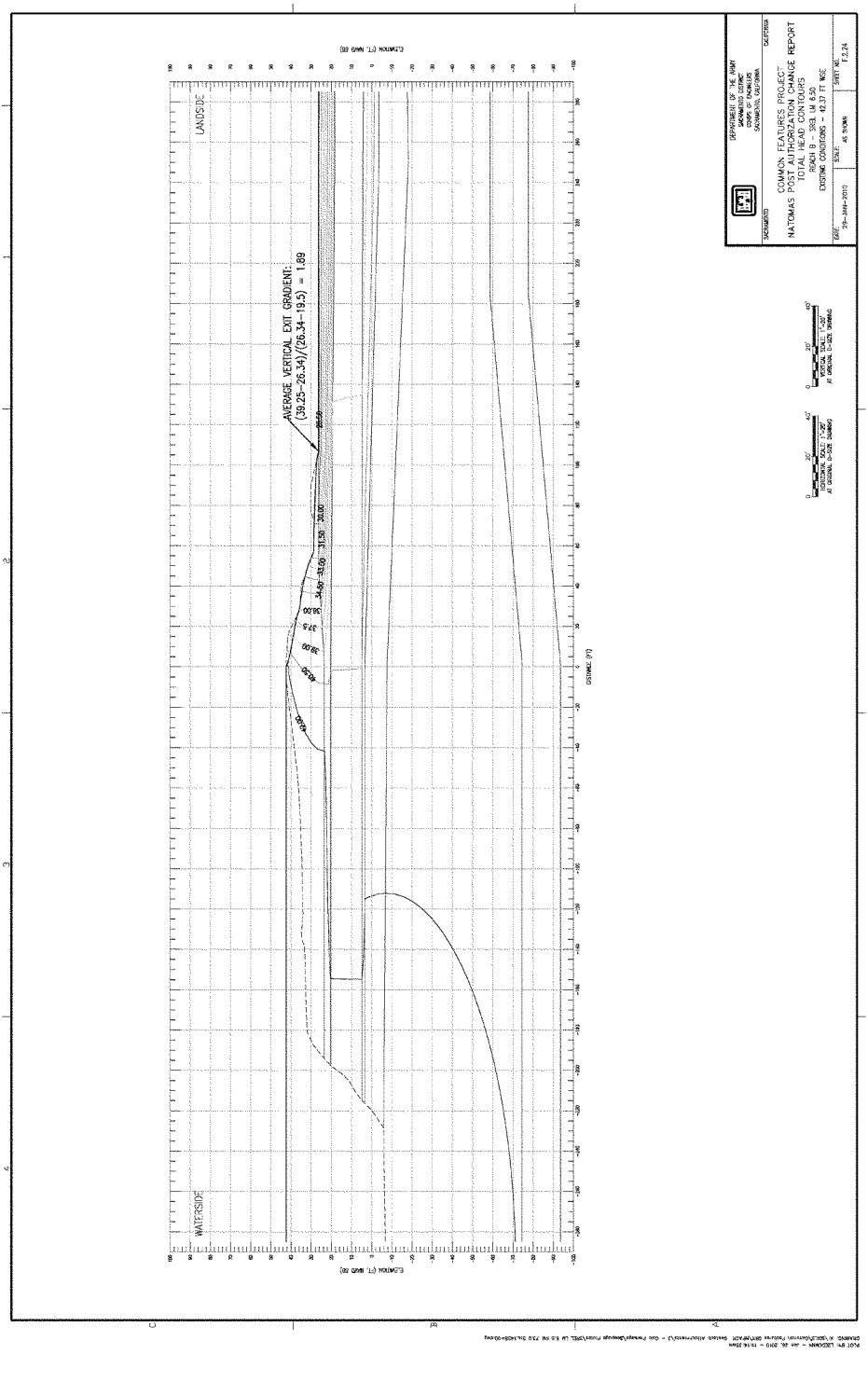
Sheet 2 of 2

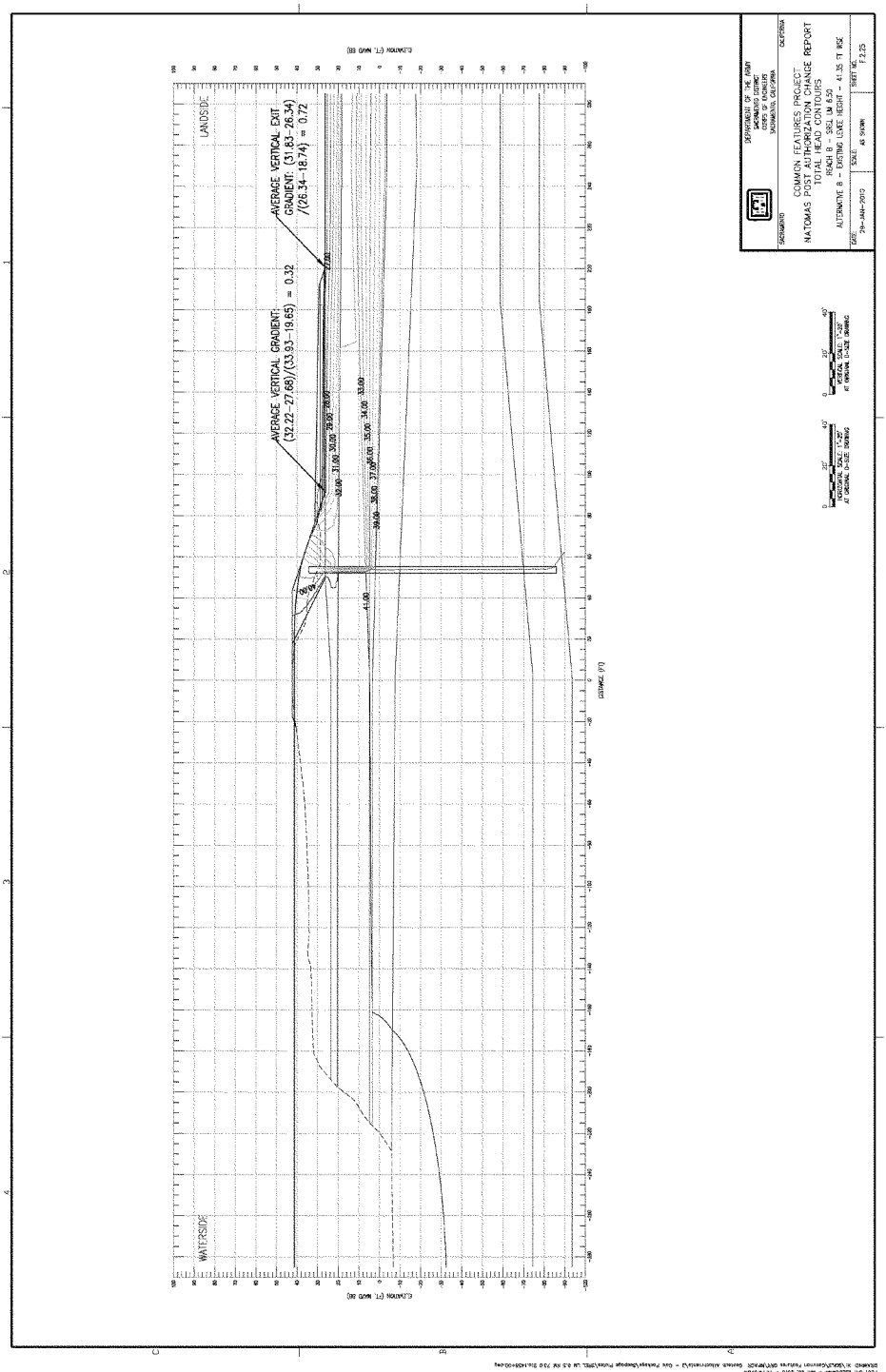
Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / Foot	N_{60}	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	% Gravel	% Sand	% Fines	Liquid Limit	Plasticity Index	Moisture, %	REMARKS AND OTHER TESTS
	30		FS16A FS16B	1	1	100		**LEAN CLAY, CL:** Very soft; saturated; very dark grayish brown (2.5Y 3/2); ~80% medium plasticity fines; ~10% sand *(continued)* **SILTY SAND, SM:** Very loose; saturated; very dark grayish brown (2.5Y 3/2); ~85% fine sand; ~15% nonplastic fines							
-10	35		FS17	17	23	80		**POORLY GRADED SAND WITH SILT, SP-SM:** Firm; wet; very dark gray (5Y 3/1); ~90% fine to medium sand; ~10% nonplastic fines	0	91	9				
			FS18	11	15	80									
-15	40		FS19	13	17	100		At 38.5 ft, as above except trace of coarse sand							
								Bottom of boring at 41.0 feet							
-20	45														
-25	50														
-30	55														
-35	60														
-40	65														

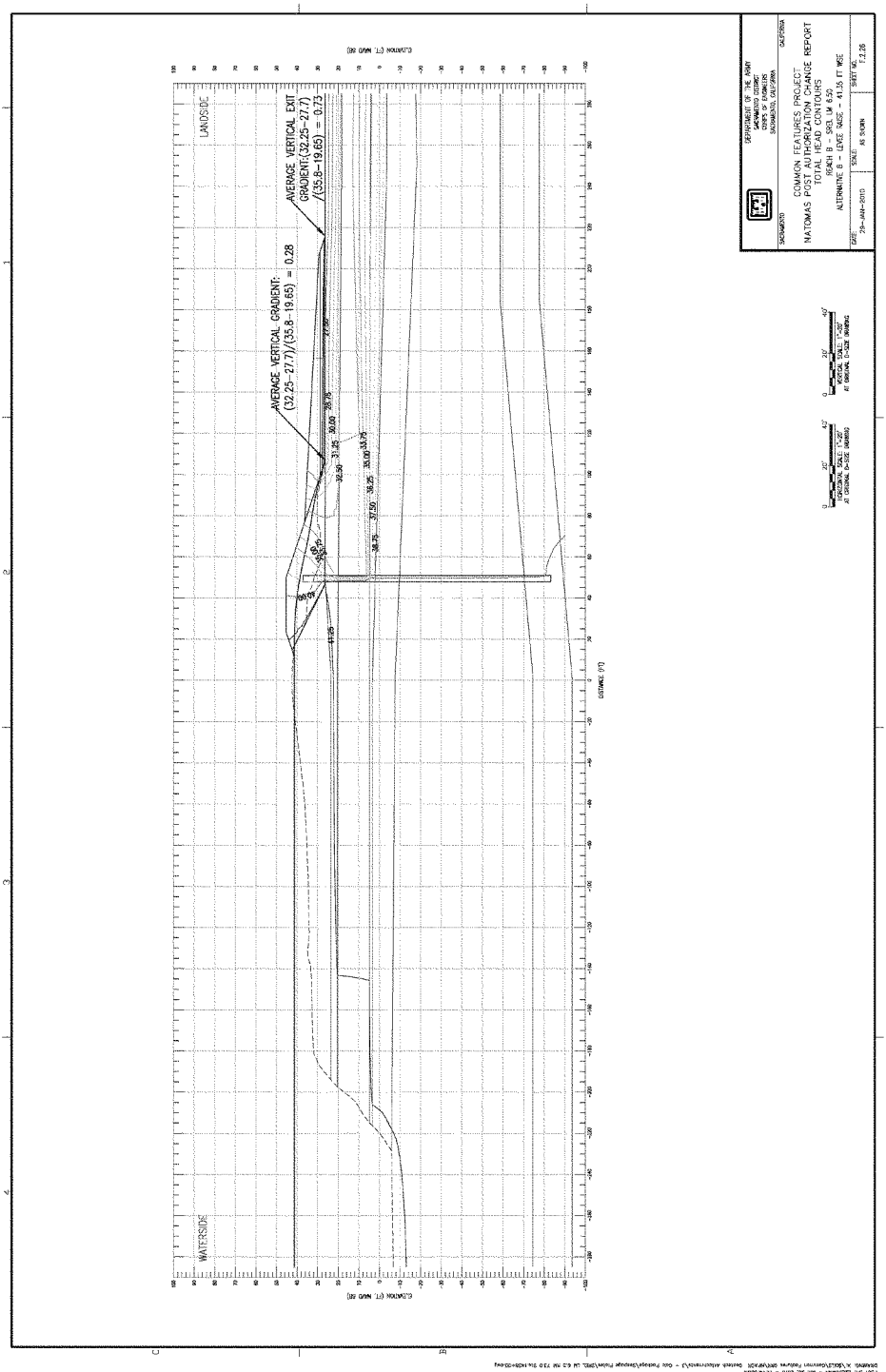
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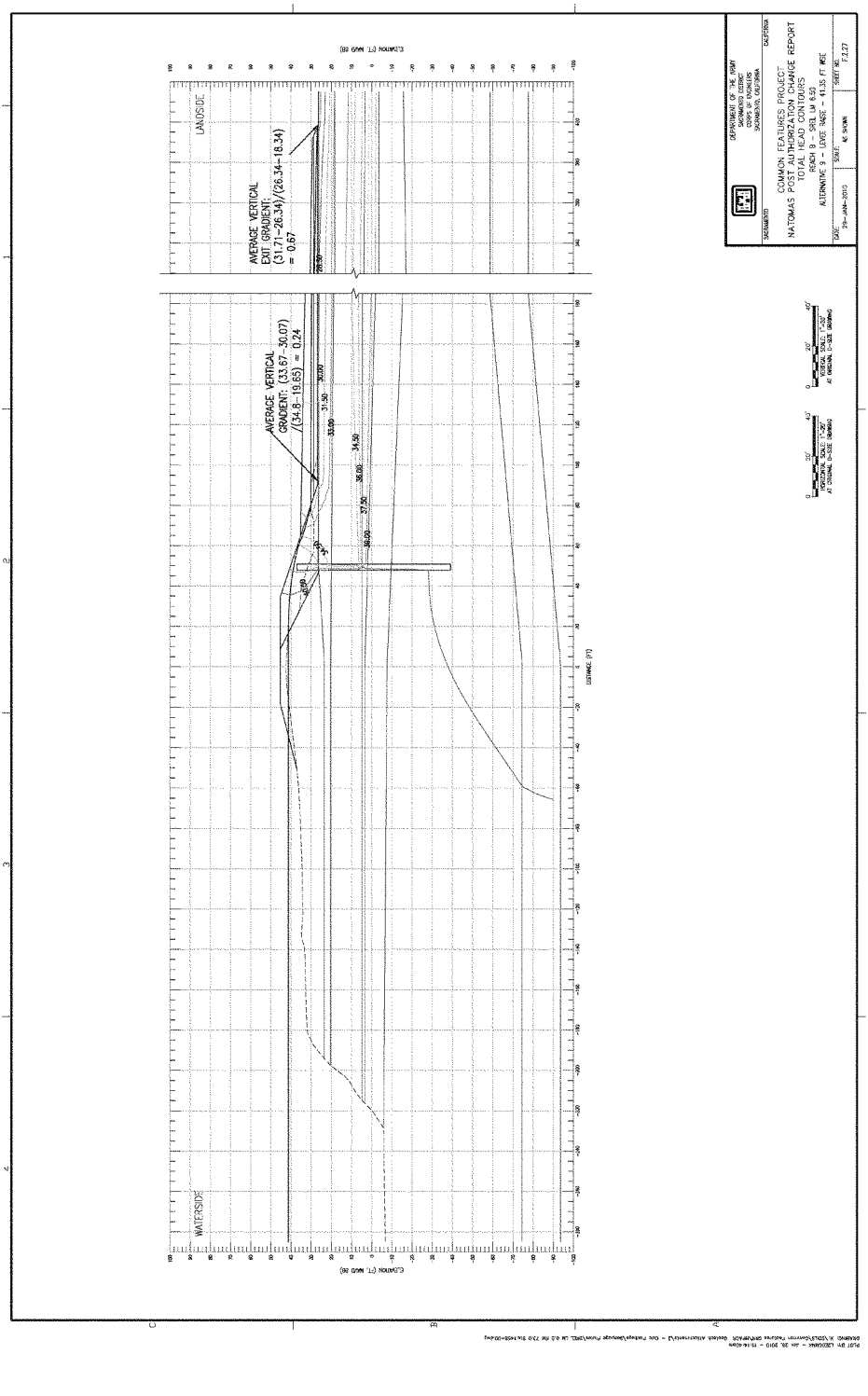
URS

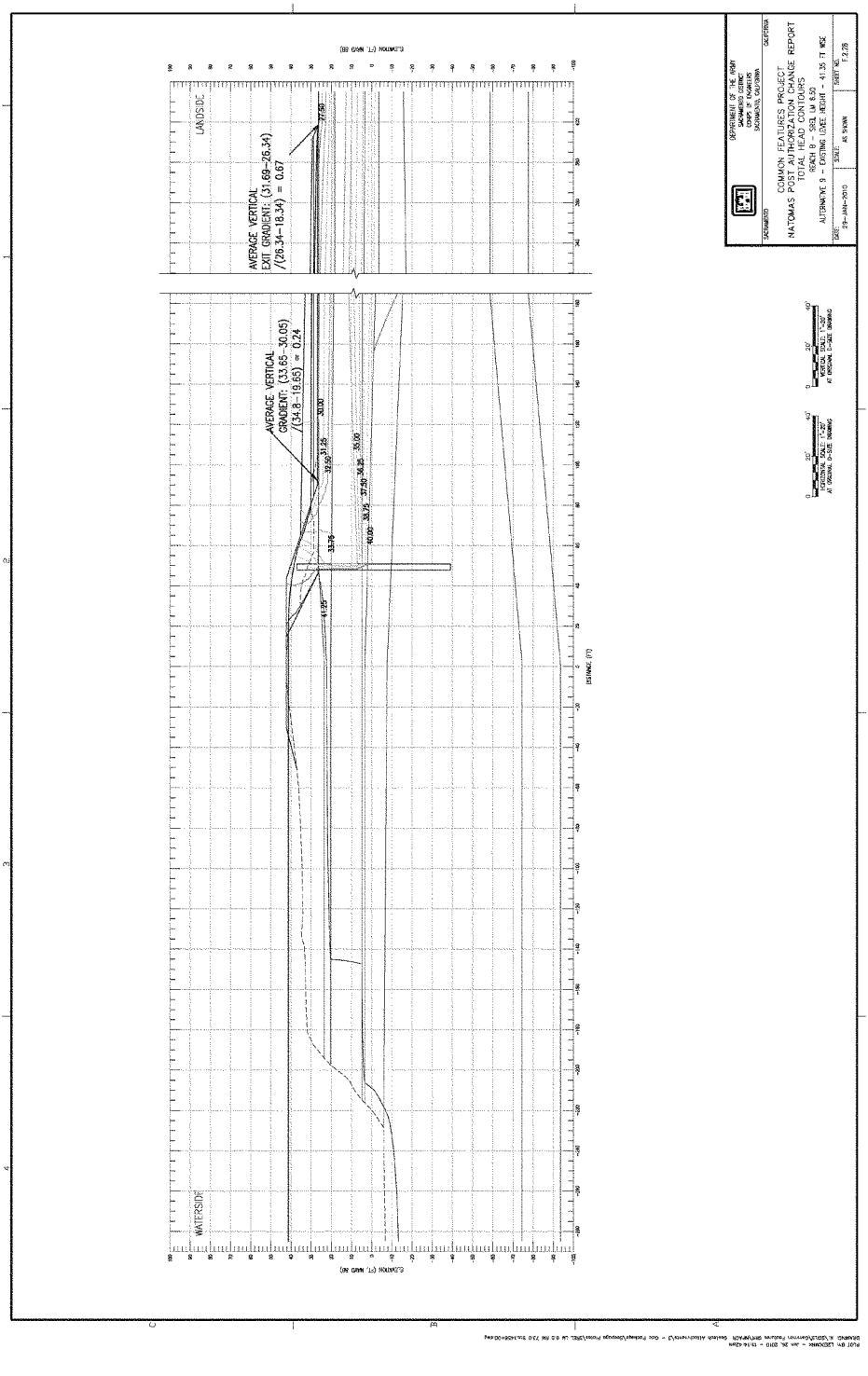
Figure A-42

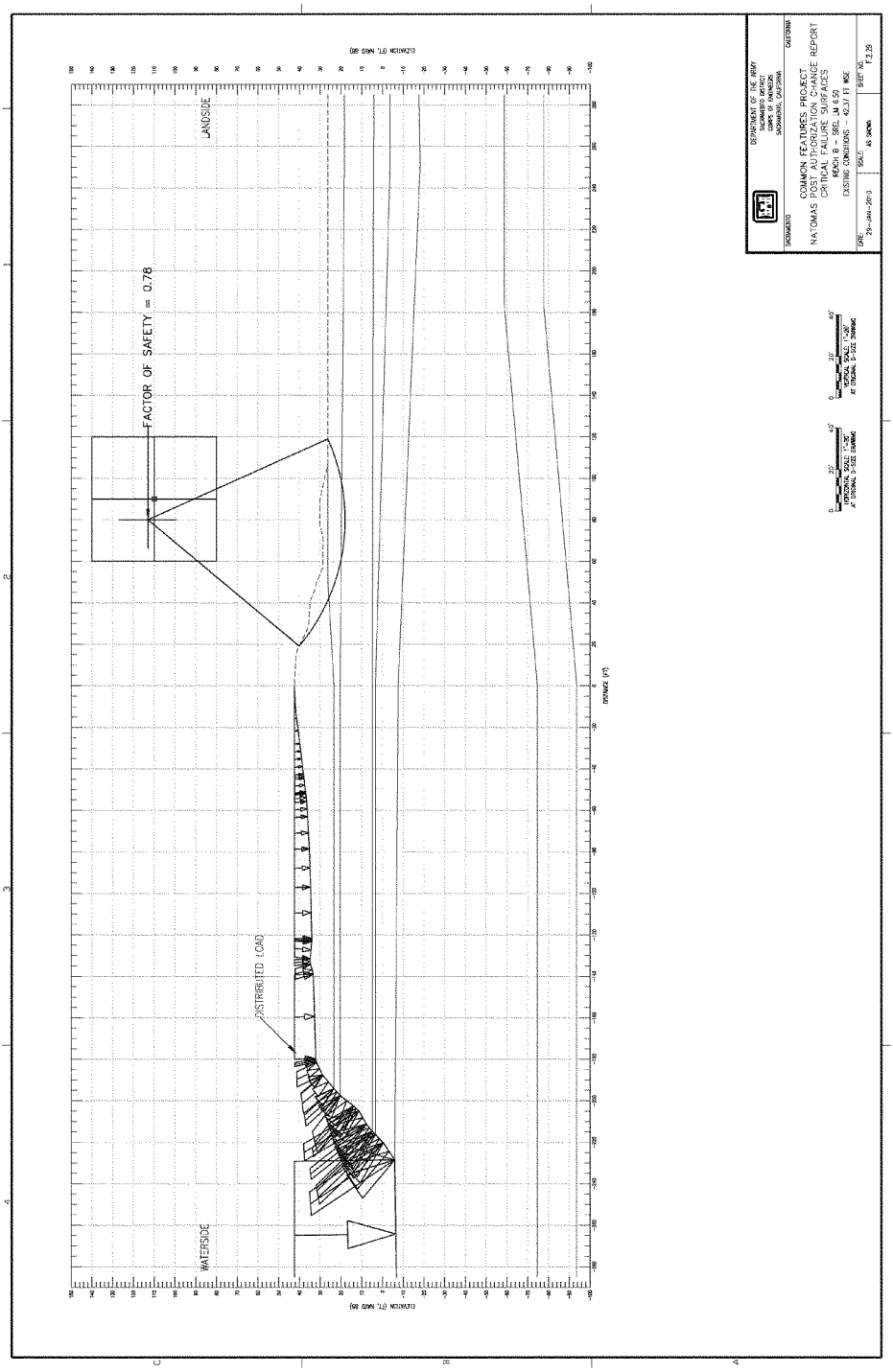

LANDSIDE
WATERSIDE
AVERAGE VERTICAL EXIT GRADIENT:
(39.25-26.34)/(26.34-19.5) = 1.89
39.25
38.00
37.5
36.00
34.50
33.00
31.50
30.00
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH B, STATION 1+55
EXISTING CONDITIONS - 42.37 FT MSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
E.2.24

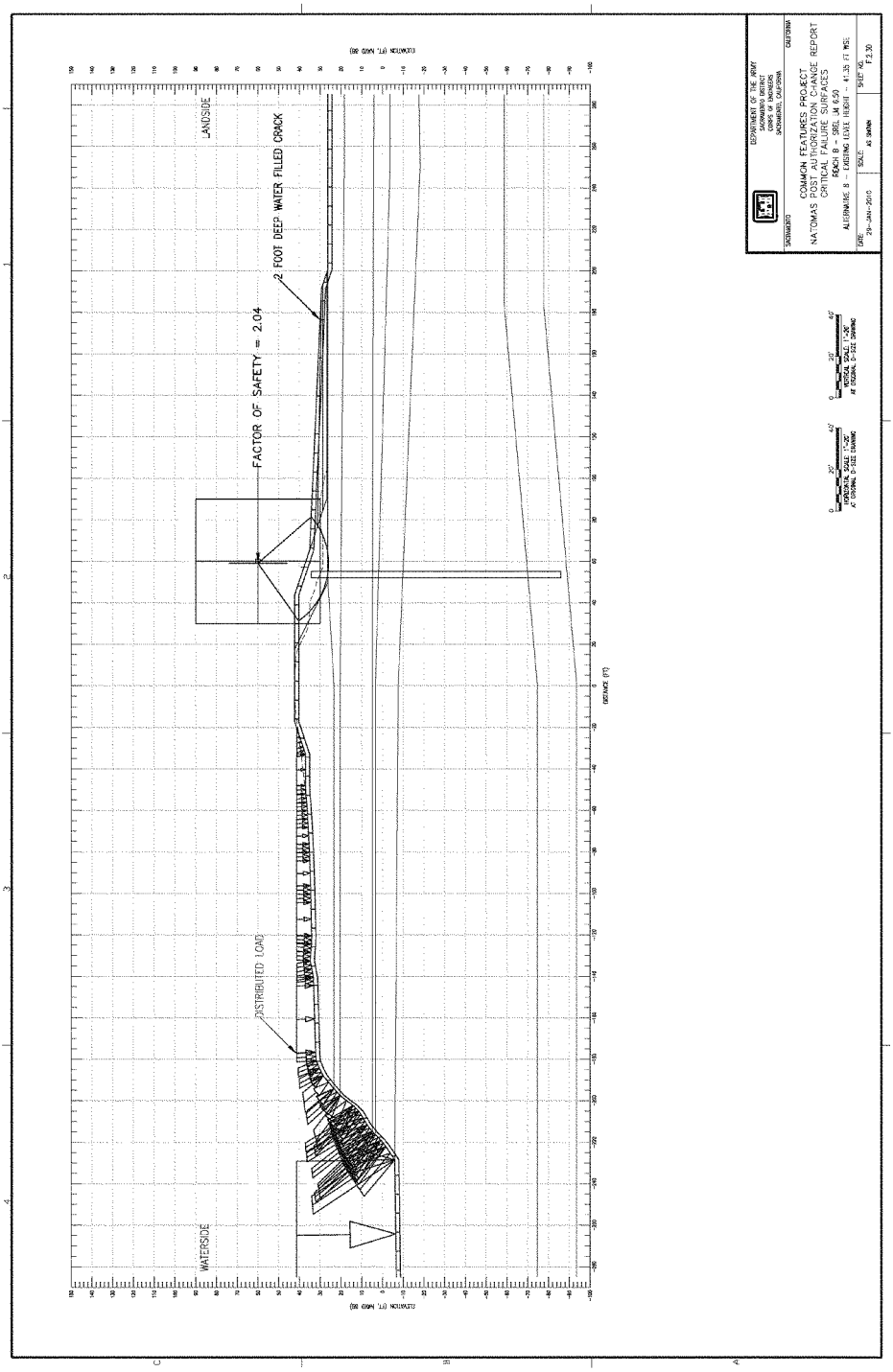

AVERAGE VERTICAL GRADIENT:
(32.22-27.68)/(33.93-19.65) = 0.32
AVERAGE VERTICAL EXIT
GRADIENT: (31.83-26.34)
/(26.34-18.74) = 0.72
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH B SEEP/S SLOPE STAB
ALTERNATIVE 8 - EXISTING LEVEE HEIGHT - 41.35 FT MSL
DATE: 29-JAN-2013
SCALE: AS SHOWN
SHEET NO. F.2.25

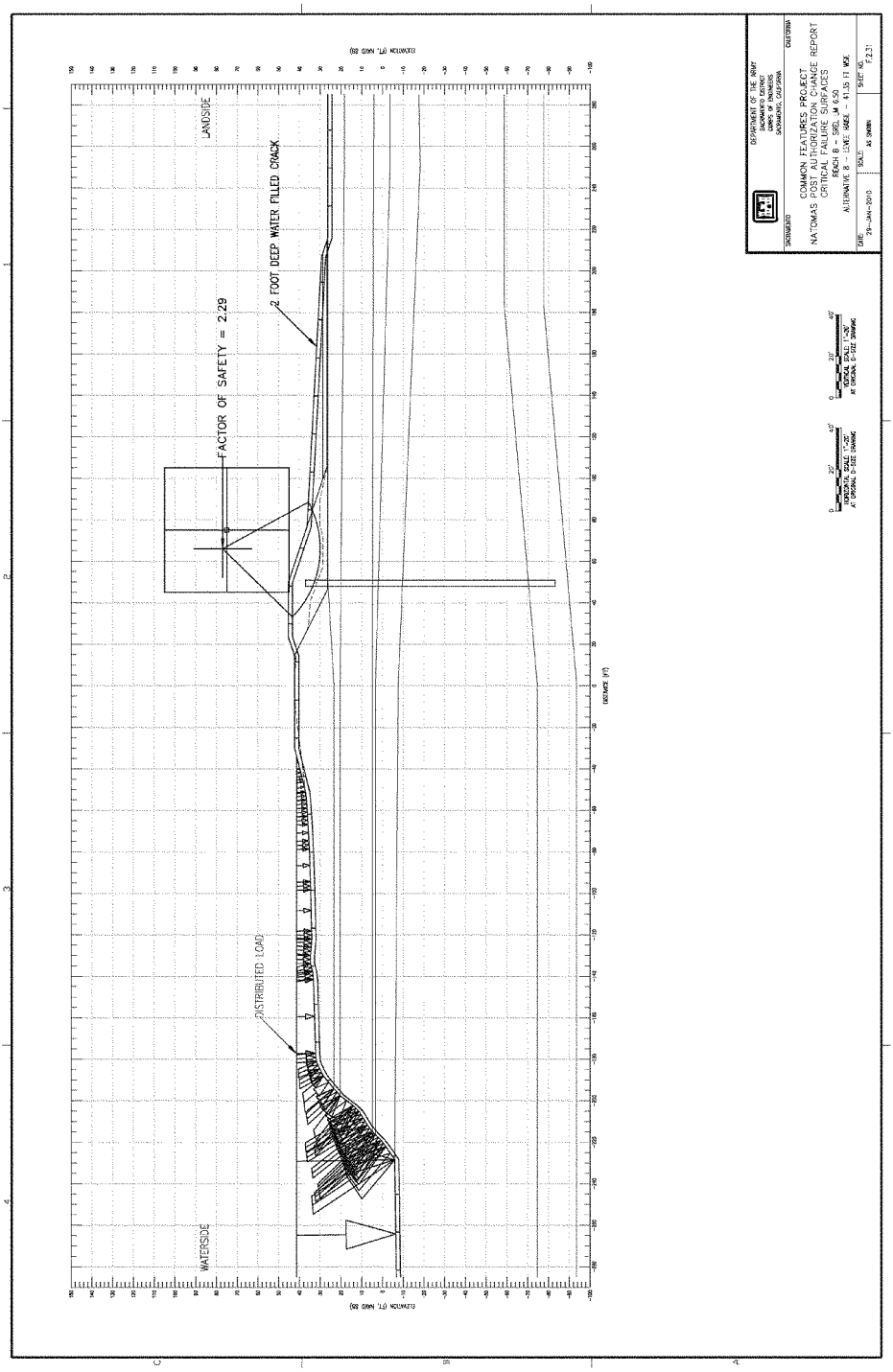

AVERAGE VERTICAL GRADIENT:
(32.25-27.7)/(35.8-19.65) = 0.28
AVERAGE VERTICAL EXIT
GRADIENT:(32.25-27.7)
/(35.8-19.65) = 0.73
LANDSIDE
WATERSIDE
ELEVATION (FT MSL 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH B - SCEL 34.5
ALTERNATIVE 6 - LEVEE RAISE - 41.35 FT MSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.26

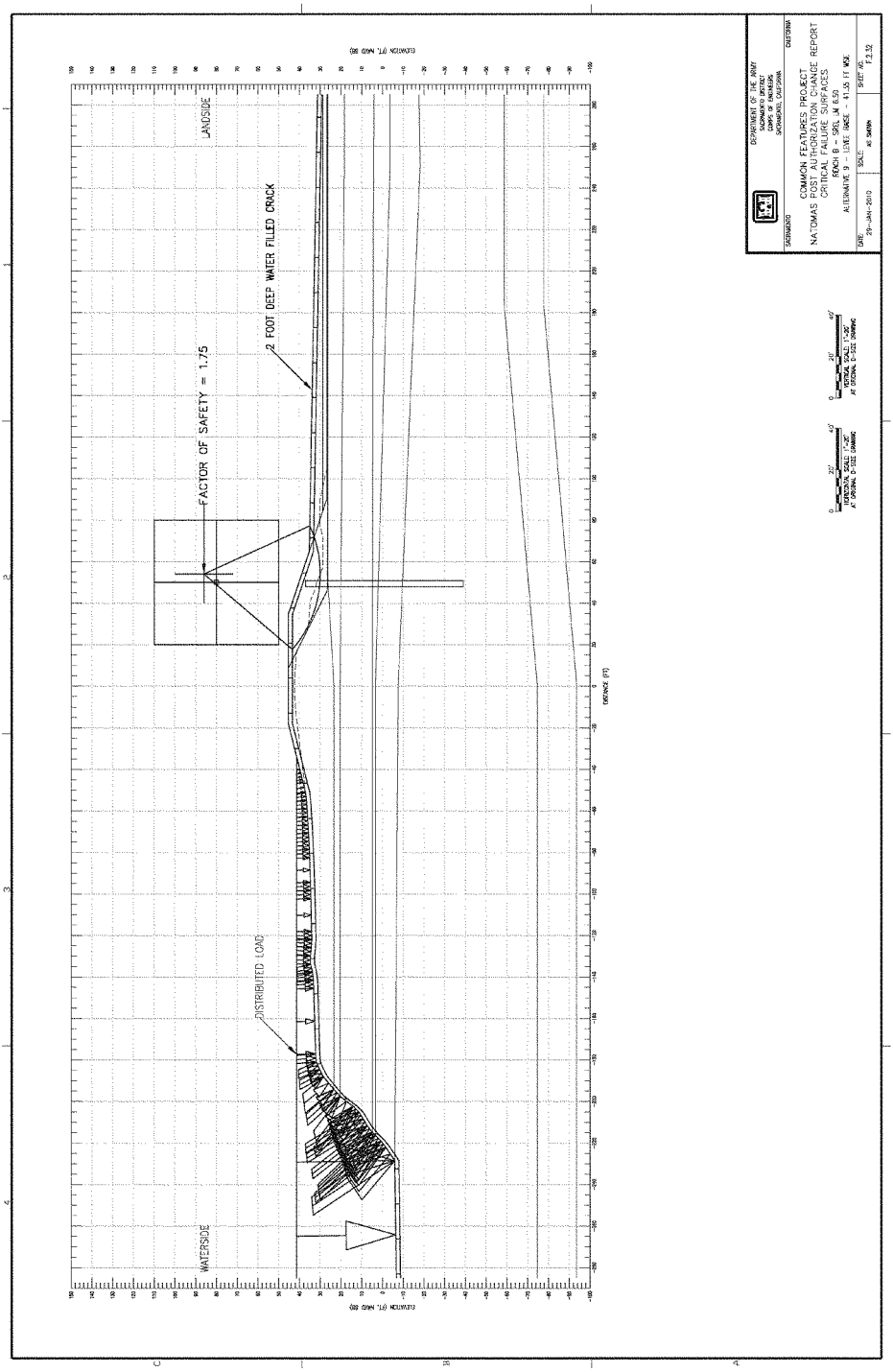

WATERSIDE
LANDSIDE
AVERAGE VERTICAL GRADIENT: (33.67-30.07) /(34.8-19.65) = 0.24
AVERAGE VERTICAL EXIT GRADIENT: (31.71-26.34)/(26.34-18.34) = 0.67
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH B, STA 1+00
ALTERNATIVE 9 - LEVEE RAISE - 41.35 FT MSL
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.27

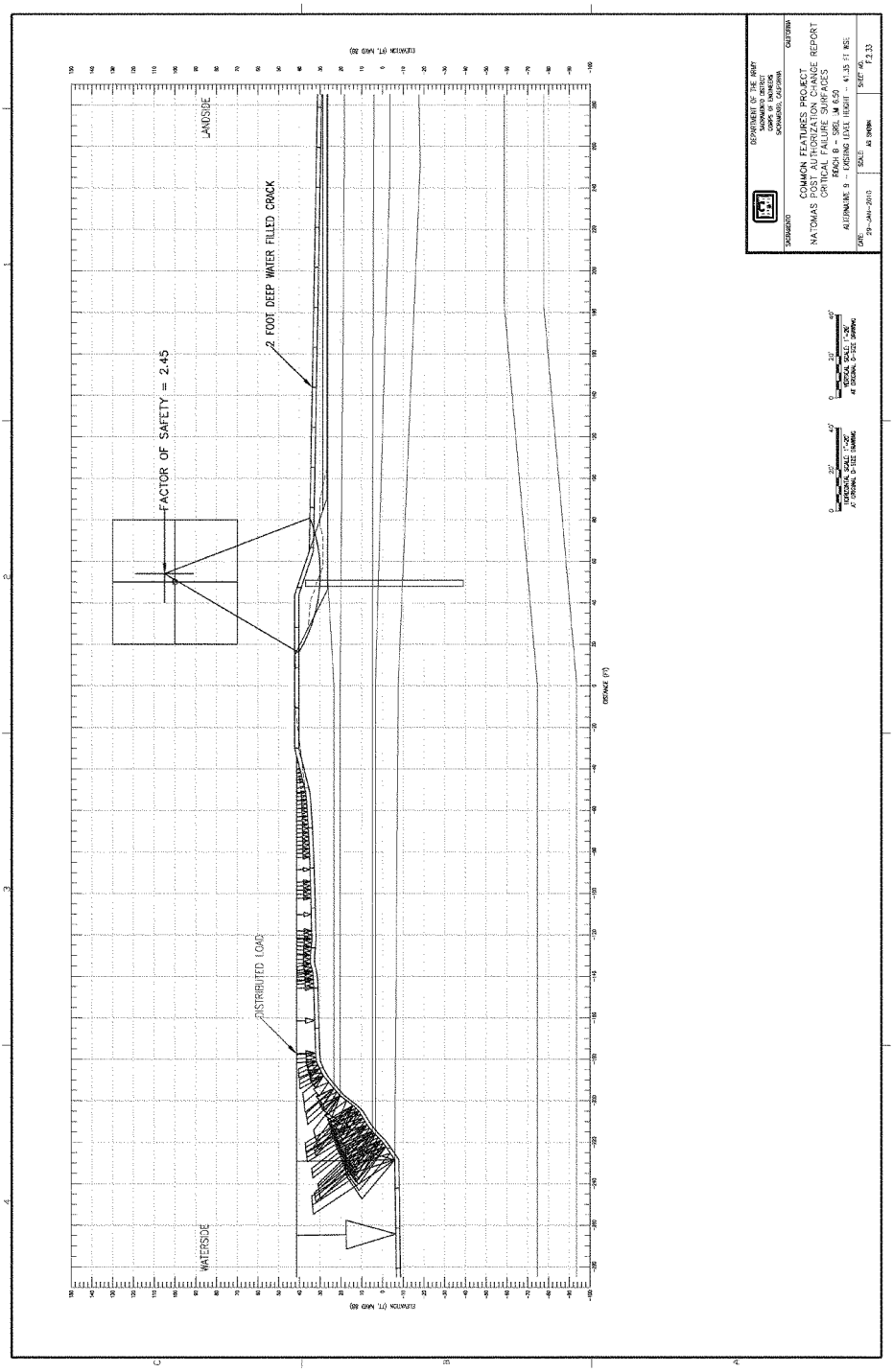

AVERAGE VERTICAL GRADIENT: (33.65-30.05) /(34.8-19.65) = 0.24
AVERAGE VERTICAL EXIT GRADIENT: (31.69-26.34) /(26.34-18.34) = 0.67
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
30.05
31.26
33.76
41.25
35.00
36.25
37.50
38.75
40.00
21.50
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH B, STA 1+53
ALTERNATIVE 9 - EXISTING LEVEE HEIGHT + 41.35 FT MSL
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.28


FACTOR OF SAFETY = 0.78
LANDSIDE
WATERSIDE
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SPK044850
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
CRITICAL FAILURE SURFACES
REACH B, SEEPAGE SEC. 42-47 FR MSE
EXISTING CONDITIONS
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.29


LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 2.04
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH B - SOIL NO. 5
ALTERNATIVE 8 - EXISTING LEVEE HEIGHT + 4.35 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.30


FACTOR OF SAFETY = 2.29
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH B - SHEET PILE WALL
ALTERNATIVE 8 - CWE 566.5 + 41.35 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.21


FACTOR OF SAFETY = 1.75
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, SHEET 1 OF 1
ALTERNATIVE 9 - LEVEE RAISE - 41.05 FT MOE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.32


FACTOR OF SAFETY = 2.45
2 FOOT DEEP WATER FILLED CRACK
LANDSIDE
WATERSIDE
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE
CRITICAL FAILURE SURFACES
REACH A, SAC M-3 LEVEE
ALTERNATIVE 9 - EXISTING LEVEE HEIGHT + 41.35 FT MSL
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.33

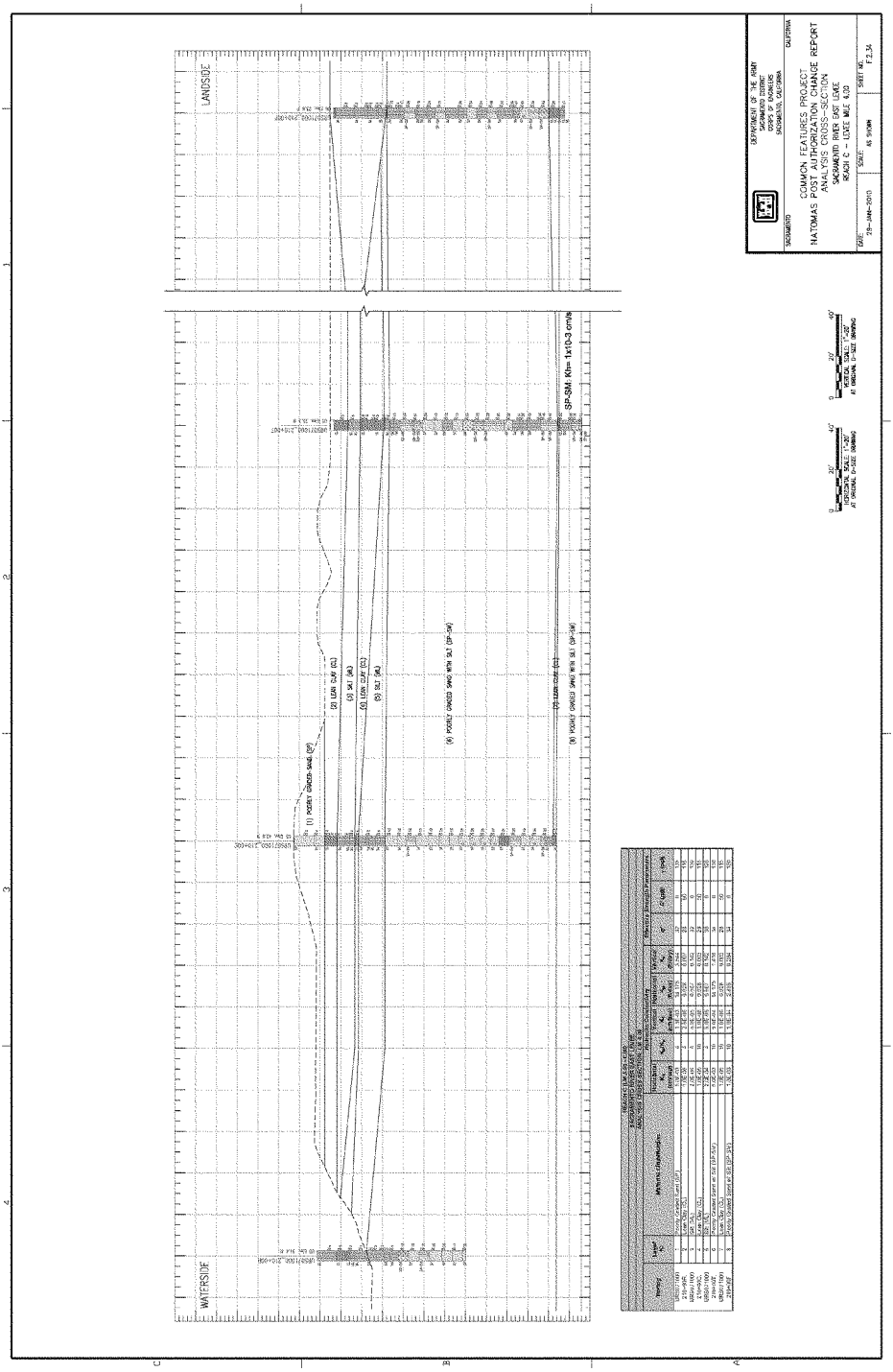
REACH C

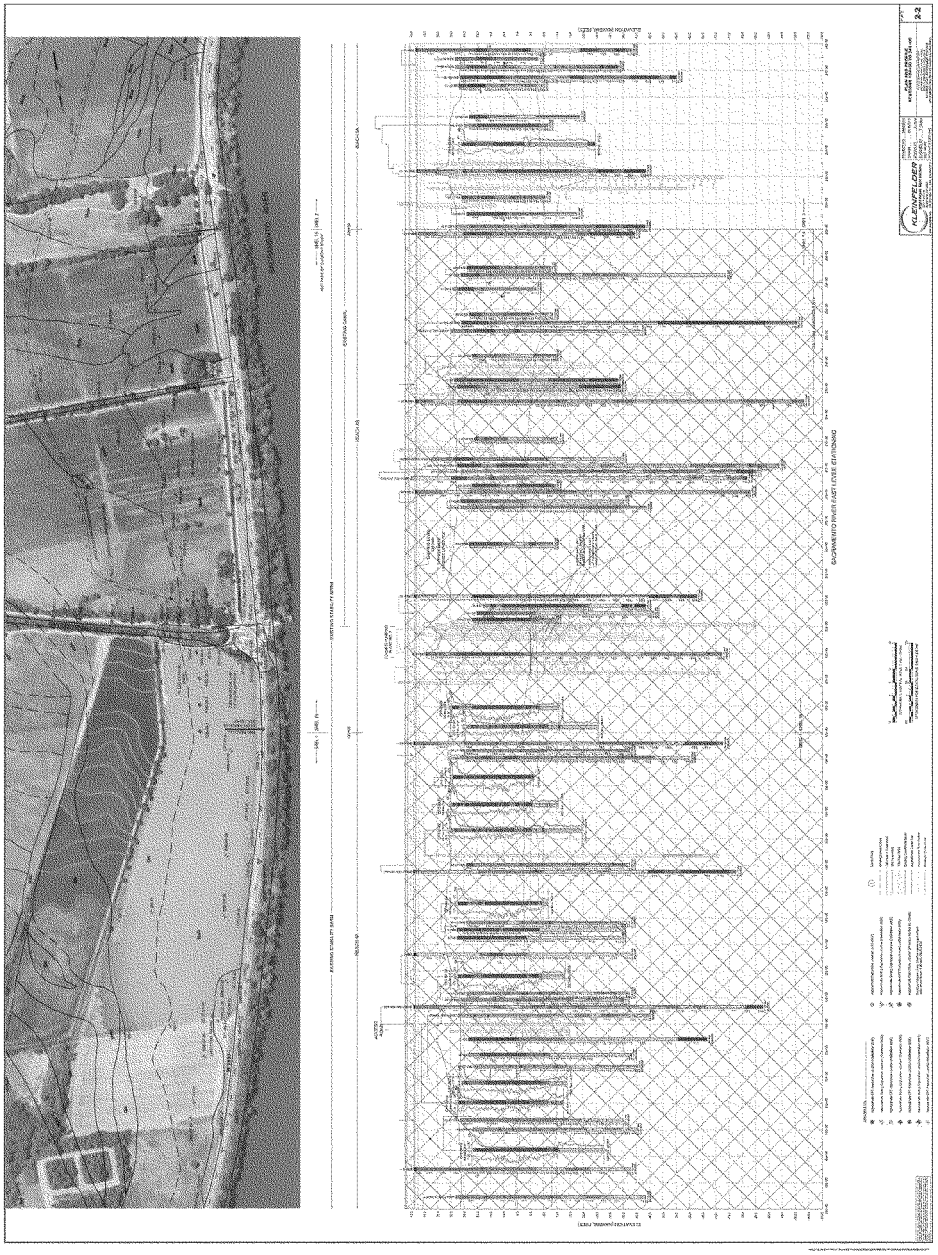
CALCULATION PACKAGE

SACRAMENTO RIVER EAST LEVEE

(SREL)

LM 5.00 – 0.00


LANDSIDE
WATERSIDE
(1) POORLY GRADED SAND (SP)
(2) LEAN CLAY (CL)
(3) SAT (SM)
(4) LEAN CLAY (CL)
(5) SILT (ML)
(6) POORLY GRADED SAND WITH SILT (SP-SM)
(7) LEAN CLAY (CL)
(8) POORLY GRADED SAND WITH SILT (SP-SM)
SP-SM: Kh= 1x10-3 cm/s
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
SACRAMENTO RIVER EAST LEVEE
REACH C - LEVEE MILE 4.03
DATE: 28-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.34



Boring Designation URS071000_210+00R

DRILLING LOG	DIVISION: South Pacific	INSTALLATION: Sacramento District	SHEET 1 OF 5 SHEETS
1. PROJECT: Natomas GRR 2007		9. COORDINATE SYSTEM: State Plane CA Zone 4	HORIZONTAL: NAD 83 / VERTICAL:
		10. SIZE AND TYPE OF BIT: 4 inch drag bit	
2. HOLE NUMBER: 2F-07-48	LOCATION COORDINATES: N 2,026,869.0 E 6,674,699.0	11. MANUFACTURER'S DESIGNATION OF DRILL: Track Mounted CME 55	
3. DRILLING AGENCY: Taber Consultants		12. TOTAL SAMPLES	DISTURBED / UNDISTURBED
4. NAME OF DRILLER: Dan Davis		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG FROM VERTICAL: --- / BEARING:	14. ELEVATION GROUND WATER	
		15. DATE BORING: STARTED 5/8/07	COMPLETED 5/9/07
6. THICKNESS OF OVERBURDEN		16. ELEVATION TOP OF BORING: 31.4	
7. DEPTH DRILLED INTO ROCK		17. TOTAL CORE RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 71.5		18. SIGNATURE AND TITLE OF INSPECTOR: S. Orgill	

ELEV	DEPTH	Blows/ 0.5 ft.	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Silt with sand (ML); dry; light olive brown (2.5Y 5/4); 75% low plasticity, low dry strength, slow dilatancy, low toughness fines; 25% fine sand; trace medium sand.										Began boring at 2:00PM (5/8/07)
		2 4 5	9				100	S1	0	25						S1A 5'-7'
22.4	9.0					Lean clay (CL); moist; light yellowish brown (2.5Y 6/4); 95% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 5% sand.										S2A 10'-12'
		3 3 3	6				53	S2				46	20	13		
17.4	14.0															

0.0 2.5 5.0 7.5 10.0 12.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00R SHEET 1 of 5

Boring Designation URS071000_210+00R

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 2 OF 5 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,699.0

ELEVATION TOP OF BORING: 31.4

ELEV	DEPTH	Blows/0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Sample No	Laboratory: Gravel	Sand	Fines	LL	PI	WC	ASTM Class	REMARKS
						Lean clay with sand (CL); moist; olive brown (2.5Y 4/4); 80% medium plasticity, high dry strength, no dilatancy, medium toughness fines; 20% sand.											
		2														S3B 15-17' taken from top of sampler
15.4	16.0	4 5	9				100	S3								S3A 15'-17' taken from sampler shoe
						Silt with sand (ML); moist; light yellowish brown (2.5Y 6/3); 70% nonplastic, no dry strength, rapid dilatancy, no toughness fines; 30% fine sand.			0	28						grades sandier with depth within sampler
13.4	18.0															
						Silt (ML); wet; olive brown (2.5Y 4/3); 90% low plasticity, low dry strength, slow dilatancy, low toughness fines; 10% sand.											
		2														S4A 20'-22'
		1	3				33	S4				44	17	46		
		2														
7.4	24.0					Silty sand (SM); wet; dark gray (2.5Y 4/1), 65% fine sand; 35% fines, loose.										
																T5A 25'-27'
							100	T5								
		1														S6A 27'-29'
		2 3	5				47	S6	0	65	35					
																No recovery on S7A 30'-32'
		1														
		1					0	S7								

15.0 17.5 20.0 22.5 25.0 27.5 30.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00R SHEET 2 of 5

Boring Designation URS071000_210+00R

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District

SHEET 3 OF 5 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,699.0

ELEVATION TOP OF BORING: 31.4

ELEV	DEPTH	Blows/0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		1	2			Silty sand (SM); wet; dark gray (2.5Y 4/1); 65% fine sand; 35% fines; loose. *(continued)*										
-0.6	32.0					Silty sand (SM); wet; dark gray (2.5Y 4/1); 60% fine sand; 40% fines; very loose.	100	T8								T8A 32'-34'
-3.6	35.0	1 1 3	4			Silty sand (SM); wet; greenish black (10Y 2.5/1); 55% fine sand; 45% fines; very loose.	53	S9	0	55						S9A 35'-37'
-7.6	39.0	4 7 6	13			Well graded sand with silt (SW-SM); wet; greenish black (10Y 2.5/1); 80% fine to coarse sand; 10% fine gravel; 10% fines; medium dense.	67	S10	11	77						S10A 40'-42'
-12.6	44.0	6 6 10	16			Poorly graded sand (SP); wet; very dark gray (5Y 3/1); 90% fine to medium sand; 5% gravel; 5% fines; medium dense.	60	S11								S11A 45'-47' Wood at 45.5'

32.5 35.0 37.5 40.0 42.5 45.0 47.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00R SHEET 3 of 5

Boring Designation URS071000_210+00R

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 4 OF 5 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,699.0

ELEVATION TOP OF BORING: 31.4

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
-17.6	49.0															
		7 7 8	15			Poorly graded sand with silt (SP-SM); wet; dark olive gray (5Y 3/2); 90% fine to medium sand; 10% fines; medium dense.	60	S12								S12A 50'-52'
-22.6	54.0					Poorly graded sand (SP); wet; dark olive gray (5Y 3/2); 100% fine to medium sand; 0% fines; medium dense; trace fines.										
		8 9 11	20				73	S13	0	96	4				SP	S13A 55'-57'
-28.6	60.0															
		12 14 14	28			Poorly graded sand (SP); wet; dark olive gray (5Y 3/2); 95% fine to medium sand; 5% fines; medium dense.	67	S14								S14A 60'-62'
-33.6	65.0															

50.0 52.5 55.0 57.5 60.0 62.5 65.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00R

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 5 OF 5 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,699.0

ELEVATION TOP OF BORING: 31.4

ELEV	DEPTH	Blows/ 0.5 ft	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		8				Poorly graded sand (SP); wet; dark olive gray (5Y 3/2); 95% fine to medium sand; 5% fines; medium dense.										Very little recovery on S15A 65'-67'
		9	17				20	S15								
		8														
-38.6	70.0															S16A 70'-72'
		7				Poorly graded sand (SP); wet; dark olive gray (5Y 3/2); 95% fine to medium sand; 5% fines; medium dense.										
		7	20				53	S16								
-40.1	71.5	13														

65.0 | 67.5 | 70.0

Bottom of boring at 71.5 feet

Terminated boring at 11:00AM (5/9/07)

Boring Designation URS071000_210+00F

DRILLING LOG	DIVISION: South Pacific	INSTALLATION: Sacramento District	SHEET 1 OF 7 SHEETS
1. PROJECT: Natomas GRR 2007		9. COORDINATE SYSTEM: State Plane CA Zone 4	HORIZONTAL: NAD 83 / VERTICAL:
		10. SIZE AND TYPE OF BIT: 4 inch drag bit	
2. HOLE NUMBER: 2F-07-49	LOCATION COORDINATES: N 2,026,869.0 E 6,675,223.0	11. MANUFACTURER'S DESIGNATION OF DRILL: Truck Mounted CME 75	
3. DRILLING AGENCY: Taber Consultants		12. TOTAL SAMPLES	DISTURBED / UNDISTURBED
4. NAME OF DRILLER: Dan Davis		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG FROM VERTICAL: --- / BEARING:	14. ELEVATION GROUND WATER	
		15. DATE BORING	STARTED: 4/16/07 / COMPLETED: 4/17/07
6. THICKNESS OF OVERBURDEN		16. ELEVATION TOP OF BORING: 23.6	
7. DEPTH DRILLED INTO ROCK		17. TOTAL CORE RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 111.5		18. SIGNATURE AND TITLE OF INSPECTOR: M. Hogaboom	

ELEV	DEPTH	Blows/0.5 ft	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Topsoil.										Began boring at 10:00AM (4/16/07)
22.6	1.0					Sandy silt (ML); moist; brown (10YR 4/3); 60% nonplastic, medium dry strength, rapid dilatancy, no toughness fines; 40% sand; micaceous.											
		2 1 2	3				100	S1								S01A_005_007S
13.6	10.0															
		1 1 2	3			Sandy silt (ML); moist to wet; brown (10YR 4/3); 55% nonplastic, medium dry strength, rapid dilatancy, no toughness fines; 45% sand; micaceous.	100	S2			53					S02A_010_012S

0.0 2.5 5.0 7.5 10.0 12.5

Boring Designation URS071000_210+00F

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District	SHEET 2 OF 7 SHEETS
PROJECT Natomas GRR 2007	COORDINATE SYSTEM State Plane CA Zone 4	HORIZONTAL NAD 83 / VERTICAL
LOCATION COORDINATES N 2,026,869.0 E 6,675,223.0	ELEVATION TOP OF BORING 23.6	

ELEV	DEPTH	Blows/0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		1				Sandy silt (ML); moist to wet; brown (10YR 4/3); 55% nonplastic, medium dry strength, rapid dilatancy, no toughness fines; 45% sand; micaceous. *(continued)*											
		1					0									No recovery at 15'-16.5'
7.1	16.5	1	2													
		4				Sandy silt (ML); moist to wet; brown (10YR 4/3); 50% sand; 50% nonplastic, medium dry strength, rapid dilatancy, no toughness fines; micaceous.											
		4					93	M3			50					S03A_017_018M contains sand catcher and no sleeves; collected bag sample
		4	8*													
		1														No recovery at 20'-21.5'
		2					0									
2.1	21.5	2	4*													
		2				Sandy silt (ML); moist to wet; greenish black (10Y 2.5/1); 60% nonplastic, medium dry strength, rapid dilatancy, no toughness fines; 40% sand; micaceous.											
		3					100	M4								S04A_022_023M contains sand catcher and no sleeves; collected bag sample
		3	6*													
		2														No recovery at 25'-26.5'
		5					0									
-2.4	26.0	6	11*													
		4				Silty sand (SM); moist to wet; greenish black (10Y 2.5/1); 55% fine sand; 45% fines; loose; micaceous.											
		5					100	M5	0	51						S05A_027_028M contains sand catcher and no sleeves; collected bag sample
		5	10*													
		1														No recovery at 30'-31.5'
		1					0									

15.0 17.5 20.0 22.5 25.0 27.5 30.0

Boring Designation URS071000_210+00F

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 3 OF 7 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,675,223.0

ELEVATION TOP OF BORING: 23.6

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
-7.9	31.5	2	3													
		1				Silty sand (SM); moist; greenish black (10Y 2.5/1); 60% fine sand; 40% fines; medium dense; trace medium sand; trace fine, subrounded gravel to 0.4 inches; micaceous.	87	S6								S06A_032_033S contains sand catcher
		4	12**													
		8														
-10.4	34.0					Poorly graded sand with silt (SP-SM); moist; very dark greenish gray (10Y 3/1); 90% fine to coarse sand; 10% fines; medium dense; trace fine, subangular gravel up to 0.5 inches.										
		7														S07A_035_037S
		9	20				67	S7	2	93						
		11														
-15.9	39.5															
-16.7	40.3	4				Silty sand (SM); moist; greenish black (5G 2.5/1); 70% fine to medium sand; 30% fines; medium dense; micaceous; trace organics.										S08A_040_042S
		8	18			Silty sand (SM); moist; greenish black (10Y 2.5/1); 75% fine to coarse sand; 25% fines; medium dense; trace fine gravel up to 0.5 inches; micaceous.	27	S8								
		10														
-21.4	45.0	4				Silty sand (SM); moist; 80% fine to medium sand; 20% fines; medium dense; trace fine, subrounded gravel up to 0.5 inches; micaceous.										S09A_045_047S
		12	24				53	S9								
		12														

Boring Designation URS071000_210+00F

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 4 OF 7 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,675,223.0

ELEVATION TOP OF BORING: 23.6

ELEV	DEPTH	Blows/0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
-25.4	49.0															
		4 6 11	19			Poorly graded sand with silt (SP-SM); moist; very dark greenish gray (10Y 3/1); 85% fine to coarse sand; 10% fines; 5% fine gravel; medium dense; micaceous.	33	S10	4	88	8					S10A_050_052S Gradational change in sample; fines downward
-30.4	54.0															
						Silty sand (SM); moist; very dark greenish gray (10Y 3/1); 75% fine to medium sand; 25% fines; medium dense; micaceous.	67	S11								S11A_055_057S
-36.4	60.0															
		8 11 15	26			Silty sand (SM); moist; very dark greenish gray (10Y 3/1); 80% fine to medium sand; 20% fines; medium dense; trace fine, subangular to subrounded gravel up to 0.7 inches; micaceous.	53	S12								S12A_060_062S
-40.4	64.0															

50.0 52.5 55.0 57.5 60.0 62.5 65.0

SPK FORM 1836-A SEP 05

Boring Designation URS071000_210+00F

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 5 OF 7 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,675,223.0

ELEVATION TOP OF BORING: 23.6

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		14 17 17	34			Poorly graded sand (SP); moist; very dark greenish gray (10Y 3/1); 95% fine to medium sand; 5% fines; dense; trace coarse sand; trace fine, subangular to subrounded gravel up to 1.25 inches. *(continued)*	53	S13								S13A_065_067S
-45.4	69.0															Rig chatter
		12 18 16	34			Silty sand (SM); moist; very dark greenish gray (10Y 3/1); 80% fine to medium sand; 15% fines; 5% gravel; dense; trace coarse, angular to subrounded sand; trace fine to coarse, subangular to rounded gravel up to 1.3-inches.	27	S14								S14A_070_072S
-50.4	74.0															
		13 15 15	30			Poorly graded sand with silt and gravel (SP-SM); moist; very dark greenish gray (10Y 3/1); 60% fine to medium sand; 30% fine to coarse, subangular to rounded gravel up to 1.3 inches; 10% fines; dense; trace coarse, angular to rounded sand.	47	S15	30	64	6					S15A_075_077S
-55.4	79.0															
		16 18 16	32			Silty sand (SM); moist; very dark greenish gray (10Y 3/1); 80% fine to medium sand; 15% fines; 5% fine to coarse, subangular to rounded gravel; dense; trace coarse, angular to subrounded sand.	27	S16								S16A_080_082S

65.0 67.5 70.0 72.5 75.0 77.5 80.0

Boring Designation URS071000_210+00F

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 6 OF 7 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,675,223.0

ELEVATION TOP OF BORING: 23.6

ELEV	DEPTH	Blows/ 0.5 ft	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	WC	ASTM Class	REMARKS
						Silty sand (SM); moist; very dark greenish gray (10Y 3/1); 80% fine to medium sand; 15% fines; 5% fine to coarse, subangular to rounded gravel; dense; trace coarse, angular to subrounded sand. *(continued)*											
		17														
		15	29				0									No recovery at 85'-86.5'
-62.9	86.5	14														
		5				Silty sand (SM); moist; dark greenish gray (10Y 4/1); 80% fine to coarse sand; 15% fines; 5% fine to coarse, angular to rounded gravel up to 1.1 inches; dense; trace coarse, angular to subrounded sand.		S17								S17A_087_088S contains sand catcher
		18	31***													
-65.9	89.5	13														
		25				Poorly graded sand with gravel (SP); moist; (N 3/) very dark gray; 60% fine to coarse, angular to rounded sand; 30% fine to coarse, subangular to rounded gravel up to 1.1 inches; medium dense; trace fines.	47	S18	33	63	3				SP	S18A_090_092S
		14	29													
		15														Heavy rig chatter
-70.4	94.0					Poorly graded sand with silt (SP-SM); moist; (N 3/) very dark gray; 85% fine to medium sand; 10% fines; 5% fine to coarse, subangular to rounded gravel up to 1.9 inches; medium dense; trace coarse, subangular to rounded sand.										
		7														S19A_095_097S
		17	33				27	S19								
		16														
-75.4	99.0															

82.5 | 85.0 | 87.5 | 90.0 | 92.5 | 95.0 | 97.5

SPK FORM 1836-A
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Boring Designation URS071000_210+00F SHEET 6 of 7

Boring Designation URS071000_210+00F

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 7 OF 7 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,675,223.0

ELEVATION TOP OF BORING: 23.6

ELEV	DEPTH	Blows/0.5 ft.	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Well graded sand with silt and gravel (SW-SM); moist; dark greenish gray (10Y 4/1); 55% fine to coarse, angular to rounded sand; 35% fine to coarse, angular to rounded gravel up to 1.9 inches; 10% fines; dense.											
		7														S20A_100_102S
		26	45				33	S20								
		19														
-80.4	104.0					Sandy lean clay (CL); moist; dark greenish gray (10GY 4/1); 70% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; 30% sand, micaceous; interbedded with fine sand.											
-81.9	105.5	8														S21A_105_107S
-82.4	106.0	9	20			Lean clay (CL); moist; dark greenish gray (10GY 4/1); 90% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; 10% sand; micaceous.	93	S21				31	11	27		
		11				Lean clay with sand (CL); moist; dark greenish gray (10GY 4/1); 75% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; 20% fine sand; 5% fine to coarse, subangular to subrounded gravel up to 1.7 inches; trace medium to coarse sand.										
-85.4	109.0					Sandy lean clay (CL); moist; (N 3/) very dark gray; 60% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 40% sand.											
		7														S22A_110_112S
-87.2	110.8	4	12				80	S22			64					
-87.9	111.5	8				Sandy silt (ML); moist; (N 3/) very dark gray; 65% nonplastic, low dry strength, rapid dilatancy, no toughness fines; 35% sand; 1 inch layer of wood pieces at 110.5'; 1 inch medium grained sand lense at 110.65'.										
						Terminated boring at 4:45PM (4/17/07) at 111.5 feet										

100.0
102.5
105.0
107.5
110.0

SPK FORM 1836-A
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Boring Designation URS071000_210+00F SHEET 7 of 7

Boring Designation URS071000_210+00C

DRILLING LOG	DIVISION: South Pacific	INSTALLATION: Sacramento District	SHEET 1 OF 8 SHEETS
1. PROJECT: Natomas GRR 2007		9. COORDINATE SYSTEM: State Plane CA Zone 4	HORIZONTAL: NAD 83 / VERTICAL:
		10. SIZE AND TYPE OF BIT: 4 inch drag bit	
2. HOLE NUMBER	LOCATION COORDINATES: N 2,026,869.0 E 6,674,797.0	11. MANUFACTURER'S DESIGNATION OF DRILL: Dietrich D120	
3. DRILLING AGENCY: Taber Consultants		12. TOTAL SAMPLES	DISTURBED / UNDISTURBED
4. NAME OF DRILLER: Breece Franks		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG FROM VERTICAL: --- / BEARING:	14. ELEVATION GROUND WATER	
		15. DATE BORING: STARTED 4/2/07	COMPLETED 4/3/07
6. THICKNESS OF OVERBURDEN		16. ELEVATION TOP OF BORING: 42.5	
7. DEPTH DRILLED INTO ROCK		17. TOTAL CORE RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 126.5		18. SIGNATURE AND TITLE OF INSPECTOR: S. Orgill	

ELEV	DEPTH	Blows/0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
42.3	0.3					Gravel shoulder at surface.										Began boring at 9:45AM (4/2/07)
						Poorly graded sand (SP); moist; olive brown (2.5Y 4/3) olive brown; 85% fine to coarse sand, 10% fine to coarse gravel; 5% fines; loose.										
																Hand auger to 5 feet
		2														
		2					100	S1								S01A_005_007S
		3	5													
32.5	10.0															
		2				Poorly graded sand (SP); moist; light olive brown (2.5Y 5/4) light olive brown; 95% fine to medium sand; 5% fines; very loose.	80	S2								S02A_010_012S
		2														
		2	4													

0.0 · 2.5 · 5.0 · 7.5 · 10.0 · 12.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00C

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 2 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,797.0

ELEVATION TOP OF BORING: 42.5

ELEV	DEPTH	Blows/0.5 ft	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
27.5	15.0															
		2 2 2	4			Lean clay with sand (CL); moist; dark brown (10YR 3/3) dark brown; 80% medium plasticity, high dry strength, no dilatancy, medium toughness fines; 20% sand.	67	S3								S03A_015_017S
																S04A_017_019T
							100	T4								
21.5	21.0						100	T5								S05A_020_022T
						Sandy silt (ML); moist; dark brown (10YR 3/3) dark brown; 65% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 35% sand.										
17.5	25.0						100	T6								S06A_025_027T
						Sandy silt (ML); moist; dark brown (10YR 3/3) dark brown; 65% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 35% sand.										
15.5	27.0	2 1 1	2			Silt with sand (ML); moist; olive brown (2.5Y 4/4) olive brown; 85% nonplastic, no dry strength, rapid dilatancy, no toughness fines; 15% sand.	20	S7	0	16						S07A_027_029S
13.0	29.5															
		2 2				Lean clay with sand (CL); moist; olive brown (2.5Y 4/4) olive brown; 85% low to medium plasticity, medium dry strength, slow dilatancy, low to medium toughness fines; 15% sand.	33	M8				30	12	36		S08A_030_032M

15.0 17.5 20.0 22.5 25.0 27.5 30.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00C SHEET 2 of 8

Boring Designation URS071000_210+00C

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 3 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,797.0

ELEVATION TOP OF BORING: 42.5

ELEV	DEPTH	Blows/0.5 ft	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
11.3	31.3	3	5*													
						Silty sand (SM); wet; dark brown (10YR 3/3) dark brown; 60% fine sand; 40% fines.										
7.5	35.0	1														S09B_035_037S
		1				Silty sand (SM); wet; dark brown (10YR 3/3) dark brown; 55% fine sand; 45% fines; very loose.	33	S9								
6.5	36.0	1	2									NP	NP	41		S09A_035_037S
						Sandy silt (ML); wet; dark gray (2.5Y 4/1) dark gray; 65% nonplastic, no dry strength, rapid dilatancy, no toughness fines; 35% sand.										
3.0	39.5															
		1				Sandy silt (ML); wet; dark gray (2.5Y 4/1) dark gray; 70% nonplastic, no dry strength, rapid dilatancy, no toughness fines; 30% fine sand.										
		1					53	S10	0	32						S10A_040_042S
		3	4													
-1.5	44.0															
						Poorly graded sand (SP); wet; very dark gray (2.5Y 3/1) very dark gray; 90% fine to medium sand; 5% fine gravel; 5% fines; medium dense.										
		6														S11A_045_047S
		5	13				53	S11								
		8														

32.5 35.0 37.5 40.0 42.5 45.0 47.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00C SHEET 3 of 8

Boring Designation URS071000_210+00C

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 4 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,797.0

ELEVATION TOP OF BORING: 42.5

ELEV	DEPTH	Blows/0.5 ft	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
-7.5	50.0					Poorly graded sand (SP); wet; very dark gray (2.5Y 3/1) very dark gray; 90% fine to medium sand; 5% fine gravel; 5% fines; medium dense. *(continued)*										
-11.5	54.0	5 7 9	16			Poorly graded sand (SP); wet; very dark gray (2.5Y 3/1) very dark gray; 90% fine to medium sand; 5% fine gravel; 5% fines; medium dense.	53	S12								S12A_050_052S
-16.5	59.0	8 8 8	16			Poorly graded sand with silt and gravel (SP-SM); wet; dark yellowish brown (10YR 3/6) dark yellowish brown; 70% fine to medium sand; 20% fine gravel; 10% fines; medium dense.	33	S13								S13A_055_057S
-22.5	65.0	6 7 8	15			Poorly graded sand (SP); wet; olive brown (2.5Y 4/4) olive brown; 95% fine to medium sand; 5% fines; medium dense.	53	S14								S14A_060_062S

50.0 52.5 55.0 57.5 60.0 62.5 65.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00C

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 5 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,797.0

ELEVATION TOP OF BORING: 42.5

ELEV	DEPTH	Blows/0.5 ft	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		7 10 9	19			Poorly graded sand (SP); wet; olive brown (2.5Y 4/4) olive brown; 95% fine to medium sand; 5% fines; medium dense.	53	S15								S15A_065_067S
-27.5	70.0															
		5 7 9	16			Poorly graded sand (SP); wet; olive brown (2.5Y 4/4) olive brown; 95% fine to medium sand; 5% fines; medium dense.	47	S16								S16A_070_072S
-32.5	75.0															
		6 6 7	13			Poorly graded sand (SP); wet; dark gray (2.5Y 4/1) dark gray; 95% fine to medium sand; 5% fines; medium dense.	53	S17	0	95	5				SP	S17A_075_077S
-37.0	79.5															
		10 10 9	19			Poorly graded sand with gravel (SP); wet; dark gray (2.5Y 4/1) dark gray; 70% fine to coarse sand; 25% fine to coarse gravel; 5% fines; medium dense.	47	S18								S18A_080_082S

65.0 67.5 70.0 72.5 75.0 77.5 80.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00C SHEET 5 of 8

Boring Designation URS071000_210+00C

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 6 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,797.0

ELEVATION TOP OF BORING: 42.5

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Poorly graded sand with gravel (SP); wet; dark gray (2.5Y 4/1) dark gray; 70% fine to coarse sand; 25% fine to coarse gravel; 5% fines; medium dense. *(continued)*											
-42.5	85.0	9 14 14		28		Poorly graded sand with gravel (SP); wet; dark gray (2.5Y 4/1) dark gray; 60% fine to medium sand; 35% fine to coarse gravel; 5% fines; medium dense.	47	S19								S19A_085_087S
-47.5	90.0	10 15 11		26		Poorly graded sand with gravel (SP); wet; dark gray (2.5Y 4/1) dark gray; 70% fine to medium sand; 25% gravel; 5% fines; medium dense.	40	S20								S20A_090_092S
-52.5	95.0	7 7 10		17		Poorly graded sand with gravel (SP); wet; dark gray (2.5Y 4/1) dark gray; 85% fine to coarse sand; 15% fine to coarse gravel; 0% fines; medium dense; trace fines, lense of poorly-graded gravel with sand at 96 feet.	100	S21	16	83	2				SP	S21A_095_097S
-56.5	99.0															

82.5 85.0 87.5 90.0 92.5 95.0 97.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00C SHEET 6 of 8

Boring Designation URS071000_210+00C

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 7 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,869.0 E 6,674,797.0

ELEVATION TOP OF BORING: 42.5

ELEV	DEPTH	Blows/0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		19				Poorly graded gravel with sand (GP); wet; dark gray (2.5Y 4/1) dark gray; 75% fine to coarse gravel; 20% sand; 5% fines; medium dense.										
		16	29				20	S22								S22A_100_102S
		13														
-61.5	104.0															
		10				Poorly graded sand with silt (SP-SM); wet; dark gray (2.5Y 4/1) dark gray; 90% fine to medium sand; 10% fines; dense; trace coarse sand and fine gravel.										
		16	33				53	S23	0	94	5					S23A_105_107S
		17														
-67.0	109.5															
		7				Poorly graded sand (SP); wet; dark gray (2.5Y 4/1) dark gray; 95% fine sand; 5% fines; medium dense.										
		7	16				33	S24								S24A_110_112S
		9														
-71.5	114.0															
		15				Poorly graded sand with gravel (SP); wet; dark gray (2.5Y 4/1) dark gray; 75% fine to coarse sand; 20% gravel; 5% fines; dense.										
		15					33	S25								S25A_115_117S

100.0 | 102.5 | 105.0 | 107.5 | 110.0 | 112.5 | 115.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00C SHEET 7 of 8

Boring Designation URS071000_210+00C

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District	SHEET 8 OF 8 SHEETS
PROJECT Natomas GRR 2007	COORDINATE SYSTEM State Plane CA Zone 4 / HORIZONTAL NAD 83 / VERTICAL	
LOCATION COORDINATES N 2,026,869.0 E 6,674,797.0	ELEVATION TOP OF BORING 42.5	

ELEV	DEPTH	Blows/0.5 ft	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		19	34			Poorly graded sand with gravel (SP); wet; dark gray (2.5Y 4/1) dark gray; 75% fine to coarse sand; 20% gravel; 5% fines; dense. *(continued)*											
-76.5	119.0															
		6				Poorly graded sand with silt (SP-SM); wet; dark greenish gray (10G 4/1) dark greenish gray; 90% fine sand; 10% fines; medium dense.											S26B_120_122S S26A_120_122S
-78.5	121.0	10 18	28				47	S26								
						Sandy silt (ML); moist; dark greenish gray (10G 4/1) dark greenish gray; 60% nonplastic, low dry strength, rapid dilatancy, low toughness fines; 40% sand.											
-82.5	125.0	4				Sandy lean clay (CL); moist; dark greenish gray (10G 4/1) dark greenish gray; 55% low to medium plasticity, medium dry strength, slow dilatancy, low to medium toughness fines; 45% sand.										S27A_125_127S
-84.0	126.5	4 7	11				53	S27				32	11	34		

Bottom of boring at 126.5 feet

Terminated boring at 6:00PM (4/3/07)

417.5

420.0

422.5

425.0

Boring Designation URS071000_210+00T

DRILLING LOG	DIVISION: South Pacific	INSTALLATION: Sacramento District	SHEET 1 OF 8 SHEETS
1. PROJECT: Natomas GRR 2007		9. COORDINATE SYSTEM: State Plane CA Zone 4	HORIZONTAL: NAD 83 / VERTICAL:
		10. SIZE AND TYPE OF BIT: 4 inch drag bit	
2. HOLE NUMBER: 2F-07-50	LOCATION COORDINATES: N 2,026,891.0 E 6,674,994.0	11. MANUFACTURER'S DESIGNATION OF DRILL: Truck Mounted CME 75	
3. DRILLING AGENCY: Taber Consultants		12. TOTAL SAMPLES	DISTURBED / UNDISTURBED
4. NAME OF DRILLER: Dan Davis		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED	DEG FROM VERTICAL: ---	BEARING:	14. ELEVATION GROUND WATER
		15. DATE BORING: STARTED 4/3/07	COMPLETED 4/4/07
6. THICKNESS OF OVERBURDEN		16. ELEVATION TOP OF BORING: 25.3	
7. DEPTH DRILLED INTO ROCK		17. TOTAL CORE RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 121.5		18. SIGNATURE AND TITLE OF INSPECTOR: M. Hogaboom	

ELEV	DEPTH	Blows/0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Topsoil.										Began boring at 8:30AM (4/3/07)
23.3	2.0					Lean clay with sand (CL); moist; dark grayish brown (10YR 4/2); 80% medium plasticity, high dry strength, slow dilatancy, medium toughness fines; 20% sand; micaceous; orangish brown mottling throughout.										
		0 0 3	3				100	S1				35	13	31		S01A_005_007S
16.3	9.0					Sandy silt (ML); moist; dark grayish brown (10YR 4/2); 65% nonplastic, low dry strength, slow dilatancy, no toughness fines; 35% fine sand; becomes wet @ 11.5 ft bgs micaceous.										
		1 2 3	5				87	S2	0	34	66					S02A_010_012S
14.1	11.3					Sandy silt (ML); wet; dark grayish brown (10YR 4/2); 55% nonplastic, low dry strength, slow dilatancy, no toughness fines; 45% sand.										

0.0 2.5 5.0 7.5 10.0 12.5

Boring Designation URS071000_210+00T

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 2 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,891.0 E 6,674,994.0

ELEVATION TOP OF BORING: 25.3

ELEV	DEPTH	Blows/0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
10.3	15.0															
		2														No recovery at 15'-16.5'
		2	6				0									
		4														
		2														No recovery on Cal. Mod. sample attempt at 16.5'-18'
		3	6*				0									
		3														
		1														No recovery at 20'-21.5'
		2	4				0									
3.8	21.5	2														
		3				Sandy lean clay (CL); moist; very dark greenish gray (10Y 3/1); 55% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; 45% sand; micaceous.											S03A_022_023M contains sand catcher
		4	8***				100	S3				28	11	36		
		4														
		3														No recovery at 25'-26.5'
		3	7				0									
-1.2	26.5	4														
		3				Sandy silt (ML); moist; very dark greenish gray (10Y 3/1); 55% nonplastic, low dry strength, slow dilatancy, no toughness fines; 45% sand; micaceous.											S04A_027_028M contains sand catcher and no sleeves
		4					87	M4								
		5	9*													
-3.7	29.0															
						Silty sand (SM); moist; very dark greenish gray (10Y 3/1); 70% fine to coarse sand; 30% fines; medium dense; micaceous.											
		3														S05A_030_032S
-5.5	30.8	5					87	S5								

15.0 17.5 20.0 22.5 25.0 27.5 30.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00T SHEET 2 of 8

Boring Designation URS071000_210+00T

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 3 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,891.0 E 6,674,994.0

ELEVATION TOP OF BORING: 25.3

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		8	13			Silty sand (SM); moist; very dark greenish gray (10Y 3/1); 75% fine to medium sand; 25% fines; medium dense; angular to subrounded; micaceous. *(continued)*										
-8.7	34.0					Poorly graded sand with silt (SP-SM); moist; very dark greenish gray (10Y 3/1); 90% fine to medium sand; 10% fines; medium dense; trace fine gravel; micaceous.										
		4														S06A_035_037S
		8	18				100	S6	0	94	6					
		10														
-14.2	39.5					Well graded sand with silt and gravel (SW-SM); moist; brown (10YR 4/3); 70% fine to coarse sand; 20% gravel; 10% fines; dense; angular to subrounded; gravel to 0.7-inch, subangular to subrounded; micaceous.										S07A_040_042S
-15.2	40.5	46					53	S7								
		20	41													
		21				Well graded sand with silt (SW-SM); moist; brown (10YR 4/3); 85% fine to medium sand; 10% fines; 5% gravel; dense; angular to subrounded; gravel to 0.7-inch, subangular to subrounded; micaceous.										
-19.2	44.5					Poorly graded sand (SP); moist; olive gray (5Y 4/2); 95% fine to coarse sand; 5% fines; dense; color change to olive gray (5Y 4/2) at 45'9".										
		12														S08A_045_047S
		15	35				73	S8	2	94	5				SP	
		20														

32.5 35.0 37.5 40.0 42.5 45.0 47.5

Boring Designation URS071000_210+00T

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 4 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,891.0 E 6,674,994.0

ELEVATION TOP OF BORING: 25.3

ELEV	DEPTH	Blows/0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Poorly graded sand (SP); moist; olive gray (5Y 4/2); 95% fine to coarse sand; 5% fines; dense; color change to olive gray (5Y 4/2) at 45'9". *(continued)*											
-24.7	50.0															
		6 6 9	15			Poorly graded sand (SP); moist; greenish black (10Y 2.5/1); 95% fine to medium sand; 5% fines; medium dense; trace fine gravel; micaceous.	67	S9	0	95	5				SP	S09A_050_052S
-28.7	54.0															
		8 8 11	19			Silty sand (SM); moist; greenish black (10Y 2.5/1); 85% sand; 15% fines; medium dense; micaceous.	40	S10								S10A_055_057S
-33.7	59.0															
		5 5 10	15			Poorly graded sand (SP); moist; (N 4/) dark gray; 90% sand; 5% fines; medium dense; 5% organics (includes wood pieces) at ~ 60' 4" to 60' 5"; micaceous.	47	S11								S11A_060_062S
-38.7	64.0															

50.0 52.5 55.0 57.5 60.0 62.5 65.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00T

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 5 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,891.0 E 6,674,994.0

ELEVATION TOP OF BORING: 25.3

ELEV	DEPTH	Blows/0.5 ft.	N_c	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		8 12 12	24			Well graded sand (SW); moist; very dark greenish gray (10Y 3/1); 95% fine to coarse sand; 5% fine to coarse, subangular to subrounded gravel up to 0.9 inches; medium dense. *(continued)*	53	S12								S12A_065_067S
-43.7	69.0															
		8 11 11	22			Well graded sand with silt and gravel (SW-SM); moist; very dark greenish gray (10Y 3/1); 65% fine to coarse, angular to subrounded sand; 25% fine to coarse, angular to subrounded gravel up to 1.3 inches; 10% fines; medium dense.	33	S13								S13A_070_072S
-48.7	74.0															
		6 13 16	29			Poorly graded sand with silt (SP-SM); moist; dark greenish gray (10Y 4/1); 85% fine to medium sand; 10% fines; 5% fine to coarse, subangular to subrounded gravel up to 0.8 inches; medium dense.	20	S14								S14A_075_077S
																Rig chatter
		8 13 22	35*				0									No recovery at 80'-81.5' due to gravel in sampler shoe; driller already drilled to next sampling interval

65.0 67.5 70.0 72.5 75.0 77.5 80.0

Boring Designation URS071000_210+00T

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 6 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,891.0 E 6,674,994.0

ELEVATION TOP OF BORING: 25.3

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Poorly graded sand with silt (SP-SM); moist; dark greenish gray (10Y 4/1); 85% fine to medium sand; 10% fines; 5% fine to coarse, subangular to subrounded gravel up to 0.8 inches; medium dense. *(continued)*										
-58.7	84.0					Poorly graded sand with gravel (SP); moist; greenish black (10Y 2.5/1); 55% fine to coarse, angular to subrounded sand; 40% fine to coarse, angular to subrounded gravel up to 1.3 inches; 5% fines; dense.										
		11 15 17	32***				40	S15	41	54	4				SP	S15A_085_087S
-62.7	88.0															
		10 13 16	31*				0									No recovery at 90'-91.5'
-66.2	91.5					Silty sand with gravel (SM); moist; (10Y 4/2); 65% fine to coarse, angular to rounded sand; 20% fines; 15% fine to coarse, subangular to subrounded gravel up to 1.3 inches.	20	S16								S16A_092_093S contains sand catcher
		5 12 14	26***													
-69.7	95.0					Silty sand (SM); moist; (10Y 4/2); 80% fine to medium sand; 20% fines; medium dense; trace coarse, angular to rounded sand; trace fine to coarse, angular to rounded gravel up to 1.1 inches.	13	S17								S17A_095_097S
		12 12 12	24													

62.5 85.0 87.5 90.0 92.5 95.0 97.5

Boring Designation URS071000_210+00T

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 7 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,891.0 E 6,674,994.0

ELEVATION TOP OF BORING: 25.3

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		23				Silty sand (SM); moist; (10Y 4/2); 80% fine to medium sand; 20% fines; medium dense; trace coarse, angular to rounded sand; trace fine to coarse, angular to rounded gravel up to 1.1 inches. *(continued)*											
		19	36"				0									No recovery at 100'-101.5'
-76.2	101.5	17														
		35				Poorly graded sand with silt and gravel (SP-SM); moist; (10Y 4/2); 50% fine to coarse, angular to subrounded sand; 40% fine to coarse, angular to rounded gravel up to 1.4 inches; 10% fines.											S18A_102_104S contains sand catcher
		24	35***				60	S18	39	53	8					
		11														
-79.7	105.0															
		12				Poorly graded sand with silt and gravel (SP-SM); moist; (10Y 4/2); 50% fine to coarse, angular to subrounded sand; 40% fine to coarse, angular to rounded gravel up to 1.4 inches; 10% fines; dense.											S19A_105_107S
		21	44				47	S19								
		23														
-84.7	110.0															
		12				Sandy lean clay (CL); moist; very dark greenish gray (10Y 3/1); 60% medium plasticity, high dry strength, no dilatancy, medium toughness fines; 40% sand; very hard; gravels to 1.5-inches in first two inches in sample interval.											S20A_110_112S
-85.5	110.8	13	30				93	S20								
		17				Silty sand (SM); moist; black (5Y 2.5/1); 75% fine to medium sand; 25% fines; dense; micaceous.											
		16														No Recovery with Cal. Mod. at 115'-116.5'
		20					0									

400.0
402.5
405.0
407.5
410.0
412.5
415.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_210+00T SHEET 7 of 8

Boring Designation URS071000_210+00T

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District | SHEET 8 OF 8 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES: N 2,026,891.0 E 6,674,994.0

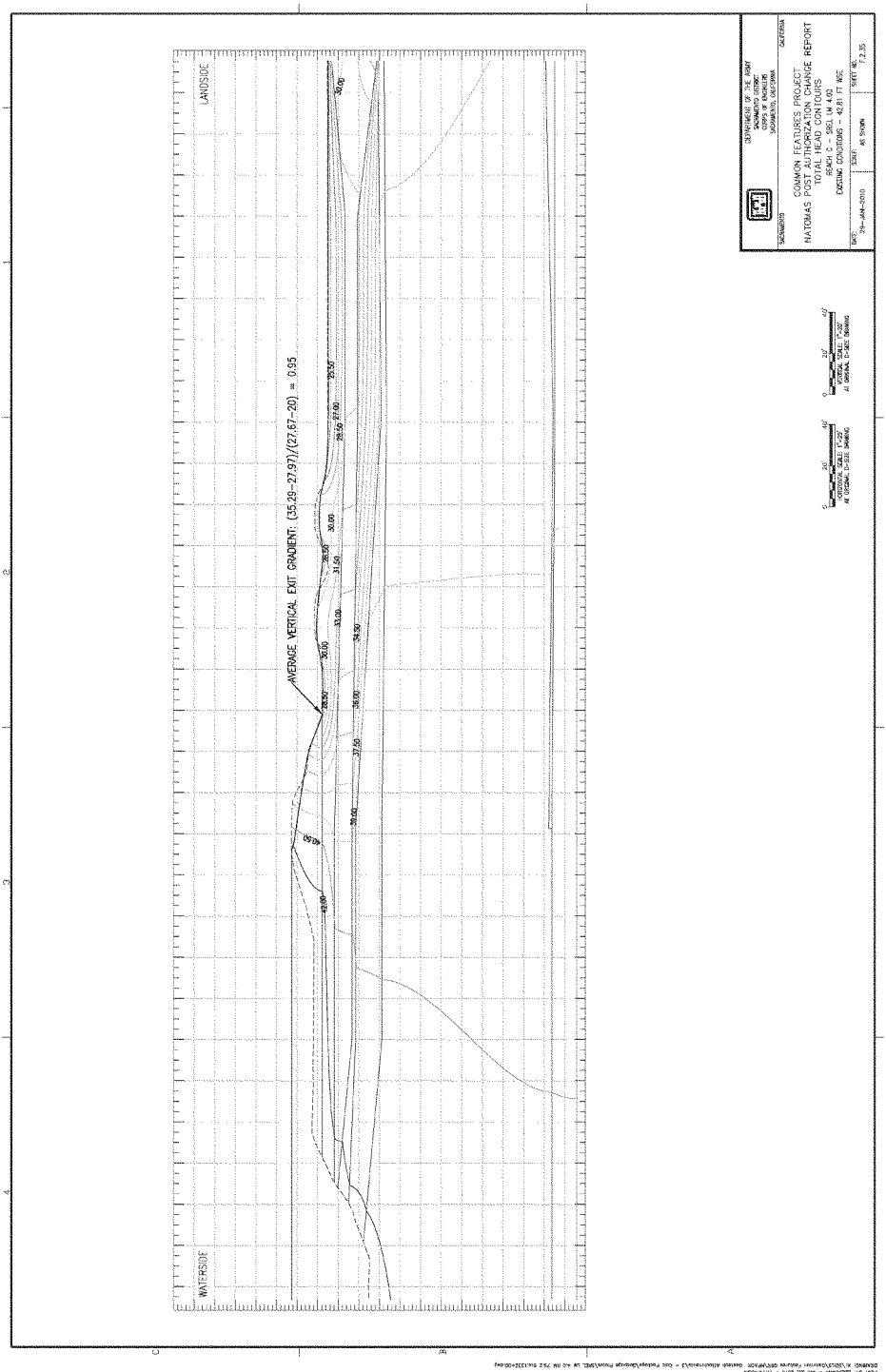
ELEVATION TOP OF BORING: 25.3

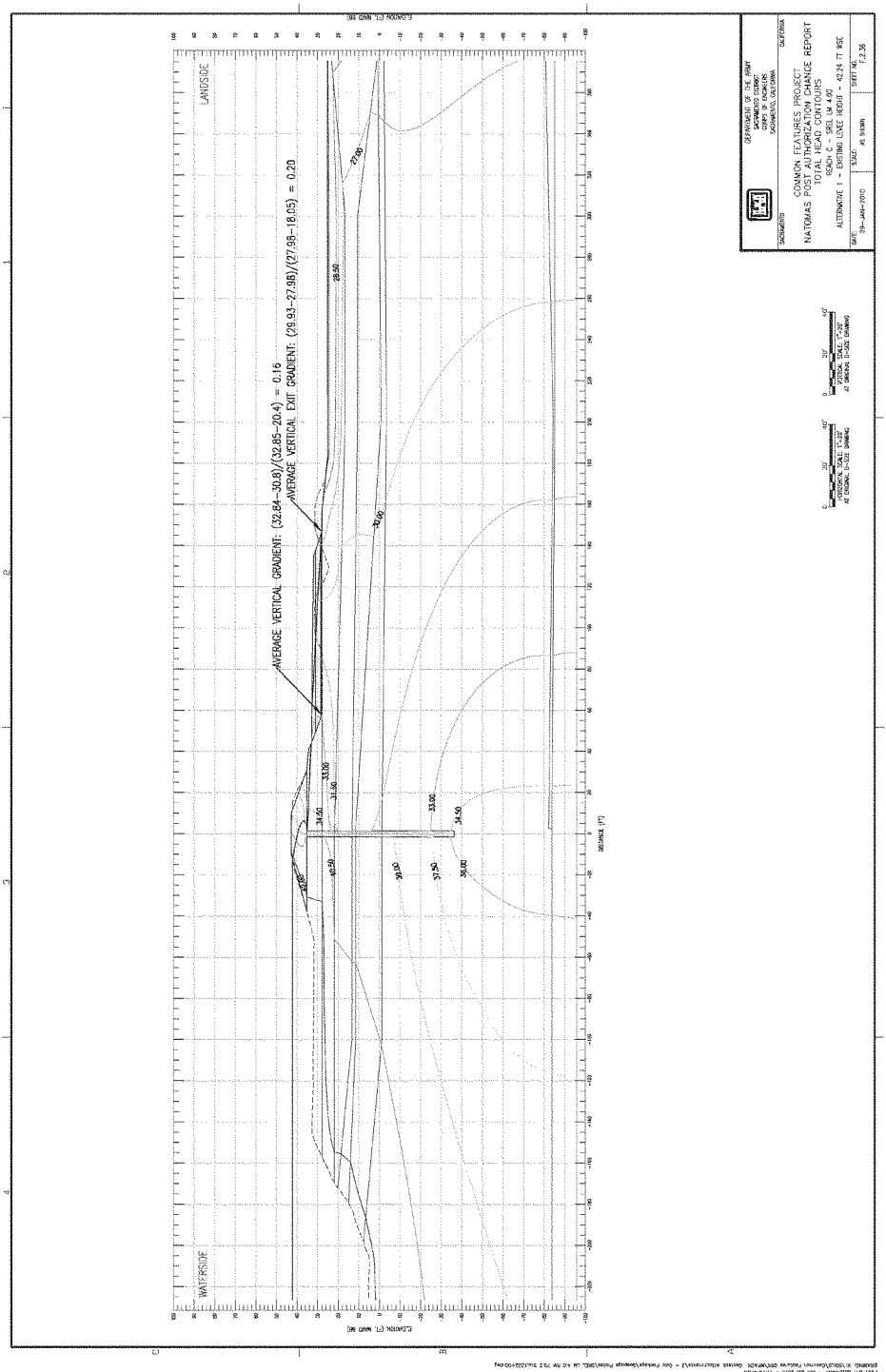
ELEV	DEPTH	Blows/0.5 ft	N_i	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
-91.2	116.5	26	46													
		10				Well graded sand with silt (SW-SM); moist; greenish gray (10G 5/1); 90% fine to coarse, angular to subrounded sand; 10% fines; dense; trace fine to coarse, subangular to subrounded gravel up to 1.2 inches.	100	S21								S21A_117_119S contains sand catcher
		12	33*													
		15														
-94.7	120.0	7				Well graded sand with silt (SW-SM); moist; dark greenish gray (5BG 4/1); 90% fine to coarse, angular to subrounded sand; 10% fines; medium dense.	100	S22								S22A_120_122S
		7	14													
-95.7	121.0	7														
-96.2	121.5					Poorly graded sand with silt (SP-SM); moist; dark greenish gray (5BG 4/1); 90% sand; 10% fines; medium dense.										Terminated boring at 2:45PM (4/4/07) at 121.5 feet

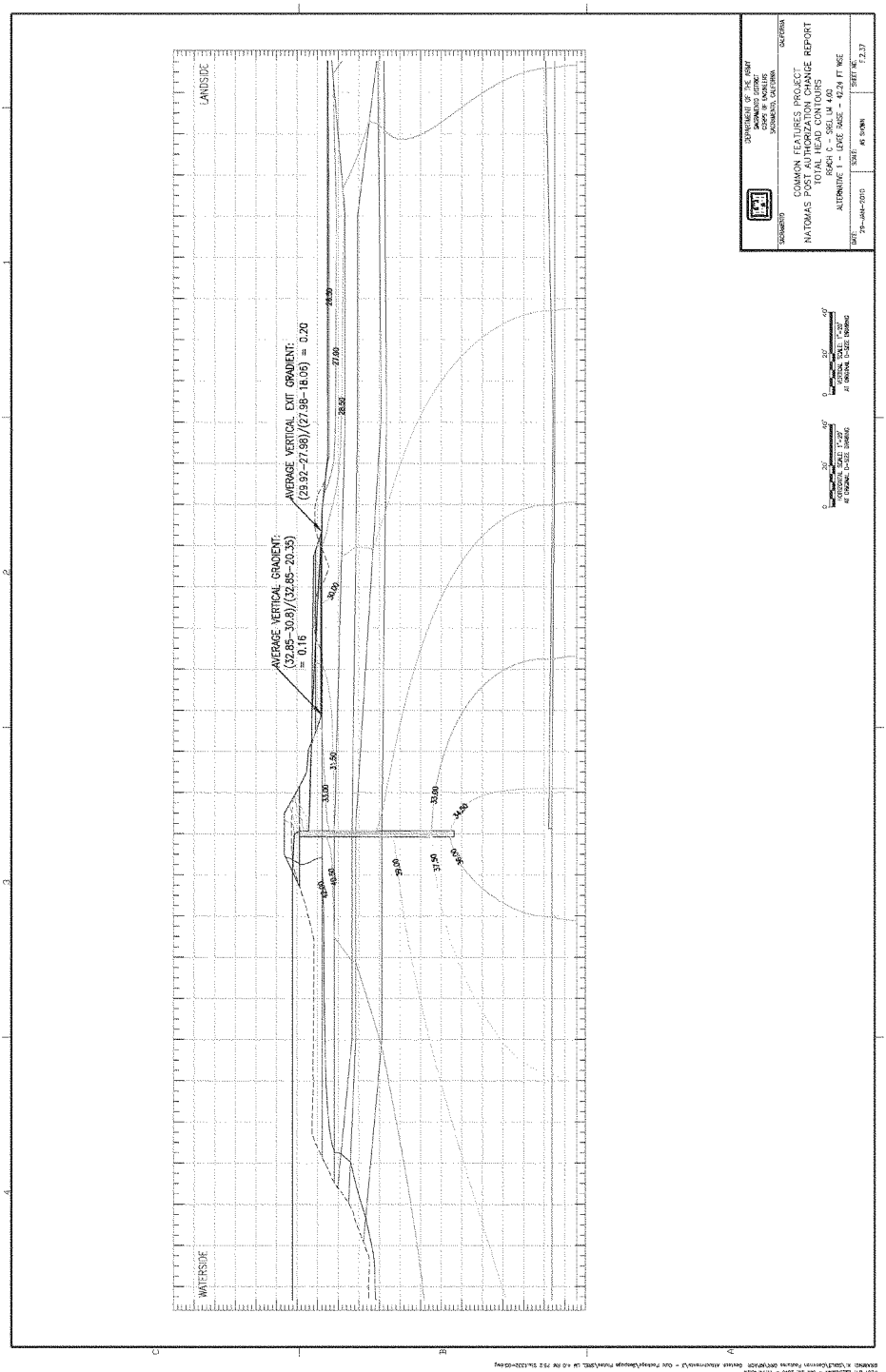
117.5

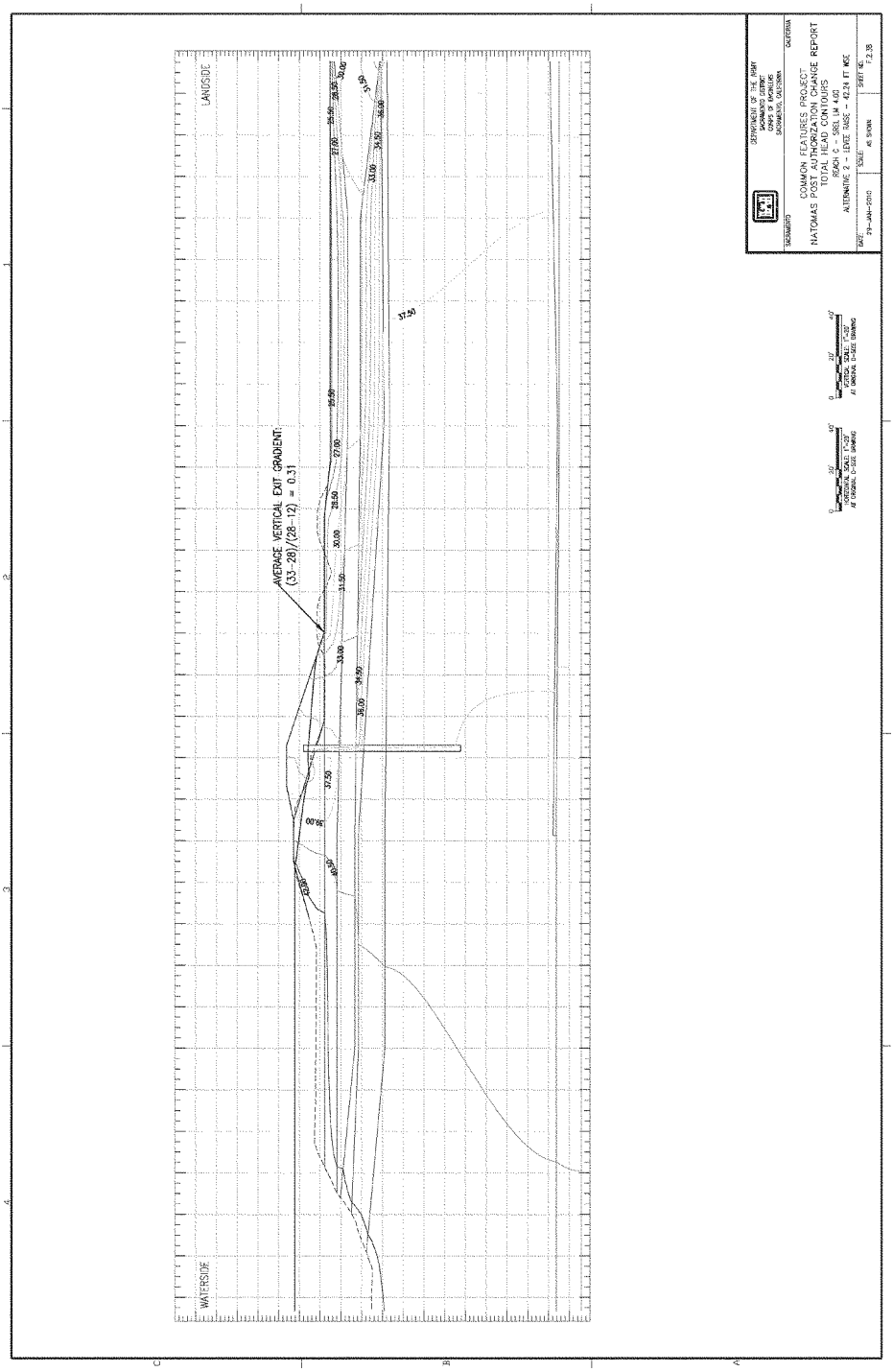
120.0

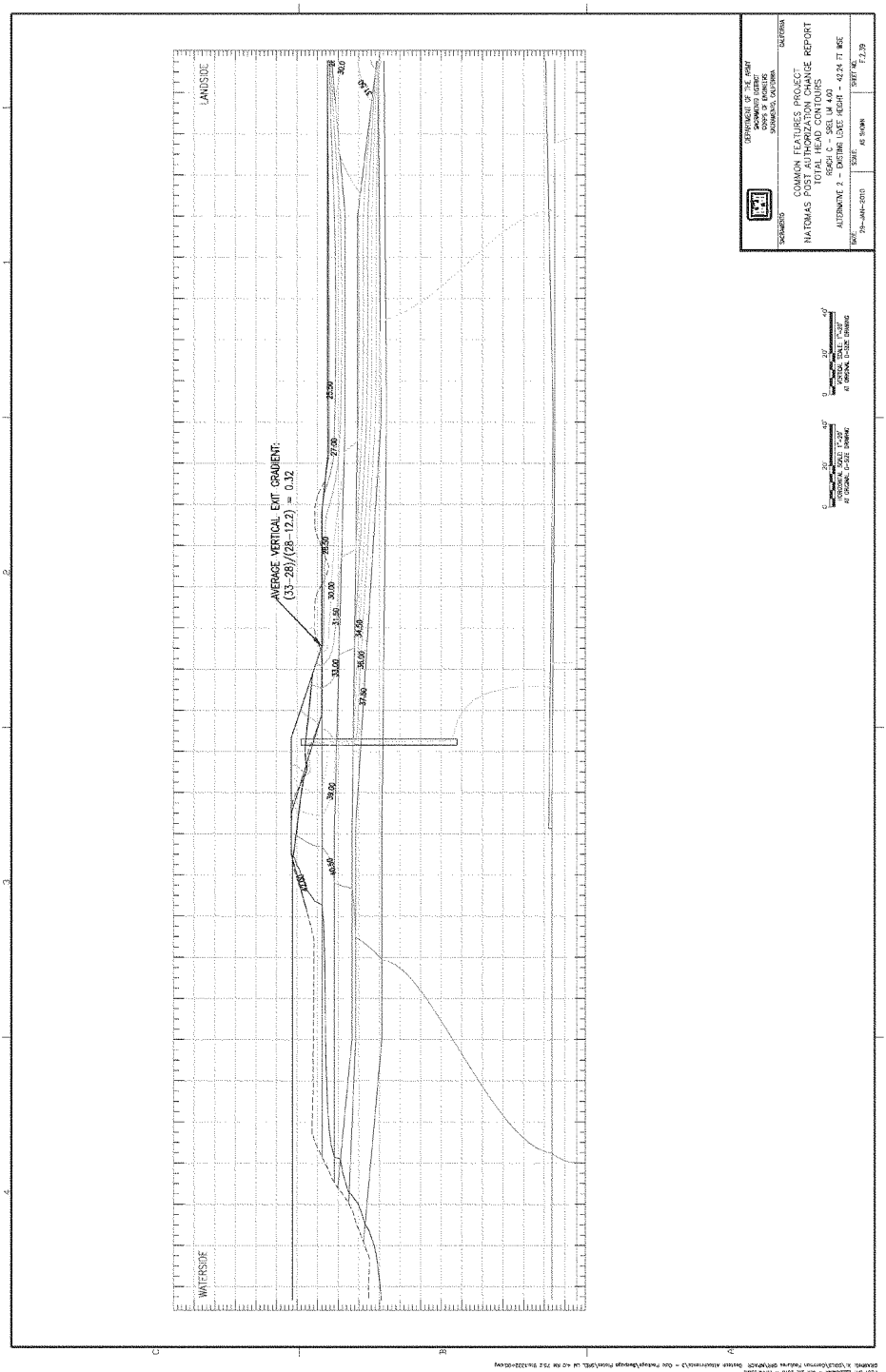
SPK FORM 1836-A
SEP 05

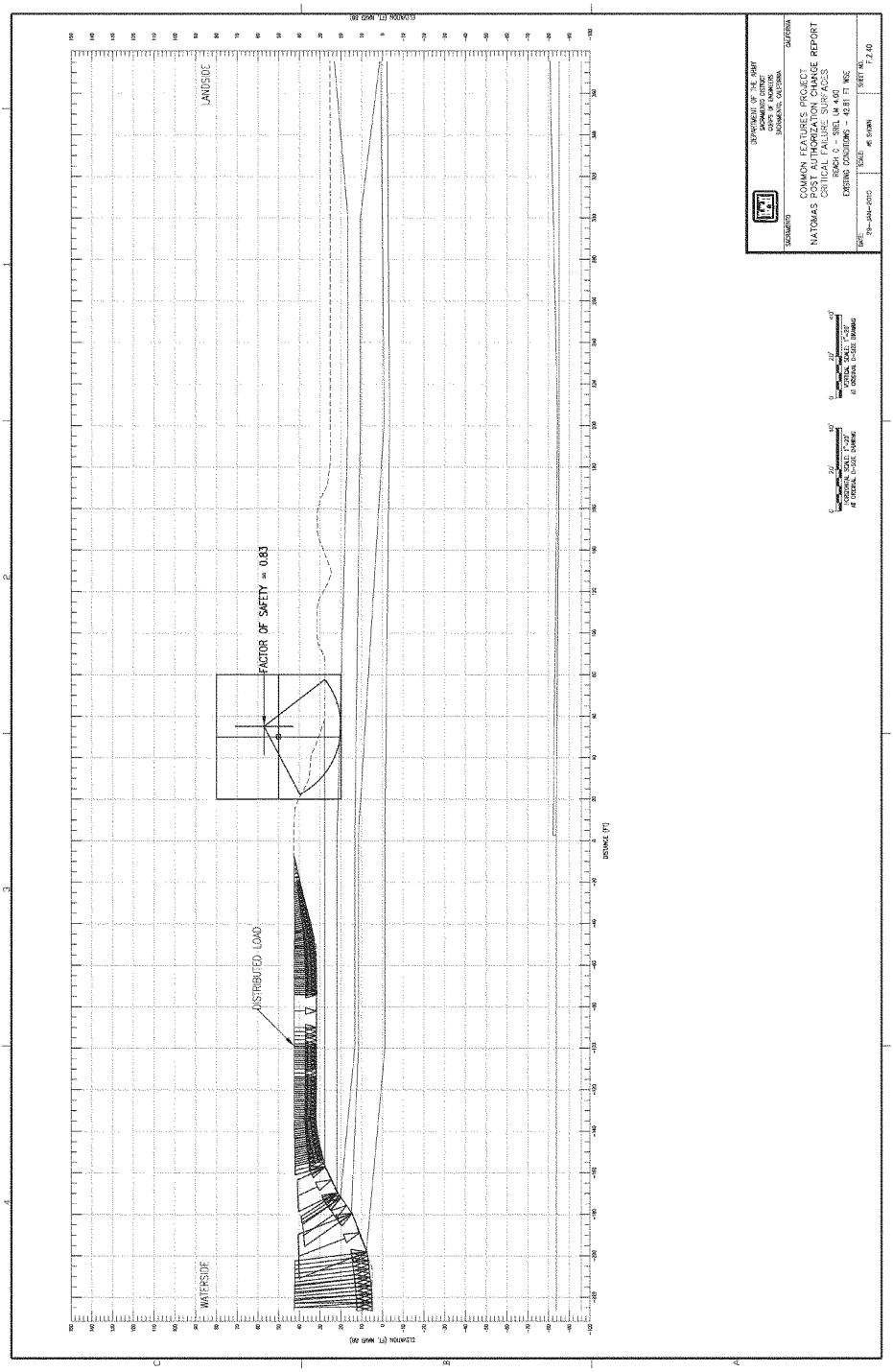

AVERAGE VERTICAL EXIT GRADIENT: (35.29-27.97)/(27.67-20) = 0.95
WATERSIDE
LANDSIDE
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C, STA 14+00
EXISTING CONDITIONS - 42.81 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.35

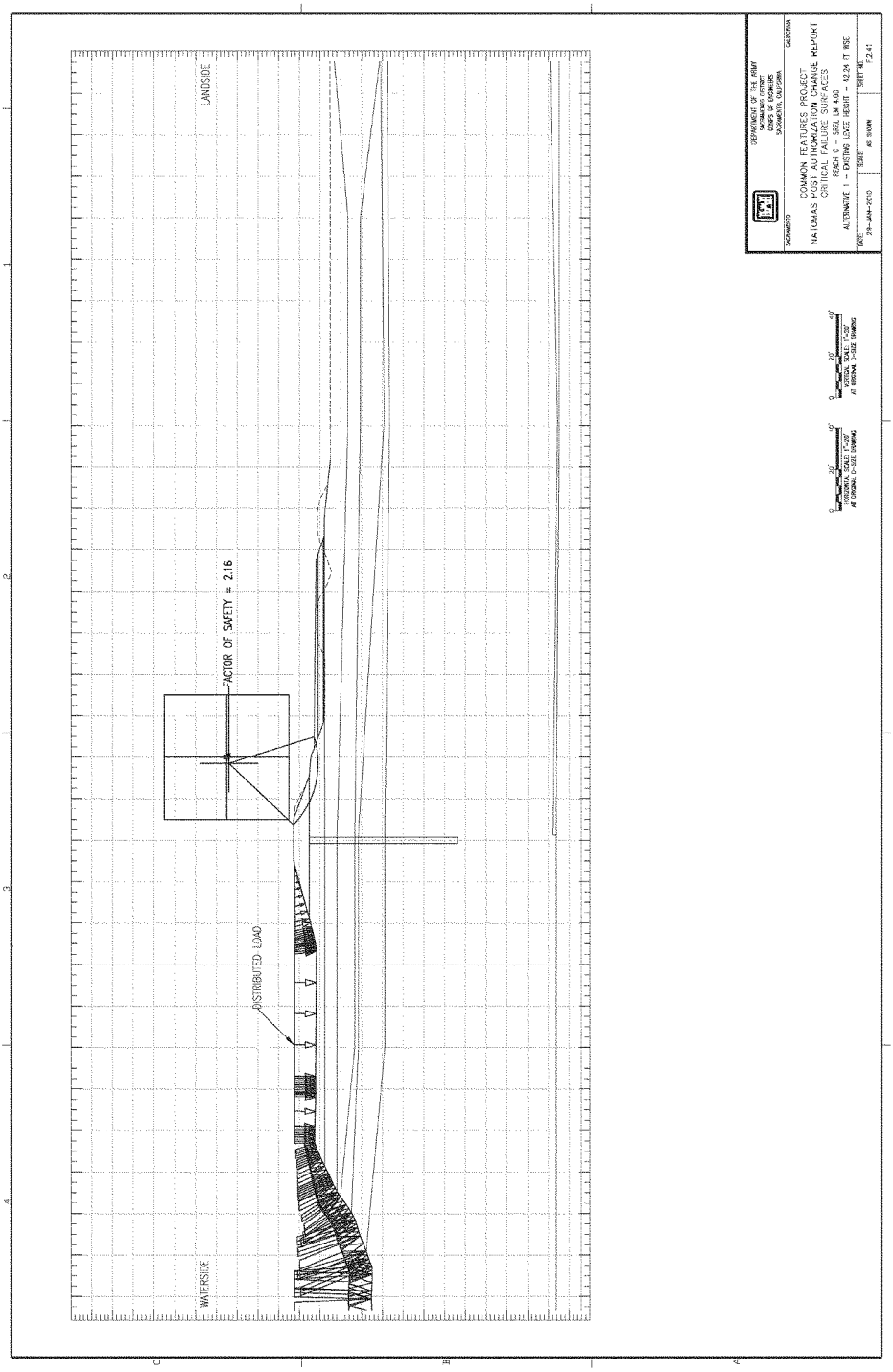

AVERAGE VERTICAL GRADIENT: (32.64-30.8)/(32.85-20.4) = 0.16
AVERAGE VERTICAL EXIT GRADIENT: (29.93-27.98)/(27.98-18.05) = 0.20
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
SECTION C - STEEL SHEET PILE
ALTERNATIVE 1 - EXISTING LEVEE REPAIR + 42.24 FT RISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.55

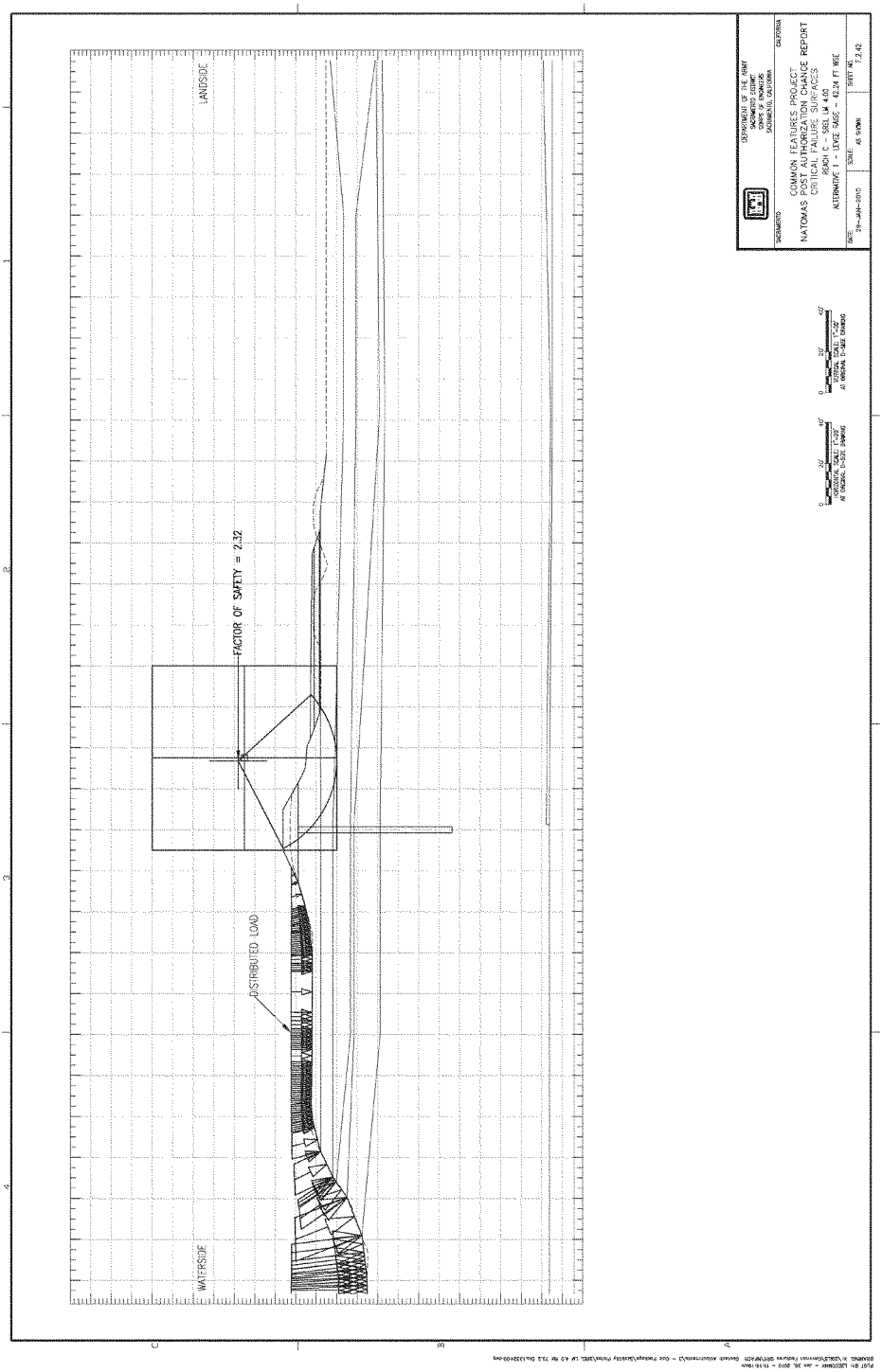

WATERSIDE
LANDSIDE
AVERAGE VERTICAL GRADIENT:
(32.85-30.8)/(32.85-20.35)
= 0.16
AVERAGE VERTICAL EXIT GRADIENT:
(29.92-27.98)/(27.98-18.05) = 0.20
40
20
0
20
0
40
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C, SHEET 4 OF 4
ALTERNATIVE 1 - LEVEE RAISE = 42.24 FT MSL
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.37

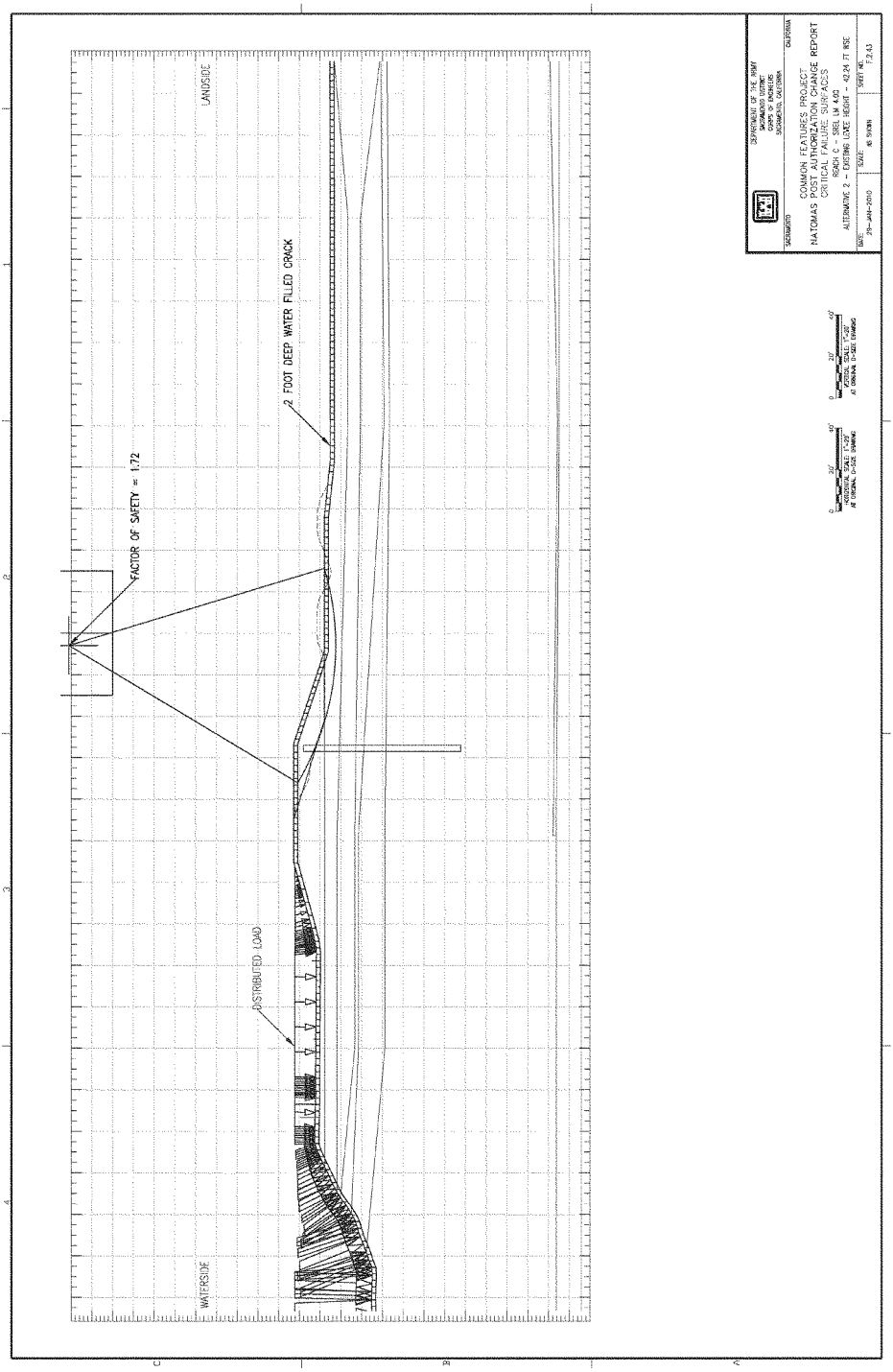

LANDSIDE
WATERSIDE
AVERAGE VERTICAL EXIT GRADIENT:
(33 - 28)/(28 - 12) = 0.31
37.50
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
TOTAL HEAD CONTOURS
REACH C - SOIL M-65
ALTERNATIVE 2 - LEVEE RAISE - 42.24 FT MSL
DATE
29-JAN-2010
SCALE
AS SHOWN
SHEET NO.
F2.28

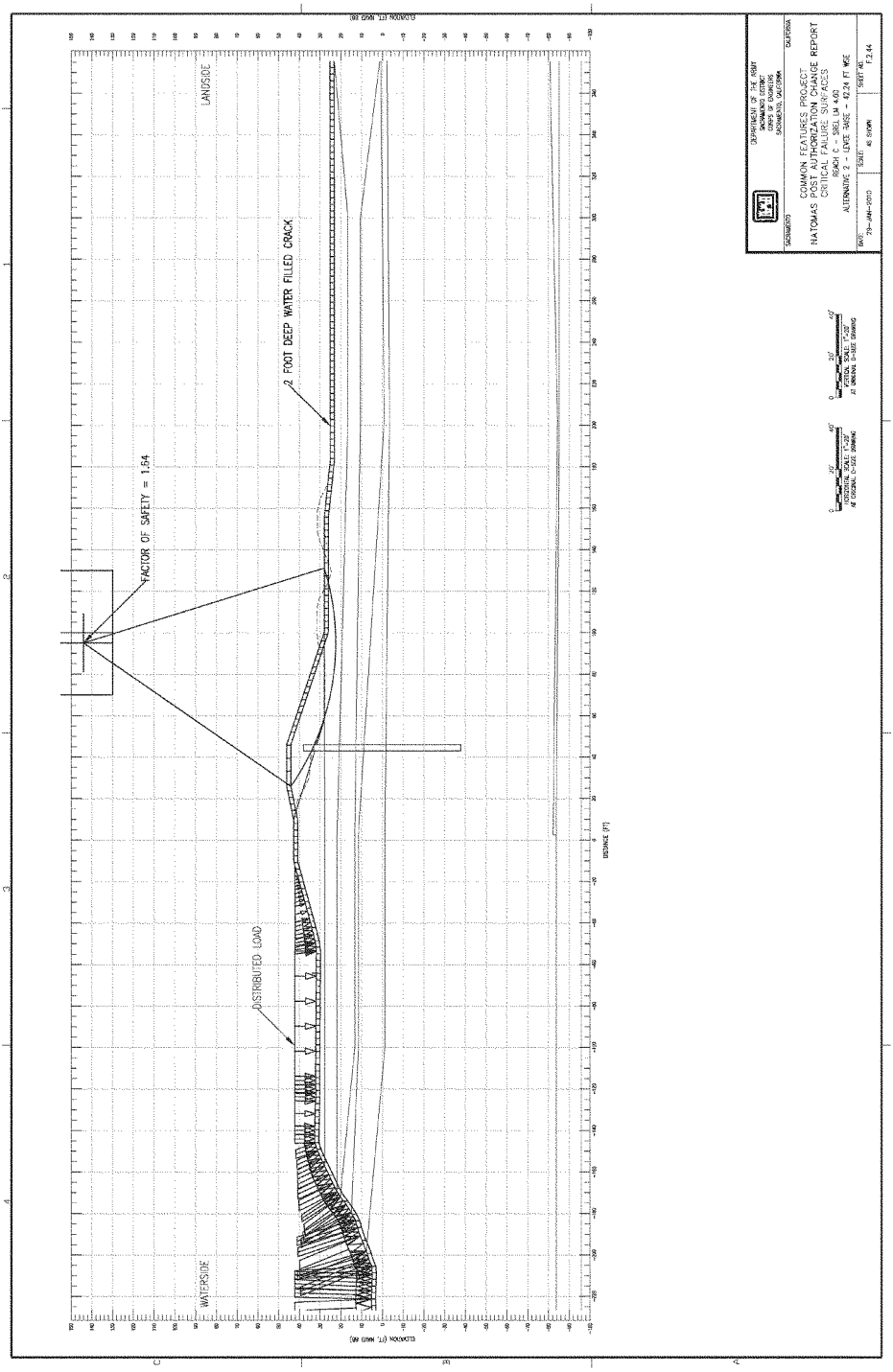

LANDSIDE
WATERSIDE
AVERAGE VERTICAL EXIT GRADIENT:
(33-28)/(28-12.2) = 0.32
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C, STA 14+00
ALTERNATIVE 2 - EXISTING LEVEE HEIGHT + 42.24 FT WSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F2.39

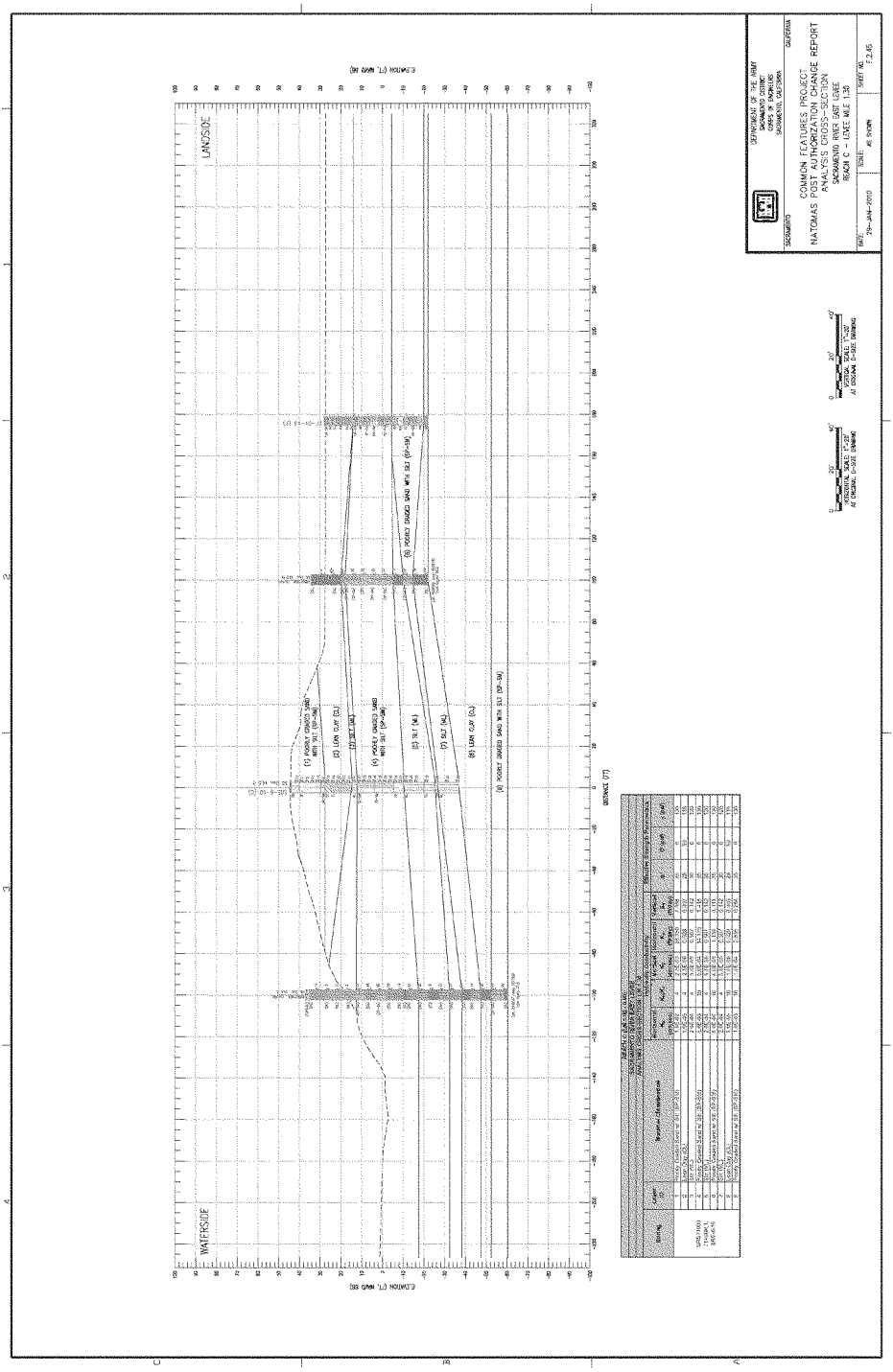

ELEVATION (FT, NAVD 88)
LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 0.83
DISTRIBUTED LOAD
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, SAC 44.65
42.81 FT WSE
EXISTING CONDITIONS
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.40

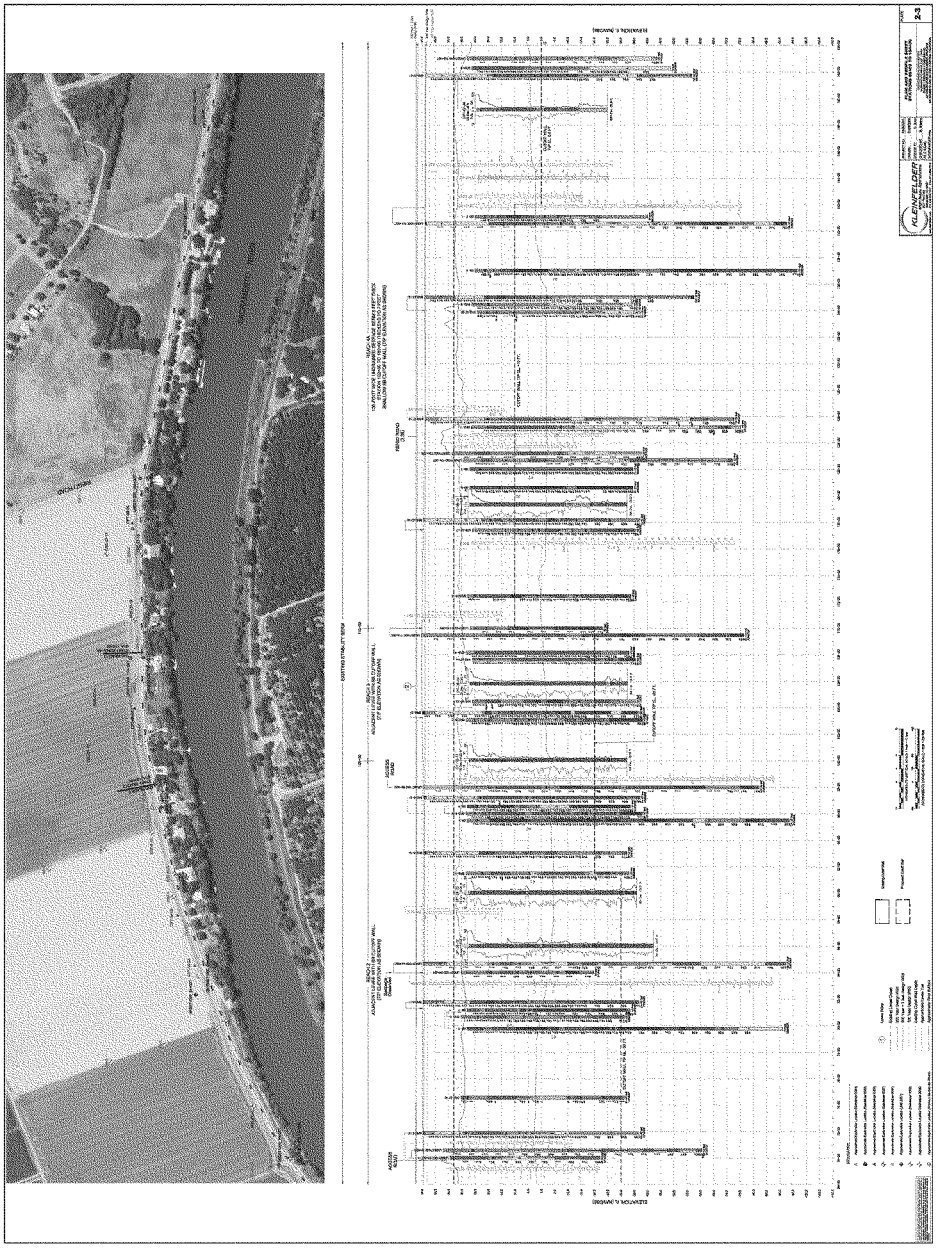

LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 2.16
DISTRIBUTED LOAD
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, SEMI 4 OF 5
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT - 42.24 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.41


LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 2.32
DISTRIBUTED LOAD
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH 1, SCHEME 1A-65
ALTERNATIVE 1 - LEVEE GAGE - 42.24 FT MSE
DATE:
28-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
7.2.42


LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 1.72
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, SEM 46
ALTERNATIVE 2 - EXISTING LEVEE HEIGHT + 42.24 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.63


2 FOOT DEEP WATER FILLED CRACK
FACTOR OF SAFETY = 1.54
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, STA 1+40
ALTERNATIVE 2 - LEVEE RAISE - 42.24 FT MSE
DATE:
29-JAN-2013
SCALE:
AS SHOWN
SHEET NO.
F.2.44


WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
(1) POORLY GRADED SAND WITH SILT (SP-SM)
(2) LEAN CLAY (CL)
(3) SILT (ML)
(4) CLAY (CH)
(5) POORLY GRADED SAND WITH SILT (SP-SM)
(6) LEAN CLAY (CL)
(7) POORLY GRADED SAND WITH SILT (SP-SM)
(8) POORLY GRADED SAND WITH SILT (SP-SM)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
SACRAMENTO RIVER EAST LEVEE
REACH C - LEVEE MILE 1.30
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F-2.45



Boring Designation URS071000_70+00R

DRILLING LOG	DIVISION: South Pacific	INSTALLATION: Sacramento District	SHEET 1 OF 6 SHEETS
1. PROJECT: Natomas GRR 2007		9. COORDINATE SYSTEM: State Plane CA Zone 4	HORIZONTAL: NAD 83 / VERTICAL:
		10. SIZE AND TYPE OF BIT: 3 inch tricone	
2. HOLE NUMBER / LOCATION COORDINATES		11. MANUFACTURER'S DESIGNATION OF DRILL	
3. DRILLING AGENCY: PC Exploration		12. TOTAL SAMPLES / DISTURBED / UNDISTURBED	
4. NAME OF DRILLER: Bob Wharff		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BOING: ☒ VERTICAL ☐ INCLINED / DEG FROM VERTICAL: --- / BEARING		14. DEPTH GROUND WATER	
		15. DATE BORING: STARTED 3/12/07 / COMPLETED 3/13/07	
6. THICKNESS OF OVERBURDEN		16. ELEVATION TOP OF BORING	
7. DEPTH DRILLED INTO ROCK		17. TOTAL CORE RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 96.0		18. SIGNATURE AND TITLE OF INSPECTOR	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Hand auger to 5' bgs.										
	5.0	5 8 7	15			Silty sand (SM); moist; dark yellowish brown (10YR 4/4) dark yellowish brown; 55% sand; 45% fines; poorly graded.	67	S1S								S01A_005_007S. Switch to mud rotary.
	9.5	2 3 5	8			Silty sand (SM); moist; dark yellowish brown (10YR 4/4) dark yellowish brown; 55% sand; 45% fines; poorly graded.	87	S2S								S02A_010_012S Driller said small lense of gravel encountered at 11-12.5' bgs.

0.0 2.5 5.0 7.5 10.0 12.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_70+00R Sheet 1 of 6

Boring Designation URS071000 70+00R

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District		SHEET 2 OF 6 SHEETS
PROJECT Natomas GRR 2007	COORDINATE SYSTEM State Plane CA Zone 4	HORIZONTAL NAD 83	VERTICAL
LOCATION COORDINATES	ELEVATION TOP OF BORING		

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC.	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
	14.5															
		7				Sandy silt (ML); moist; yellowish brown (10YR 5/4) yellowish brown; 70% low dry strength, rapid dilatancy, low toughness fines; 30% sand.											S03_015_017S
		7	15				40	S3S								
		8														
	19.5															
		3				Silty sand (SM); moist; yellowish brown (10YR 5/4) yellowish brown; 60% sand; 40% fines; poorly graded.											S04S_020_022S
		4	9				93	S4S								
		5														
	24.5															
		9				Silty sand (SM); moist; olive gray (5Y 4/2) olive gray; 85% sand; 15% fines; poorly graded.											S05A_025_027S
		7	13				60	S5S								
		6														
	29.5															
		5				Silty sand with gravel (SM); moist; dark olive gray (5Y 3/2) dark olive gray; 65% sand; 20% fines; 15% gravel; well graded.											S06_030_032S
		13					73	S6S								

15.0 17.5 20.0 22.5 25.0 27.5 30.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_70+00R Sheet 2 of 6

Boring Designation URS071000 70+00R

DRILLING LOG (Cont Sheet)	INSTALLATION Sacramento District	SHEET 3 OF 6 SHEETS
PROJECT Natomas GRR 2007	COORDINATE SYSTEM State Plane CA Zone 4 / HORIZONTAL NAD 83 / VERTICAL	
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC.	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		15	28			Silty sand with gravel (SM); moist; dark olive gray (5Y 3/2) dark olive gray; 65% sand; 20% fines; 15% gravel; well graded. *(continued)*										
	34.5															
		9				Silty sand (SM); moist; dark olive gray (5Y 3/2) dark olive gray; 80% sand; 20% fines; poorly graded.										S07A_035_037S
		12	28				67	S7S								
		16														
	39.5															
		10				Silty sand (SM); moist; dark olive gray (5Y 3/2) dark olive gray; 60% sand; 30% fines; 10% gravel; poorly graded.										S08A_040_042S
		13	29				53	S8S								
		16														
	44.5															
		9				Silty sand (SM); moist; dark grayish brown (2.5Y 4/2) dark grayish brown; 55% sand; 45% fines; poorly graded.										S09A_045_047S
		5	13				80	S9S								
		8														
	47.0															
						Clay, no sample collected..										Driller said we hit clay at 47' bgs when bit was at 50' bgs,.

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_70+00R SHEET 3 of 6

Boring Designation URS071000_70+00R

DRILLING LOG (Cont Sheet)	INSTALLATION: Sacramento District	SHEET 4 OF 6 SHEETS
PROJECT: Natomas GRR 2007	COORDINATE SYSTEM: State Plane CA Zone 4	HORIZONTAL: NAD 83 / VERTICAL
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC.	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Clay, no sample collected.. *(continued)*										
	49.0															
		8 17 17	34			Silty sand (SM); moist; olive brown (2.5Y 4/3) olive brown; 70% sand; 30% fines; poorly graded.	53	S10S								S10A_050_052S
	54.5															
		7 9 11	20			Elastic silt (MH); moist; olive (5Y 5/3) olive grades to greenish gray (5G 5/1) greenish gray; 90% low dry strength, slow dilatancy, medium toughness fines; 10% sand.	67	S11S								S11A_055_057S
	59.5															
		3 3 5	8			Elastic silt (MH); moist; olive (5Y 4/3) olive; 90% low dry strength, slow dilatancy, low toughness fines; 10% sand.	100	S12S								S12A_060_062S
	64.5															

50.0 52.5 55.0 57.5 60.0 62.5 65.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_70+00R Sheet 4 of 6

Boring Designation URS071000_70+00R

DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 5
	Sacramento District	OF 6 SHEETS
PROJECT	COORDINATE SYSTEM	HORIZONTAL / VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC.	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		9 10 11	21			Elastic silt (MH); moist; greenish gray (5G 5/1) greenish gray; 90% low dry strength, no dilatancy, low toughness fines; 10% sand. *(continued)*	47	S13S								S13A_065_067S. End on 3/12/07 at 65' bgs. Resume on 3/13/07.
	69.5					Silty sand (SM); wet; very dark greenish gray (10Y 3/1) very dark greenish gray; 80% sand; 20% fines; poorly graded.										
		7 9 12	21				73	S14S								S14A_070_072S
	75.5	9														S15A_075_077S
		9 15	24			Lean clay (CL); moist; dark greenish gray (5G 4/1) dark greenish gray; 90% medium dry strength, slow dilatancy, medium toughness fines; 10% sand.	87	S15S								
	79.5					Sandy elastic silt (MH); moist; dark greenish gray (5G 4/1) dark greenish gray; 70% low dry strength, slow dilatancy, low toughness fines; 30% sand.										
		7 6 8	14				83	S16S_080_082S								S16A_080_082S

65.0
67.5
70.0
72.5
75.0
77.5
80.0

Boring Designation URS071000 70+00R

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District		SHEET 6 OF 6 SHEETS
PROJECT: Natomas GRR 2007	COORDINATE SYSTEM: State Plane CA Zone 4 / HORIZONTAL: NAD 83 / VERTICAL	
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC.	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Sandy elastic silt (MH); moist; dark greenish gray (5G 4/1) dark greenish gray; 70% low dry strength, slow dilatancy, low toughness fines; 30% sand. *(continued)*											
	84.5															
		11				Sandy lean clay (CL); moist; dark greenish gray (10GY 4/1) dark greenish gray; 60% medium dry strength, no dilatancy, medium toughness fines; 40% sand.											S17S_085_087S
		16	44				100	S17S								
		28														
	89.5															
		11				Poorly graded sand with silt (SP-SM); moist; dark greenish gray (10GY 4/1) dark greenish gray; 90% sand; 10% fines.											S18A_090_092S
		18	44				87	S18S								
		26														
		9														S19A_095_097S
	95.8															
	96.0	22	50			Sandy lean clay (CL); moist; greenish gray (10GY 5/1) greenish gray; 70% medium dry strength, slow dilatancy, medium toughness fines; 30% sand.	100	S19S								
		28														

82.5 85.0 87.5 90.0 92.5 95.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_70+00R 6 of 6

Boring Designation URS071000_70+00T

DRILLING LOG	DIVISION: South Pacific	INSTALLATION: Sacramento District	SHEET 1 OF 4 SHEETS
1. PROJECT: Natomas GRR 2007		9. COORDINATE SYSTEM: State Plane CA Zone 4	HORIZONTAL: NAD 83 / VERTICAL:
		10. SIZE AND TYPE OF BIT: 4 inch drag bit	
2. HOLE NUMBER / LOCATION COORDINATES		11. MANUFACTURER'S DESIGNATION OF DRILL	
3. DRILLING AGENCY: Taber Consultants		12. TOTAL SAMPLES / DISTURBED / UNDISTURBED	
4. NAME OF DRILLER: Dan Davis		13. TOTAL NUMBER CORE BOXES	
5. DIRECTION OF BOING: ☒ VERTICAL ☐ INCLINED / DEG FROM VERTICAL: --- / BEARING		14. DEPTH GROUND WATER: 15.5 4/11/07	
		15. DATE BORING: STARTED 4/11/07 / COMPLETED 4/11/07	
6. THICKNESS OF OVERBURDEN		16. ELEVATION TOP OF BORING	
7. DEPTH DRILLED INTO ROCK		17. TOTAL CORE RECOVERY FOR BORING: N/A	
8. TOTAL DEPTH OF BORING: 56.5		18. SIGNATURE AND TITLE OF INSPECTOR	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No	Laboratory: Gravel	Sand	Fines	LL	PI	M/C	ASTM Class	REMARKS
						Sandy organic soil (OL/OH); moist; very dark grayish brown (2.5Y 3/2) very dark grayish brown; 55% high dry strength, slow dilatancy, medium toughness fines; 45% sand; 0% gravel.											Began drilling at 11:30AM (4/11/07)
		3 2 2	4				67	S1A								S1A_005_007S
	10.8	6 7 12	19			Lean clay with sand (CL); moist; olive brown (2.5Y 4/4) olive brown; 85% high dry strength, slow dilatancy, medium toughness fines; 15% sand; 0% gravel.	67	M2A								S2B_010_012M S2A_010_012M

0.0 2.5 5.0 7.5 10.0 12.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_70+00T Sheet 1 of 4

Boring Designation URS071000_70+00T

DRILLING LOG (Cont Sheet)

INSTALLATION: Sacramento District

SHEET 2 OF 4 SHEETS

PROJECT: Natomas GRR 2007

COORDINATE SYSTEM: State Plane CA Zone 4 | HORIZONTAL: NAD 83 | VERTICAL:

LOCATION COORDINATES:

ELEVATION TOP OF BORING:

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC.	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
	15.0															
	16.5	7 11 15	26			Sandy silt (ML); moist; olive brown (2.5Y 4/4) olive brown; 55% low dry strength, rapid dilatancy, low toughness fines; 45% sand; 0% gravel; grades sandier with depth.	67	M3B								S3B_015_017M; S3A_015_017M; S3A-1_015_017M (taken from sampler shoe)
	20.0	7 11 15	26			Poorly graded sand with silt (SP-SM); wet; olive brown (2.5Y 4/3) olive brown; 90% sand; 10% fines; 0% gravel.	13	M3A								
	25.0	9 9 19	28			Poorly graded sand with silt (SP-SM); wet; dark olive brown (2.5Y 3/3) dark olive brown; 90% sand; 10% fines; 0% gravel; lense of poorly graded sand with silt at 21 feet.	67	S4A								S5B_020_022S (Contains SP-SM lense); S5A_020_022S
	30.0	10 12 14	26			Poorly graded sand with silt and gravel (SP-SM); wet; olive brown (2.5Y 4/3) olive brown; 70% sand; 20% gravel; 10% fines.	67	S5A								S5A_025_027S
		13 15				Poorly graded sand with silt (SP-SM); wet; olive brown (2.5Y 4/3) olive brown; 90% sand; 10% fines; 0% gravel.	47	S6A								S6A_030_032S

15.0 17.5 20.0 22.5 25.0 27.5 30.0

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_70+00T

DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 3
	Sacramento District	OF 4 SHEETS
PROJECT	COORDINATE SYSTEM	HORIZONTAL / VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC.	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		18	33			Poorly graded sand with silt (SP-SM); wet; olive brown (2.5Y 4/3) olive brown; 90% sand; 10% fines; 0% gravel. *(continued)*										
	35.0	9 10 14	24			Poorly graded sand (SP); wet; olive gray (5Y 4/2) olive gray; 95% sand; 5% fines; 0% gravel.	53	S7A								S7A_035_037S
	40.0	8 8 7	15			Lean clay (CL); moist; olive (5Y 5/4) olive; 95% high dry strength, slow dilatancy, medium toughness fines; 5% sand; 0% gravel.	47	S8A								S8A_040_042S
	45.0	23 37 37	74			Poorly graded sand with silt (SP-SM); moist; dark olive brown (2.5Y 3/3) dark olive brown; 90% sand; 10% fines; 0% gravel.	67	M9A								S9B_045_047M S9A_045_047M

-32.5 -35.0 -37.5 -40.0 -42.5 -45.0 -47.5

SPK FORM 1836-A
SEP 05

Boring Designation URS071000_70+00T Sheet 3 of 4

Boring Designation URS071000_70+00T

DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 4
	Sacramento District	OF 4 SHEETS
PROJECT	COORDINATE SYSTEM	HORIZONTAL / VERTICAL
Natomas GRR 2007	State Plane CA Zone 4	NAD 83
LOCATION COORDINATES	ELEVATION TOP OF BORING	

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC.	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						Poorly graded sand with silt (SP-SM); moist; dark olive brown (2.5Y 3/3) dark olive brown; 90% sand; 10% fines; 0% gravel. *(continued)*											
	50.0															50.0
		5 8 11	19			Lean clay with sand (CL); moist; dark greenish gray (10GY 4/1) dark greenish gray; 80% high dry strength, no dilatancy, medium toughness fines; 20% sand; 0% gravel.	53	S10A								S10A_050_052S
																52.5
	55.0															55.0
		14 19 24	43			Lean clay with sand (CL); moist; dark greenish gray (10GY 4/1) dark greenish gray; 80% high dry strength, no dilatancy, medium toughness fines; 20% sand; 0% gravel.	67	M11A								S11B_055_057M S11A_055_057M
	56.5															

Completed boring at 3:30PM (4/11/07)

Surface Conditions: Asphalt concrete
Groundwater: Groundwater not encountered during drilling.
Method: Hollow Stem Auger/Mud Rotary
Equipment: CME 75 with 140lb. Automatic Hammer

Date Completed: 7/21/2006
Logged By: C. Wilhite
Total Depth: 81-1/2 feet
Boring Diameter: 8 inch/4 inch

Approximate Elevation: 42 feet (msl)
Approximate Northing: 2040287.35 feet
Approximate Easting: 6678043.91 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/foot	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														ASPHALT CONCRETE: About 6 inches
														Silty SAND (SM): Dark brown, moist, fine to coarse sand, about 14% fines, (Levee Fill)
			1a	7										
			1b	5 6							14			
37	5													**Poorly Graded SAND With Gravel** (SP): Gray brown, moist, fine to coarse sand, about 10% fine gravel, about 1% fines (Levee Fill)
			2a	2										
			2b	4 3							1			
			3a	2										
			3b	3 5										
32	10													
			4a	5										
			4b	6 5							2			About 2% fines
			5a	5										
			5b	8 6							4			About 4% fines
27	15													**Poorly Graded SAND With Silt** (SP-SM): Brown, moist, fine to coarse sand, about 10% gravel, about 10% fines (Levee Fill)
			6a	4										
			6b	4 5							10			
			7a	4										**Clayey SAND** (SC): Dark brown, moist to wet, about 44% fines, (Levee Fill)
			7b	7 6							44			
22	20													**LEAN CLAY** (CL): Dark brown, moist to wet, firm, about 25% fine sand
			8a	0										
			8b	6 10	0.25									About 5% fine sand
			9a	8										
			9b	10 12	3.25									
17	25													Brown
			10a	7										
			10b	8 14	2.75									
			11a	4										
			11b	5 6										

P:\LOG_2006 BLOWS PER FOOT_72834\DSRN06.GPJ 9/13/07

KLEINFELDER

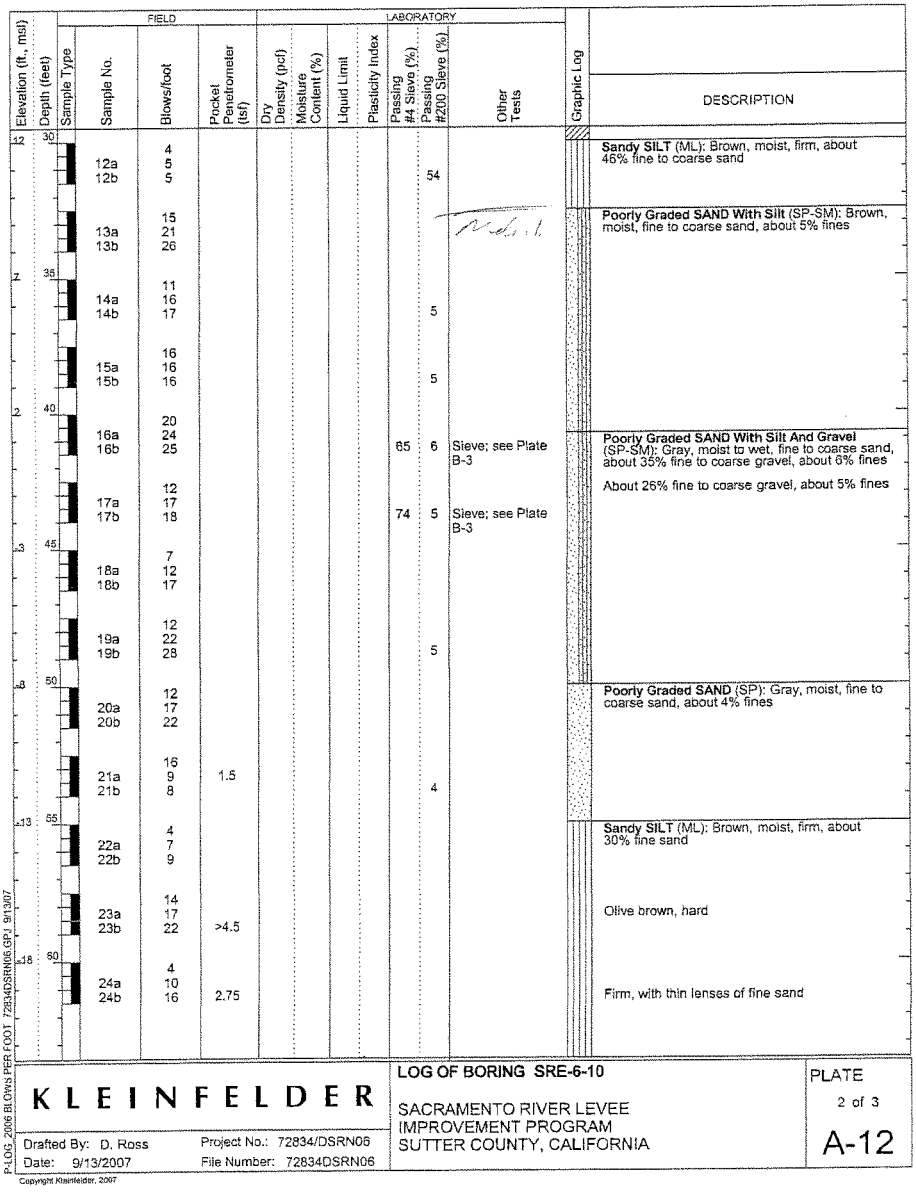
Drafted By: D. Ross
Date: 9/13/2007
Project No.: 72834/DSRN06
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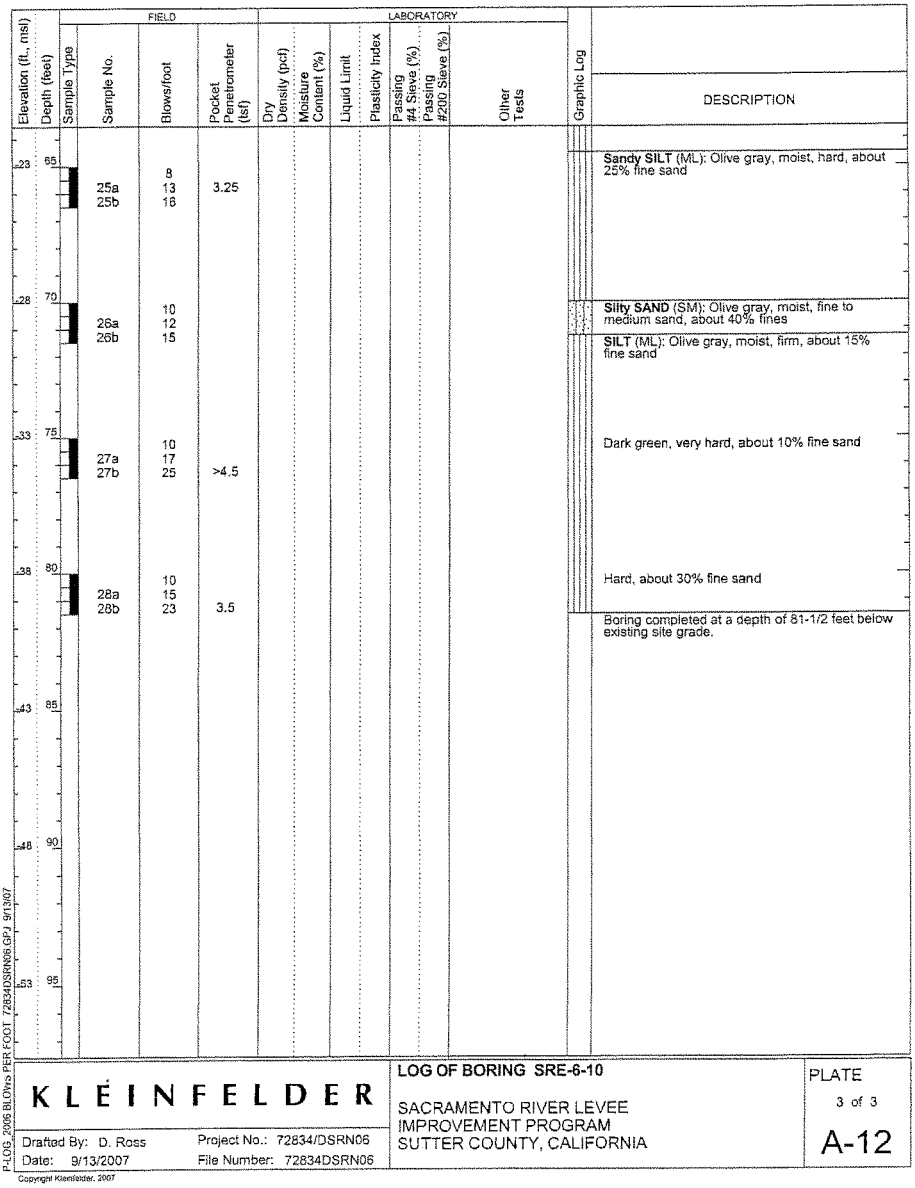
LOG OF BORING SRE-6-10

SACRAMENTO RIVER LEVEE
IMPROVEMENT PROGRAM
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 3
A-12

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FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/foot
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
12
30
12a 4
12b 5
54
15
13a 21
13b 26
Sandy SILT (ML): Brown, moist, firm, about 46% fine to coarse sand
Poorly Graded SAND With Silt (SP-SM): Brown, moist, fine to coarse sand, about 5% fines
11
14a 16
14b 17
5
16
15a 16
15b 16
5
40
20
16a 24
16b 25
65
6
Sieve; see Plate B-3
Poorly Graded SAND With Silt And Gravel (SP-SM): Gray, moist to wet, fine to coarse sand, about 35% fine to coarse gravel, about 6% fines
About 26% fine to coarse gravel, about 5% fines
12
17a 17
17b 18
74
5
Sieve; see Plate B-3
45
7
18a 12
18b 17
12
19a 22
19b 28
5
50
12
20a 17
20b 22
16
21a 9
21b 8
1.5
4
Poorly Graded SAND (SP): Gray, moist, fine to coarse sand, about 4% fines
55
4
22a 7
22b 9
Sandy SILT (ML): Brown, moist, firm, about 30% fine sand
14
23a 17
23b 22
>4.5
Olive brown, hard
60
4
24a 10
24b 16
2.75
Firm, with thin lenses of fine sand
P:\LOG_2006 BLOWS PER FOOT 72834DSRN06.GPJ 9/13/07
KLEINFELDER
Drafted By: D. Ross
Date: 9/13/2007
Project No.: 72834/DSRN06
File Number: 72834DSRN06
LOG OF BORING SRE-6-10
SACRAMENTO RIVER LEVEE IMPROVEMENT PROGRAM
SUTTER COUNTY, CALIFORNIA
PLATE
2 of 3
A-12
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FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/foot
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
23 65
25a 8
25b 13 3.25
16
28 70
26a 10
26b 12
15
Sandy SILT (ML): Olive gray, moist, hard, about 25% fine sand
Silty SAND (SM): Olive gray, moist, fine to medium sand, about 40% fines
SILT (ML): Olive gray, moist, firm, about 15% fine sand
33 75
27a 10
27b 17
25 >4.5
Dark green, very hard, about 10% fine sand
38 80
28a 10
28b 15
23 3.5
Hard, about 30% fine sand
Boring completed at a depth of 81-1/2 feet below existing site grade.
43 85
48 90
53 95
P:\LOG_2006 BLOWs PER FOOT 72834DSRN06.GPJ 9/13/07
KLEINFELDER
Drafted By: D. Ross
Date: 9/13/2007
Project No.: 72834/DSRN06
File Number: 72834DSRN06
LOG OF BORING SRE-6-10
SACRAMENTO RIVER LEVEE IMPROVEMENT PROGRAM
SUTTER COUNTY, CALIFORNIA
PLATE
3 of 3
A-12
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Project: Natomas Levee North of Powerline Road Project Location: Sutter County, California Project Number: 51971138NA.00	Log of Boring 2F-01-13 Sheet 1 of 2

Date(s) Drilled	21 September 2001	Logged By	T.C. Hoganson	Checked By	D. Simpson
Drilling Method	Rotary Wash	Drill Bit Size/Type	4-inch-OD open drag bit	Total Depth of Borehole	50.0 feet
Drill Rig Type	Mobile B-61	Drilling Contractor	Westex (M. Scott)	Surface Elevation	25.82 feet MSL
Groundwater Level(s)	16 feet bgs ATD	Sampler Type(s)	SPT, Modified California, Shelby Tube	Hammer Data	Automatic (60% efficiency), 140 lbs, 30-inch drop
Borehole Completion	Backfilled with grout to ground surface			Location	N 2,040,332 E 6,678,193

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / Foot	N_{60}	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	% Gravel	% Sand	% Fines	Liquid Limit	Plasticity Index	Moisture, %	REMARKS AND OTHER TESTS
25	0		FS1	28	26	100		SANDY SILTY CLAY, CL-ML: Very stiff; dry; dark brown (10YR 3/3); ~60% low plasticity, low toughness fines; ~40% fine sand				24	4		Set up at 0700, and begin drilling at 0800. Using hammer with 80% efficiency. Smooth, easy drilling to bottom of hole.
			FS2	8	8	100		CLAYEY SAND, SC: Loose; dry; brown (10YR 4/3); ~60% fine sand; ~40% medium plasticity, medium toughness fines							
20	5		FS3	9	9	100		SANDY LEAN CLAY, CL: Stiff; moist; dark brown (10YR 3/3); ~60% low plasticity, low toughness fines; ~40% fine sand				29	9	15	
			FS4	23	23	100		FAT CLAY, CH: Very stiff; moist; dark yellowish brown (10YR 3/4); ~60% high plasticity, high toughness fines; ~10% fine sand; trace of organics, trace of caliche; strong reaction to HCl							
			T1			100									150-300 psi down pressure in first 6 in.; 300-450 psi in next 6 in.; then 450-600 psi; 600-1000 psi in last 6 in.
15	10		FS5	24	24	100		LEAN CLAY WITH SAND, CL: Very stiff; moist; yellowish brown (10YR 5/6); ~60% medium plasticity, medium toughness fines; ~20% fine sand				35	15		
			FS6	11	11	100		SANDY LEAN CLAY, CL: Stiff; moist; dark yellowish brown (10YR 4/4); ~60% medium plasticity, medium toughness fines; ~40% fine sand							FS6 in baggie; contains organic material from ground surface.
10	15		FS7	20	13	100		POORLY GRADED SAND WITH SILT, SP-SM: Firm; moist; dark yellowish brown (10YR 3/6); ~80% fine sand; ~10% nonplastic fines							
			FS8	23	23	100		POORLY GRADED SAND, SP: Very firm; wet; dark brown (10YR 3/3); ~80% fine sand; ~5% nonplastic fines; ~5% fine gravel; abundant organic material at 16.9-17.1 ft and 17.3-17.5 ft	5	90	5				
5	20		FS9	22	22	100		POORLY GRADED SAND WITH SILT, SP-SM: Very firm; wet; dark brown (10YR 3/3); ~80% fine to medium sand; ~10% nonplastic fines; gravel to 7/8 in. dia. at 21.4-21.5 ft							Crew overdrilled to 20 ft; no sample collected.
			FS10	24	24	100		WELL-GRADED SAND WITH SILT, SW-SM: Very firm; wet; dark brown (10YR 3/3); ~85% fine to coarse, subangular to subrounded sand; ~10% nonplastic fines; ~5% subangular to subrounded gravel to 1-1/4 in. dia.							
0	25		FS11	28	28	100		At 24 ft, as above except gravel to 5/8 in. dia.; trace of iron oxide staining							
			FS12	24	24	75		POORLY GRADED SAND WITH SILT, SP-SM: Very firm; wet; dark brown (10YR 3/3); ~80% to 95% fine to medium sand with trace of coarse grains; ~5% to 10% nonplastic fines; trace of fine gravel; trace of iron oxide staining	1	93	6				
			FS13	33	33	75		At 28 ft, as above except dense; subangular to subrounded gravel to 5/8 in. dia. at 29-29.2 ft							
	30														

Report GEO_1051SW_OAKCDE; Files: MNTUREWP.GPJ; 2/26/2002; CSF-01.13

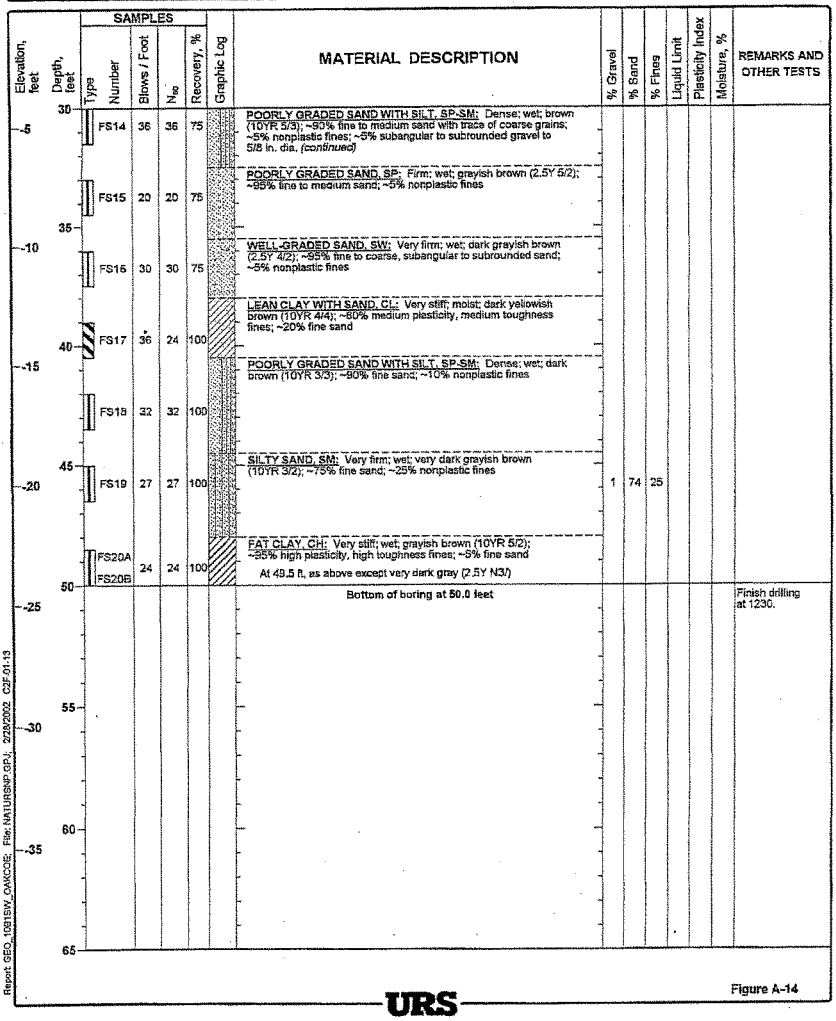
URS

Figure A-14

Project: Natomas Levee North of Powerline Road
Project Location: Sutter County, California
Project Number: 51971138NA.00

Log of Boring 2F-01-13

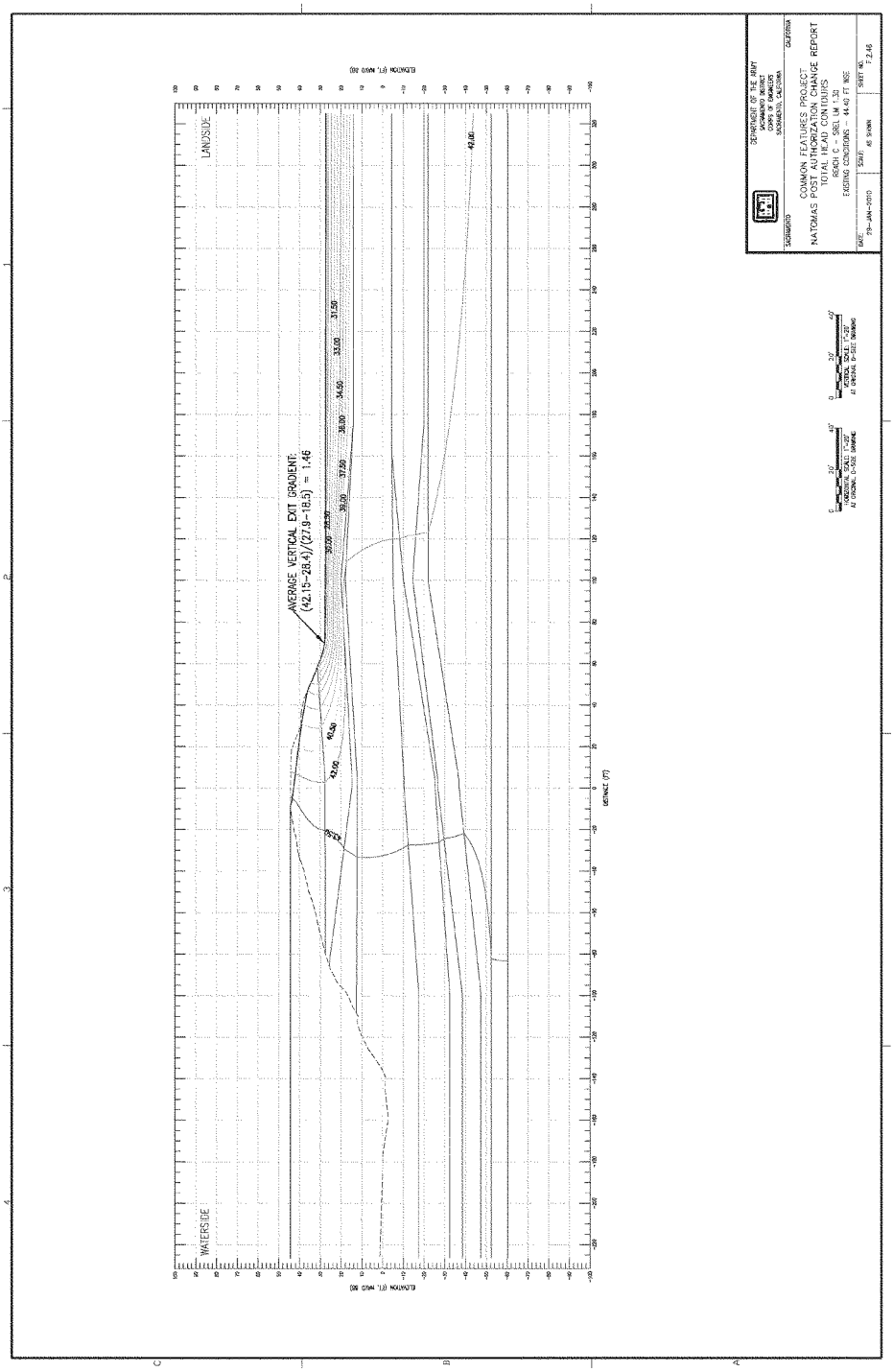
Sheet 2 of 2

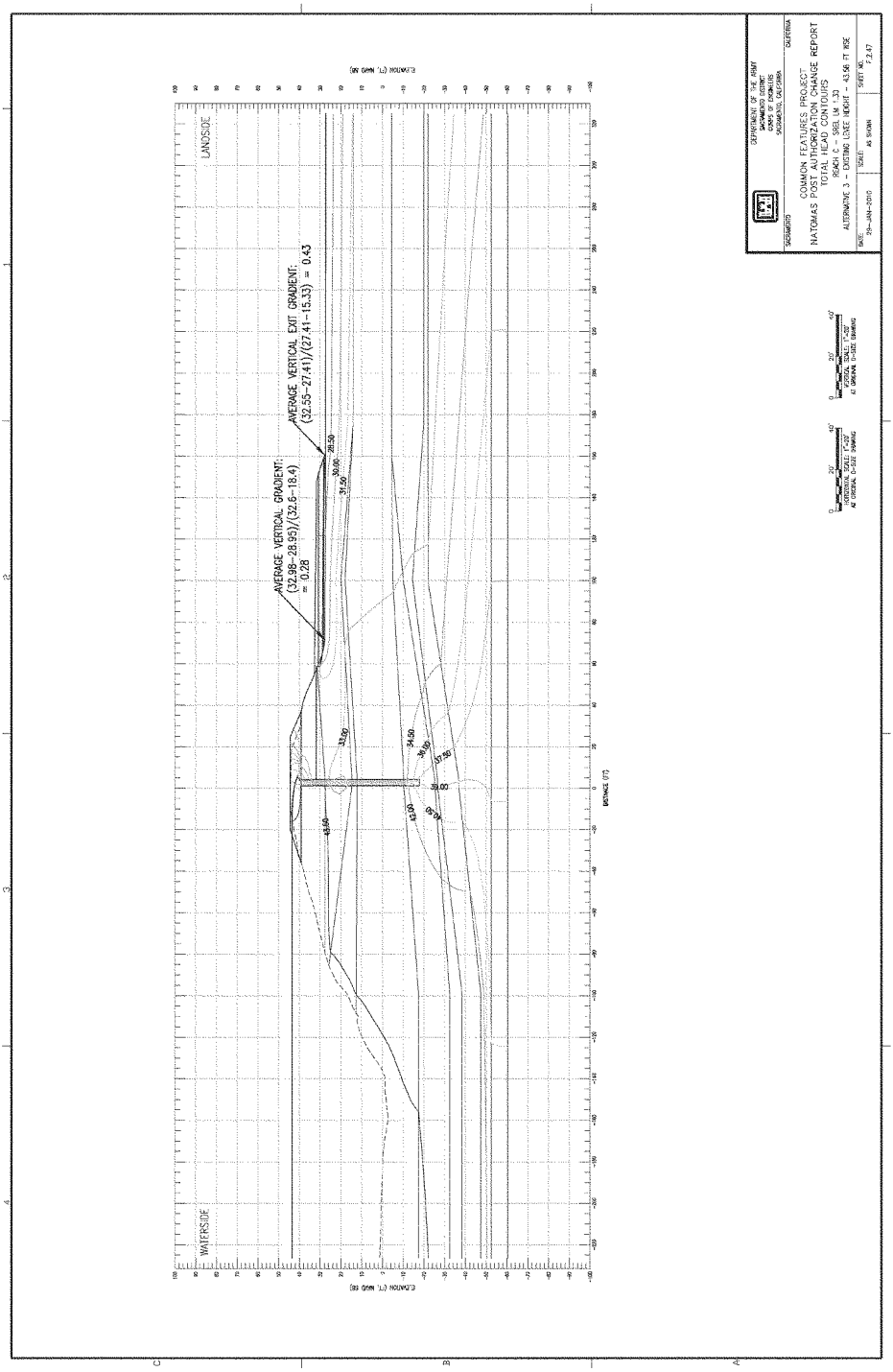


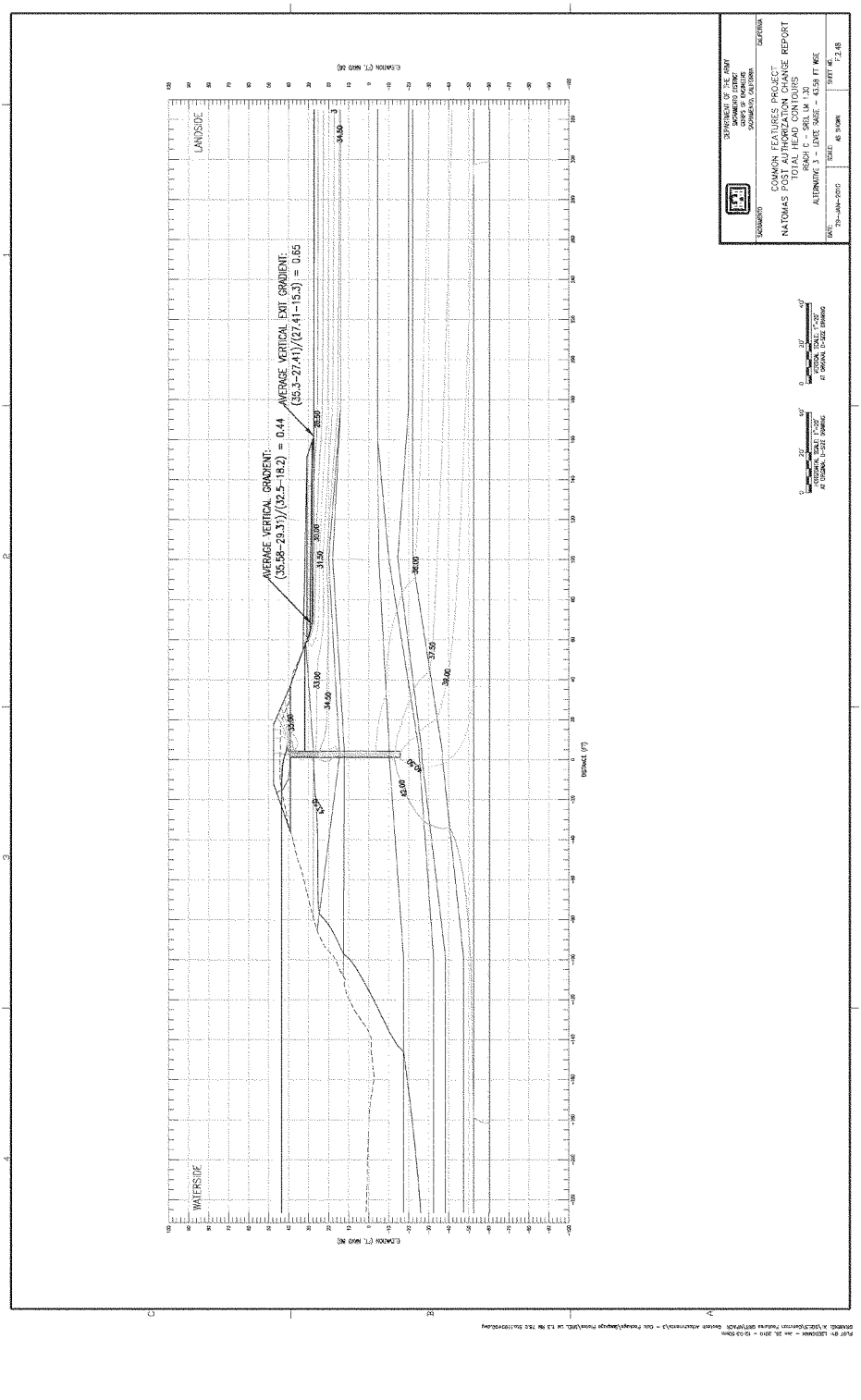
Report GEO_1091SW_OAKCOE, File: NATURSNP.GPJ, 2/28/2002, C2F-01-13

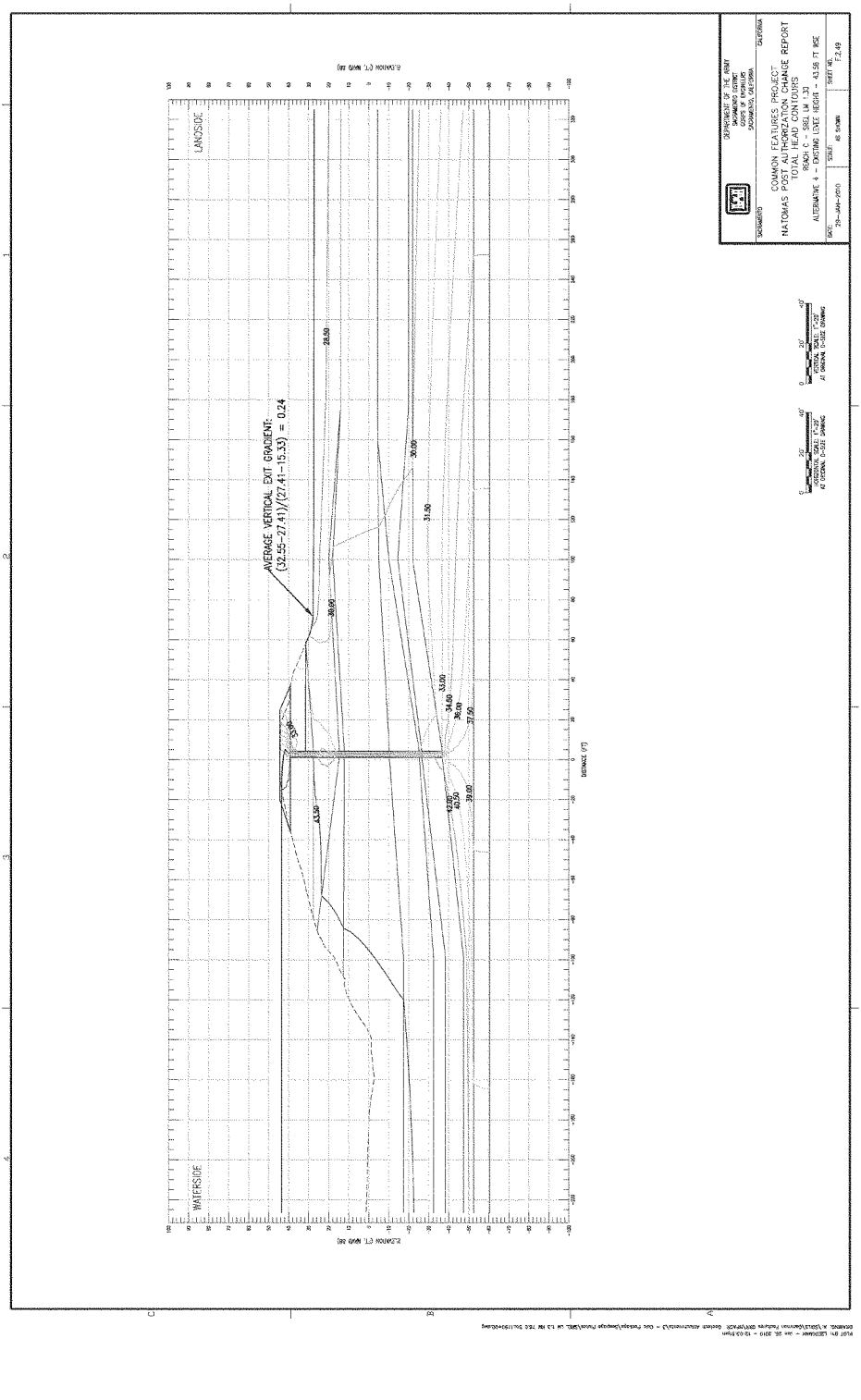
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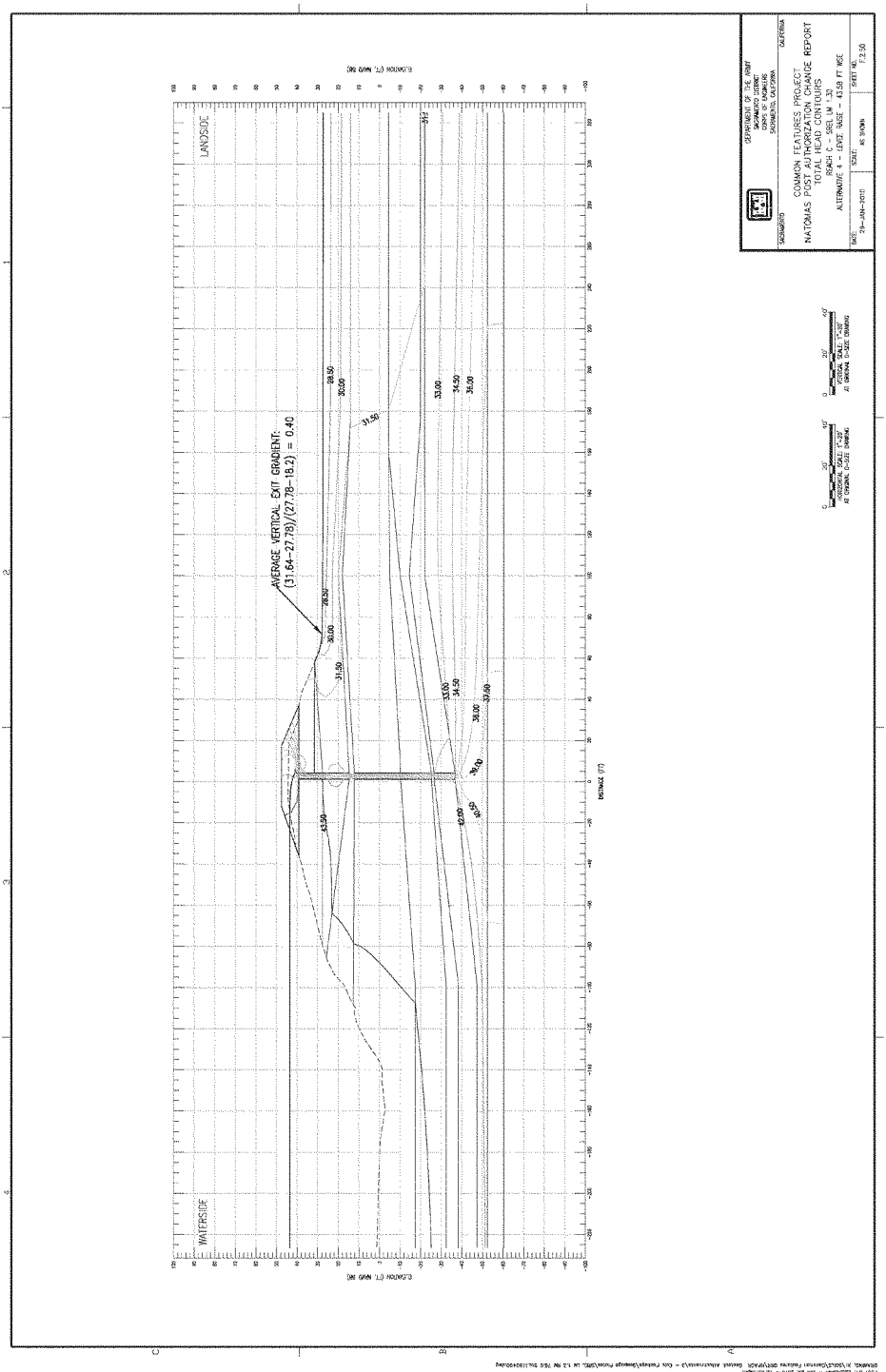
Figure A-14

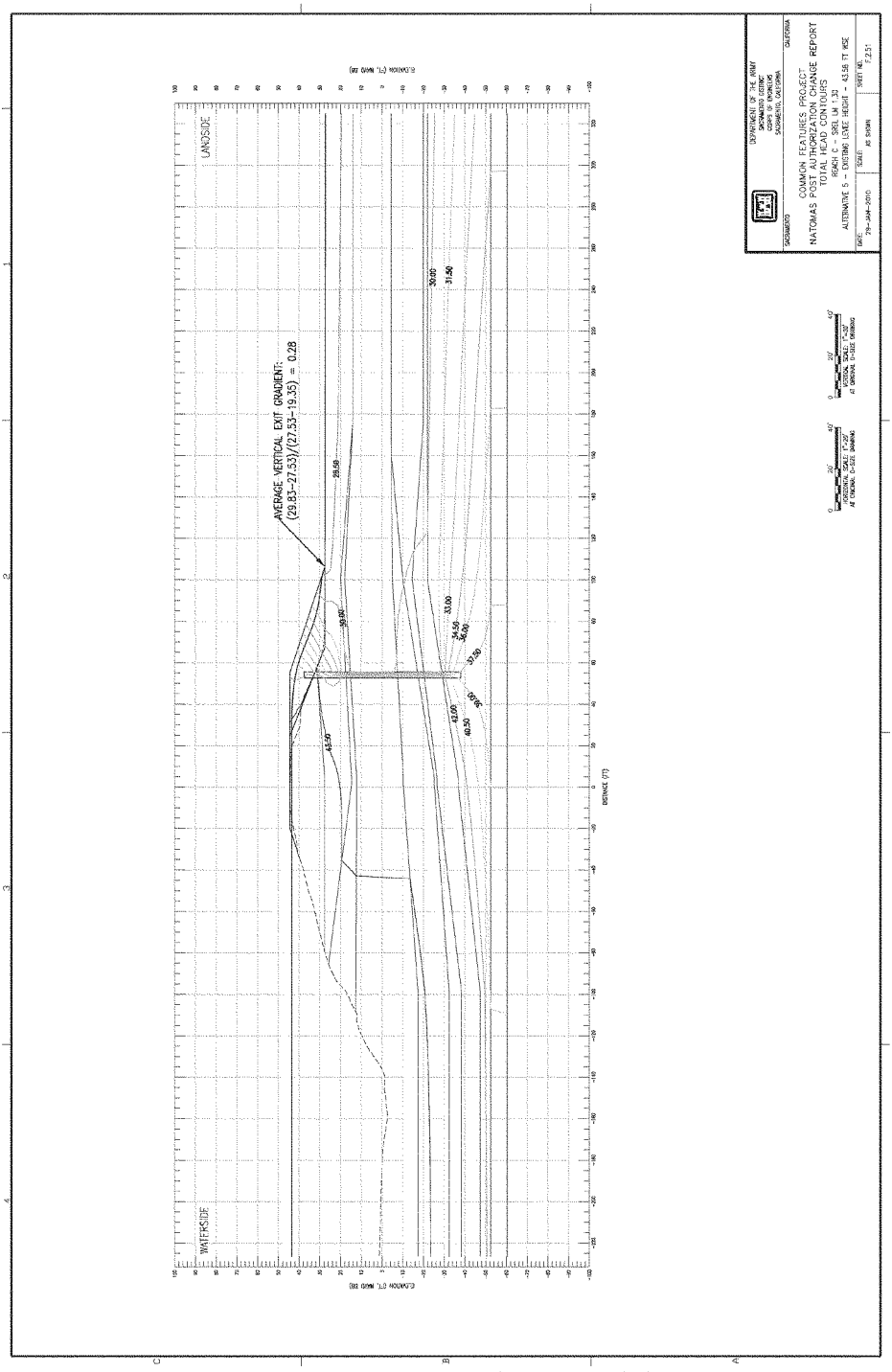

WATERSIDE
LANDSIDE
AVERAGE VERTICAL EXIT GRADIENT:
(42.15-28.4)/(27.9-18.5) = 1.46
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
EXISTING CONDITIONS
DATE: 29-JAN-2010
STAFF: AS SHOWN
SHEET NO. F2.46

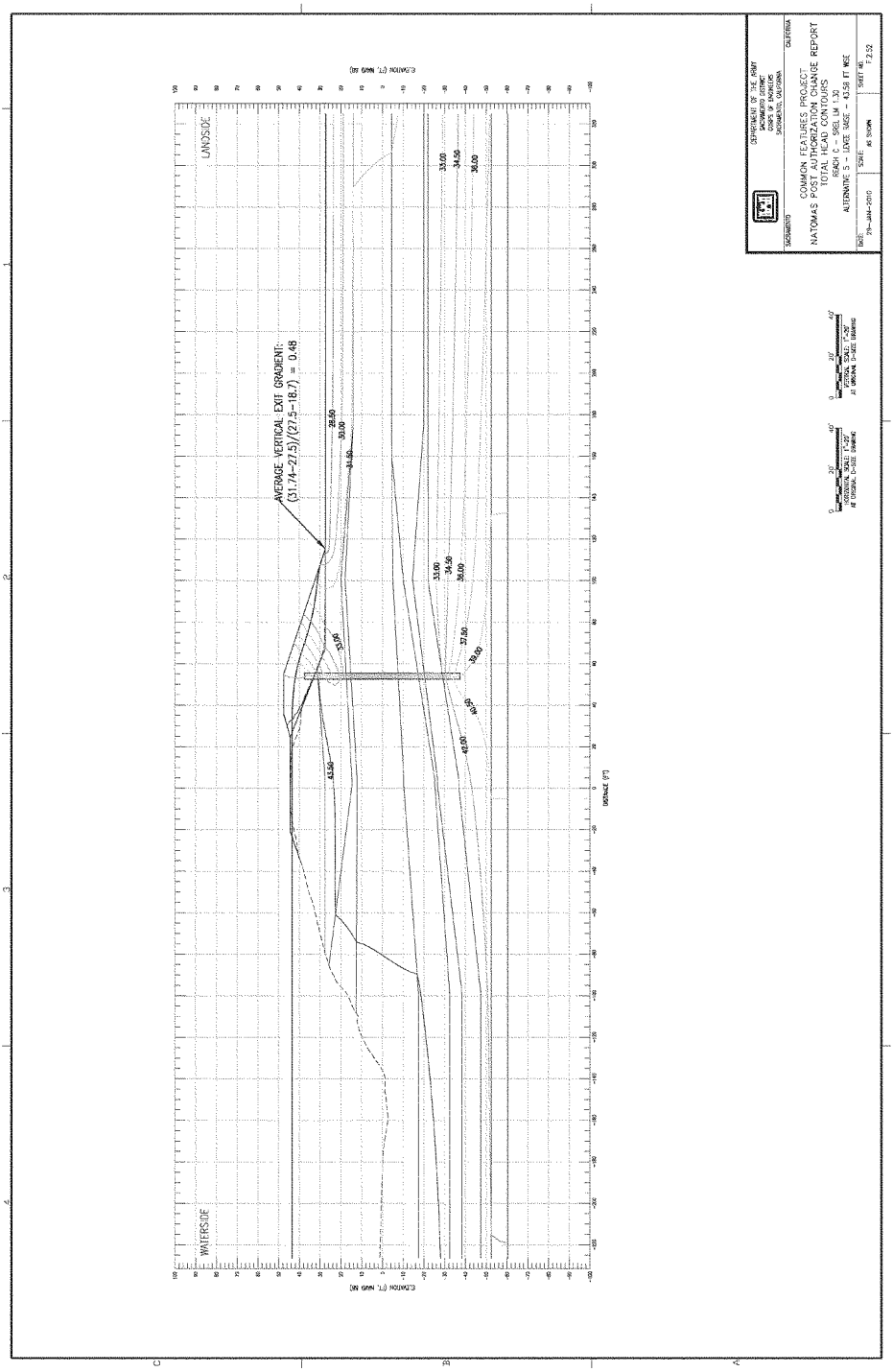

WATERSIDE
LANDSIDE
AVERAGE VERTICAL GRADIENT:
(32.98-28.95)/(32.6-18.4)
≈ 0.28
AVERAGE VERTICAL EXIT GRADIENT:
(32.55-27.41)/(27.41-15.33) ≈ 0.43
ELEVATION (FT, NGVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C, SEEPAGE SECTION 34
ALTERNATIVE 3 - EXISTING LEVEE HEIGHT + 43.56 FT RISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.47

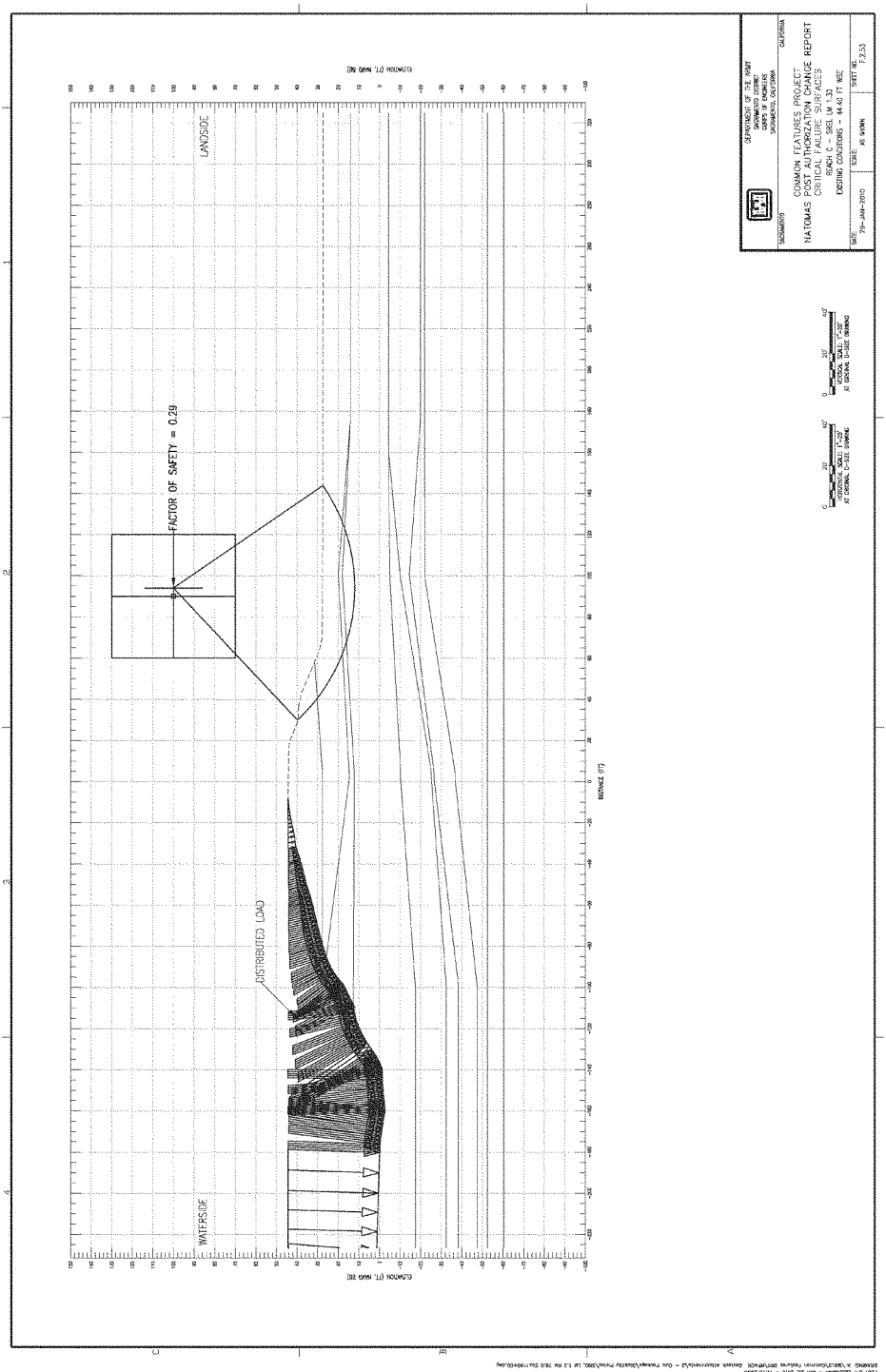

AVERAGE VERTICAL GRADIENT:
(35.58–29.31)/(32.5–18.2) = 0.44
AVERAGE VERTICAL EXIT GRADIENT:
(35.3–27.41)/(27.41–15.3) = 0.65
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C, STA 36+00
ALTERNATIVE 3 – LOWE SAGE – 43.59 FT MSL
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.48

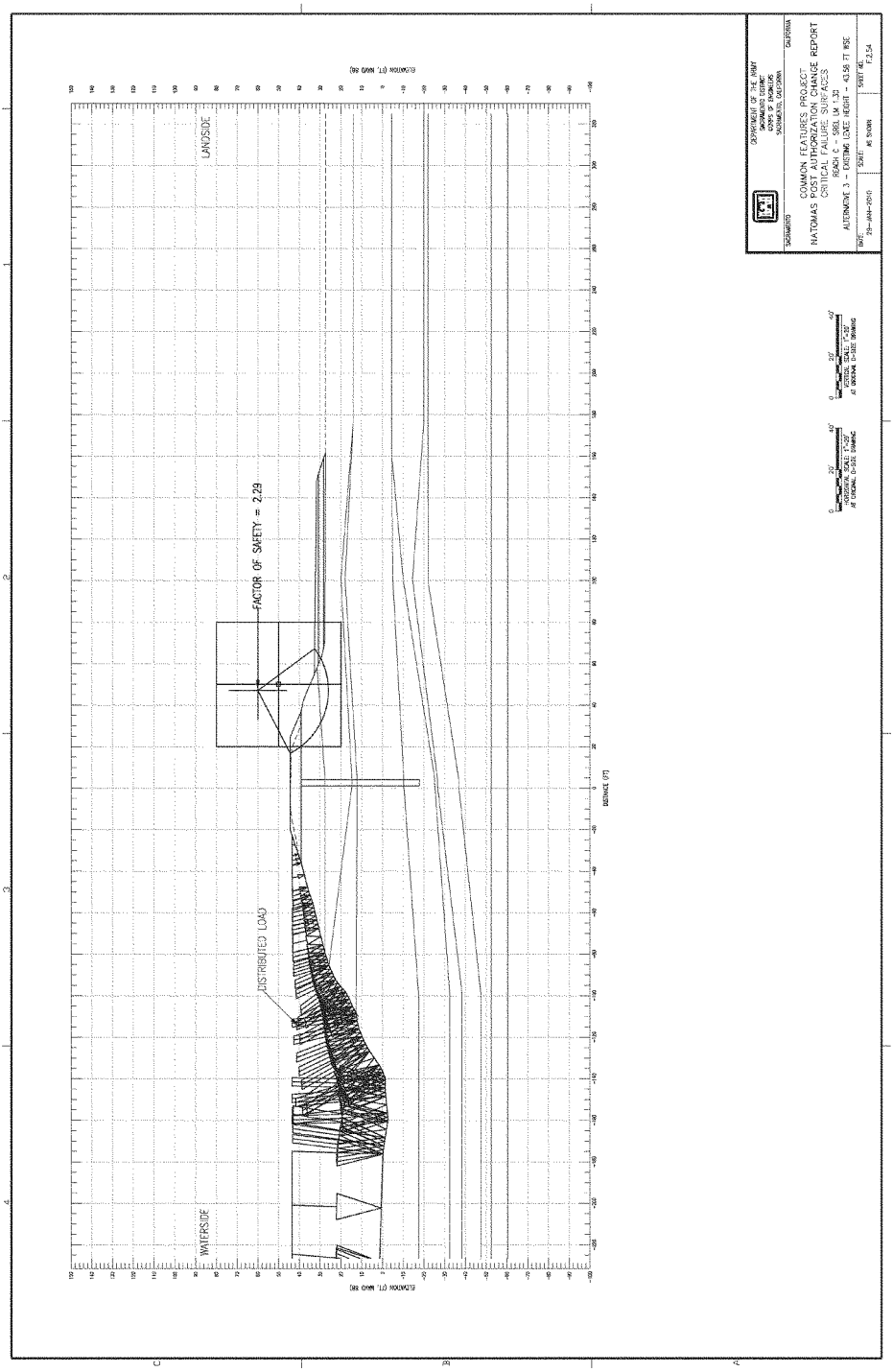

AVERAGE VERTICAL EXIT GRADIENT:
(32.55-27.41)/(27.41-15.33) = 0.24
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C, SEGS 1A, 2A, 3A
ALTERNATIVE 4 - EXISTING LEVEE HEIGHT + 43.56 FT MSL
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.49

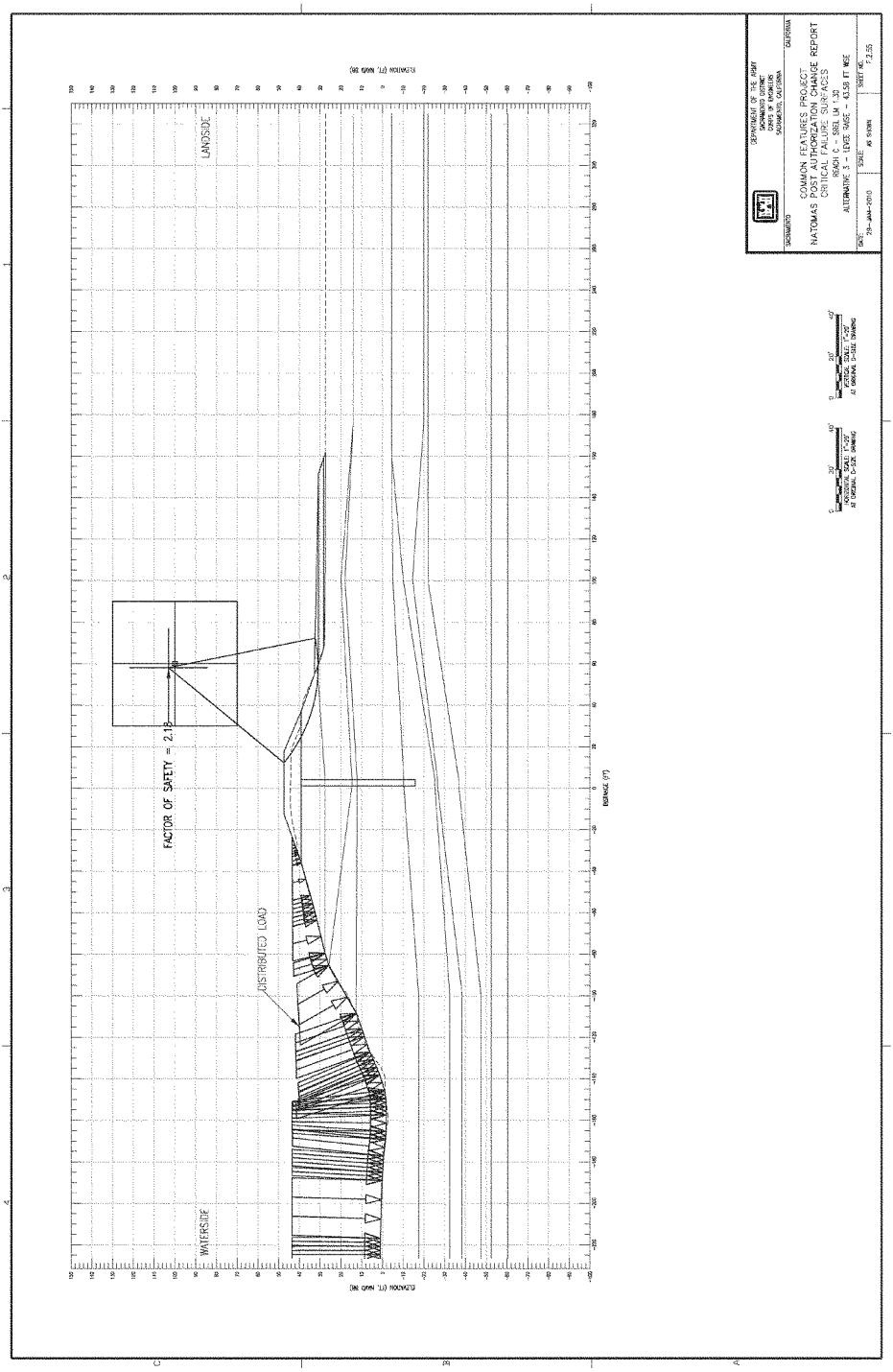

AVERAGE VERTICAL EXIT GRADIENT:
(31.64-27.78)/(27.78-18.2) = 0.40
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C, SEEP/STABILITY SECTION 34
ALTERNATIVE 4 - LEVEE RAISE - 43.59 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F-2.50

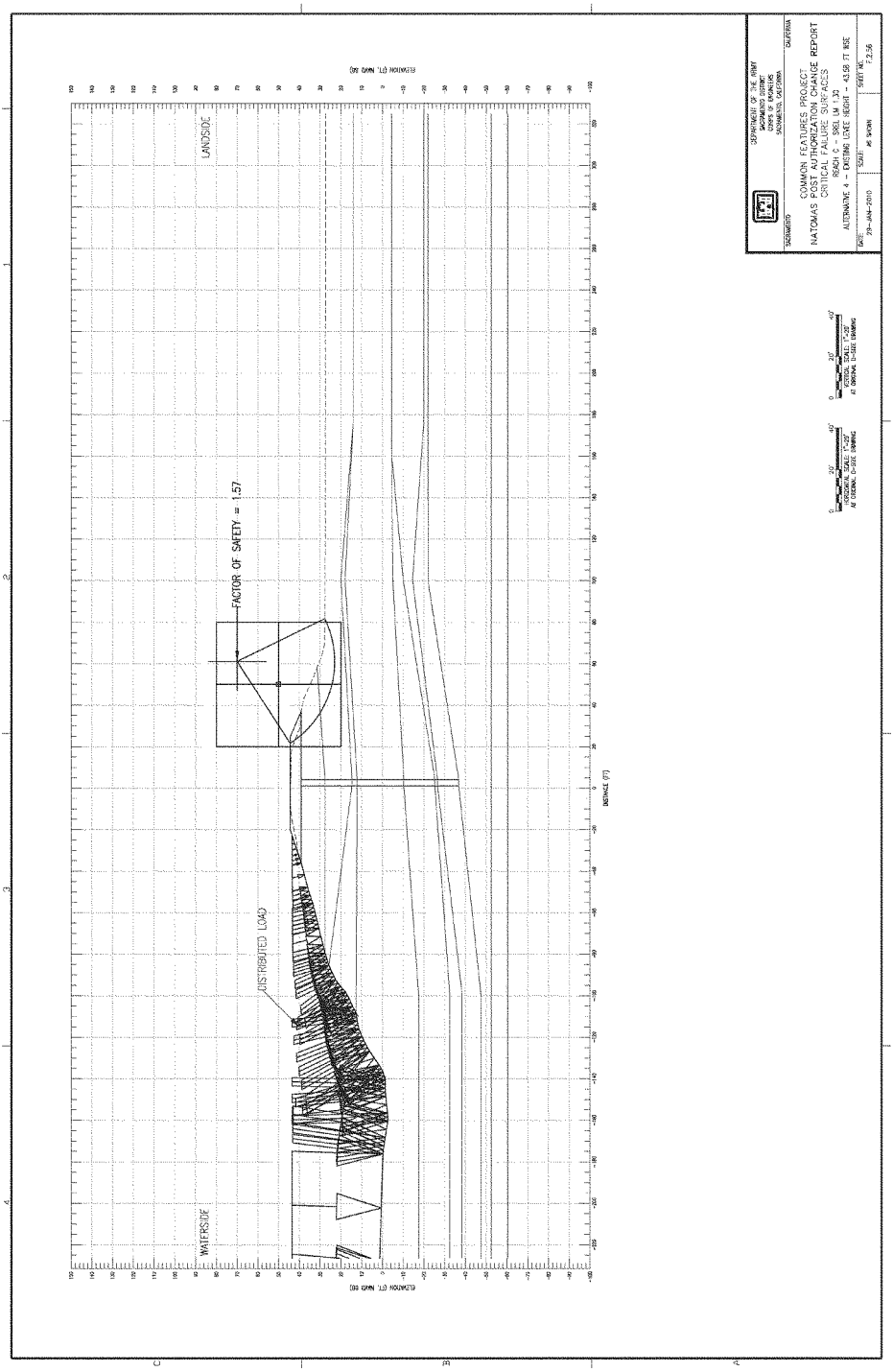

AVERAGE VERTICAL EXIT GRADIENT:
(29.83-27.53)/(27.53-19.35) = 0.28
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C, SECTION 34
ALTERNATIVE 5 - EXISTING LEVEE HEIGHT + 43.56 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.23.1

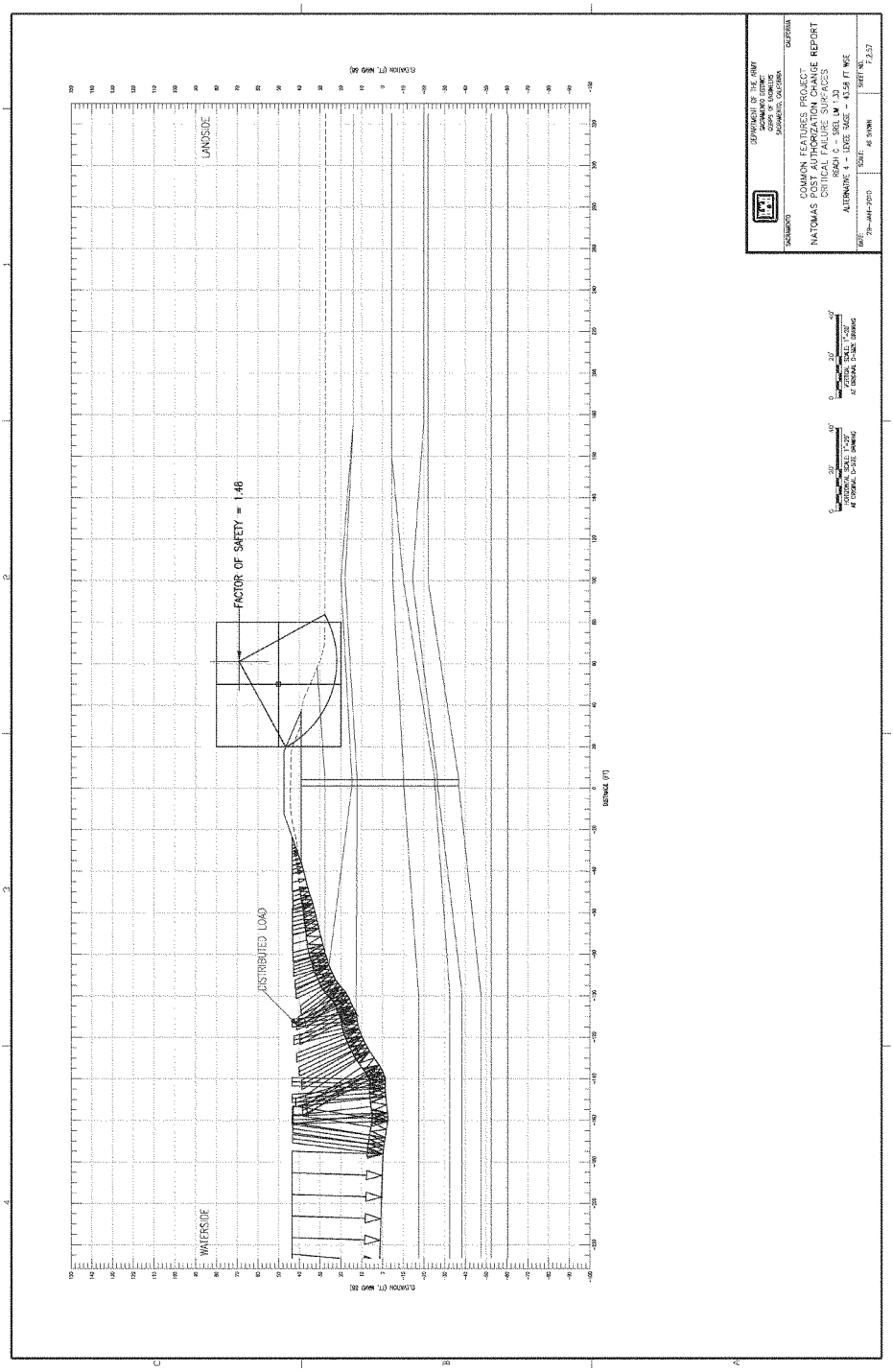

AVERAGE VERTICAL EXIT GRADIENT:
(31.74-27.5)/(27.5-18.7) = 0.48
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
TOTAL HEAD CONTOURS
REACH C, SEEP/S STA 36+00
ALTERNATIVE 5 - LEVEE RAISE - 43.5ft RT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.52

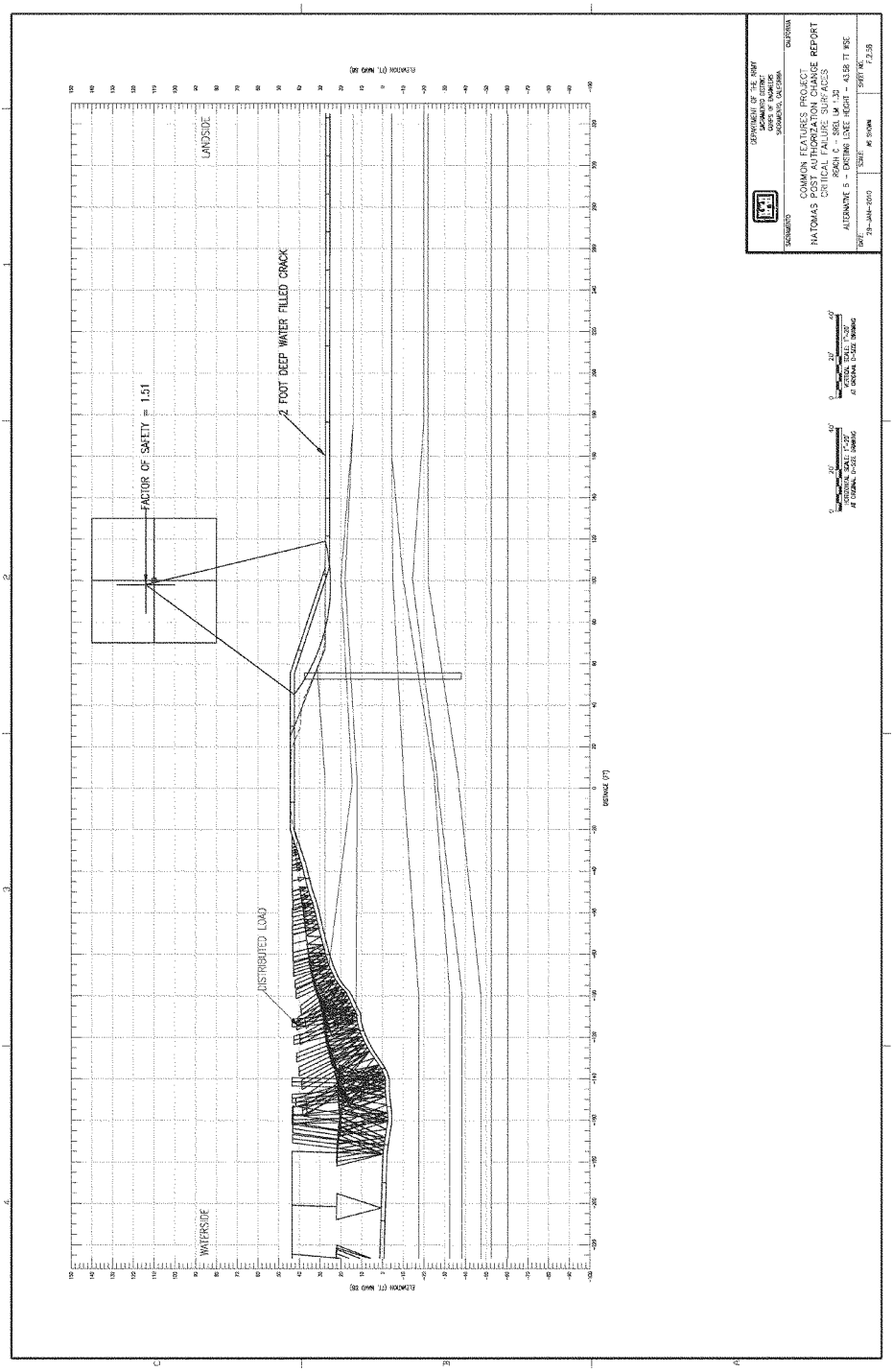

FACTOR OF SAFETY = 0.29
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, SECTION 33
EXISTING CONDITIONS - 44.40 FT MSC
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F2.53

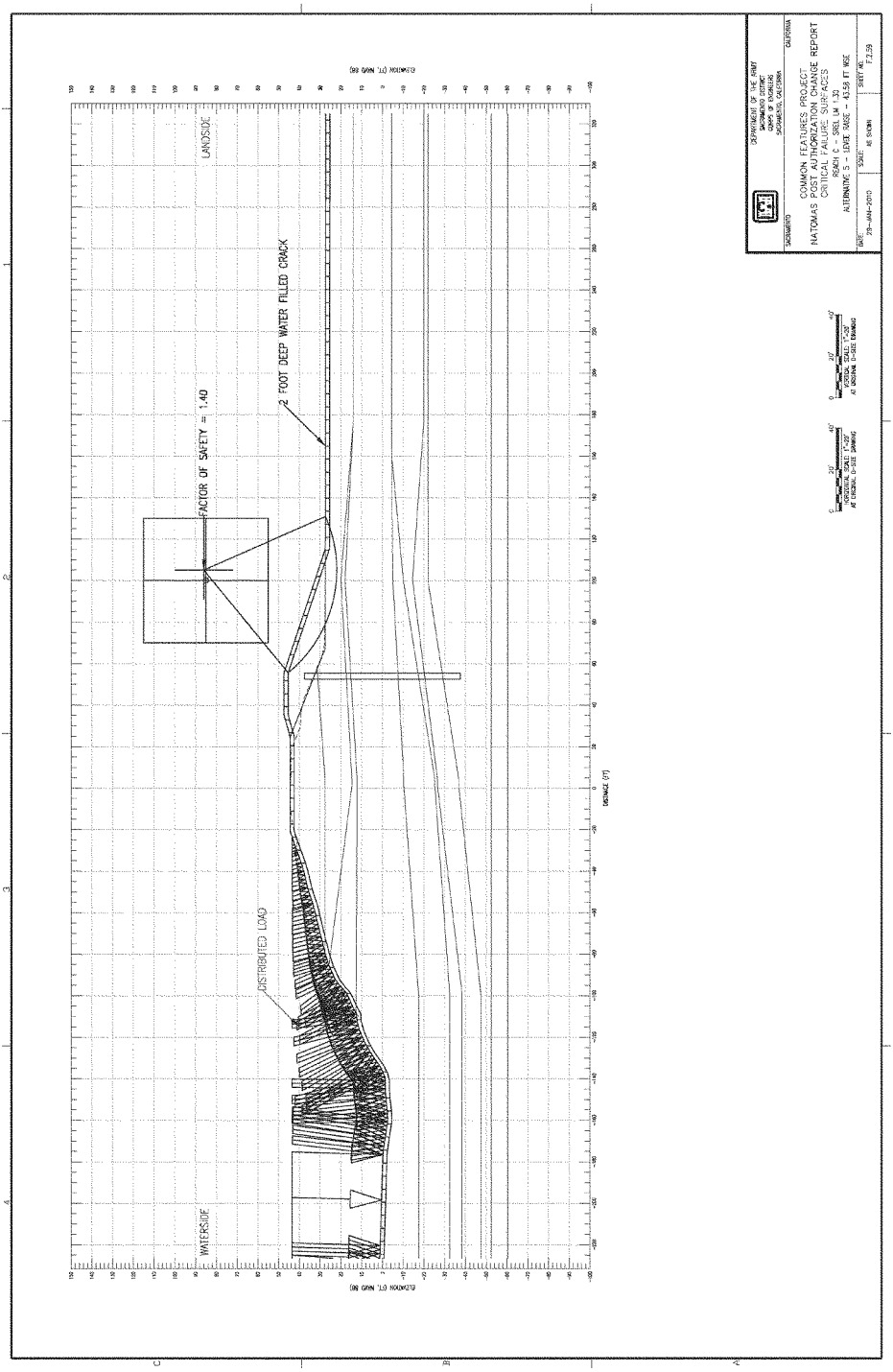

FACTOR OF SAFETY = 2.29
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, SAC 31
ALTERNATIVE 3 – EXISTING LEVEE HEIGHT + 43.56 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO.: F2.54


FACTOR OF SAFETY = 2.18
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, STA 33+00
ALTERNATIVE 3 - 1DFE SAFE - 43.59 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.55


DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, SEEP/SLIDE, SAC 35
ALTERNATIVE 4 - EXISTING LEVEE HEIGHT + 43.59 FT RISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 7.2.56
LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 1.57
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING
HORIZONTAL SCALE: 1"=40'
AT ORIGINAL D-SIZE DRAWING
PLOT BY: LBEDIKIAN - 28 JUL 2010 - 11:19:30AM
DRAWING: N:\SOLS\Common Features 09\FINAL Seismic Alternatives\A4 - Dike Flattening\Stability Models\SEE 1.3 IN R&D Soil Properties.dwg


FACTOR OF SAFETY = 1.46
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
CRITICAL FAILURE SURFACES
REACH C, SHEET 33
ALTERNATIVE 4 - LEVEE RAISE - 43.56 FT NGE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 7.2.57


FACTOR OF SAFETY = 1.51
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, STA 34+00
ALTERNATIVE 5 - EXISTING LEVEE HEIGHT + 43.58 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.59


WATERSIDE
LANDSIDE
DISTRIBUTED LOAD
2 FOOT DEEP WATER FILLED CRACK
FACTOR OF SAFETY = 1.40
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, STA. 33+00
ALTERNATIVE 5 - LEVEE RAISE - 43.5ft FT WSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F2.59

REACH D

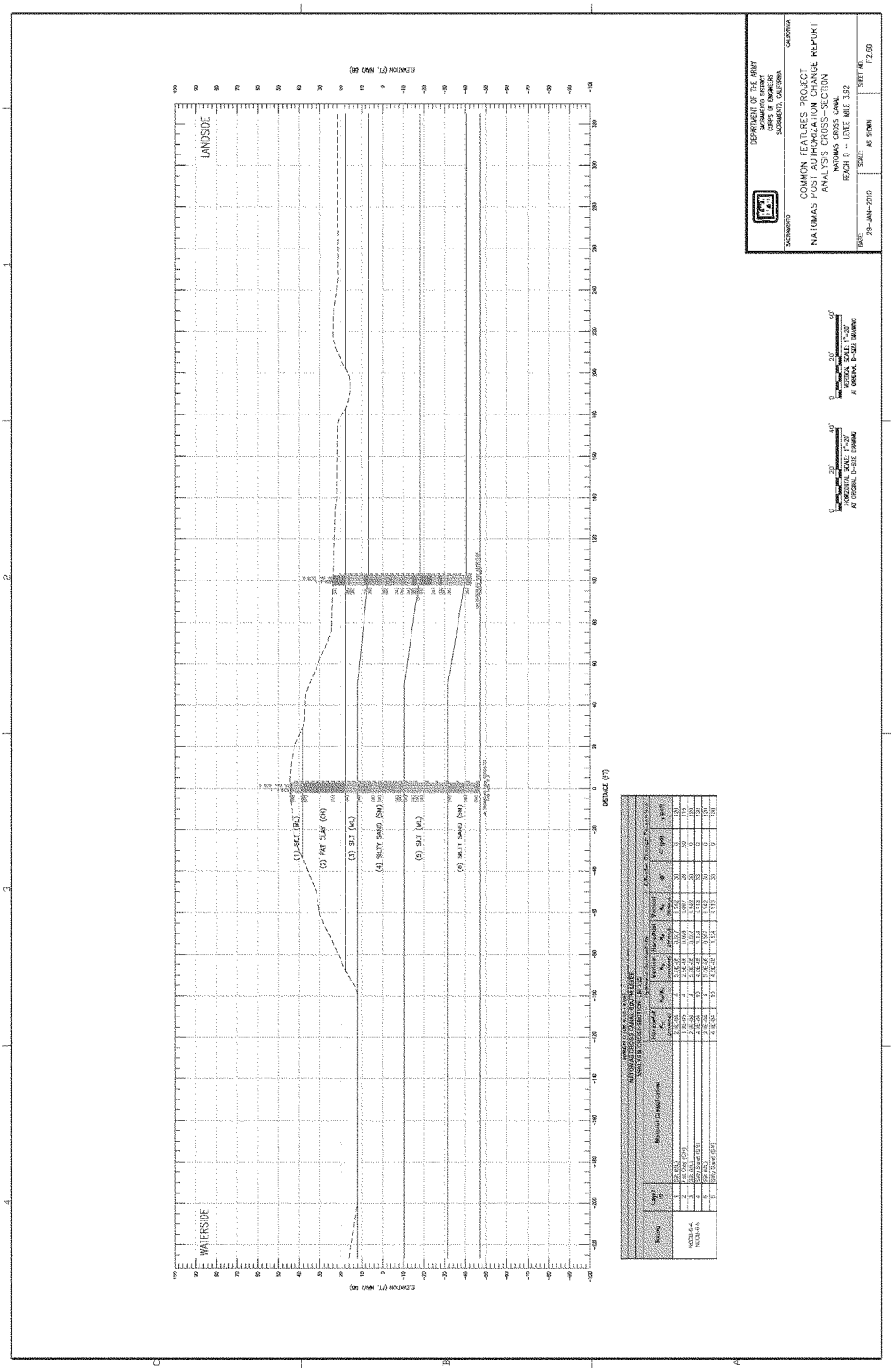
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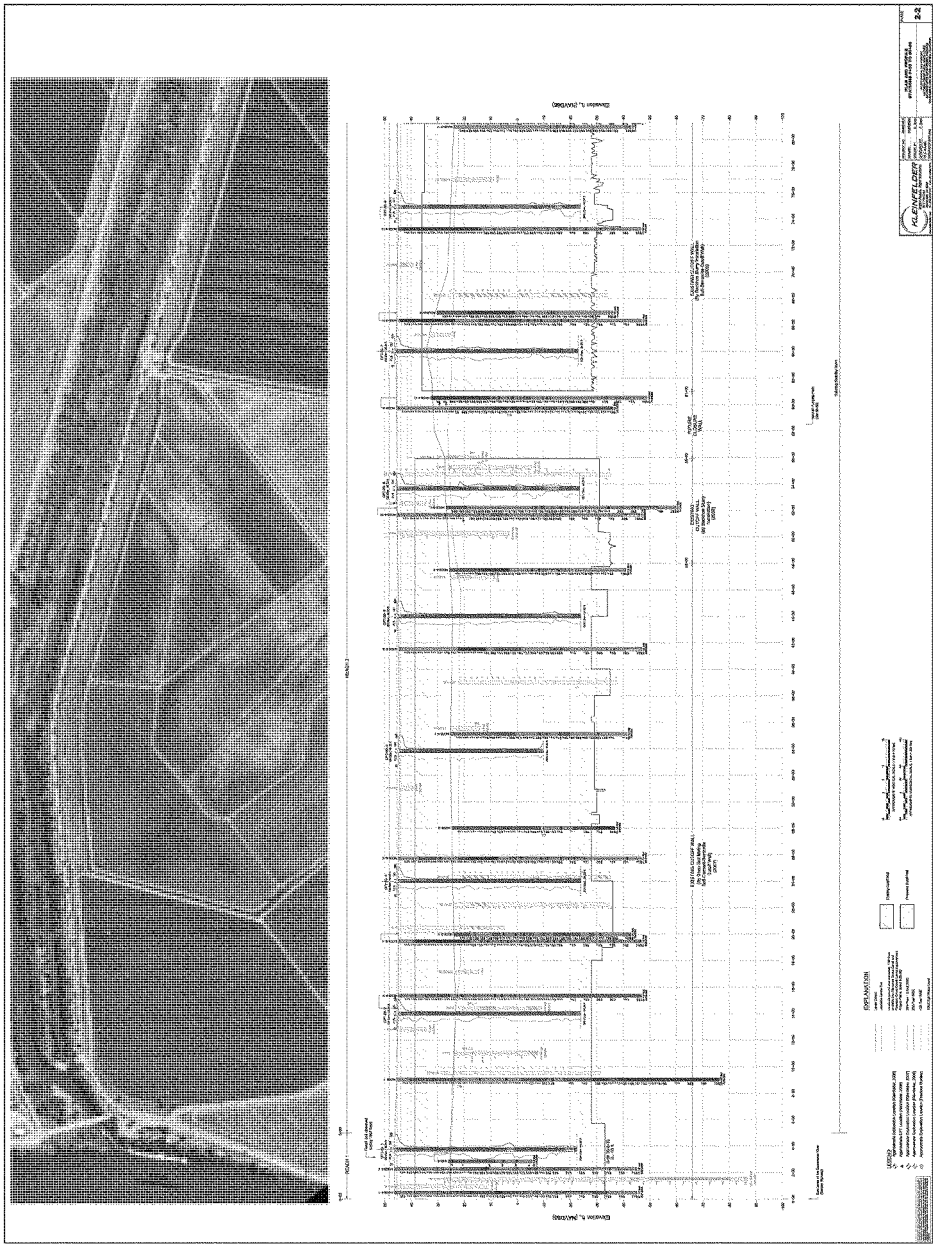
NATOMAS CROSS CANAL SOUTH LEVEE

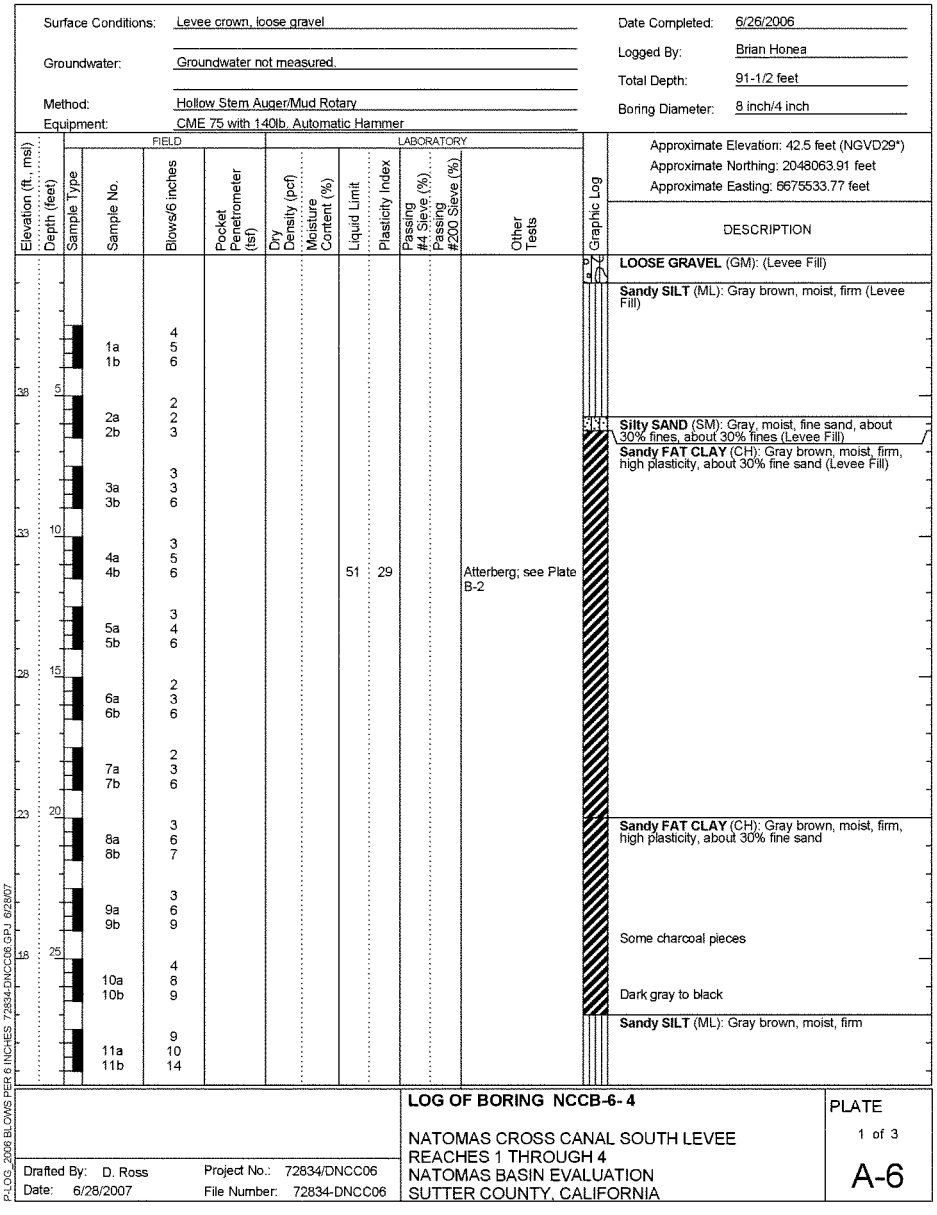
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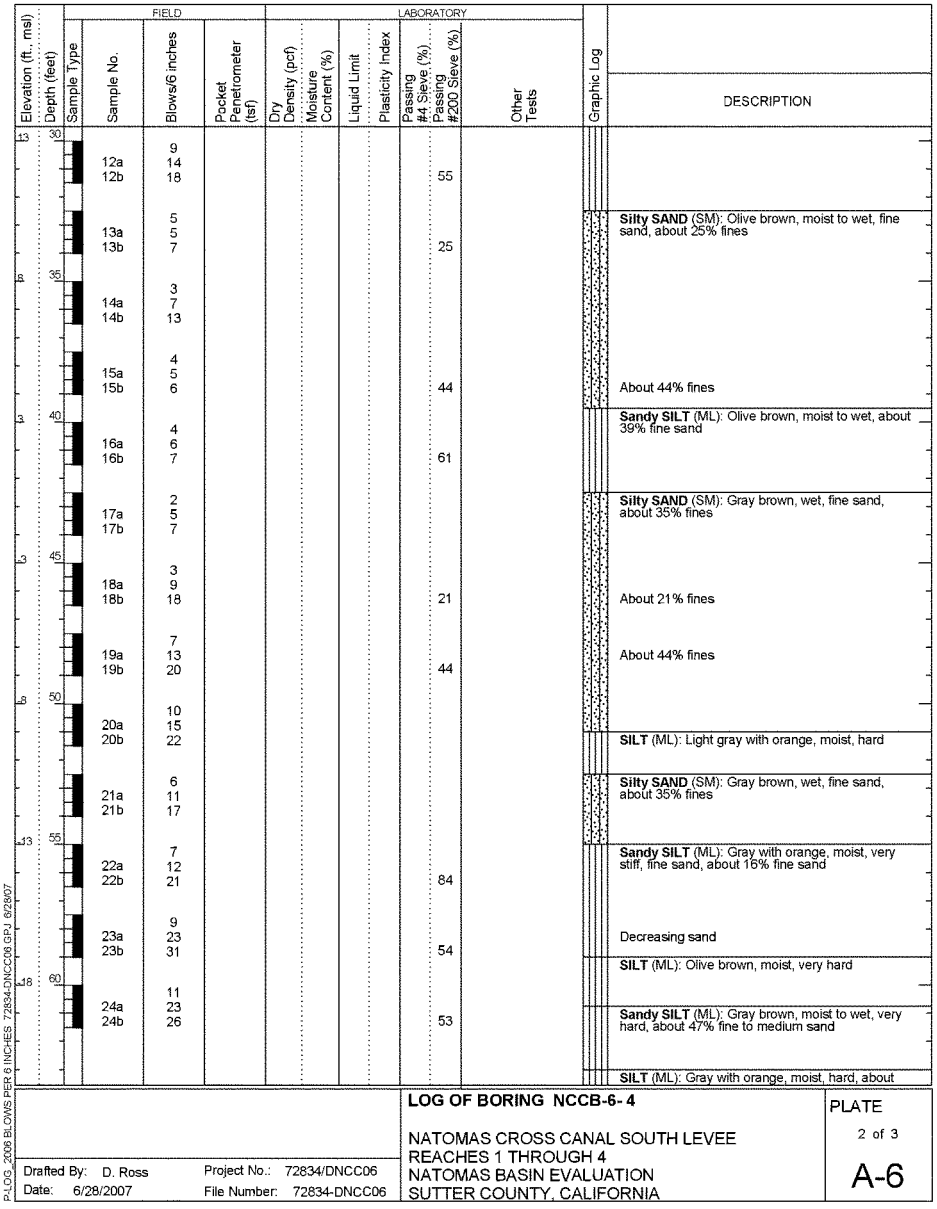
LM 4.38 – 0.00

LM 16.38 – 16.08


WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
(1) SILT (ML)
(2) FAT CLAY (CH)
(3) SILT (ML)
(4) SILTY SAND (SM)
(5) SILT (ML)
(6) SILTY SAND (SM)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
NORTH NATOMAS CANAL
REACH 0 - LEVEE MILE 3.82
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 7.2.00




Surface Conditions: Levee crown, loose gravel
Groundwater: Groundwater not measured.
Method: Hollow Stem Auger/Mud Rotary
Equipment: CME 75 with 140lb. Automatic Hammer
Date Completed: 6/26/2006
Logged By: Brian Honea
Total Depth: 91-1/2 feet
Boring Diameter: 8 inch/4 inch
FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
Approximate Elevation: 42.5 feet (NGVD29*)
Approximate Northing: 2048063.91 feet
Approximate Easting: 6675533.77 feet
DESCRIPTION
LOOSE GRAVEL (GM): (Levee Fill)
Sandy SILT (ML): Gray brown, moist, firm (Levee Fill)
Silty SAND (SM): Gray, moist, fine sand, about 30% fines, about 30% fines (Levee Fill)
Sandy FAT CLAY (CH): Gray brown, moist, firm, high plasticity, about 30% fine sand (Levee Fill)
Atterberg; see Plate B-2
Sandy FAT CLAY (CH): Gray brown, moist, firm, high plasticity, about 30% fine sand
Some charcoal pieces
Dark gray to black
Sandy SILT (ML): Gray brown, moist, firm
LOG OF BORING NCCB-6- 4
NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA
PLATE
1 of 3
A-6
Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06
P:\LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07



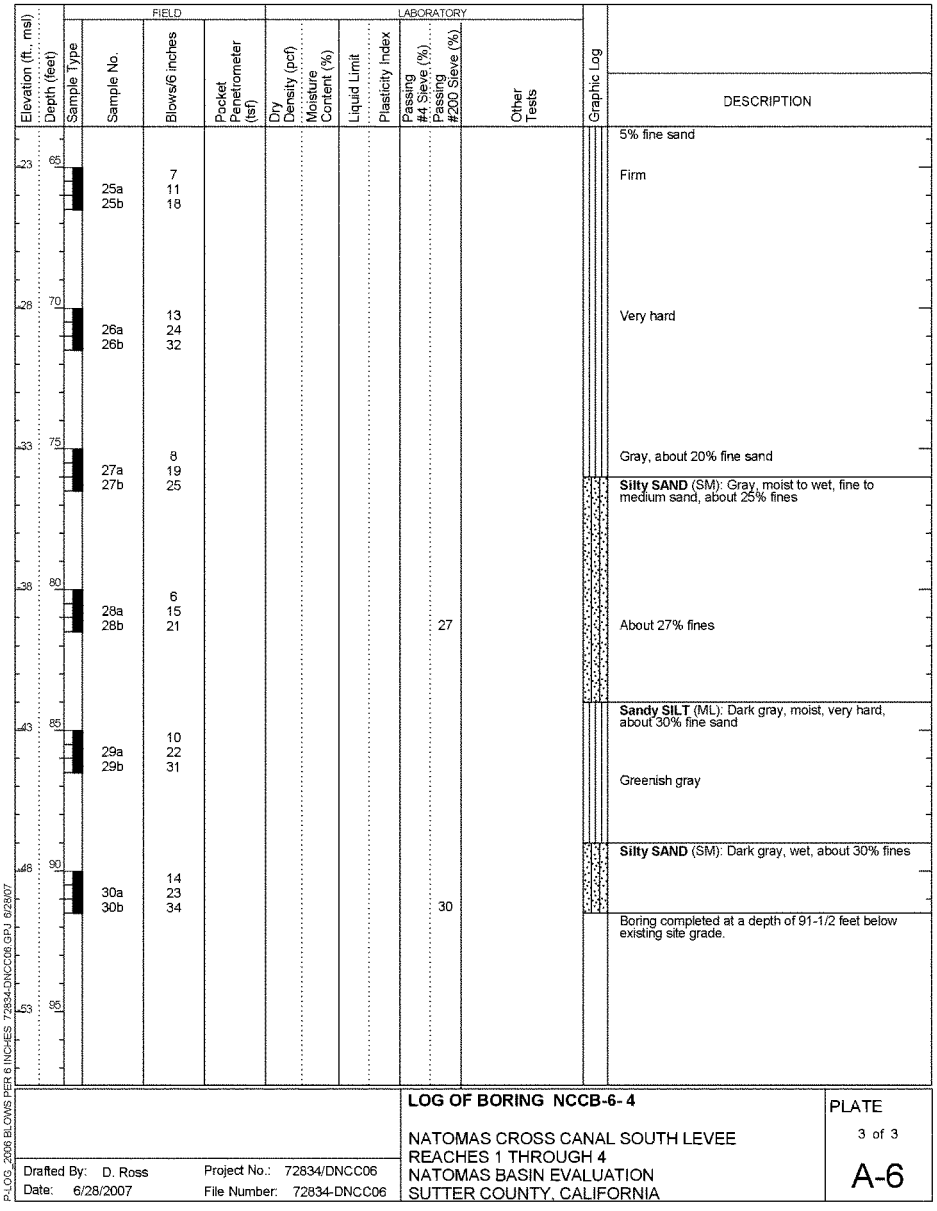
PLOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

LOG OF BORING NCCB-6- 4

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
2 of 3
A-6


FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
5% fine sand
Firm
Very hard
Gray, about 20% fine sand
Silty SAND (SM): Gray, moist to wet, fine to medium sand, about 25% fines
About 27% fines
Sandy SILT (ML): Dark gray, moist, very hard, about 30% fine sand
Greenish gray
Silty SAND (SM): Dark gray, wet, about 30% fines
Boring completed at a depth of 91-1/2 feet below existing site grade.
25a 7
25b 18
26a 13
26b 24 32
27a 8
27b 19 25
28a 6
28b 15 21 27
29a 10
29b 22 31
30a 14
30b 23 34 30
PLOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07
Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06
LOG OF BORING NCCB-6- 4
NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA
PLATE
3 of 3
A-6

Surface Conditions: Levee toe, grassy
Groundwater: Groundwater not measured.
Method: Mud Rotary
Equipment: CME 750 with 140lb. Automatic Hammer

Date Completed: 7/5/2006
Logged By: C. Wilhite
Total Depth: 66-1/2 feet
Boring Diameter: 4 inch

Approximate Elevation: 21.5 feet (NGVD29*)
Approximate Northing: 2048016.25 feet
Approximate Easting: 6675610.83 feet

Elevation (ft, msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
				8										**LEAN CLAY** (CL): Brown, dry, firm
			1a	9										
			1b	9										Moist
17	5			4										
			2a	4	1.75									Olive brown
			2b	23										**Sandy SILT** (ML): Brown, moist, firm, about 30% fine sand
				17										**Clayey GRAVEL** (GC): Brown to red, moist, fine to coarse gravel, about 30% fines
			3a	39	>4.5									**SILT** (ML): Brown, moist, very hard
			3b	39										
12	10			7										
			4a	10										Firm, some red mottling
			4b	20										
				7										
			5a	13										
			5b	20	>4.5									
7	15			9										**LEAN CLAY** (CL): Brownish gray, moist, firm
			6a	15										
			6b	15										
				6										**Silty SAND** (SM): Brown, moist, fine sand, about 39% fines
			7a	7										
			7b	8							39			
2	20			3										
			8a	5										
			8b	7										Olive brown
				3										
			9a	5							39			
			9b	6										**Sandy SILT** (ML): Brown, moist, firm, about 30% fine to medium sand
-3	25			3										**Silty SAND** (SM): Brown, moist, fine to medium sand, about 32% fines
			10a	6										
			10b	10							32			
				5										
			11a	10										
			11b	18							23			Medium sand, about 23% fines

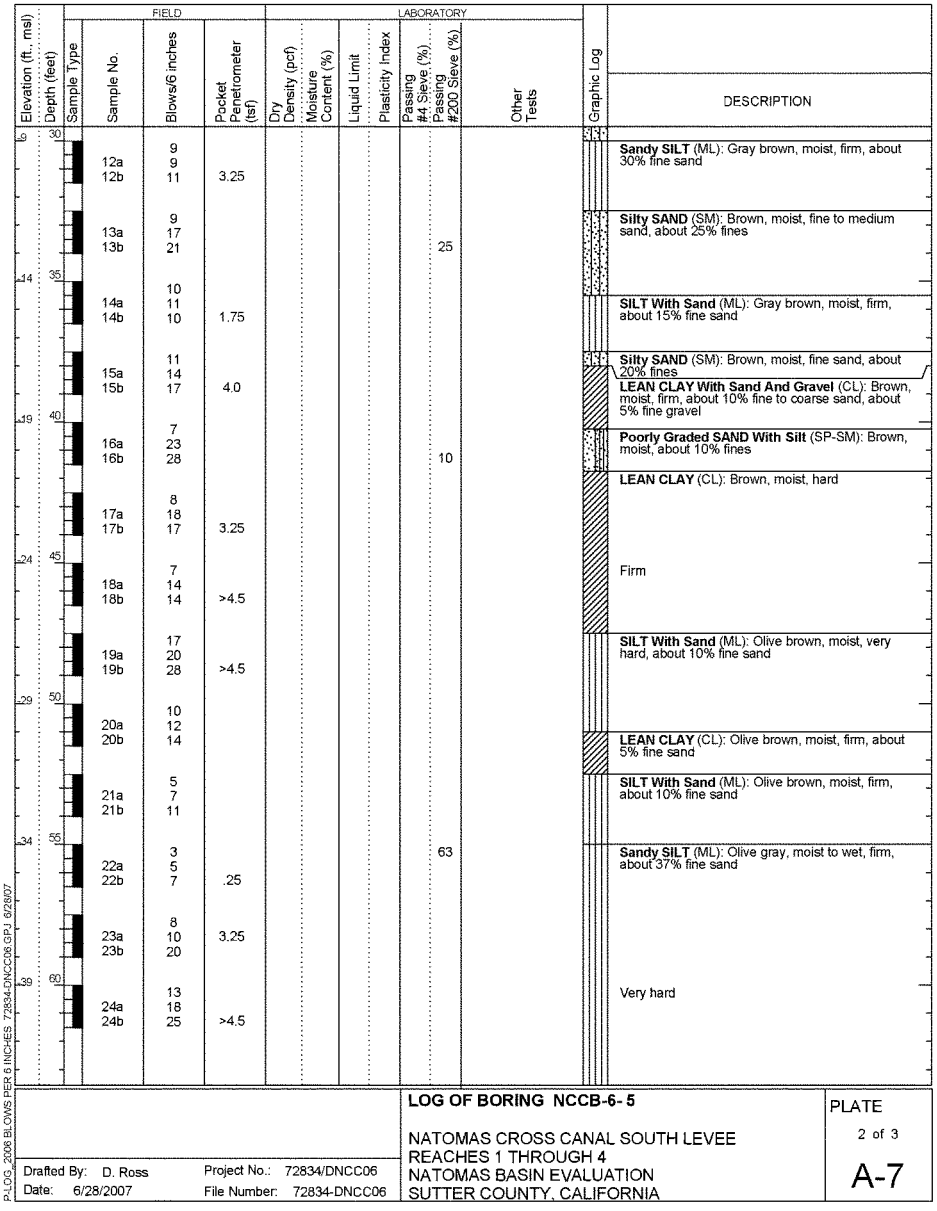
LOG OF BORING NCCB-6- 5

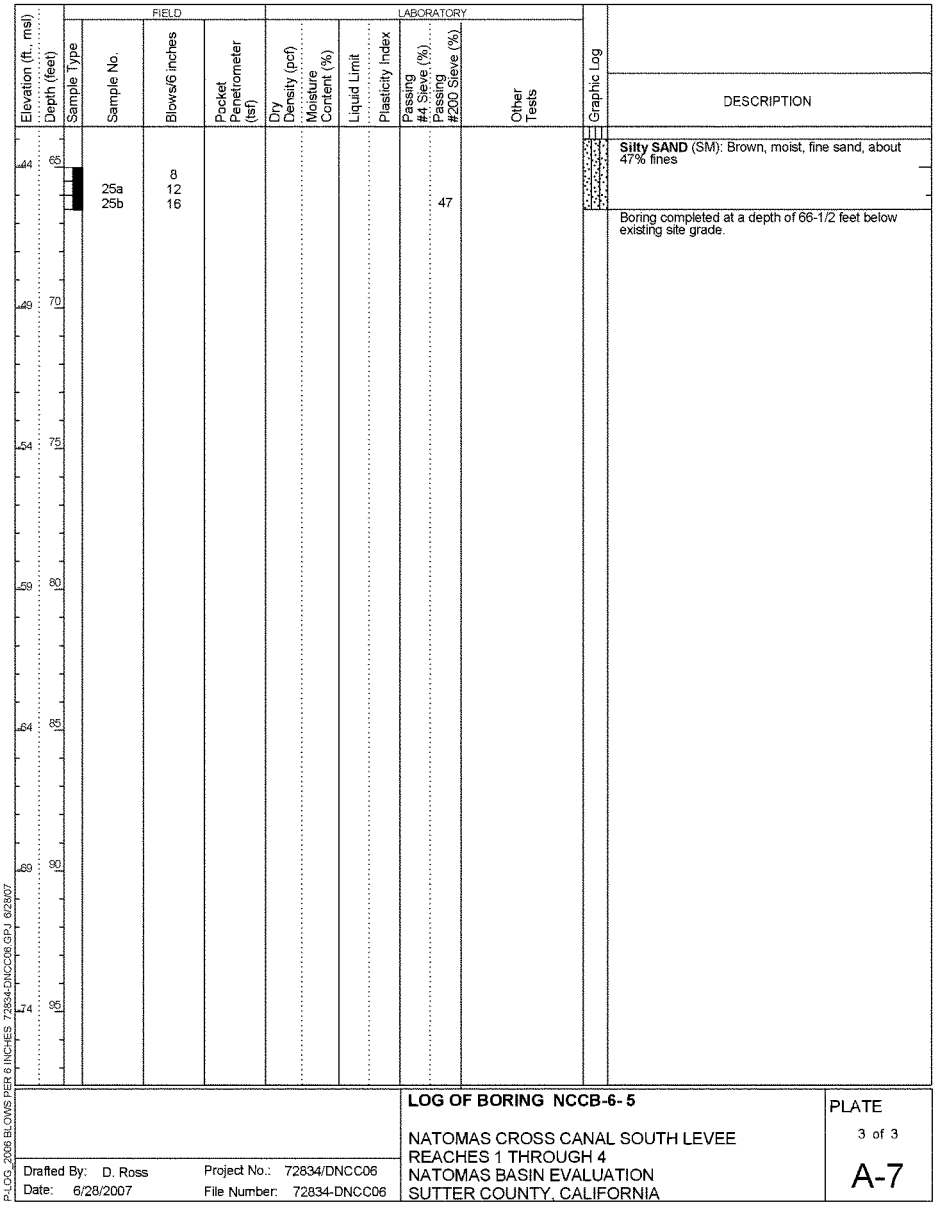
NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

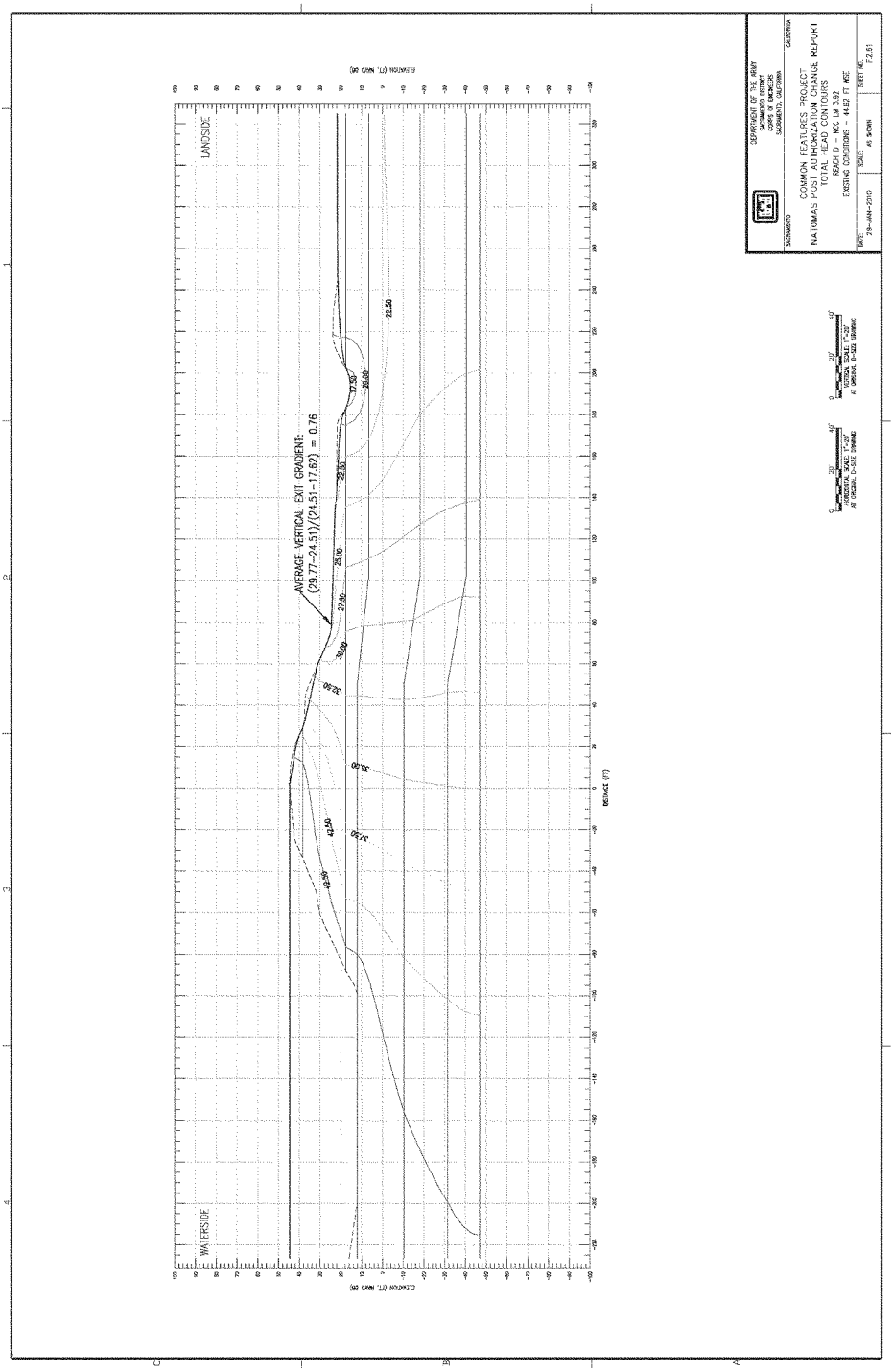
PLATE
1 of 3
A-7

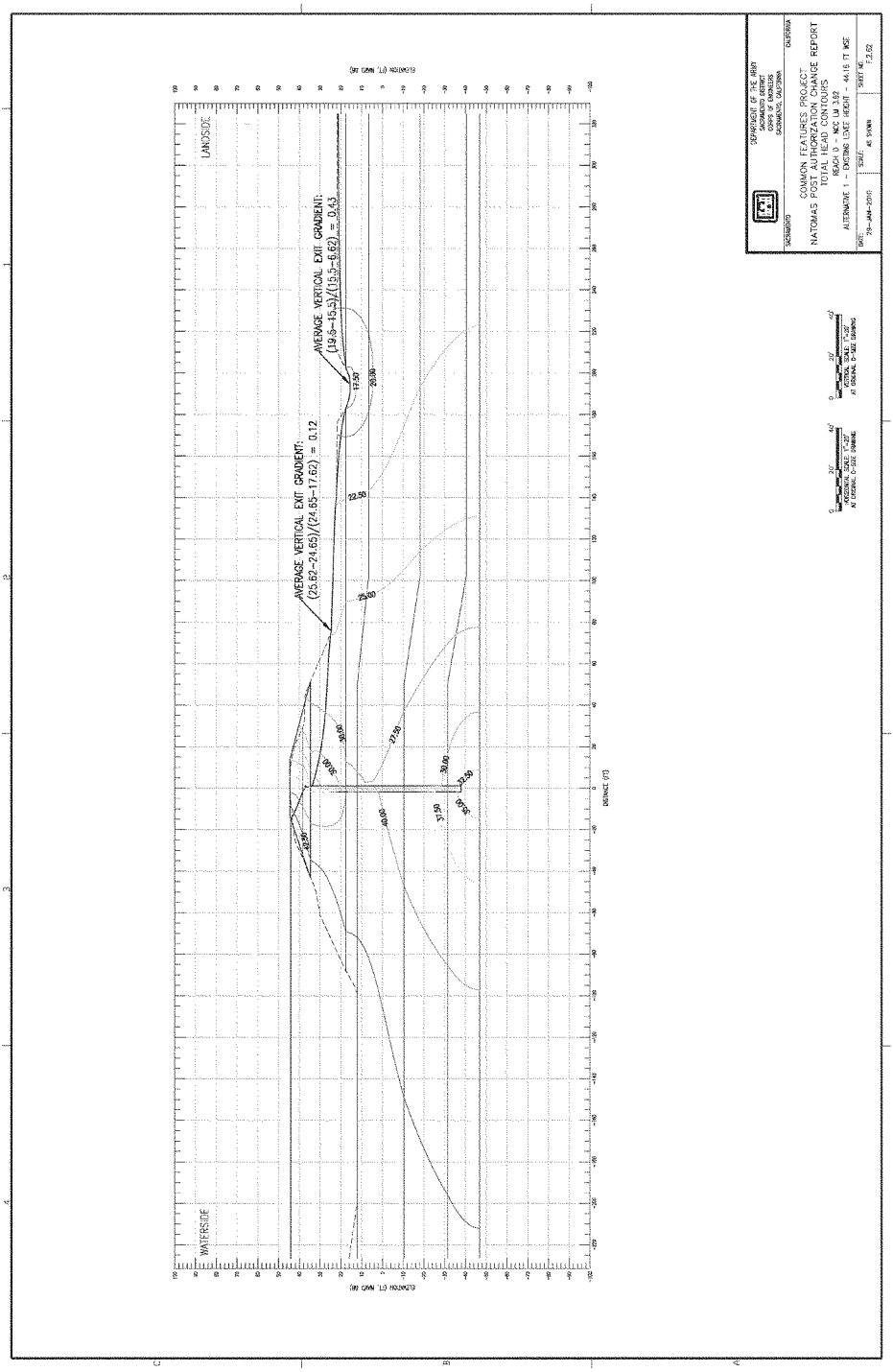
Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

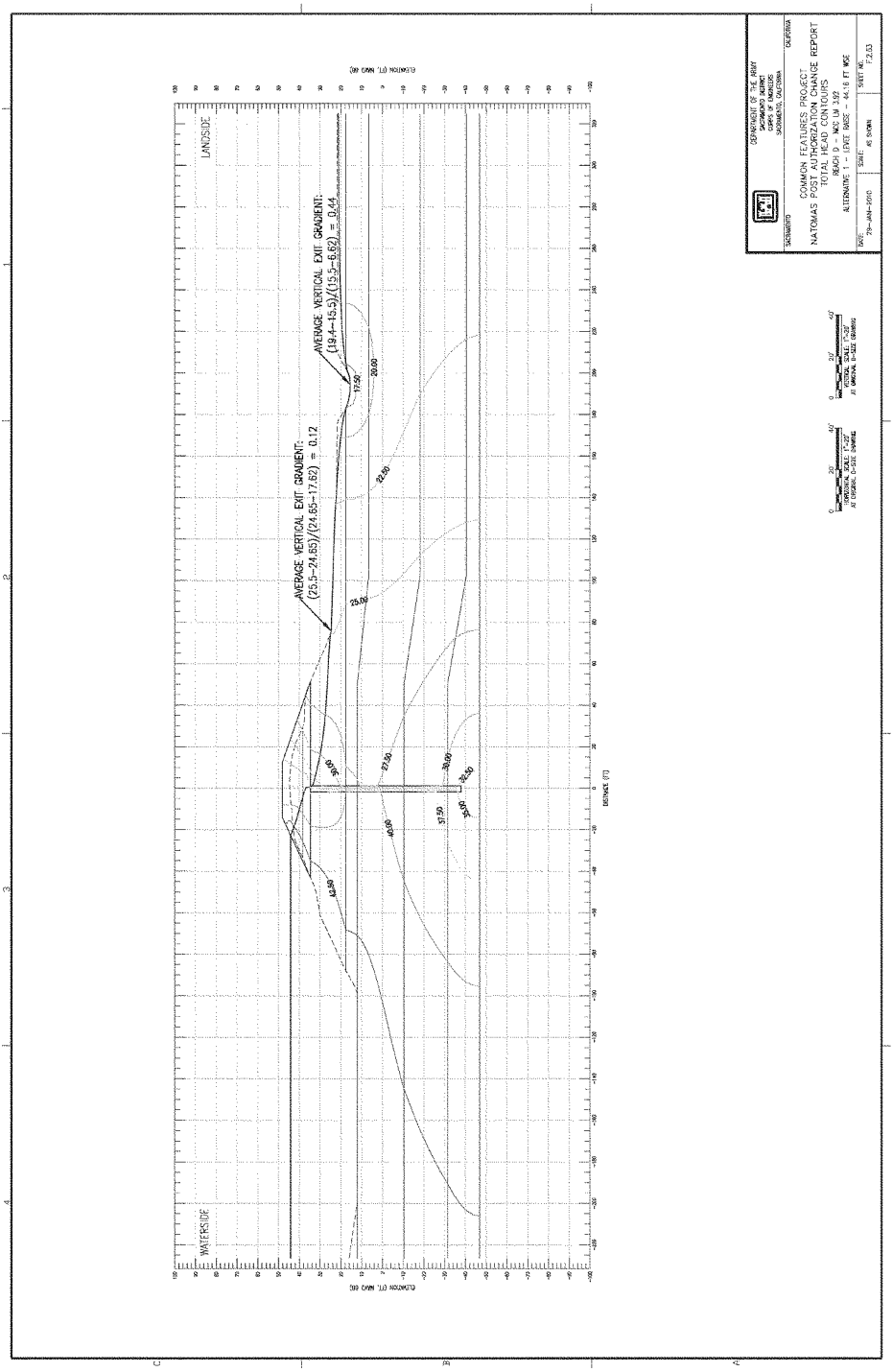
PLOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

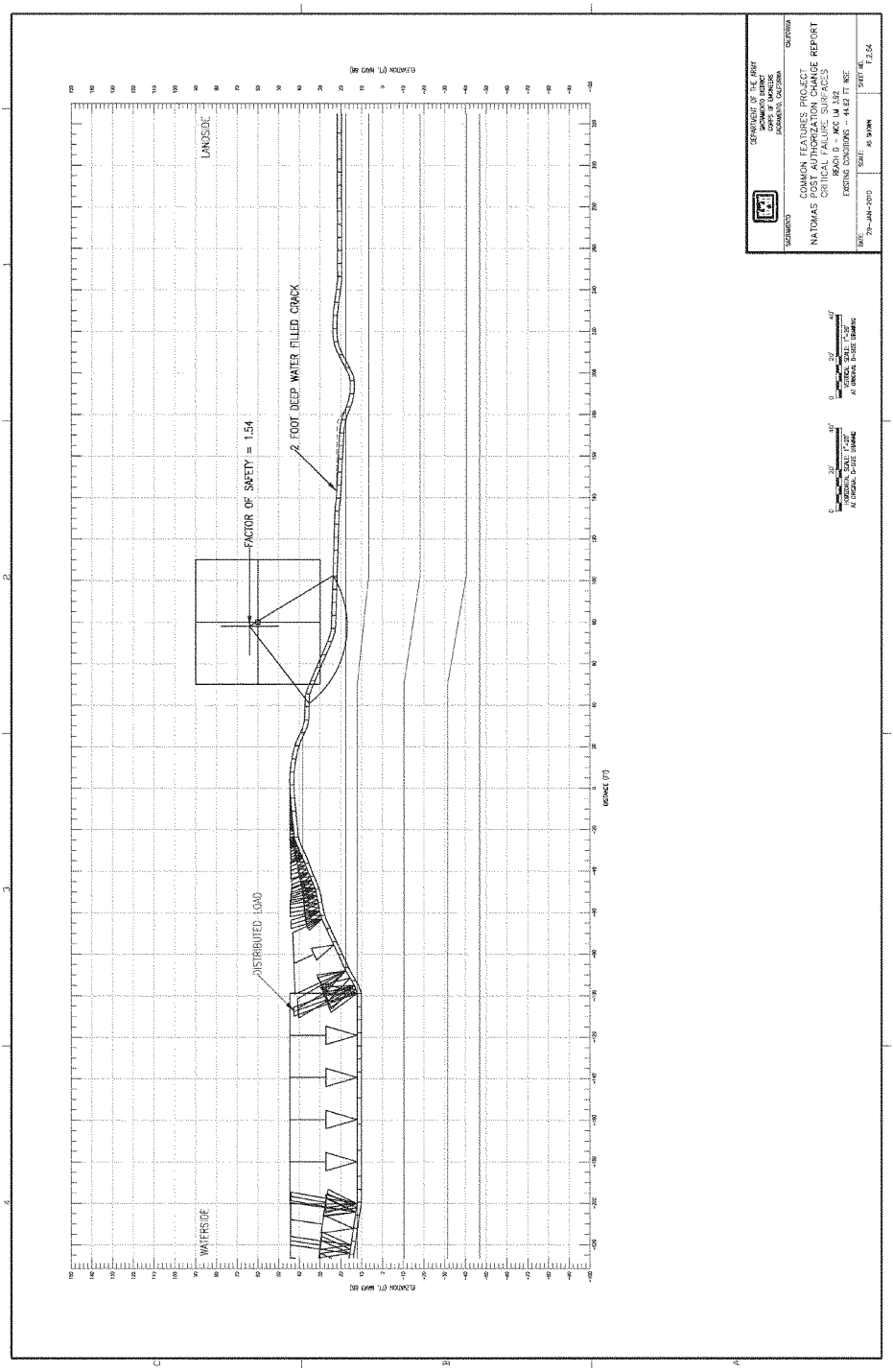

FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
30
35
40
45
50
55
60
9
14
19
24
29
34
39
12a 9
12b 11 3.25
Sandy SILT (ML): Gray brown, moist, firm, about 30% fine sand
13a 9
13b 17 21
25
Silty SAND (SM): Brown, moist, fine to medium sand, about 25% fines
14a 10
14b 11 10 1.75
SILT With Sand (ML): Gray brown, moist, firm, about 15% fine sand
15a 11
15b 14 17 4.0
Silty SAND (SM): Brown, moist, fine sand, about 20% fines
LEAN CLAY With Sand And Gravel (CL): Brown, moist, firm, about 10% fine to coarse sand, about 5% fine gravel
16a 7
16b 23 28
10
Poorly Graded SAND With Silt (SP-SM): Brown, moist, about 10% fines
17a 8
17b 18 17 3.25
LEAN CLAY (CL): Brown, moist, hard
18a 7
18b 14 14 >4.5
Firm
19a 17
19b 20 28 >4.5
SILT With Sand (ML): Olive brown, moist, very hard, about 10% fine sand
20a 10
20b 12 14
LEAN CLAY (CL): Olive brown, moist, firm, about 5% fine sand
21a 5
21b 7 11
SILT With Sand (ML): Olive brown, moist, firm, about 10% fine sand
22a 3
22b 5 7 .25
63
Sandy SILT (ML): Olive gray, moist to wet, firm, about 37% fine sand
23a 8
23b 10 20 3.25
24a 13
24b 18 25 >4.5
Very hard
PLOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07
Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06
LOG OF BORING NCCB-6- 5
NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA
PLATE
2 of 3
A-7

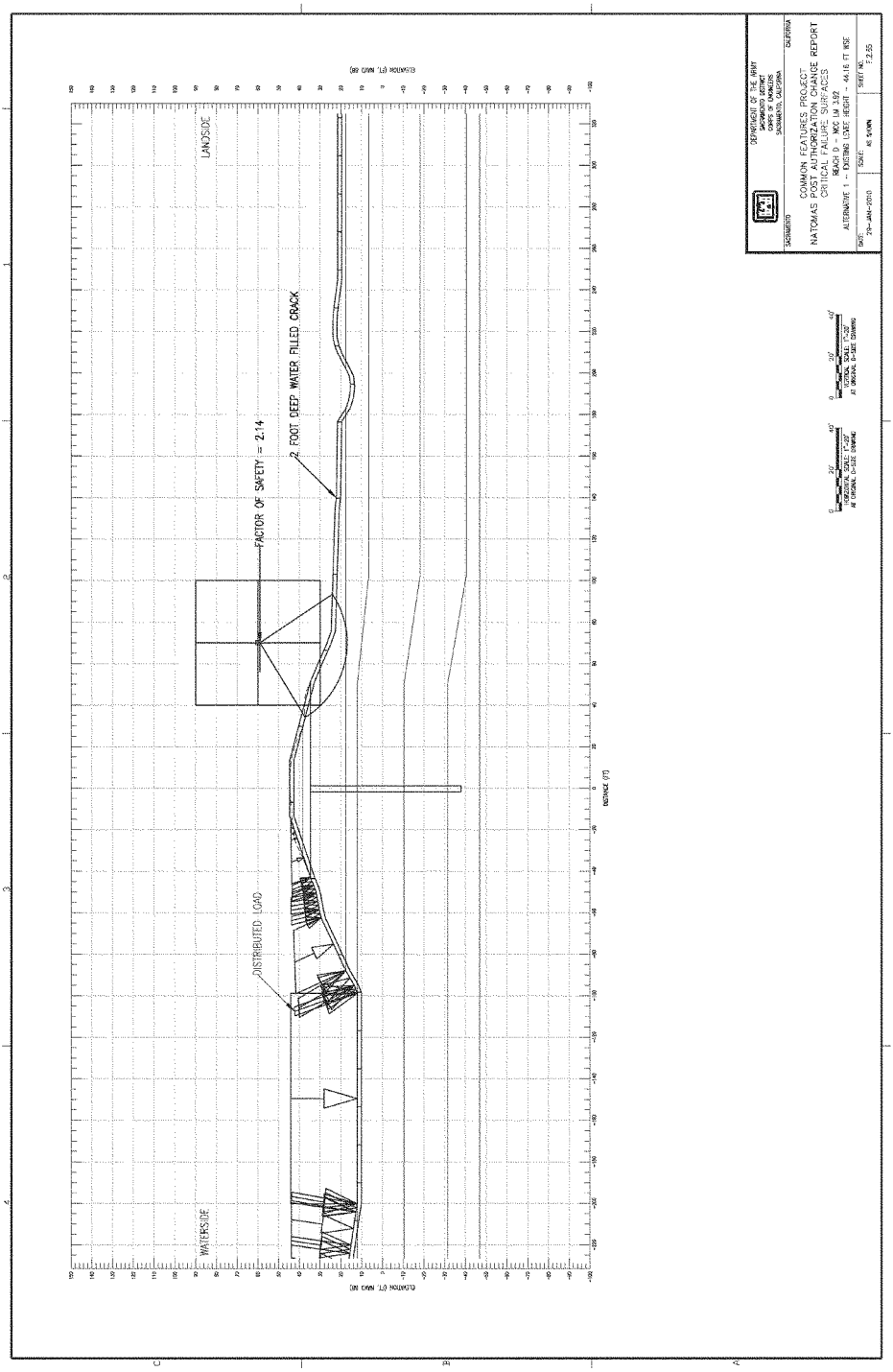

FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
44
65
49
70
54
75
59
80
64
85
69
90
74
95
25a
25b
8
12
16
47
Silty SAND (SM): Brown, moist, fine sand, about 47% fines
Boring completed at a depth of 66-1/2 feet below existing site grade.
PLOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07
LOG OF BORING NCCB-6- 5
NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA
Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06
PLATE
3 of 3
A-7

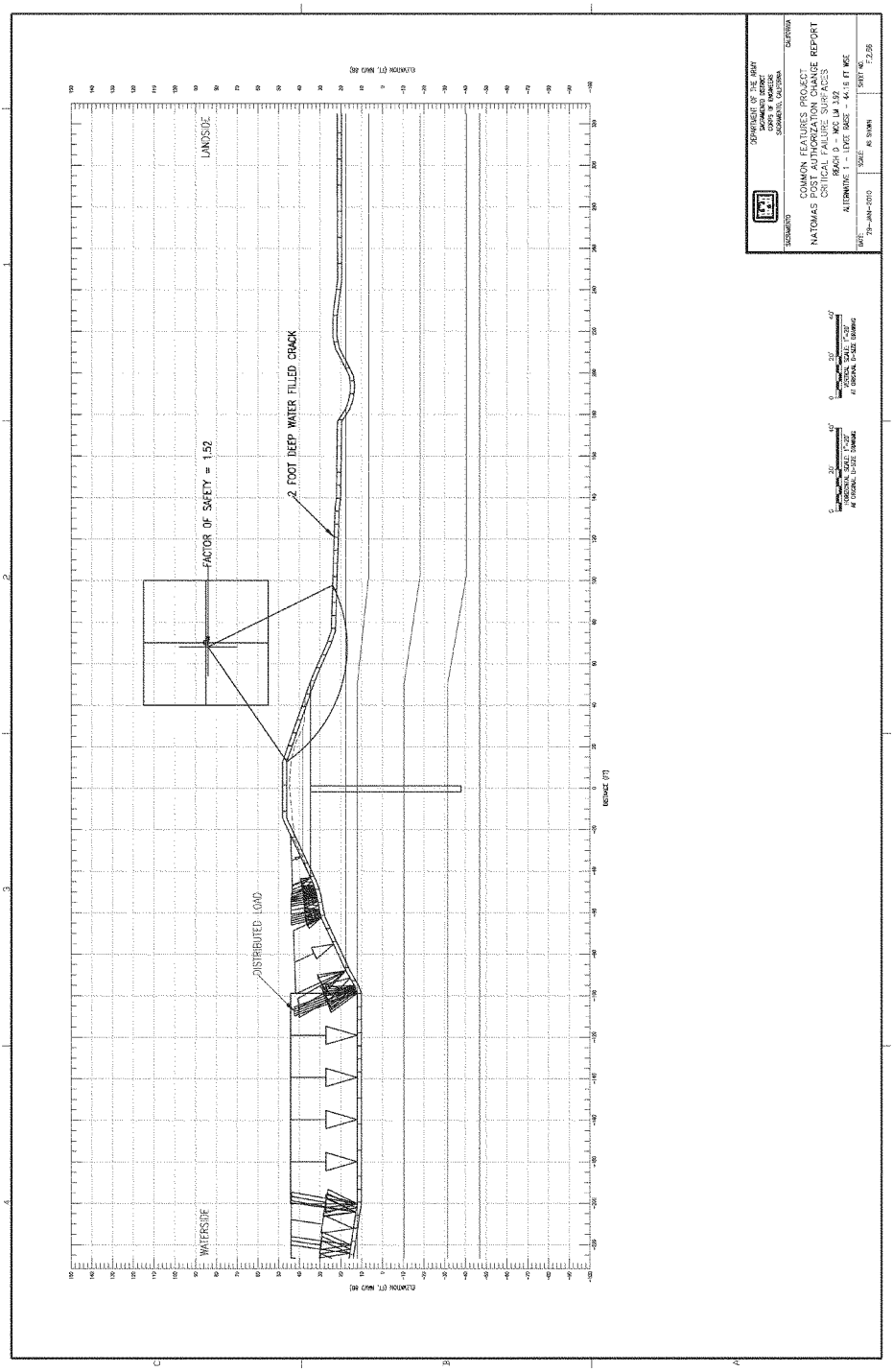

WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
AVERAGE VERTICAL EXIT GRADIENT:
(29.77-24.51)/(24.51-17.62) = 0.76
42.50
37.50
32.50
27.50
22.50
17.50
12.50
7.50
2.50
-2.50
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
SECTION A-A' (LOOKING WEST)
EXISTING CONDITIONS - 44.50 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.51

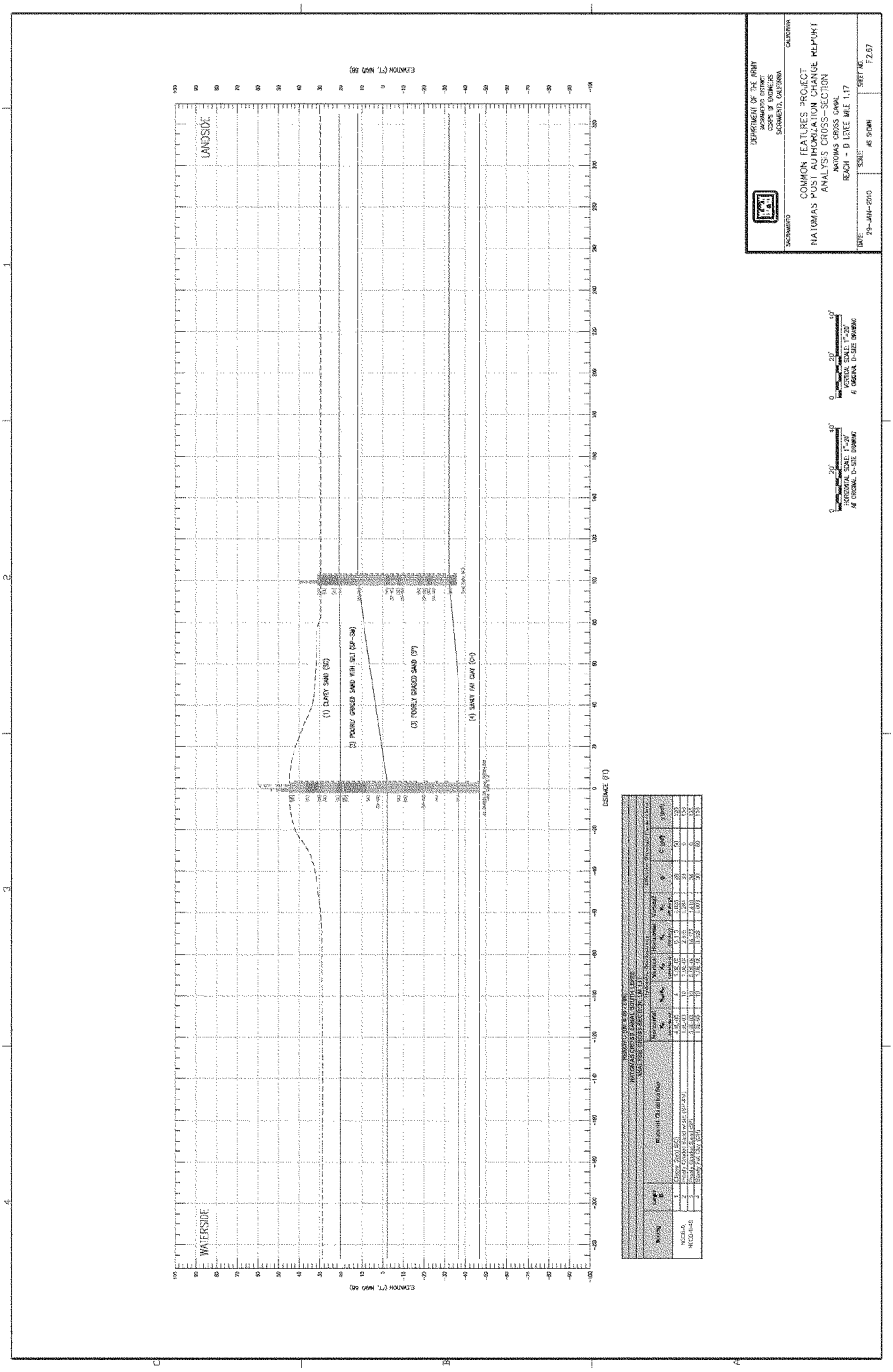

AVERAGE VERTICAL EXIT GRADIENT:
(25.62-24.65)/(24.65--17.62) = 0.12
AVERAGE VERTICAL EXIT GRADIENT:
(19.6-15.5)/(19.5-6.62) = 0.43
LANDSIDE
WATERSIDE
ELEVATION (FT NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT - 44.16 FT MSF
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F-2.02

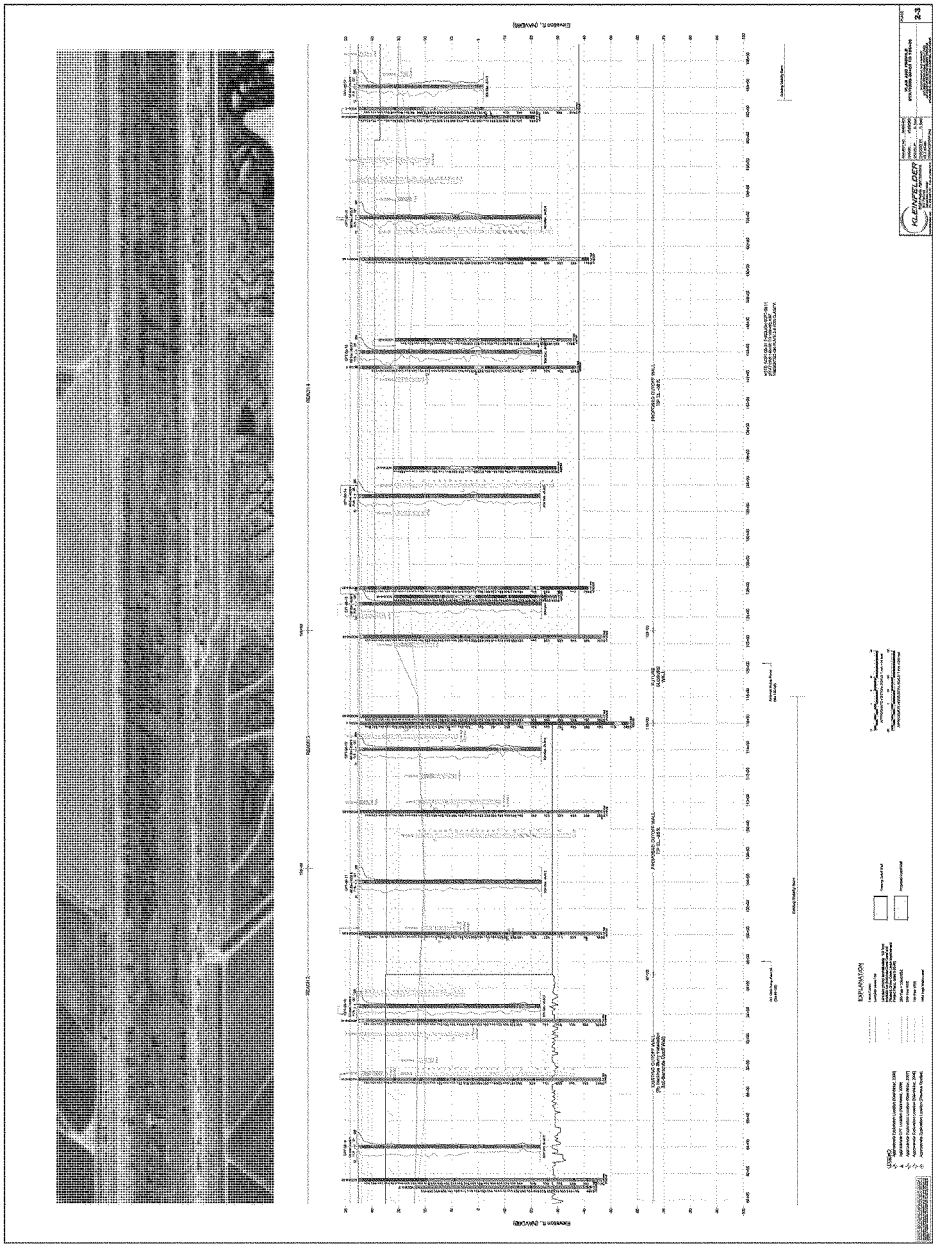

AVERAGE VERTICAL EXIT GRADIENT:
(25.5-24.65)/(24.65-17.62) = 0.12
AVERAGE VERTICAL EXIT GRADIENT:
(19.4-15.5)/(15.5-6.62) = 0.44
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
ALTERNATIVE 1 - LEVEE RAISE - 44.16 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F-2.03


LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 1.54
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH D, MILE 19.8
EXISTING CONDITIONS
WSE = 44.62 FT.
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.54


FACTOR OF SAFETY = 2.14
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH D, MILE 58.1
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT - 44.16 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.55


LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 1.52
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH 5, RIVER MILE 54.1
ALTERNATIVE 1 - LEVEE RAISE - 44.16 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.56


WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
(1) LEAN CLAY (CL)
(2) POORLY GRADED SAND WITH SILT (SP-SM)
(3) POORLY GRADED SAND (SP)
(4) LEAN TO FAT CLAY (CL)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
NATOMAS CROSS CANAL
REACH - D LEVEE MILE 1.17
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 7.2.07



Surface Conditions: Gravel road on levee crown

Groundwater: Groundwater initially encountered at a depth of about 24.5 feet below existing site grade.

Method: Hollow Stem Auger/Mud Rotary

Equipment: CME 85 with 140lb. Automatic Hammer

Date Completed: 8/1/2005

Logged By: Abhi Shethji

Total Depth: 81-1/2 feet

Boring Diameter: 8 inch and 4 inch

Approximate Elevation: 43 feet (NGVD29*)
Approximate Northing: 2057017.53 feet
Approximate Easting: 6686476.41 feet

Elevation (ft, msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														GRAVEL
			1a	9										**Clayey SAND** (SC): Brown, moist to dry, fine grained, about 40% clay, (FILL)
			1b	6										
38	5		2a	5										Trace of coarse gravels
			2b	4										
			3a	3										About 30% clay
			3b	3										
33	10		4a	9										
			4b	8										
			5a	10										Grayish brown and yellow, mottled
			5b	9							35			
28	15		6a	6										Brown, about 40% clay
			6b	6										
			7a	10										
			7b	8										
23	20		8a	12	4.5									**LEAN CLAY** (CL): Brown, moist, very hard, about 20% fine sand, (NATIVE)
				50										Switched to mud rotary
			9a	18										**Clayey SAND** (SC): Brown, moist, fine to coarse grained, about 40% clay
			9b	26										
18	25		10a	45										**Poorly Graded SAND** (SP): Brown, wet, fine to medium grained
			10b	26										
			11a	41										
			11b	50						100	6	Sieve; see Plate B-3		
				19										
				19										
				20										

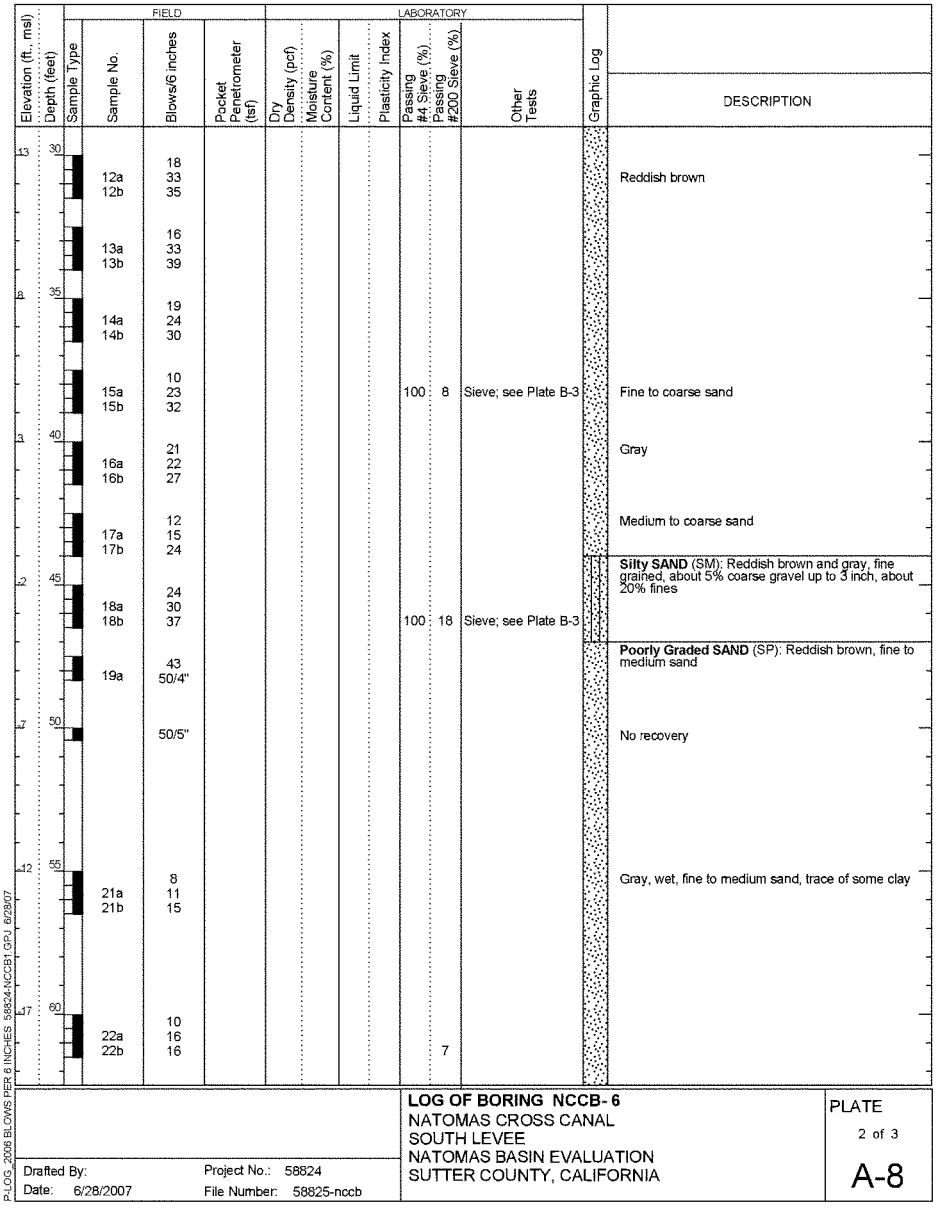
Drafted By:
Date: 6/28/2007

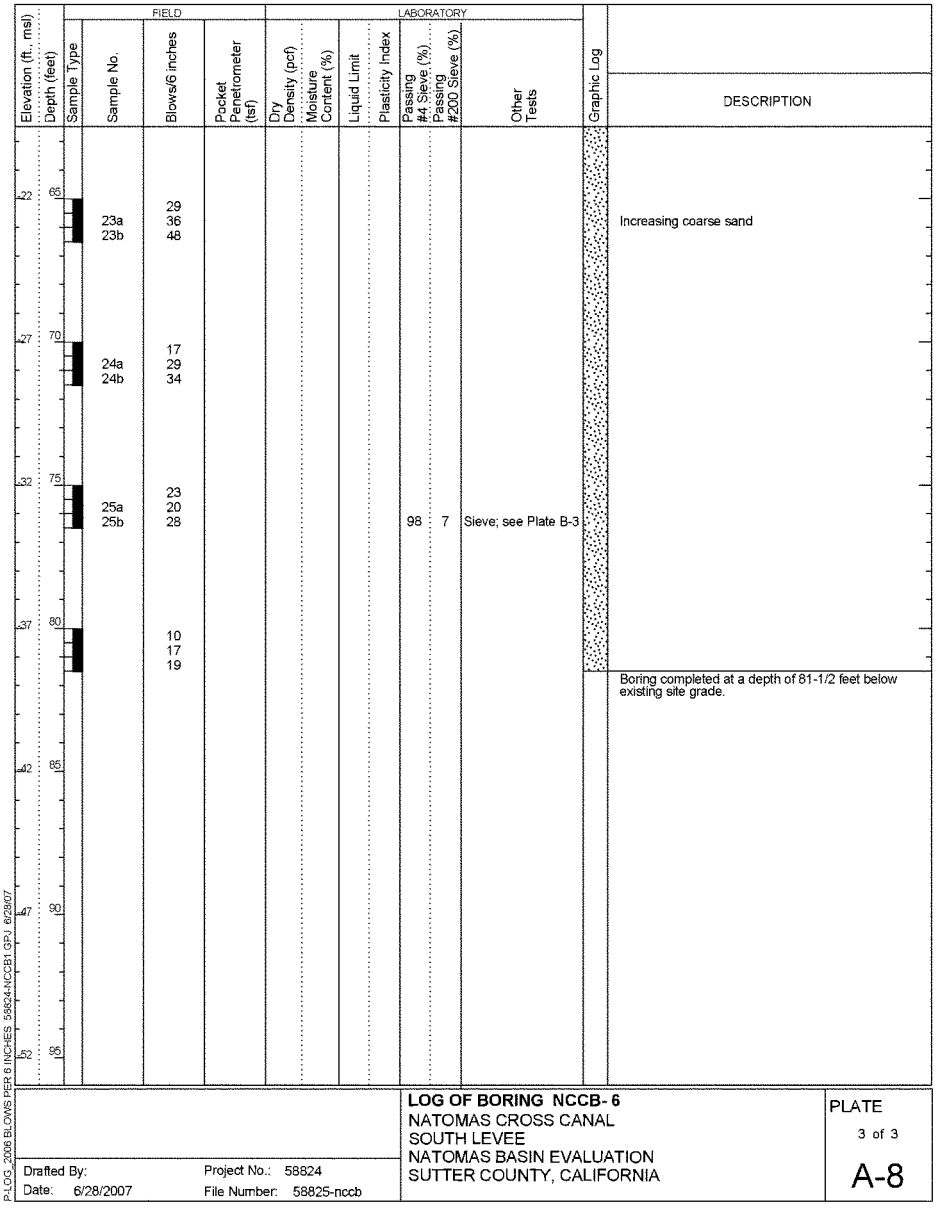
Project No.: 58824
File Number: 58825-nccb

LOG OF BORING NCCB- 6
NATOMAS CROSS CANAL
SOUTH LEVEE
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 3
A-8

P:\LOG_2006 BLOWS PER 6 INCHES_58824-NCCB1.GPJ 6/28/07


FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
30
35
40
45
50
55
60
18
12a 33
12b 35
16
13a 33
13b 39
19
14a 24
14b 30
10
15a 23
15b 32
100 8 Sieve; see Plate B-3
21
16a 22
16b 27
12
17a 15
17b 24
24
18a 30
18b 37
100 18 Sieve; see Plate B-3
43
19a 50/4"
50/5"
8
21a 11
21b 15
10
22a 16
22b 16 7
Reddish brown
Fine to coarse sand
Gray
Medium to coarse sand
Silty SAND (SM): Reddish brown and gray, fine grained, about 5% coarse gravel up to 3 inch, about 20% fines
Poorly Graded SAND (SP): Reddish brown, fine to medium sand
No recovery
Gray, wet, fine to medium sand, trace of some clay
PLOG_2006 BLOWS PER 6 INCHES 58824-NCCB1.GPJ 6/28/07
Drafted By:
Date: 6/28/2007
Project No.: 58824
File Number: 58825-nccb
LOG OF BORING NCCB- 6
NATOMAS CROSS CANAL
SOUTH LEVEE
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA
PLATE
2 of 3
A-8


FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
65
23a
23b
29
36
48
Increasing coarse sand
70
24a
24b
17
29
34
75
25a
25b
23
20
28
98
7
Sieve; see Plate B-3
80
10
17
19
Boring completed at a depth of 81-1/2 feet below existing site grade.
85
90
95
22
27
32
37
42
47
52
P:\LOG_2006 BLOWS PER 6 INCHES 58824-NCCB1.GPJ 6/29/07
Drafted By:
Date: 6/28/2007
Project No.: 58824
File Number: 58825-nccb
LOG OF BORING NCCB- 6
NATOMAS CROSS CANAL
SOUTH LEVEE
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA
PLATE
3 of 3
A-8

Surface Conditions: Levee toe, vegetation
(*Conversion from NGVD29 to NAVD88 is +2.57ft.)
Groundwater: Groundwater not measured.
Method: Mud Rotary
Equipment: CME 75 with 140lb. Automatic Hammer

Date Completed: 5/3/2007
Logged By: B. Von Dessonneck
Total Depth: 66-1/2 feet
Boring Diameter: 4 inch

Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
			FIELD		LABORATORY								
			7										**Sandy FAT CLAY** (CH): Brown (7.5YR 4/3), dry, firm, high plasticity, fine to coarse sand, high dry strength, slow dilatancy, medium toughness
		1a	14										
		1b	15										
			6										**LEAN CLAY** (CL): Brown (7.5YR 4/3), dry, firm, medium plasticity, medium dry strength, slow dilatancy, medium toughness
		2a	10										
		2b	12										
5			9										
		3a	11										
		3b	12										
			3										**FAT CLAY** (CH): Brown (7.5YR 4/3), moist, firm, high plasticity, high dry strength, slow dilatancy, medium toughness
		4a	4										
		4b	7	1.5									
10			7										**Silty SAND** (SM): Brown (7.5YR 4/3), wet, fine to medium sand
		5a	13							23			
		5b	15										
			9										
		6a	14										
		6b	22										
15			14										
		7a	18										
		7b	21							15			
			11										
		8a	11										
		8b	16										
20			9										**Poorly Graded SAND With Silt** (SP-SM): Brown (7.5YR 4/3), wet, fine to medium sand
		9a	16										
		9b	22							6			
			16										
		10a	15										Gray brown (2.5Y 5/2)
		10b	17										
25			6										
		11a	10										
		11b	12						100	5			Fine to coarse sand
			6										
		12a	14										
		12b	23										

Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

LOG OF BORING NCCB-6-49

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 3

PLOG_2006 BLOWS PER 6 INCHES 72834NCC07.GPJ 6/28/07

Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
30			20										
		13a	42										
		13b	40										Red brown (5YR 4/3), fine to medium sand
			45										
		14a	47										**Clayey SAND** (SC): Gray (7.5YR 5/1), wet, fine to coarse sand
		14b	39										
35			33										
		15a	48										**Poorly Graded SAND With Clay** (SP-SC): Olive gray (5Y 5/2), wet, fine to coarse sand
		15b	50							7			
			15										
		16a	16										**Clayey SAND** (SC): Gray (7.5YR 5/1), wet, fine to coarse sand
		16b	20										
40			6										
		17a	8										**Poorly Graded SAND With Silt** (SP-SM): Gray (7.5YR 5/1), wet, fine to coarse sand
		17b	16							11			
			11										
		18a	15										
		18b	17										
45			12										
		19a	15										
		19b	15						98	11			
			4										
		20a	5										**Silty SAND** (SM): Gray (7.5YR 5/1), wet, fine to coarse sand
		20b	17										
50			16										
		21a	26										**Poorly Graded SAND With Silt** (SP-SM): Gray (7.5YR 5/1), wet, fine to medium sand
		21b	27							8			
			23										
		22a	24										**Clayey SAND With Gravel** (SC): Gray (7.5YR 5/1), wet, fine to coarse sand, fine gravel
		22b	30										
55			19										
		23a	26										**Poorly Graded SAND With Silt** (SP-SM): Gray (7.5YR 5/1), wet, fine to coarse sand
		23b	21							11			
			11										
		24a	19										
		24b	22										
60			6										
		25a	12										
		25b	13	1.7						11			
													Sandy FAT CLAY (CH): Greenish gray (GLEY 2

FIELD

LABORATORY

LOG OF BORING NCCB-6-49

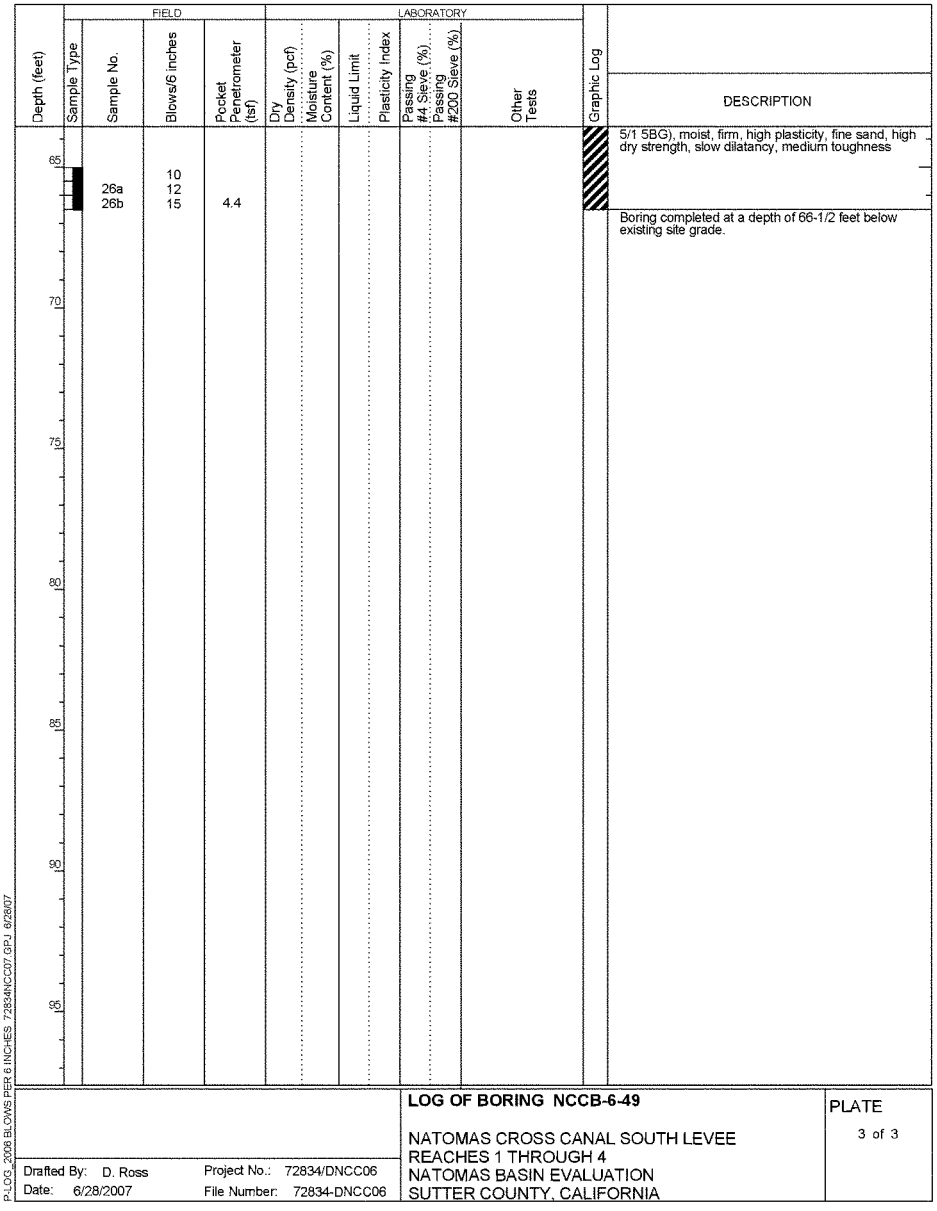
NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
2 of 3

Drafted By: D. Ross
Date: 6/28/2007

Project No.: 72834/DNCC06
File Number: 72834-DNCC06

P:\LOG_2006 BLOWS PER 6 INCHES\ 72834\NCC07.GPJ 6/28/07



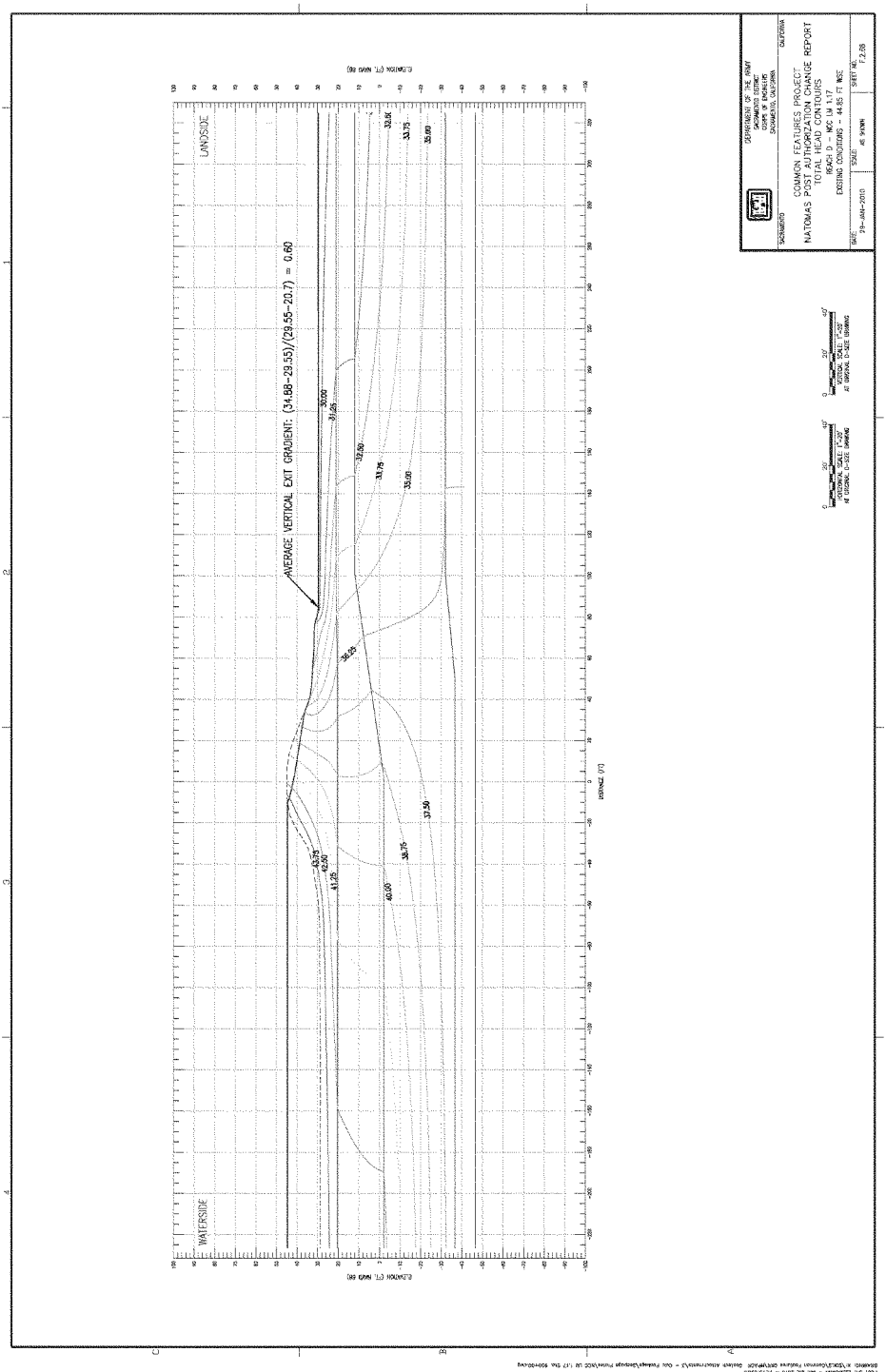
PLOG_2006 BLOWS PER 6 INCHES 72834NCC07.GPJ 6/28/07

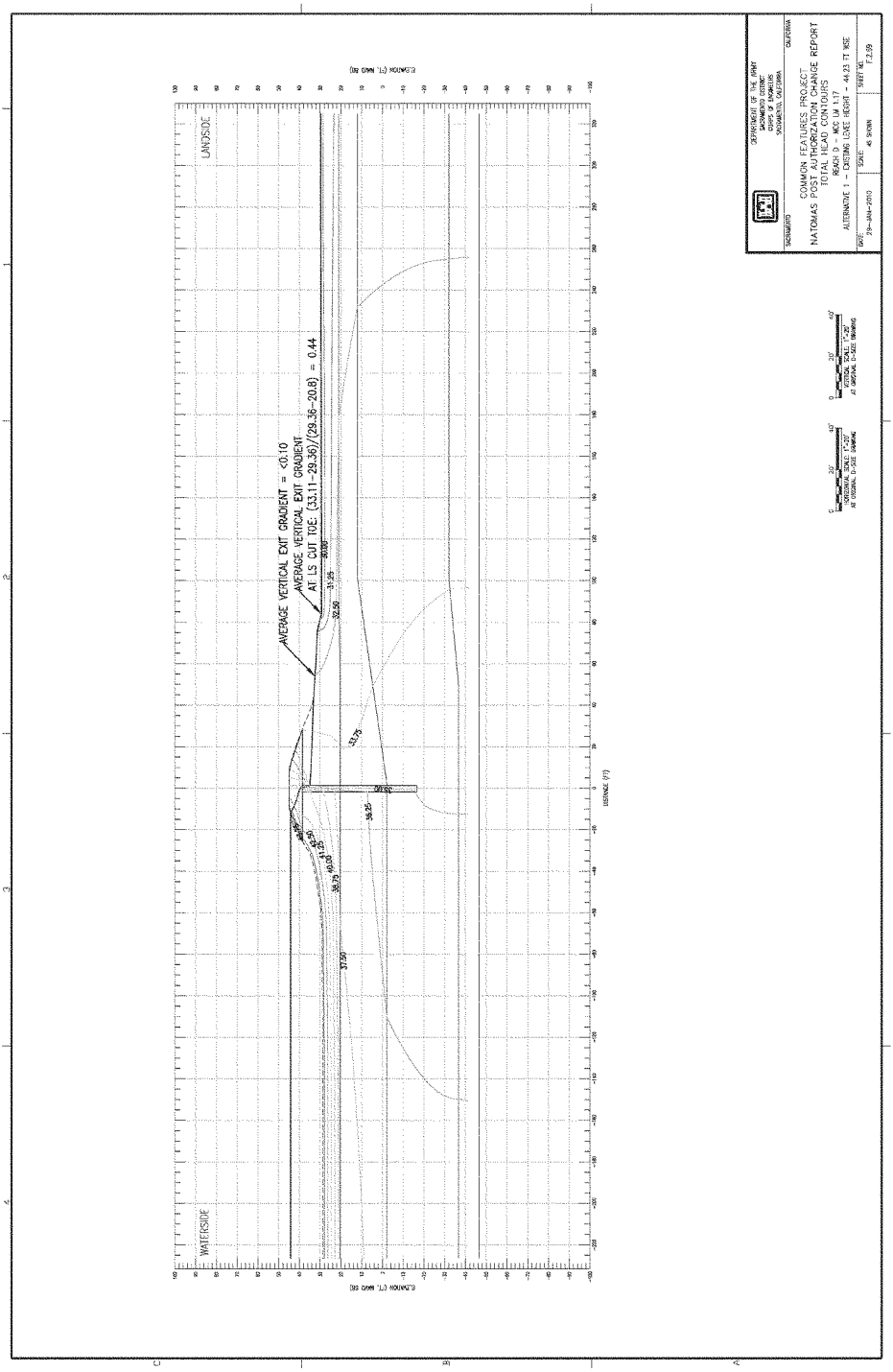
Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

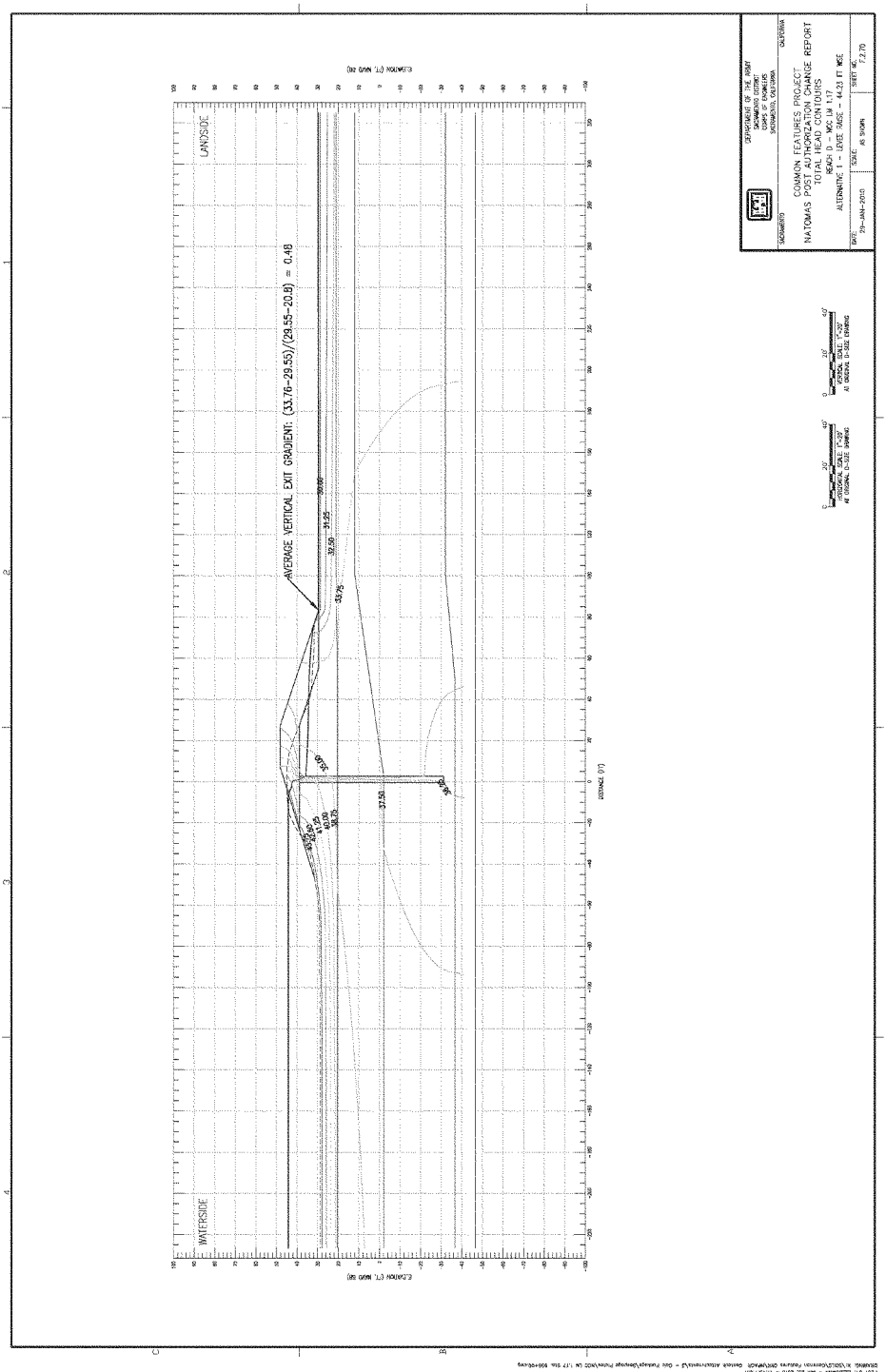
LOG OF BORING NCCB-6-49

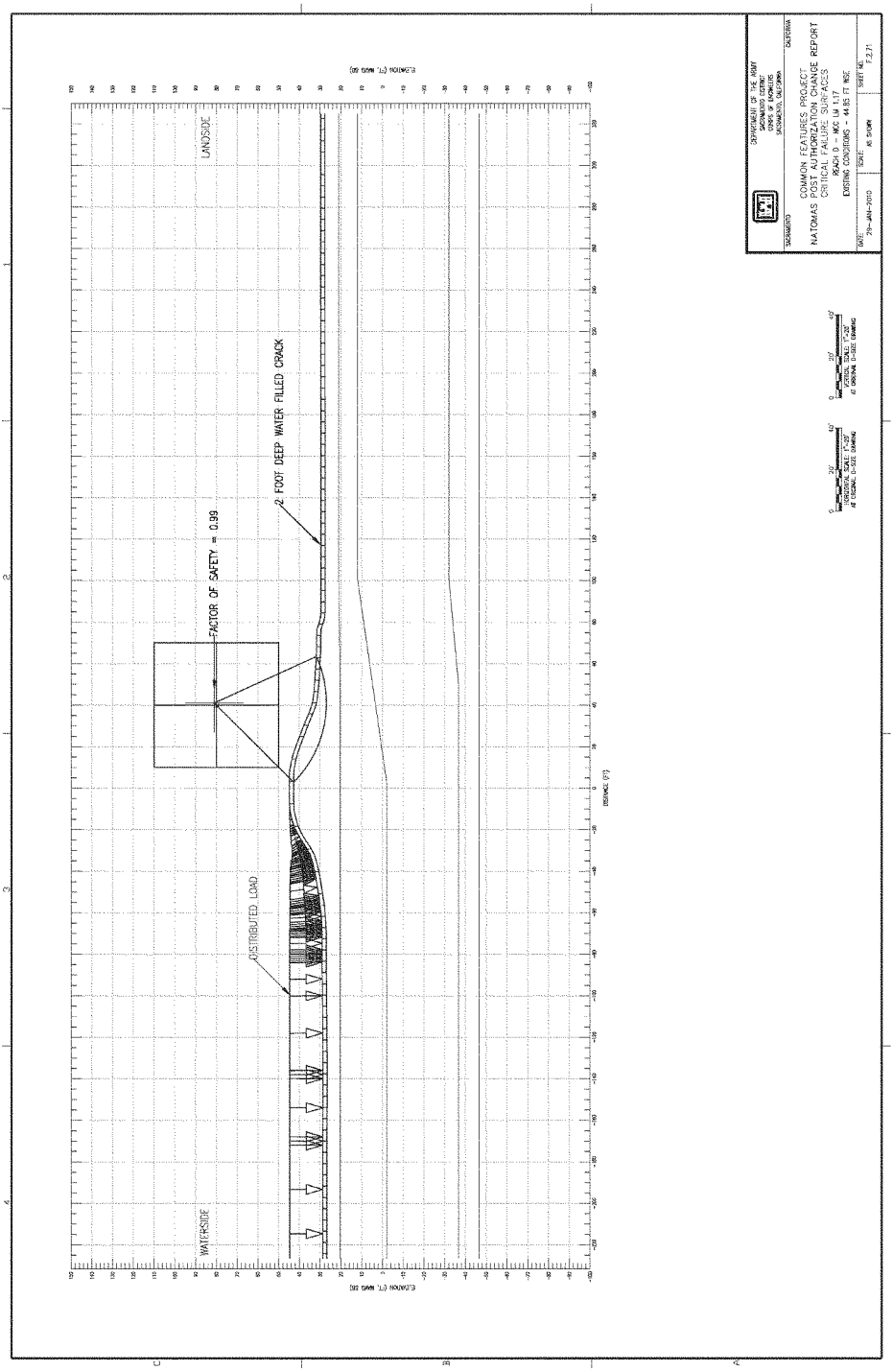
NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

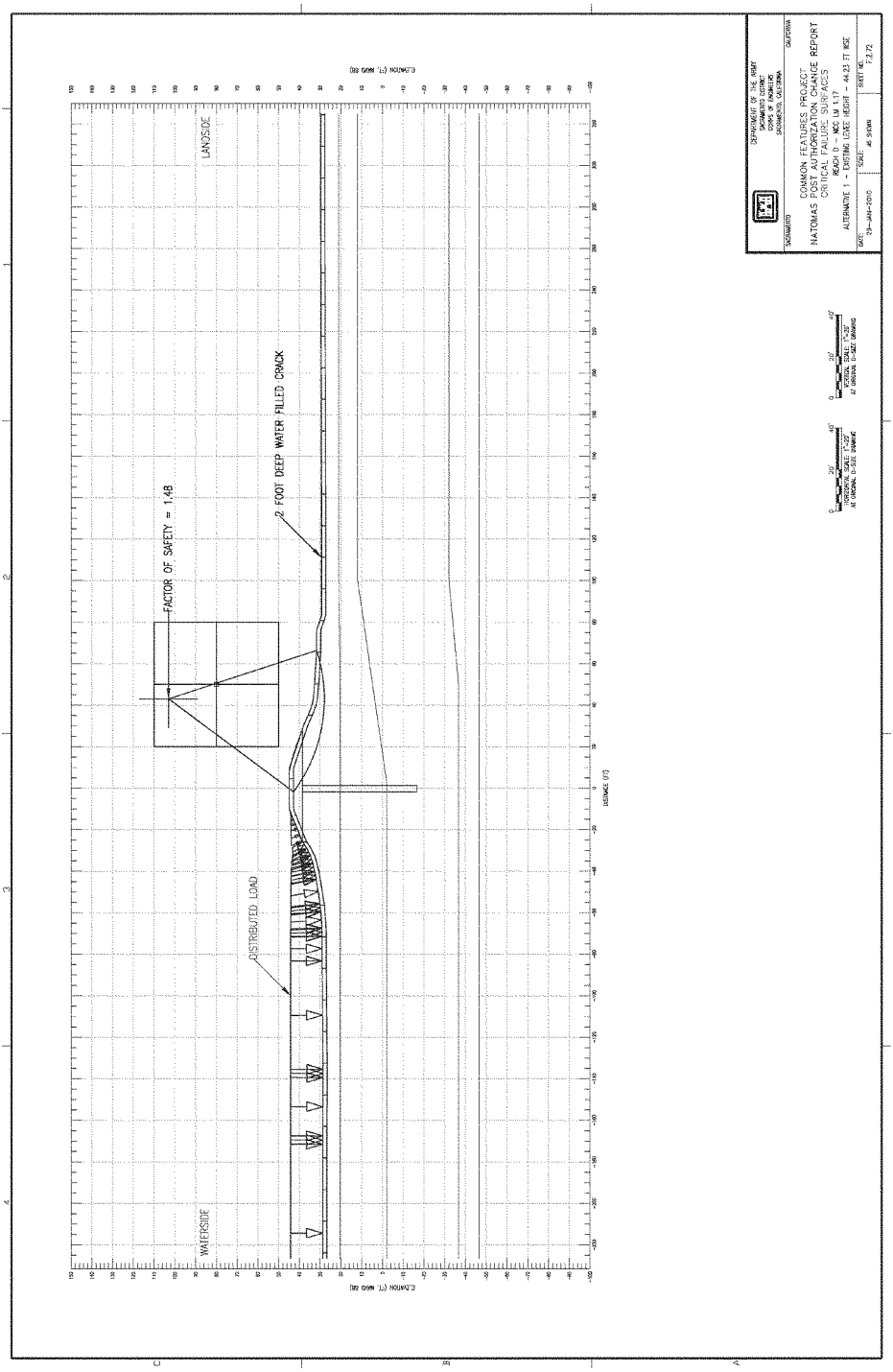
PLATE
3 of 3

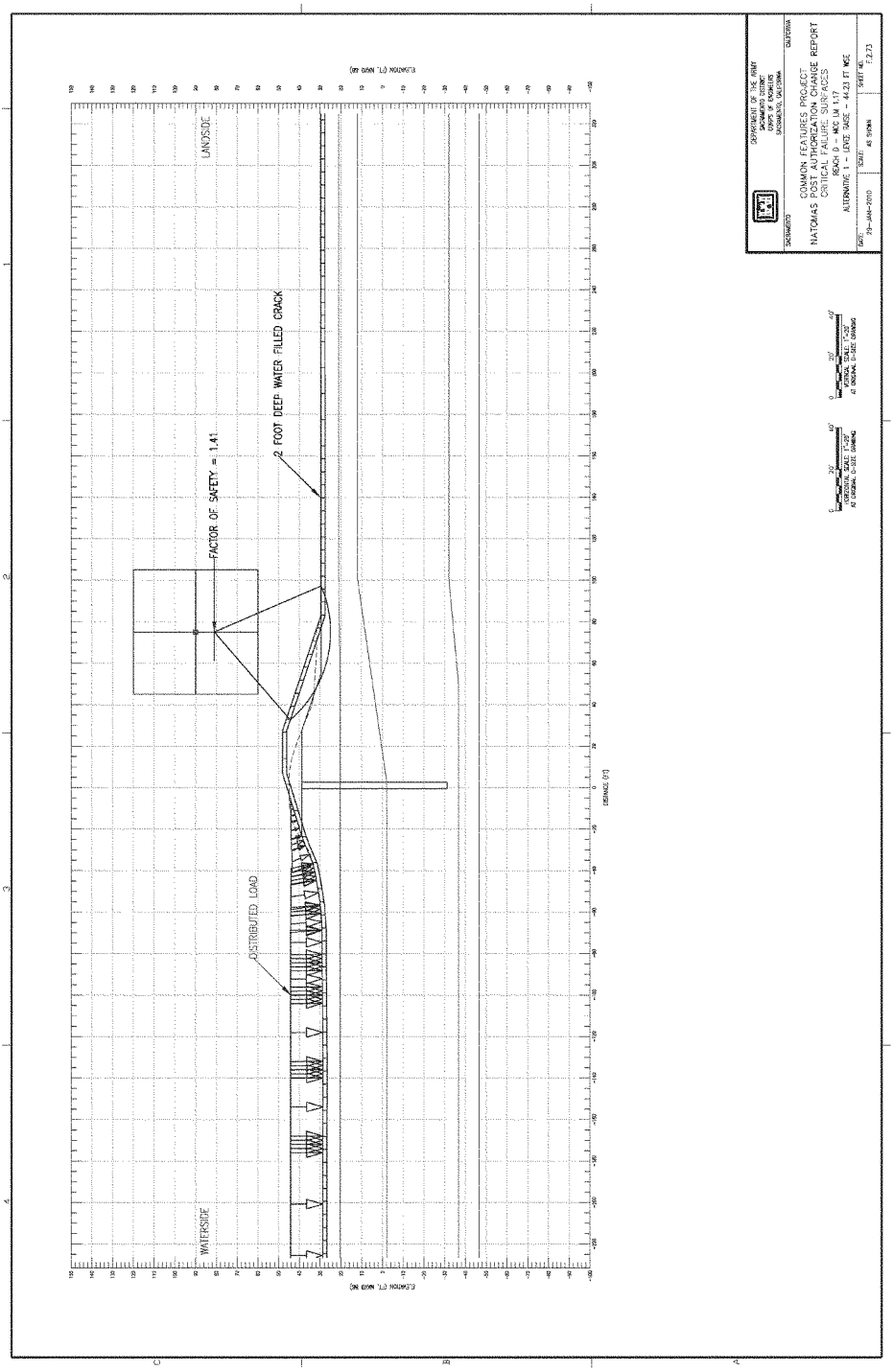

AVERAGE VERTICAL EXIT GRADIENT: (34.68-29.55)/(29.55-20.7) = 0.60
WATERSIDE
LANDSIDE
ELEVATION (FT NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH D, WITH 3 FT WSE
EXISTING CONDITIONS - 44.65 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.05


AVERAGE VERTICAL EXIT GRADIENT = <0.10
AVERAGE VERTICAL EXIT GRADIENT
AT LS CUT TOE: (33.11-29.36)/(29.36-20.8) = 0.44
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A, RM 17.2
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 44.23 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.09


AVERAGE VERTICAL EXIT GRADIENT: (33.76-29.55)/(29.55-20.8) = 0.48
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A, NEAR STA 1+00
ALTERNATIVE 1 - LEVEE RAISE - 44.23 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.70


WATERSIDE
LANDSIDE
FACTOR OF SAFETY = 0.99
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
ELEVATION (FT MSL 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH D, MILE 17
EXISTING CONDITIONS - 44.65 FT WSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.21


FACTOR OF SAFETY = 1.48
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NGVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH D, MILE 12.7
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 44.23 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 72.72


WATERSIDE
LANDSIDE
DISTRIBUTED LOAD
FACTOR OF SAFETY = 1.41
2 FOOT DEEP WATER FILLED CRACK
ELEVATION (FT, NGVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, MILE 0.73
ALTERNATIVE 1 - LEVEE RAISE - 44.23 FT MSL
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.23

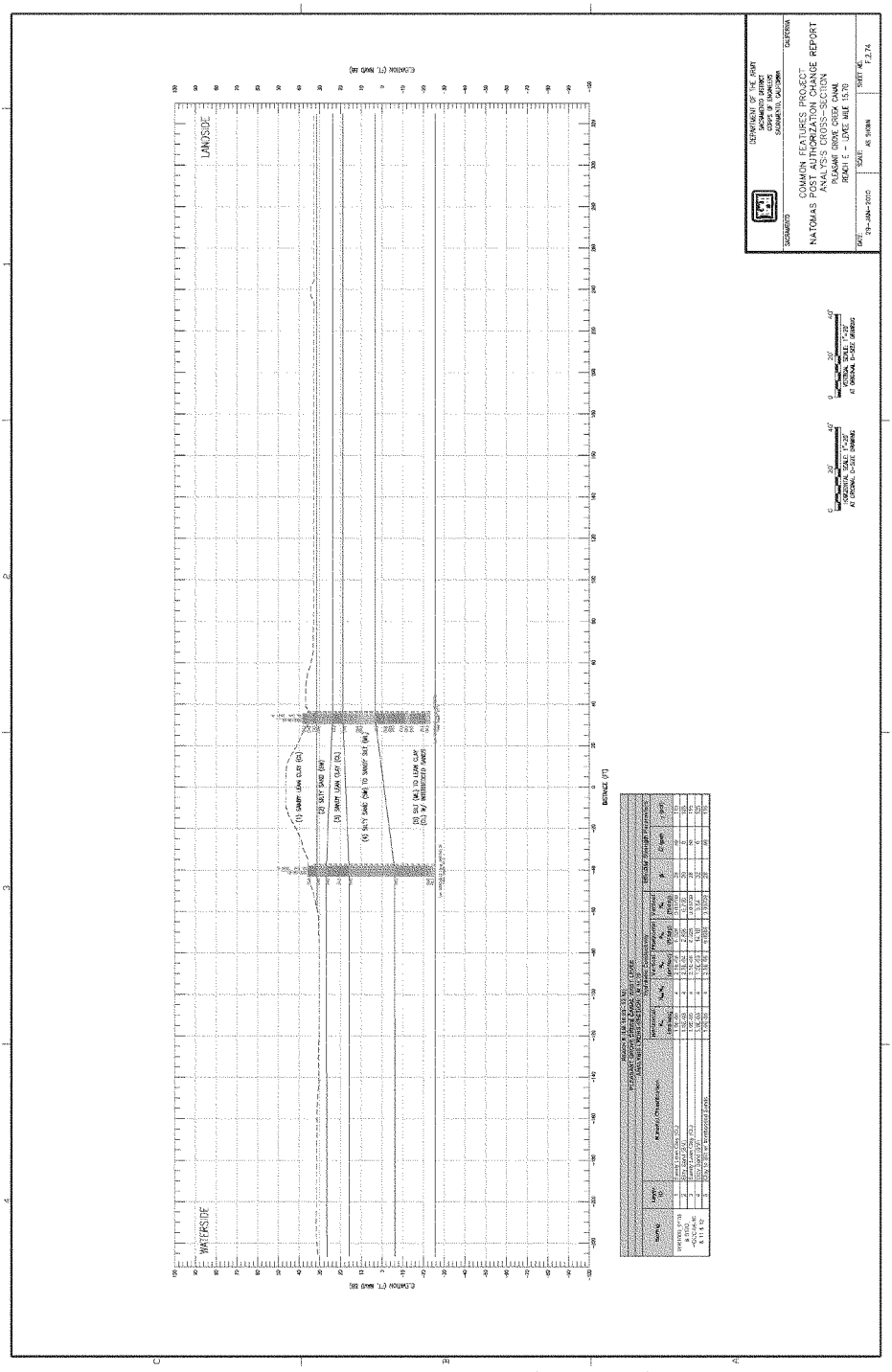
REACH E

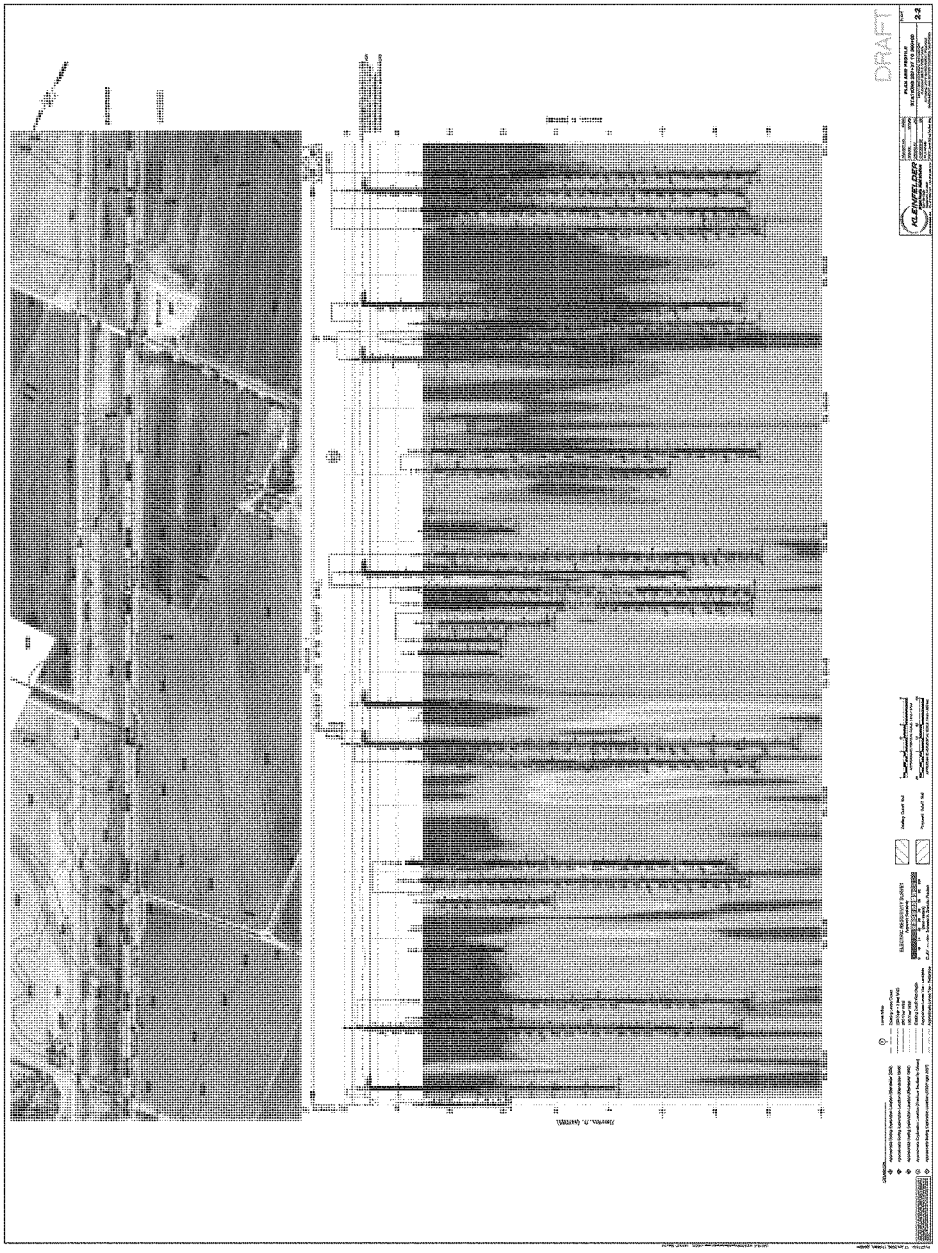
CALCULATION PACKAGE

PLEASANT GROVE CREEK CANAL WEST LEVEE

(PGCC)

LM 16.08 – 12.55


WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
(1) MED MED SANDS
(2) SILTY SAND
(3) SANDY LEAN CLAY
(4) MED TO COARSE SAND
(5) SILT AND CLAY
(6) SILTY SAND
(7) SANDY LEAN CLAY
(8) MED MED SANDS
(9) MED TO COARSE SAND
(10) SILT AND CLAY
(11) WATERSIDE SANDS
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
REACH F - LEVEE MILE 15.70
DATE
29-JAN-2010
SCALE
AS SHOWN
SHEET NO.
F2.74


DRAFT

Boring Location/ Surface Conditions: Existing waterside toe
Groundwater: Groundwater not measured due to drilling method.
Method: Mud Rotary
Equipment: CME 75 with 140 lb. Automatic Hammer

Date Completed: 4/3/2008
Logged By: J. Pemberton
Reviewed By: M. Briseno
Total Depth: 61-1/2 feet
Boring Diameter: 4 inch

Approximate Elevation: 36 feet (NAVD 88)
Approximate Northing: 2060539.23 feet
Approximate Easting: 6697163.78 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
			1b	2										**Sandy LEAN CLAY** (CL): Dark brown, moist, firm, low to medium plasticity, fine sand
			1a	6 15				31	15		54			
31	5		2b	9 12										**Silty SAND** (SM): Olive brown, moist, fine sand
			2a	15							39			
			3b	5 8										
			3a	5							20			
26	10		4b	2 7										**Sandy FAT CLAY** (CH): Light brown, moist, firm, high plasticity, fine to medium sand
			4a	10				50	28					
			5b	1 8										
			5a	12										
21	15		6b	6 18										**Sandy LEAN CLAY** (CL): Olive brown, moist, hard, low to medium plasticity, fine sand
			6a	14				25	12		60			
			7b	2 11										Red brown to blue gray, firm
			7a	16										
16	20		8b	7 7										**Silty SAND** (SM): Red brown, moist, fine to medium sand
			8a	6							44			
			9	4 7 5							13			Fine to coarse sand
11	25		10b	5 8										
			10a	15										
			11	5 7 7							24			Olive brown, fine sand

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Drafted By: D. Ross
Date: 10/27/2008
Project No.: 94582PGCC
File Number: 94582pgcc

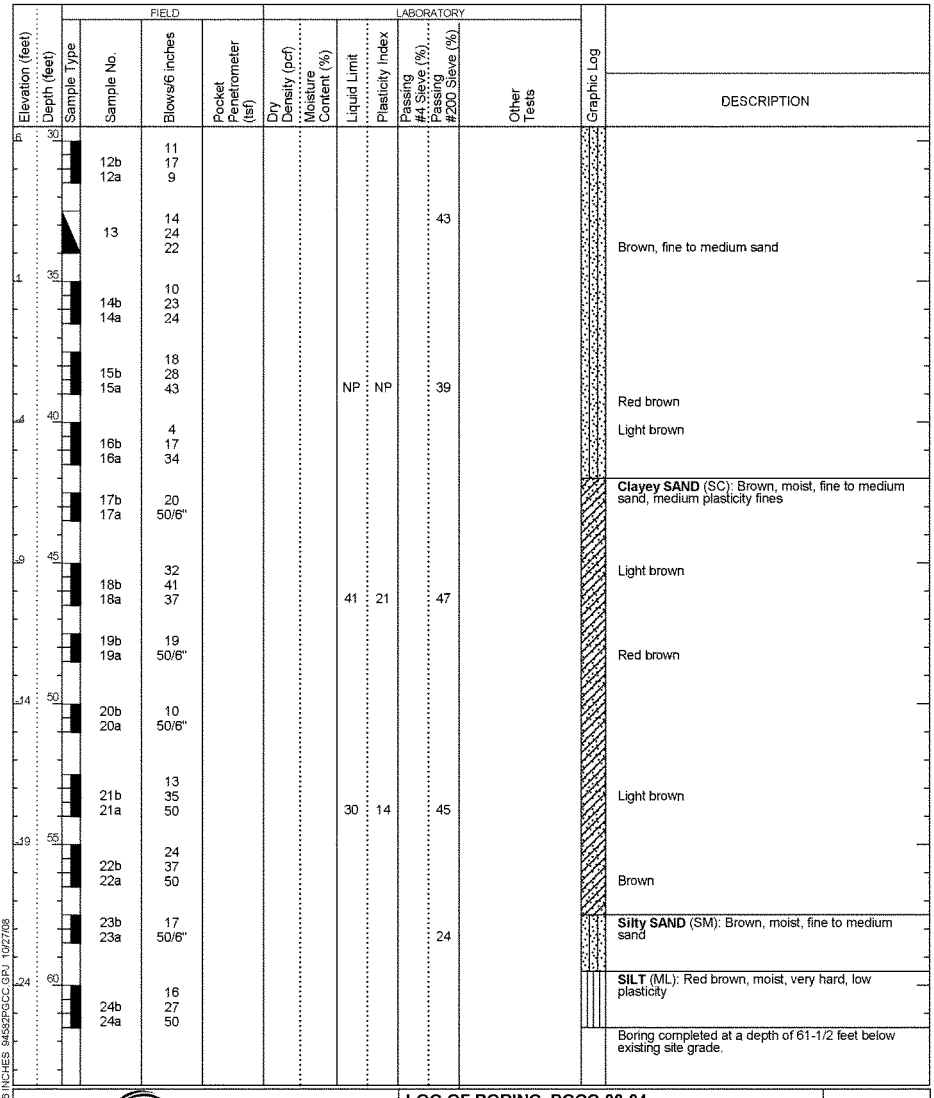
LOG OF BORING PGCC-08-04

PROBLEM IDENTIFICATION REPORT
PLEASANT GROVE CREEK CANAL
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO & SUTTER COUNTIES, CALIFORNIA

PLATE
1 of 2
A-5

P:\LOG_BLOWS PER 6 INCHES 94582\PGCC.GPJ 10/27/08

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Drafted By: D. Ross
Date: 10/27/2008
Project No.: 94582PGCC
File Number: 94582pgcc

LOG OF BORING PGCC-08-04

PROBLEM IDENTIFICATION REPORT
PLEASANT GROVE CREEK CANAL
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO & SUTTER COUNTIES, CALIFORNIA

PLATE
2 of 2
A-5

P:\LOG_BLOWS PER 6 INCHES 94582\PGCC.GPJ 10/27/08

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Boring Location/ Surface Conditions: Existing landside levee toe

Groundwater: Groundwater encountered at a depth of about 28 feet below existing site grade.

Method: Hollow Stem Auger

Equipment: CME 75 with 140 lb. Automatic Hammer

Date Completed: 6/23/2008

Logged By: D. Frazer

Reviewed By: M. Briseno

Total Depth: 61-1/2 feet

Boring Diameter: 8 inch

Approximate Elevation: 39 feet (NAVD 88)
Approximate Northing: 2060586.90 feet
Approximate Easting: 6697060.60 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														LEAN CLAY (CL): Dark brown, moist, soft, low to medium plasticity
			1	3 3 3										**Silty SAND** (SM): Dark brown, moist, fine sand
34	5		2b	3										**LEAN CLAY** (CL): Brown, moist, firm, low to medium plasticity
			2a	5	2.0		15	29	16					
			3	2 3 3							19			**Silty SAND** (SM): Brown, moist, fine to medium sand
29	10		4	3 2 3										
			5	4 4 5							15			
24	15		6b	3 5										**LEAN CLAY** (CL): Brown, moist, firm, low to medium plasticity
			6a	9	3.0		21	29	14					
			7	5 5 11										
19	20		8b	10 15										**Silty SAND** (SM): Red brown, moist, fine sand
			8a	19							29			
			9	3 5 8							32			Brown, fine to medium sand
14	25		10b	10 13										
			10a	14						94	2			**Poorly Graded SAND** (SP): Yellow brown, moist, fine to medium sand, trace fine gravel
			11	7 9 13			34	33	7					**SILT** (ML): Brown, moist, firm, low plasticity, fine sand

P:\LOG_BLOWS PER 6 INCHES 94582PGCC.GPJ 10/27/08

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Drafted By: D. Ross
Date: 10/27/2008

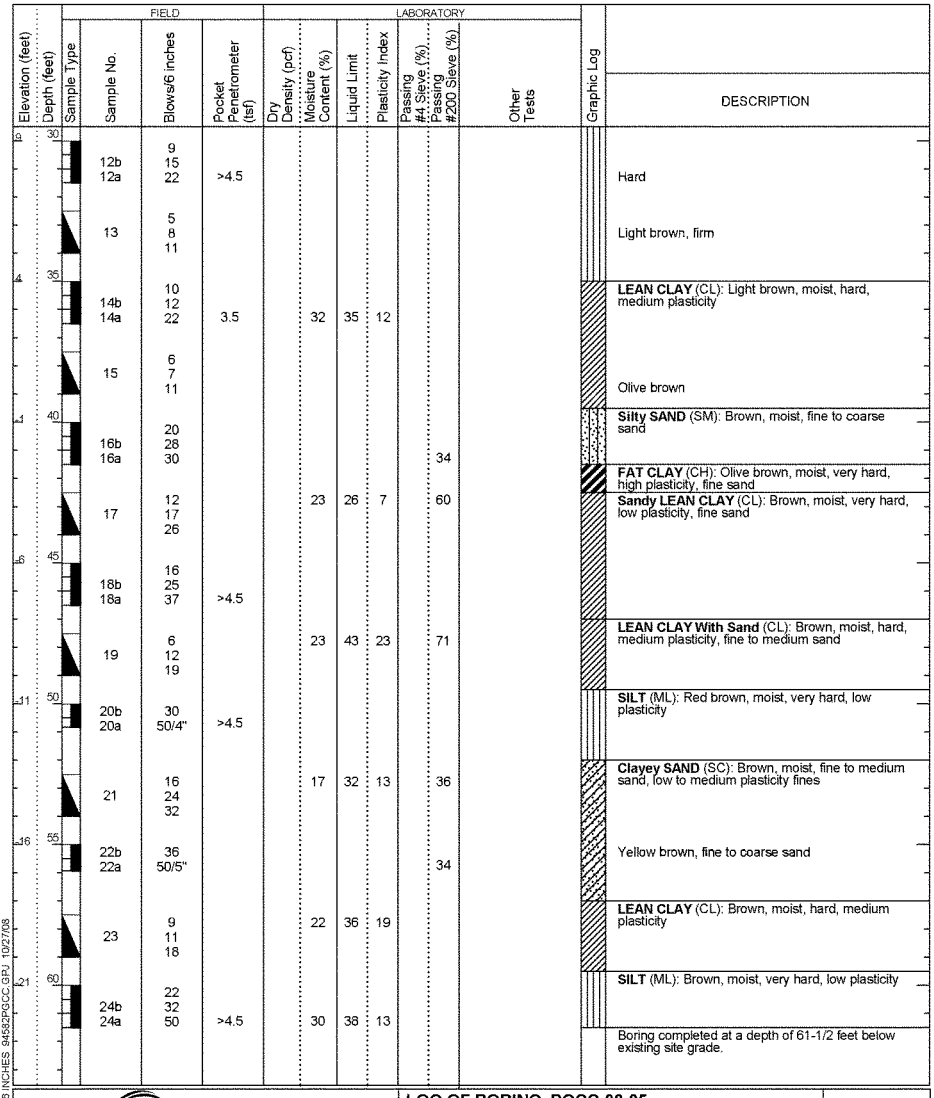
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File Number: 94582pgcc

LOG OF BORING PGCC-08-05

PROBLEM IDENTIFICATION REPORT
PLEASANT GROVE CREEK CANAL
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO & SUTTER COUNTIES, CALIFORNIA

PLATE
1 of 2
A-6

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Drafted By: D. Ross
Date: 10/27/2008
Project No.: 94582PGCC
File Number: 94582pgcc

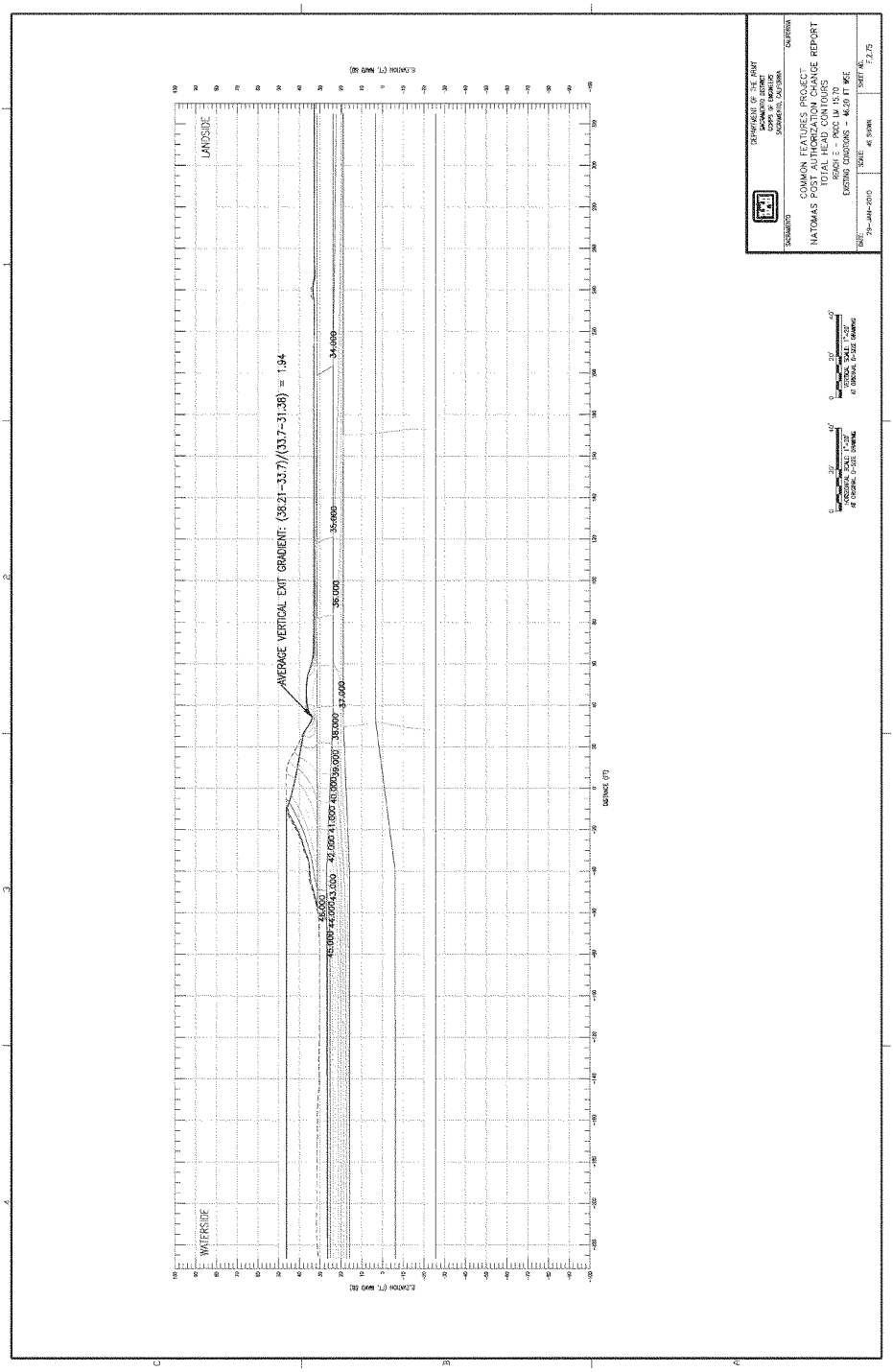
LOG OF BORING PGCC-08-05

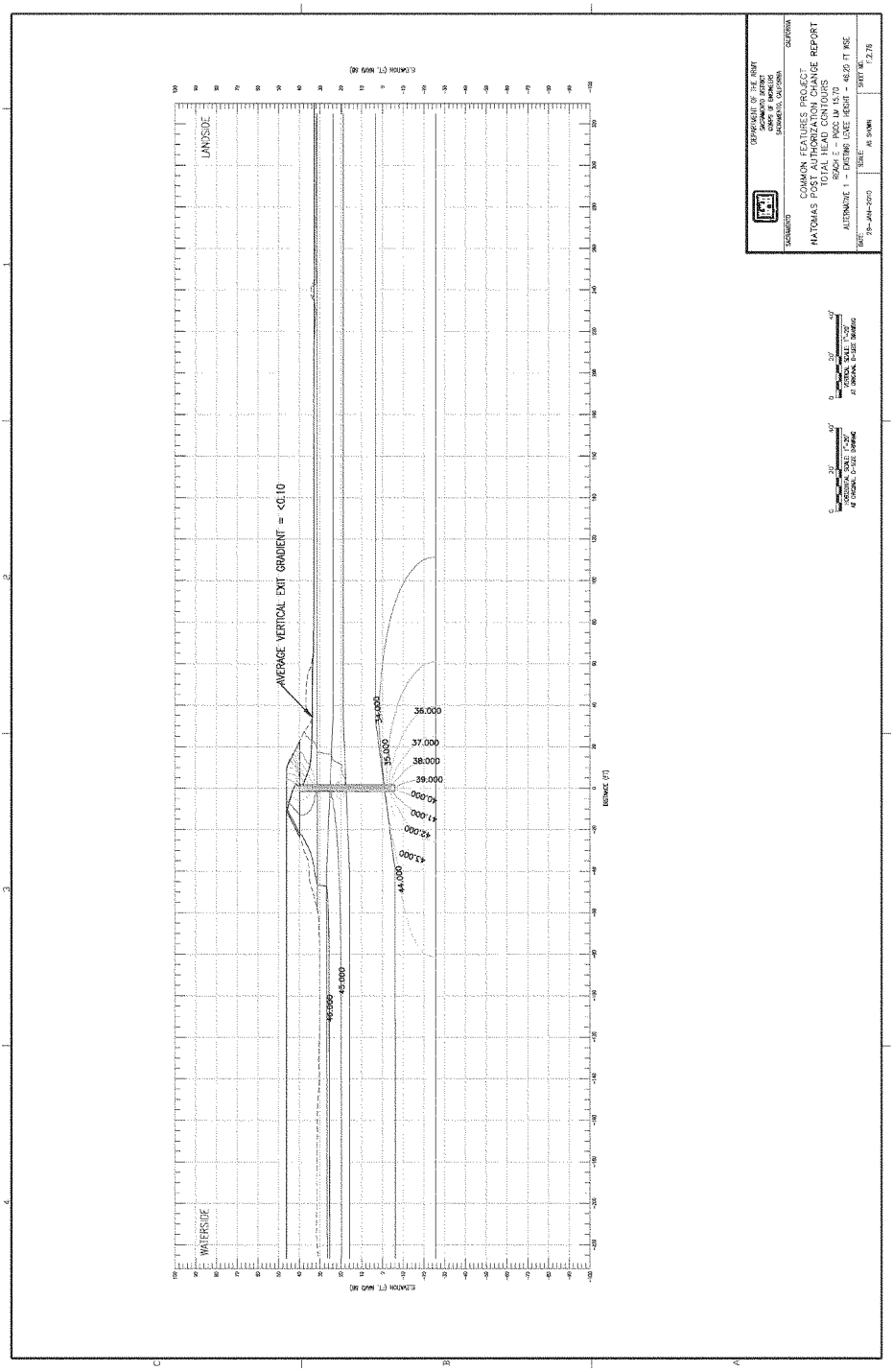
PROBLEM IDENTIFICATION REPORT
PLEASANT GROVE CREEK CANAL
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO & SUTTER COUNTIES, CALIFORNIA

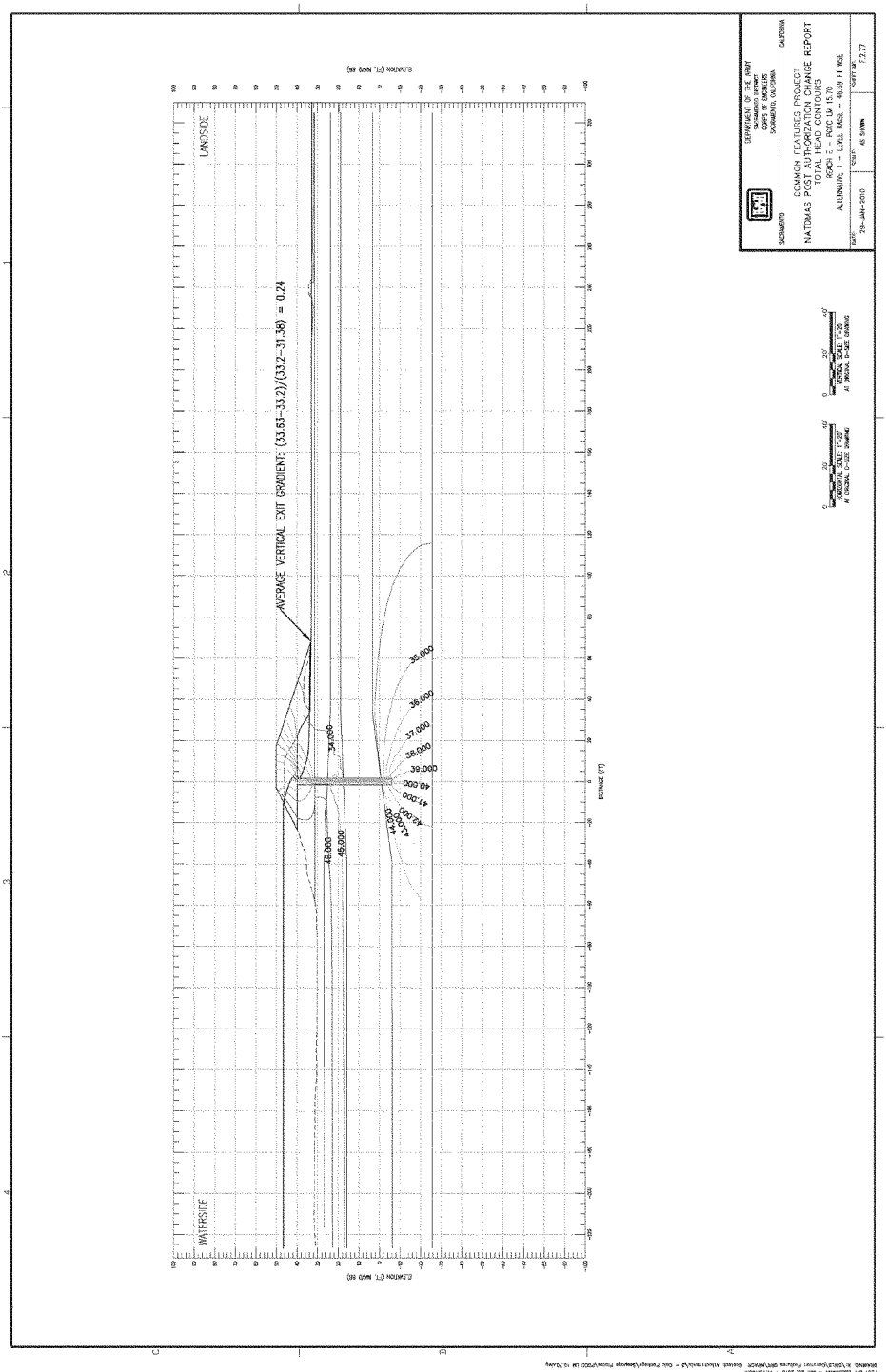
PLATE
2 of 2
A-6

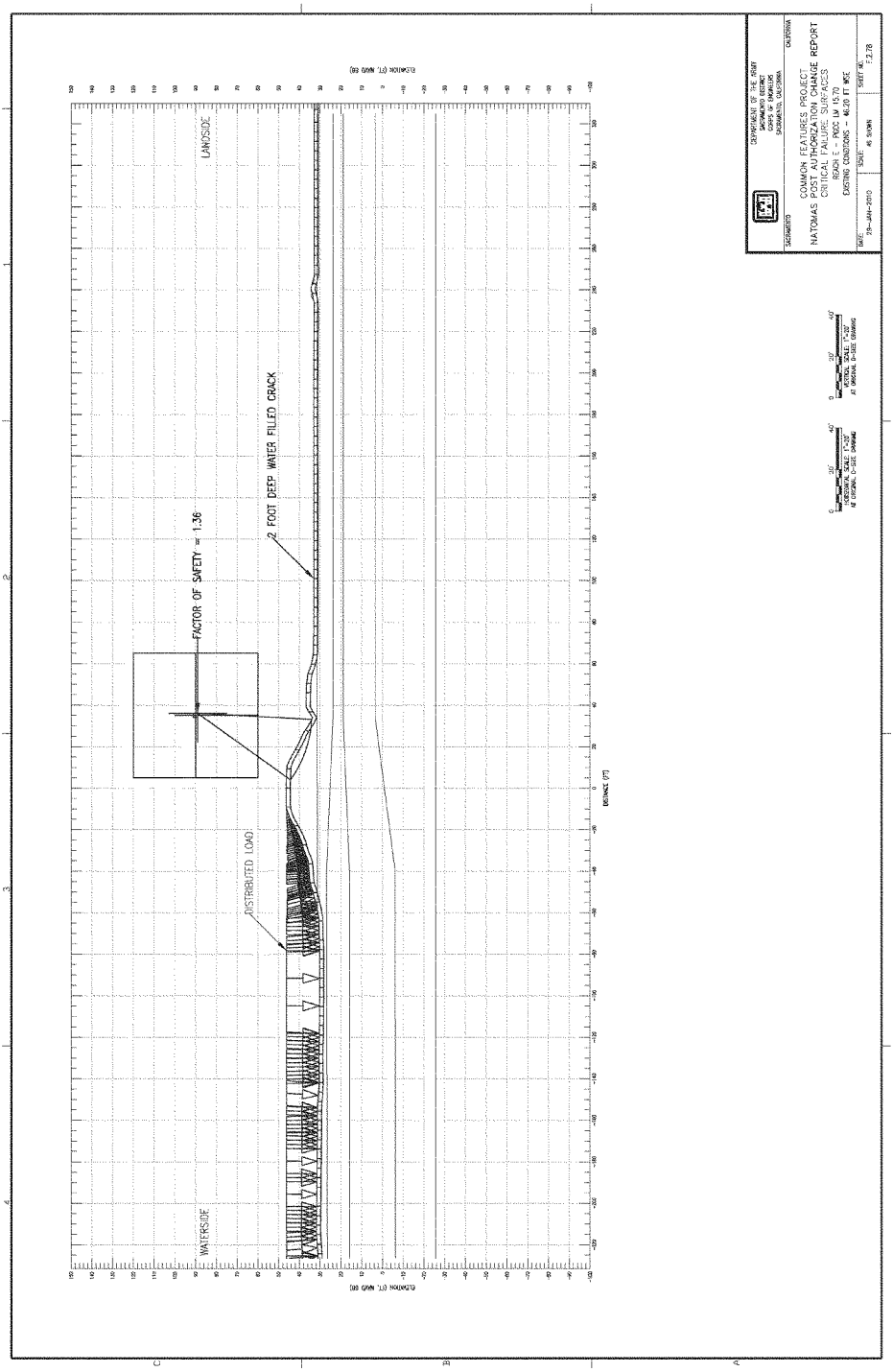
LOG_BLOWS PER 6 INCHES 94582PGCC.GPJ 10/27/08

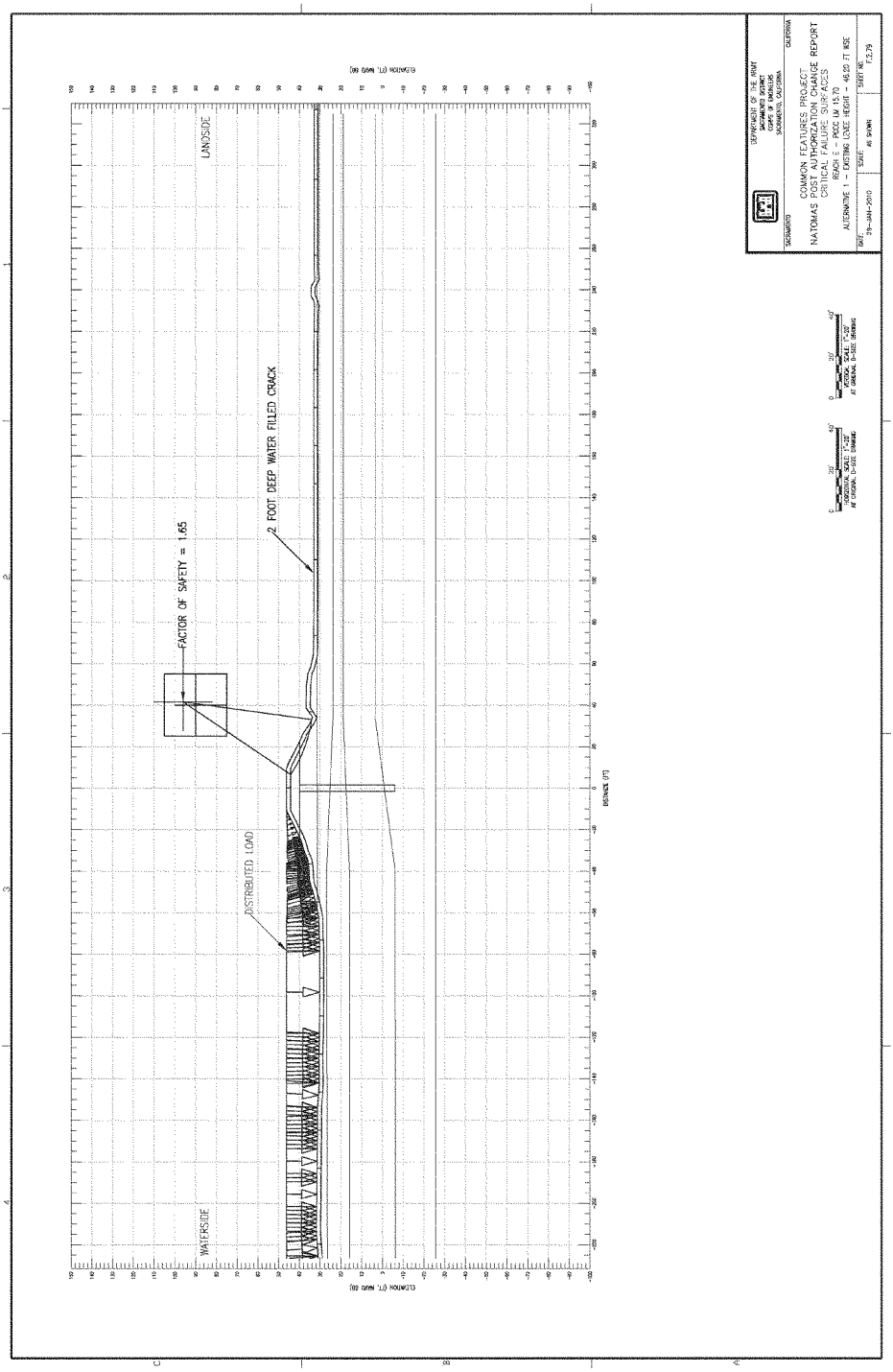
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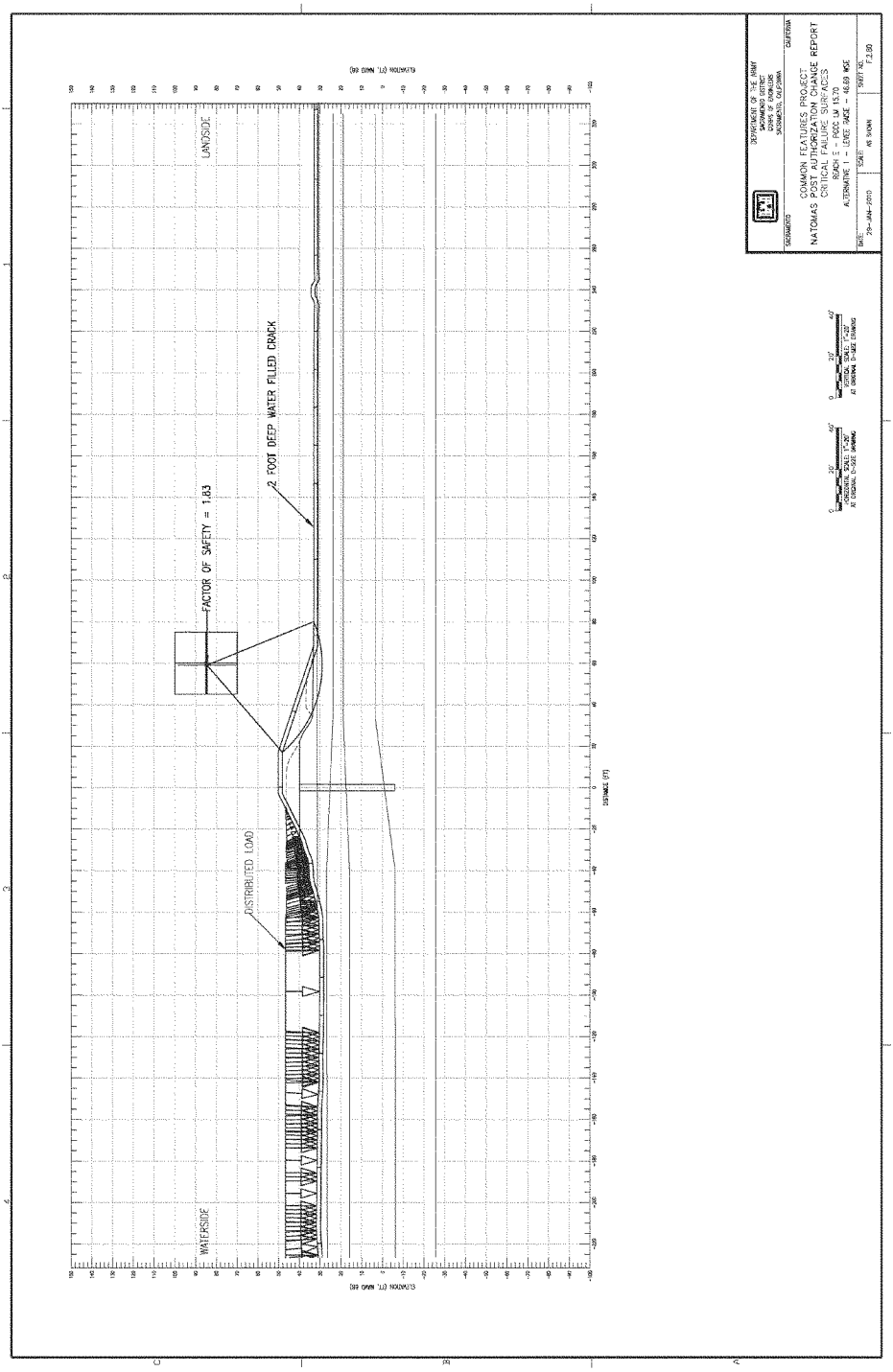

WATERSIDE
LANDSIDE
AVERAGE VERTICAL EXIT GRADIENT: (38.21-33.7)/(33.7-31.36) = 1.94
34,000
35,000
36,000
37,000
38,000
39,000
40,000
41,000
42,000
43,000
45,000
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
TOTAL HEAD CONTOURS
REACH E - STA 1+00 TO STA 11+00
EXISTING CONDITIONS - WL 20 FT MSL
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
7.2.75


LANDSIDE
WATERSIDE
AVERAGE VERTICAL EXIT GRADIENT = <0.10
36.000
37.000
38.000
39.000
40.000
41.000
42.000
43.000
44.000
34.000
35.000
46.5000
45.000
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH 1, REACH 2, REACH 3
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 46.65 FT MSE
DATE: 28-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.76


AVERAGE VERTICAL EXIT GRADIENT: (33.63-33.2)/(33.2-31.38) = 0.24
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
35.000
36.000
37.000
38.000
39.000
40.000
41.000
42.000
43.000
44.000
45.000
46.000
47.000
48.000
49.000
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH 1 - RIVER STATIONS
ALTERNATIVE 1 - LEVEE RAISE - 46.69 FT MSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
7.2.77
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING


LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 1.36
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH E, NEW ALIGN STA. 1+00 - 46+20 FT MCE
EXISTING CONDITIONS
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. E2.28


FACTOR OF SAFETY = 1.65
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH E, STATION 43+00
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 46.95 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.29


LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
FACTOR OF SAFETY = 1.83
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, RIVER MILE 75.1
ALTERNATIVE 1 - LEVEE RAISE - 46.69 MSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.80

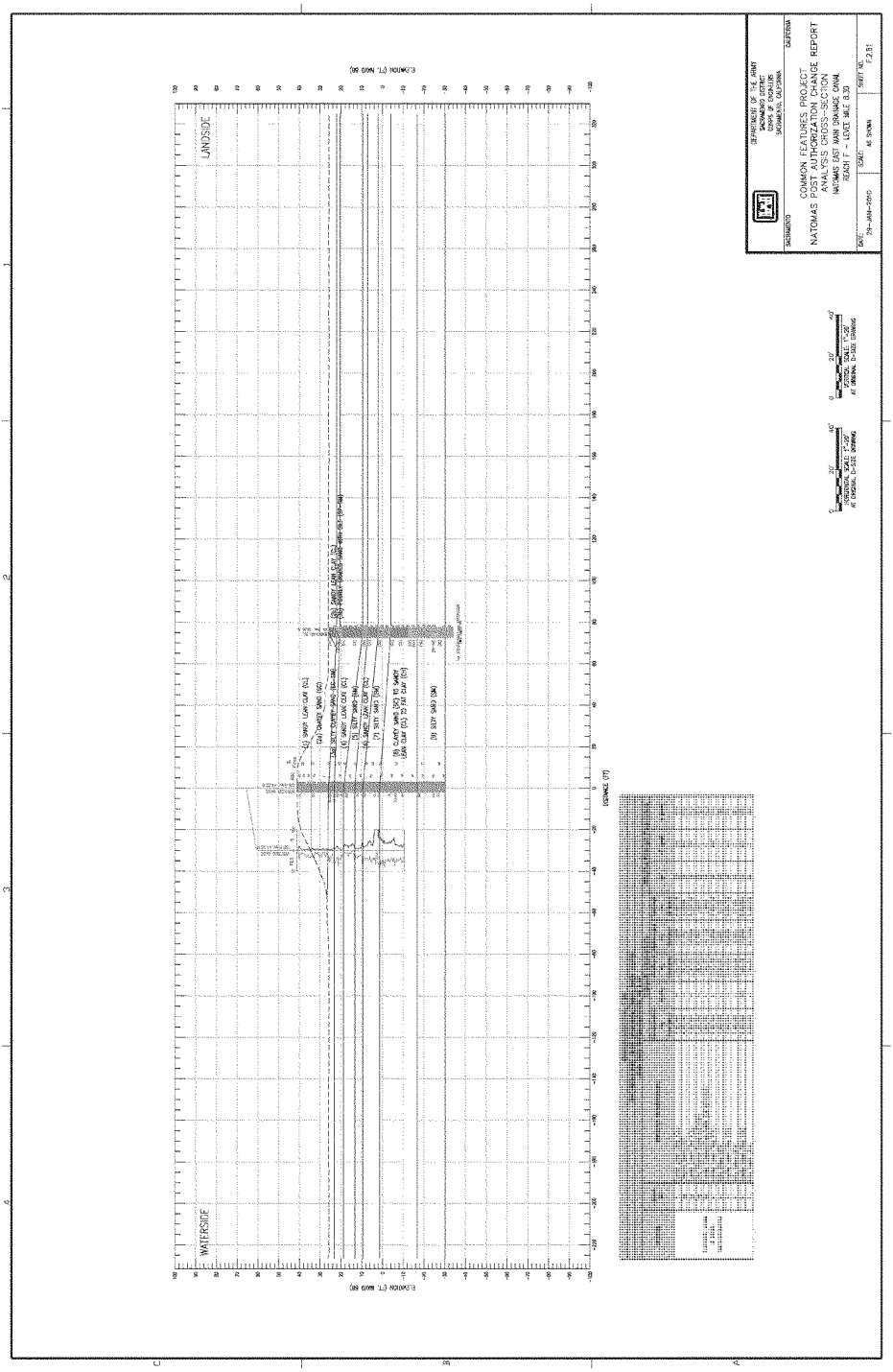
REACH F

CALCULATION PACKAGE

NATOMAS EAST MAIN DRAINAGE CANAL WEST LEVEE

(NEMDCW)

LM 12.55 – 7.89


WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
NATOMAS EAST MAIN DRAINAGE CANAL
REACH F - LEVEE MILE 8.30
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.81

NEMDC NORTH LEVEE (USACE) STATIONING
DRAFT

DATE STARTED	DATE COMPLETED	GROUND ELEVATION	ELEVATION BASIS	TOTAL DEPTH OF BORING
11/12/07	11/12/07	41.22 ft	Survey crew	71.5 ft
DRILLING CONTRACTOR		**DRILLER'S NAME**	**HELPER'S NAME**	**TOTAL DEPTH OF FILL**
Westex		Chris Minor	Richard Dugrenier	17 ft
DRILLING METHOD		**DRILL RIG MAKE AND MODEL**		**CONSULTANT COMPANY**
0-15' 8" HSA, 16.5'-61.5' Rotary Wash		CME 550		Fugro West
DRILL BIT SIZE AND TYPE (HOLE DIAMETER)		**DRILLING ROD TYPE AND DIAMETER**		**FIELD LOGGER**
8" HSA, 4-3/8" Core Bit		HQ Core 94mm, NWJ 67mm		S. Selvamohan/ C. Emilio
☒ VERTICAL ☐ INCLINED		**CASING TYPE, DIAMETER, INSTALLATION DEPTH**		**FIELD LOG REVIEWER**
		10" HSA to 15'		Gopalan Vishnan
SAMPLER TYPE(S)		**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP**		**HAMMER EFFICIENCY**
SPT(1.375"), Shelby(2.87" ID), Punch Core(2.25")		CME, swing arm automatic, 140 lbs / 30-inch drop		78%
BOREHOLE BACKFILL OR COMPLETION		**GROUNDWATER READING: DURING DRILLING**		**AFTER DRILLING (DATE-TIME)**
See the termination note		N/A due to rotary wash drilling method		

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	0		5 inches of Asphalt.												
	1		0.5 inches of Aggregate Base.												
40	1		SANDY LEAN CLAY (CL); dark yellowish brown (10YR 3/6); moist; 53% medium dry strength, no dilatancy, medium toughness fines; 47% fine to medium, rounded sand; (FILL).		1	67	8 9 10	19	25						S01A_000_001S
	2														
	3		Mottled with strong brown (7.5YR 5/8); few dark brown streaks, few caliche gravel at 3.0'.		2	67	4 3 5	8	10		16	26	13	53	S02A_002_003S
	4														
	5				3	39	3 4 5	9	12						S03A_005_006S
35	6														
	7														
	8		CLAYEY SAND (SC); loose; dark yellowish brown (10YR 3/6); moist; 68% fine to coarse sand; 32% fines; (FILL).		4	100	4 4 4	8	10		11	22	13	32	S04B_007_008S S04A_008_009S
	9														
	10														
	11				5	93					13				S05A_010_012T 300 psi
30	12														
	13				6	83	2 2 3	5	7						S06A_012_013S
	14														
	15														
	16		SILTY CLAYEY SAND (SC-SM); loose; dark yellowish brown (10YR 3/6); 60% fine to coarse sand; 40% fines; (FILL). Color changes to dark olive brown (2.5Y 3/3); wet; oxidation stains, trace gravel up to 1/4" dia. at 16.0'. (BASE OF FILL).		7	100	2 3 3	6	8		16	18	7	40	S07A_015_017S
25	17														S08B_017_017P Drill tool changed from auger to punch core at 16.5' depth
	18		SILTY CLAYEY SAND (SC-SM); loose; dark yellowish brown (10YR 3/6); 70% fine to coarse sand; 30% fines; (NATIVE).		8	100				1.5P 1P					
	19		CLAYEY SAND (SC); dark olive brown (2.5Y 3/3); moist; 59% fine to medium sand; 41% fines.							3.5P				41	S08A_019_020P
	20														

Final Report Version 5/20/2008

Borehole Location: Crest of the Levee
Coordinates: North 2,024,485.88 East 6,707,820.88
Levee Station or Milepost: STA: 432+05; OFFSET: 9.4 Left
GPS: Latitude 38.72017 Longitude -121.48776
Channel / River Name / Feature: Natomas East Main Drainage Canal
County: Sacramento

LOG OF BORING
WR1000_045B
Sheet 1 of 4

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	20														
20	21		SANDY LEAN CLAY (CL); very stiff; dark yellowish brown (10YR 4/6); moist; 56% medium dry strength, slow dilatancy, medium toughness fines; 44% fine sand.		9	89	5 6 6	12	16	4P	22	24	12	56	S09A_020_021S
	22														S10B_022_023P
	23		SILTY SAND (SM); dense; dark brown (10YR 3/3); moist; 65% fine to coarse sand; 35% fines.		10	71				1P				35	S10A_023_024P
	24														
	25														S11A_025_025S
15	26				11	39	10 11 13	24	31						
	27														S12B_027_027P
	28		SANDY LEAN CLAY (CL); stiff; olive (5Y 5/6); moist; 51% medium dry strength, slow dilatancy, medium toughness fines; 49% fine sand.		12	71				1.5P	23	23	11	51	S12A_028_029P
	29														
	30														S13A_030_031S
10	31				13	100	6 8 11	19	25						
	32		SILTY SAND (SM); very dense; olive brown (2.5Y 4/4); moist; 70% fine to medium sand; 30% fines.		14	86				4.5+P				30	S14A_034_035P
	33														
	34														
	35														S15A_035_036S
5	36		2" cemented layer at 35.5'.		15	83	15 27 38	65	85						
	37		SANDY LEAN CLAY (CL); olive brown (2.5Y 4/4); moist; 53% medium dry strength, no dilatancy, medium toughness fines; 47% sand.								18	34	20	53	S016B_037_038P
	38				16	71									S16A_038_039P
	39		CLAYEY SAND (SC); very dense; olive brown (2.5Y 4/4); moist; 62% fine to coarse sand; 38% fines.												
	40														
0	41		Color changes to brown (10YR 4/3) at 40.5'.		17	100	17 32 50	82	107		22	25	9	38	S17A_040_041S
	42														S18B_042_043P
	43				18	76				4.5+P					S18A_043_044P
	44		LEAN CLAY with Sand (CL); hard; olive (5Y 5/4); moist; 90% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 10% sand.												
	45														

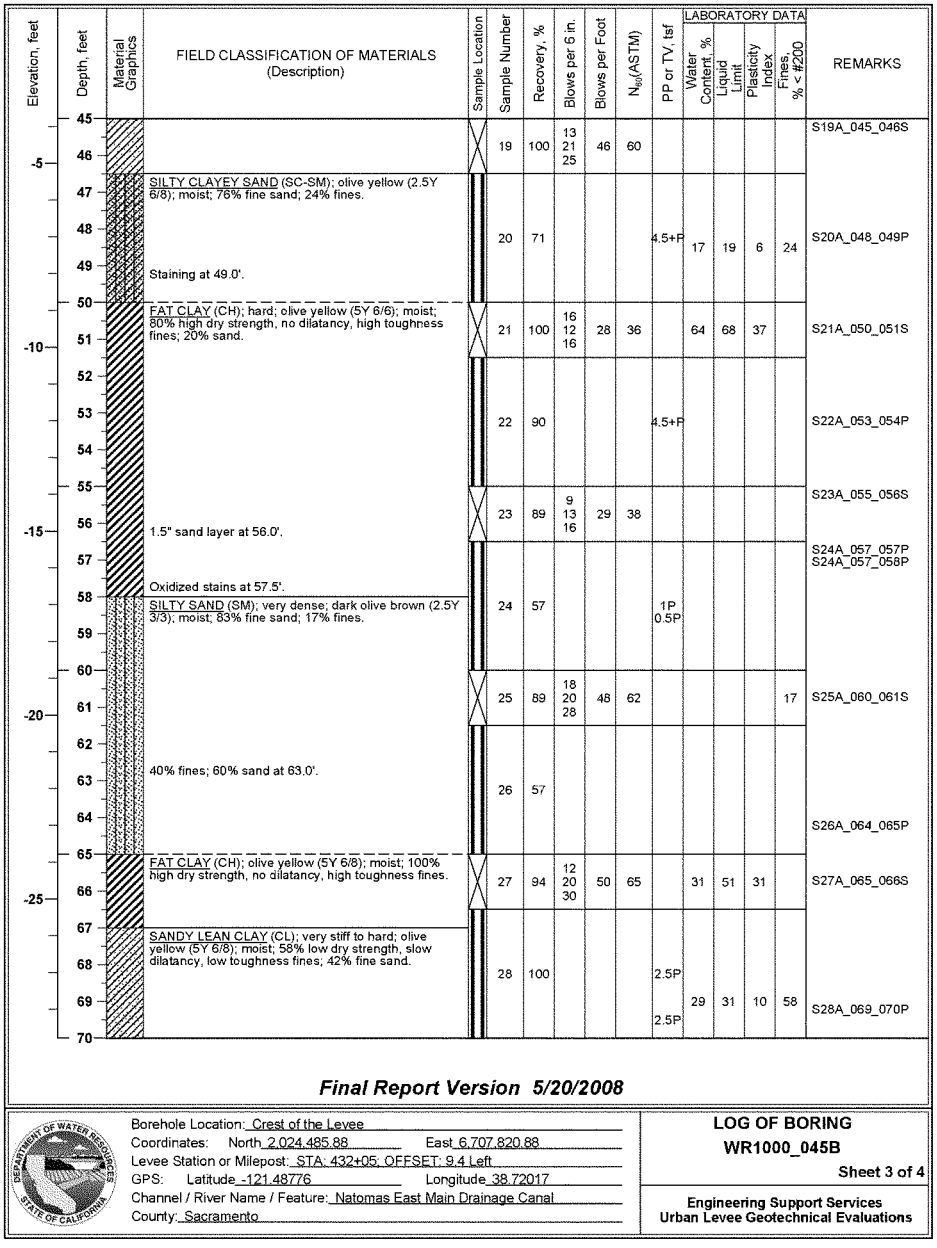
Final Report Version 5/20/2008

DEPARTMENT OF WATER RESOURCES — STATE OF CALIFORNIA

Borehole Location: Crest of the Levee
Coordinates: North 2,024,485.88 East 6,707,820.88
Levee Station or Milepost: STA: 432+05; OFFSET: 9.4 Left
GPS: Latitude 121.48776 Longitude 38.72017
Channel / River Name / Feature: Natomas East Main Drainage Canal
County: Sacramento

LOG OF BORING
WR1000_045B
Sheet 2 of 4

Engineering Support Services
Urban Levee Geotechnical Evaluations



Final Report Version 5/20/2008

Borehole Location: Crest of the Levee
Coordinates: North 2,024,485.88 East 6,707,820.88
Levee Station or Milepost: STA: 432+05; OFFSET: 9.4 Left
GPS: Latitude -121.48776 Longitude 38.72017
Channel / River Name / Feature: Natomas East Main Drainage Canal
County: Sacramento

LOG OF BORING
WR1000_045B
Sheet 3 of 4

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	REMARKS
	70														
-30	71			X	29	100	14 21 31	52	68	4.5+P					S29A_070_071S
	72		Borehole terminated at 71.5 feet. Backfilled with 5% bentonite grout.												
	73														
	74														
	75														
-35	76														
	77														
	78														
	79														
	80														
-40	81														
	82														
	83														
	84														
	85														
-45	86														
	87														
	88														
	89														
	90														
-50	91														
	92														
	93														
	94														
	95														

Final Report Version 5/20/2008

Borehole Location: Crest of the Levee
Coordinates: North 2,024,485.88 East 6,707,820.88
Levee Station or Milepost: STA: 432+05; OFFSET: 9.4 Left
GPS: Latitude -121.48776 Longitude 38.72017
Channel / River Name / Feature: Natomas East Main Drainage Canal
County: Sacramento

LOG OF BORING
WR1000_045B
Sheet 4 of 4

Engineering Support Services
Urban Levee Geotechnical Evaluations

Boring Location/ Surface Conditions: Existing landside levee toe; Disked field

Groundwater: Groundwater initially encountered at a depth of about 39 feet below existing site grade and finally at a depth of 24 feet.

Method: Hollow Stem Auger

Equipment: CME 750 with 140 lb. Automatic Hammer

Date Completed: 5/6/2008

Logged By: D. Frazer

Reviewed By:

Total Depth: 60 feet

Boring Diameter: 8 inch

Approximate Elevation: 26 feet (NAVD 88)
Approximate Northing: 2024240.07 feet
Approximate Easting: 6707794.04 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														LEAN CLAY (CL): Brown, moist, very hard, low plasticity
			1	36 32 17			11	24	7					
21	5													**Poorly Graded SAND With Silt** (SP-SM): Brown, moist, fine to coarse sand
			2b	4 7										
			2a	10							8			
														LEAN CLAY With Sand (CL): Brown, moist, soft, low plasticity, fine sand
			3	3 3 4			24	26	11		72			
16	10													
				4 5 7										
														Sandy LEAN CLAY (CL): Brown, moist, firm, low plasticity, fine sand
			4	6 14 17							51			
11	15													
			5b	9 14										
			5a	15			19	29	13					
														Silty SAND (SM): Red, moist, fine to coarse sand
			6	1 5 7			14	NP	NP		15			
6	20													**Sandy LEAN CLAY** (CL): Red, moist, hard, low plasticity, fine to medium sand
			7b	11 23										
			7a	31			15	23	10		54			
			9	6 11 18										
1	25													**Silty SAND** (SM): Brown, moist, fine to medium sand
			10b	21										
			10a	50/5"			15	NP	NP		35			
			11	6 11 18										

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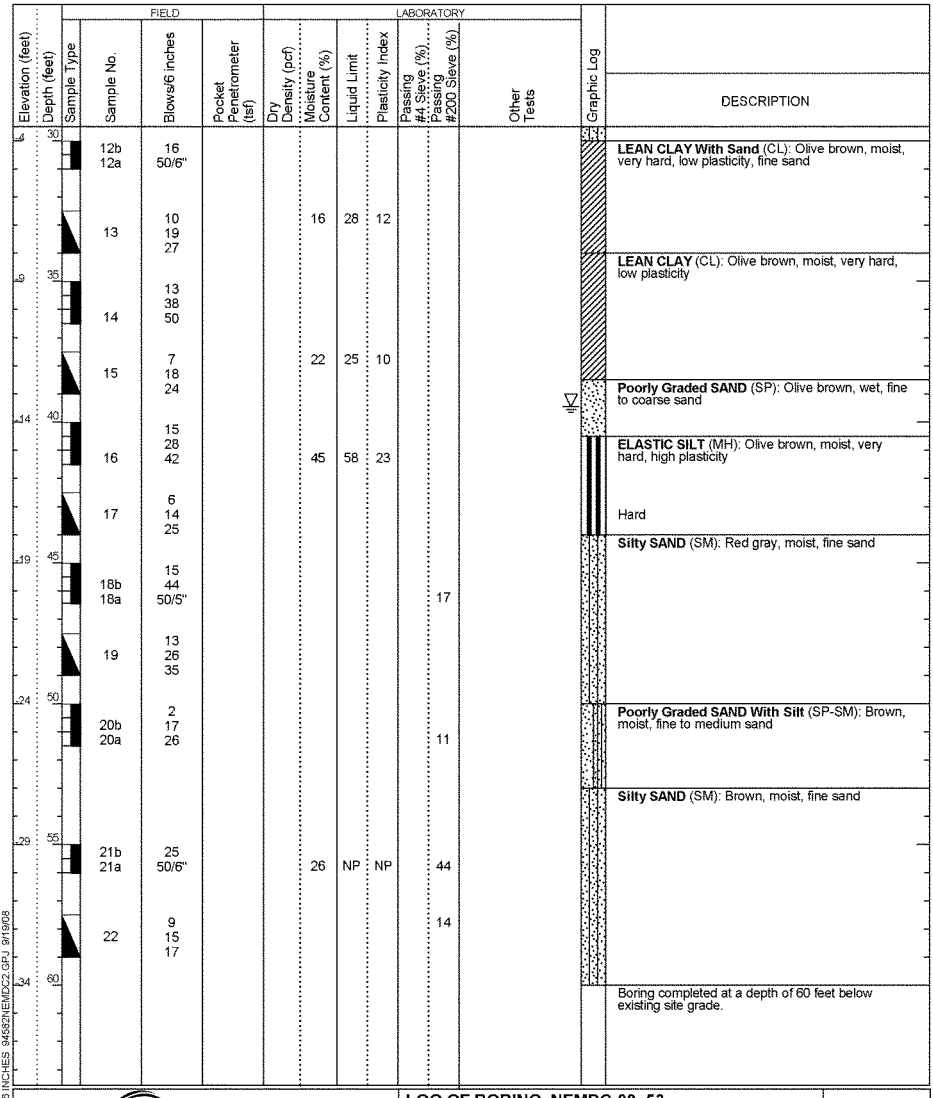
Drafted By: D. Ross
Date: 9/19/2008
Project No.: 94582NEMDC
File Number: 94582NEMDC2

LOG OF BORING NEMDC-08-53
(DRAFT)
NEMDC2

PLATE
1 of 2

PLOG_BLOWS PER 6 INCHES 94582NEMDC2.GPJ 9/19/08

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P:\LOG_BLOWS PER 6 INCHES 94582\NEMDC2.GPJ 9/19/08

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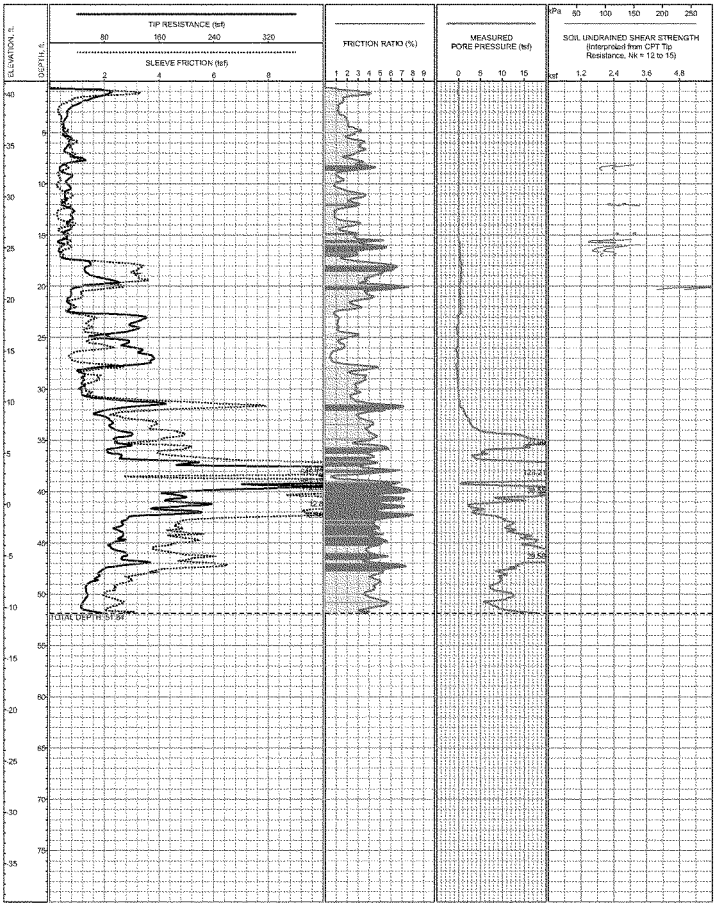
Drafted By: D. Ross
Date: 9/19/2008
Project No.: 94582NEMDC
File Number: 94582NEMDC2

LOG OF BORING NEMDC-08-53
(DRAFT)
NEMDC2

PLATE
2 of 2

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DWR Levees
Project No. 1310.016

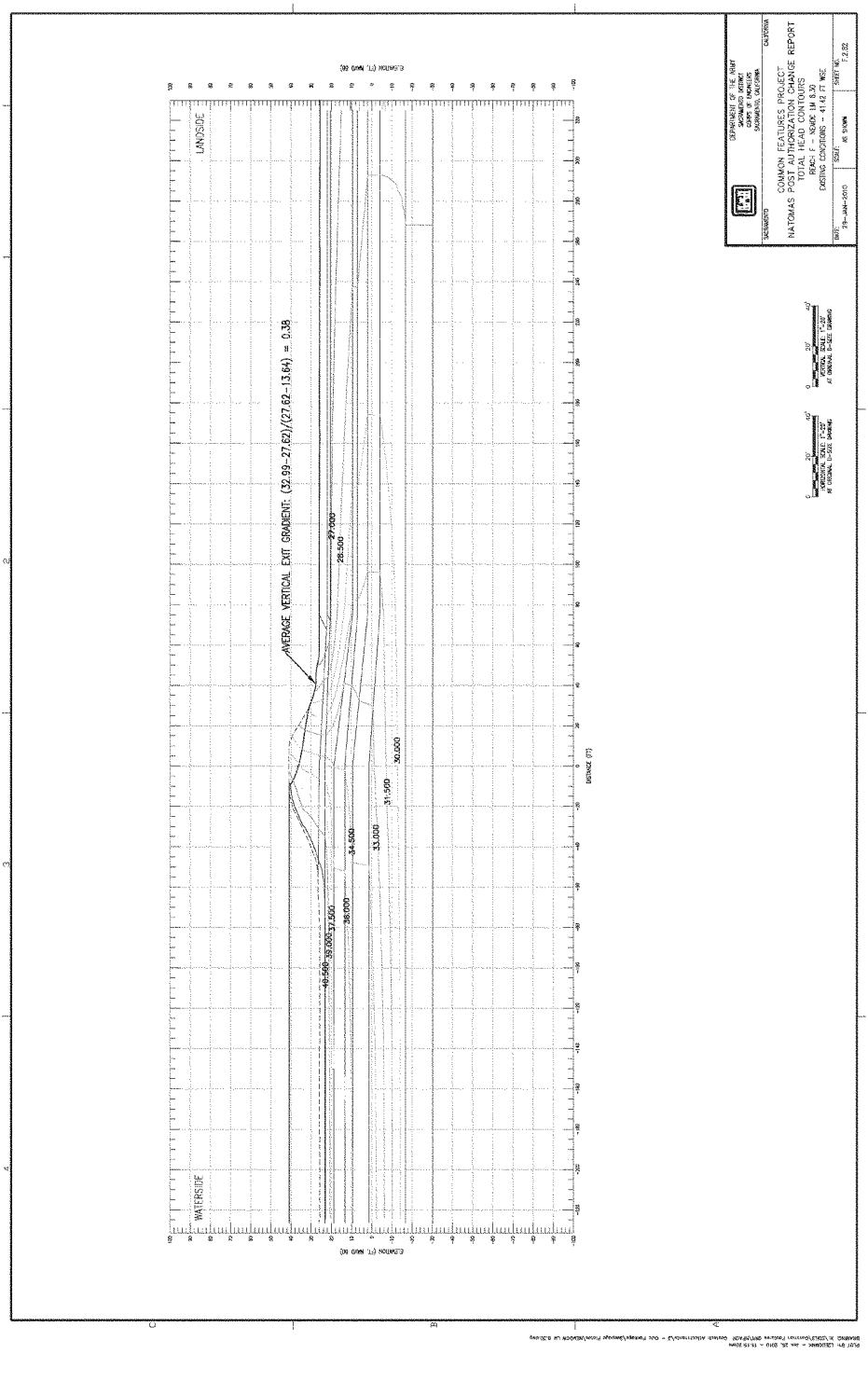


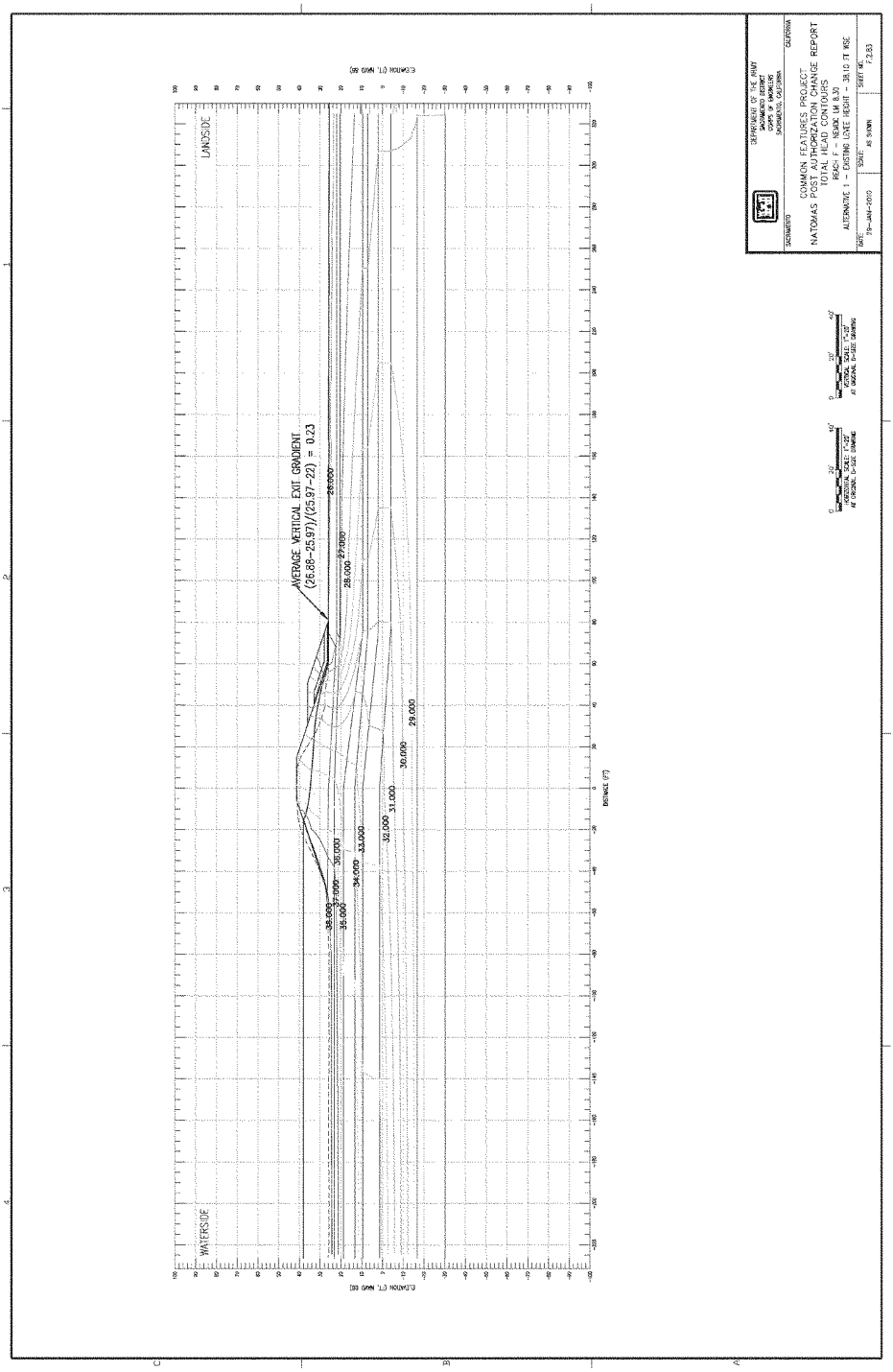
LOCATION: E6,707,820.40 N2,024,492.51 (CA SP Znll, ft.) Lat:38.72014 Long:-121.48772 (NAD83)
SURFACE EL.: 41.26ft (NAVD 88)
COMPLETION DEPTH: 51.84ft
TEST DATE: 10/2/2007

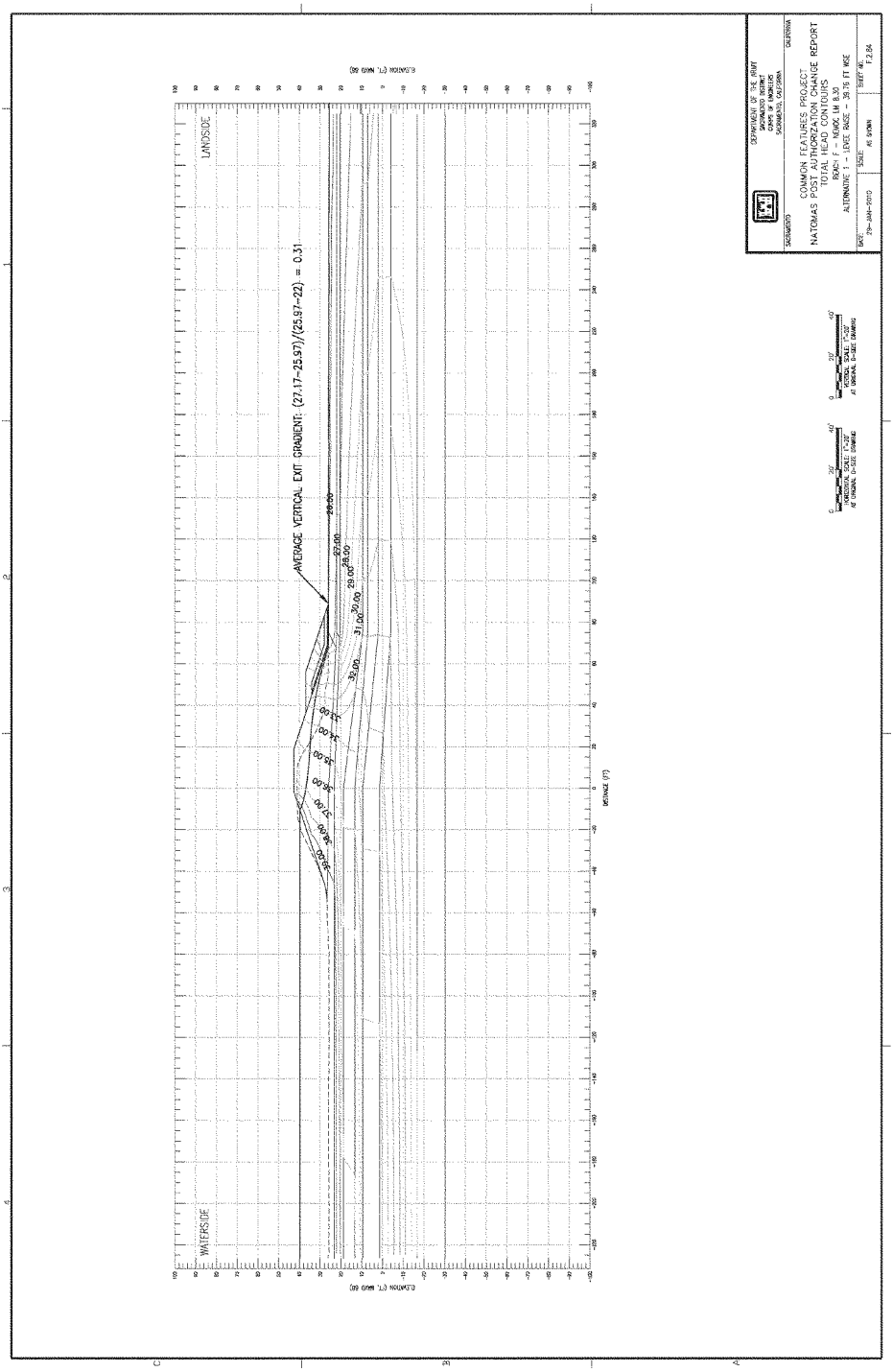
CONE: F7.5CKEW2/B 163
PERFORMED BY: Fugro Consultants
OPERATOR: R. Norris
STATIONING: 432+11.52 Left 8.83
REVIEWED BY: M. Freitas

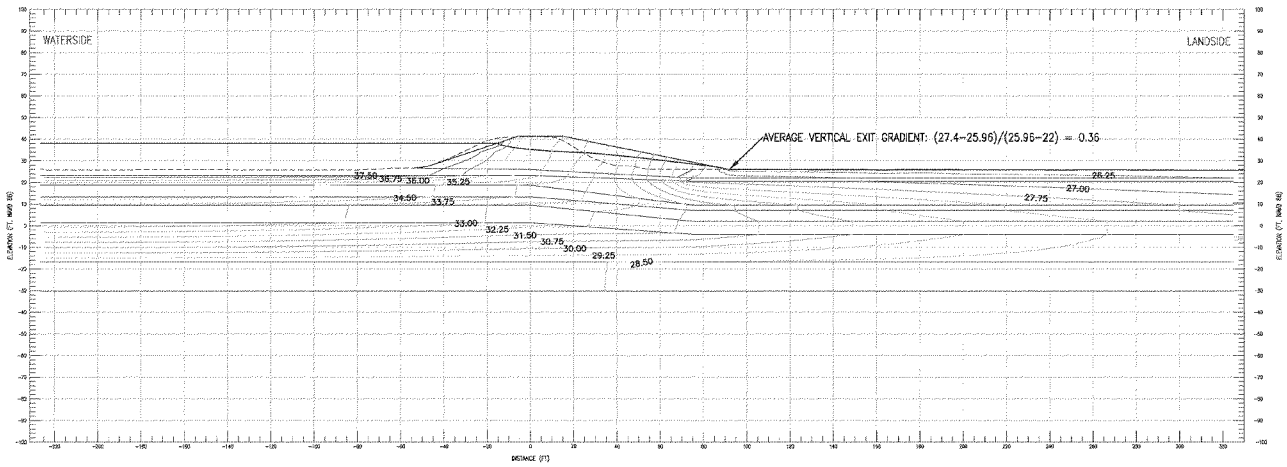
LOG OF WR1000_045C
NEMDC West Study Area

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AVERAGE VERTICAL EXIT GRADIENT: (32.99-27.62)/(27.62-13.64) = 0.38
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C - SOUTH OF I-80
EXISTING CONDITIONS - 41.62 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.22


WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
AVERAGE VERTICAL EXIT GRADIENT
(26.68-25.97)/(25.97-22) = 0.23
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH F - SECTION 33
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 3.10 FT RISE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F2.83


AVERAGE VERTICAL EXIT GRADIENT: (27.17-25.97)/(25.97-22) = 0.31
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH 1 - LEVEE RAISE - 39.75 FT WSE
ALTERNATIVE 1 - LEVEE RAISE - 39.75 FT WSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F2.84



HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

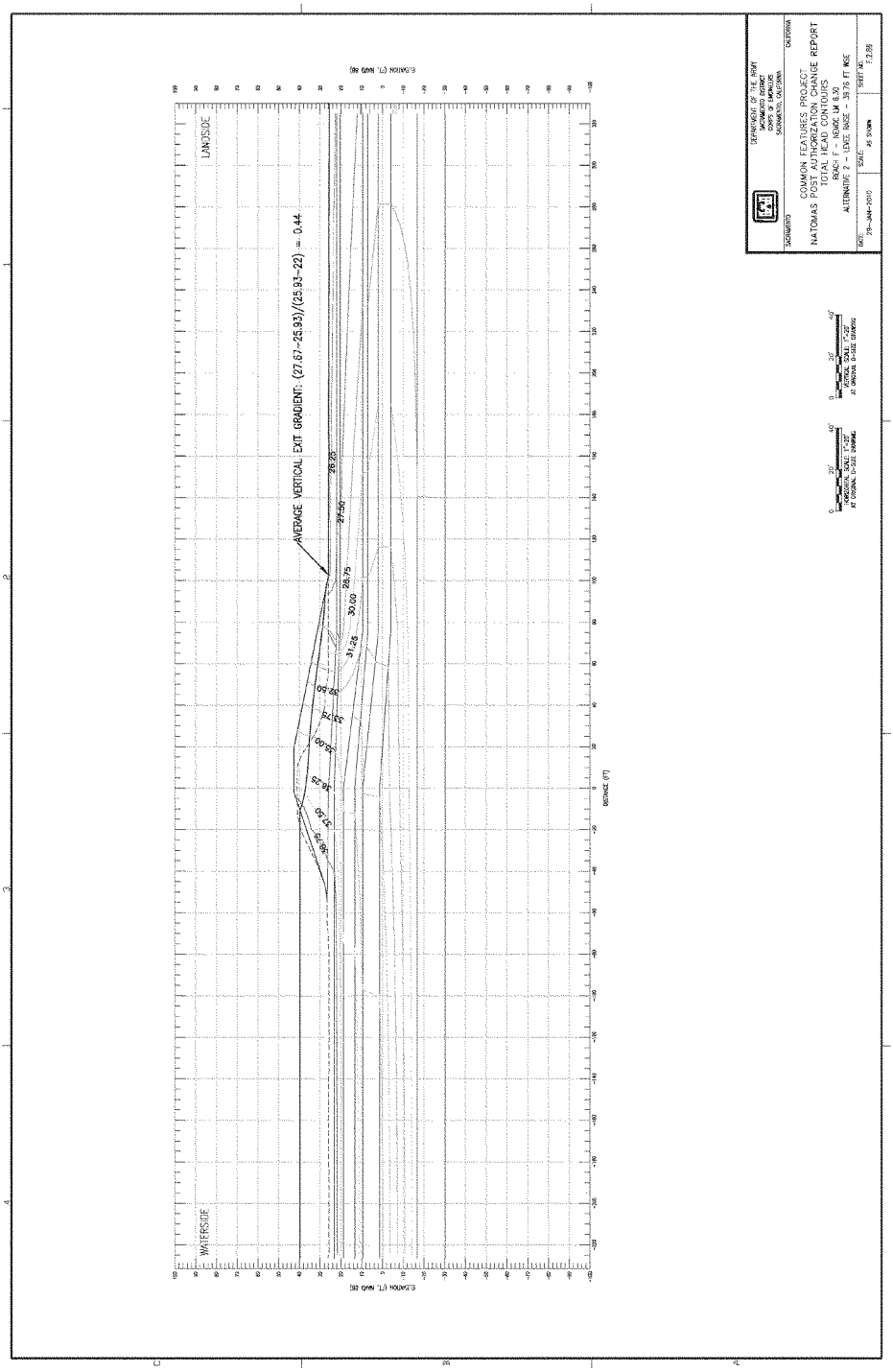
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

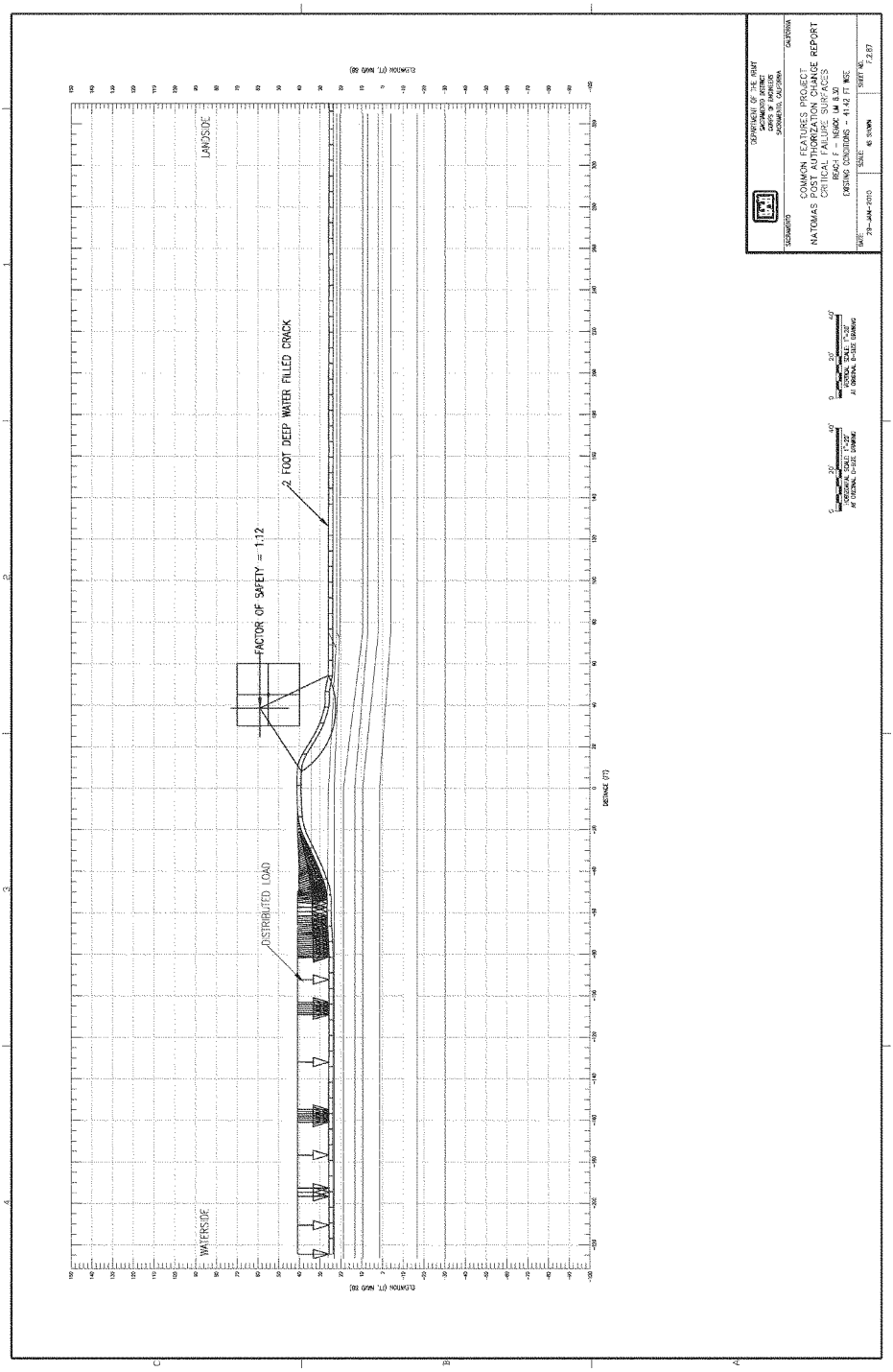
SACRAMENTO — CALIFORNIA

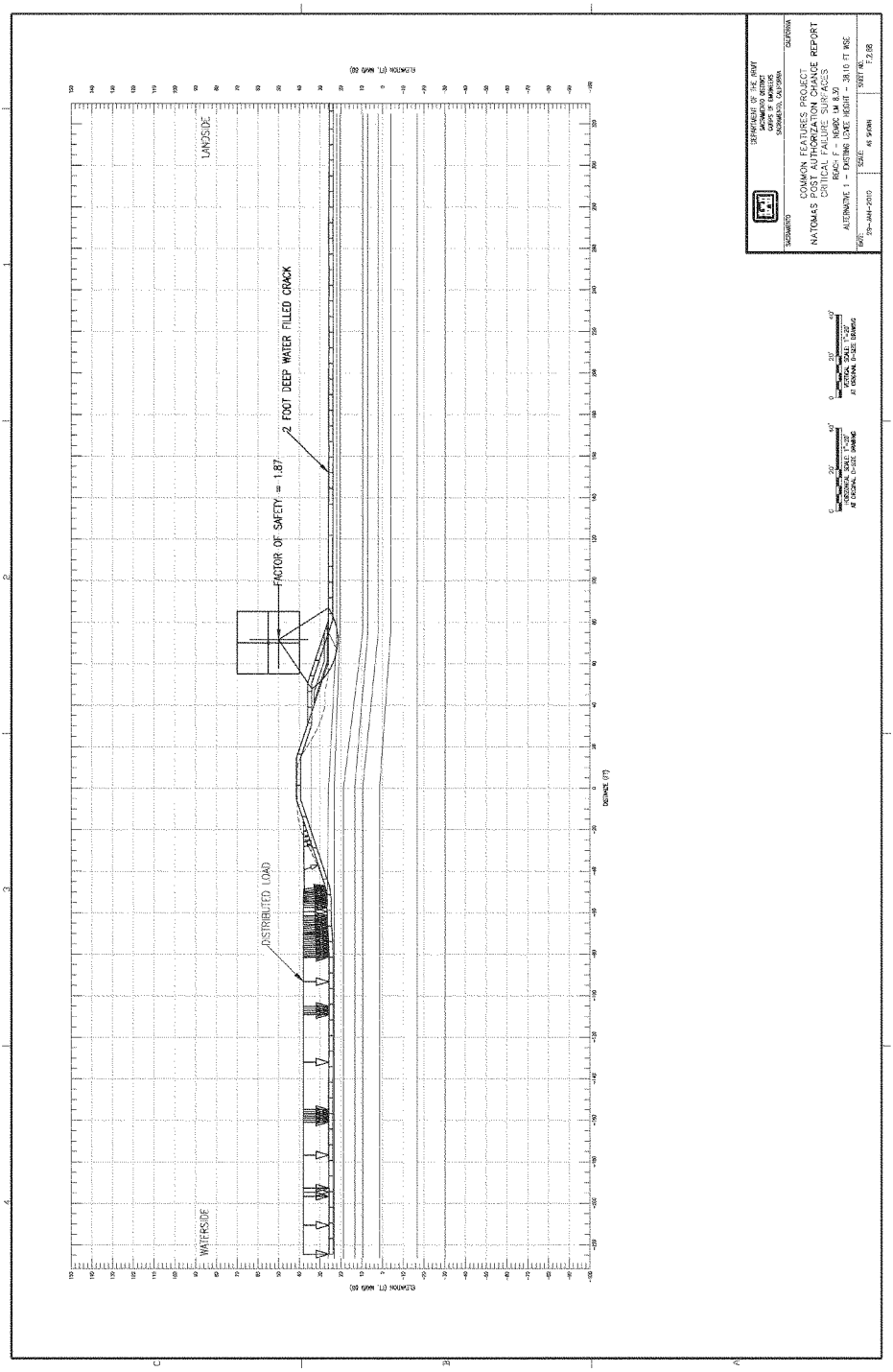
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH F - NEARIC LM 8.30
ALTERNATIVE 2 - EXISTING LOWER HEIGHT - 28.10 FT WSE

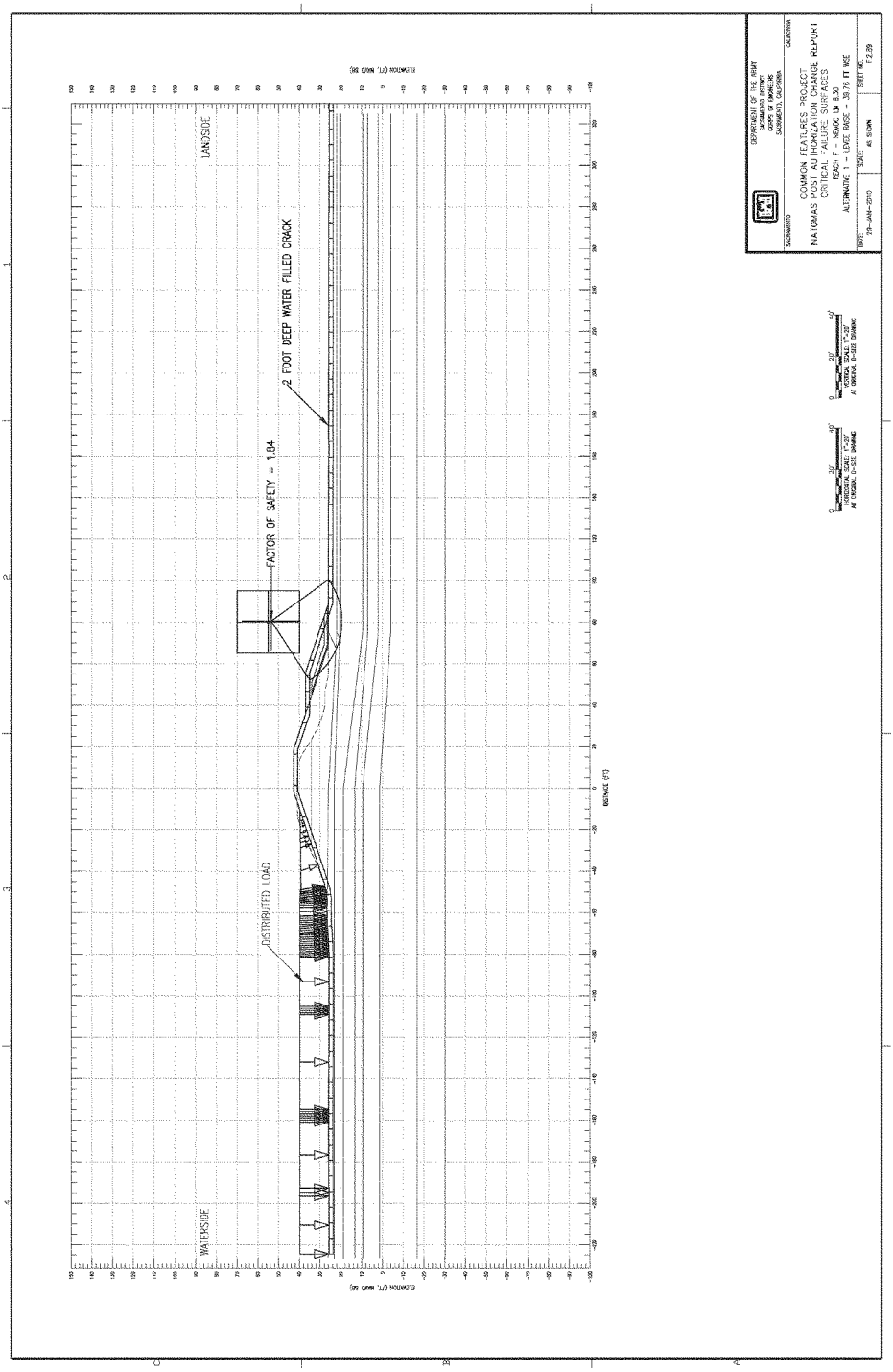
DATE:	SCALE:	SHEET NO.
29-JAN-2010	AS SHOWN	F.2.85

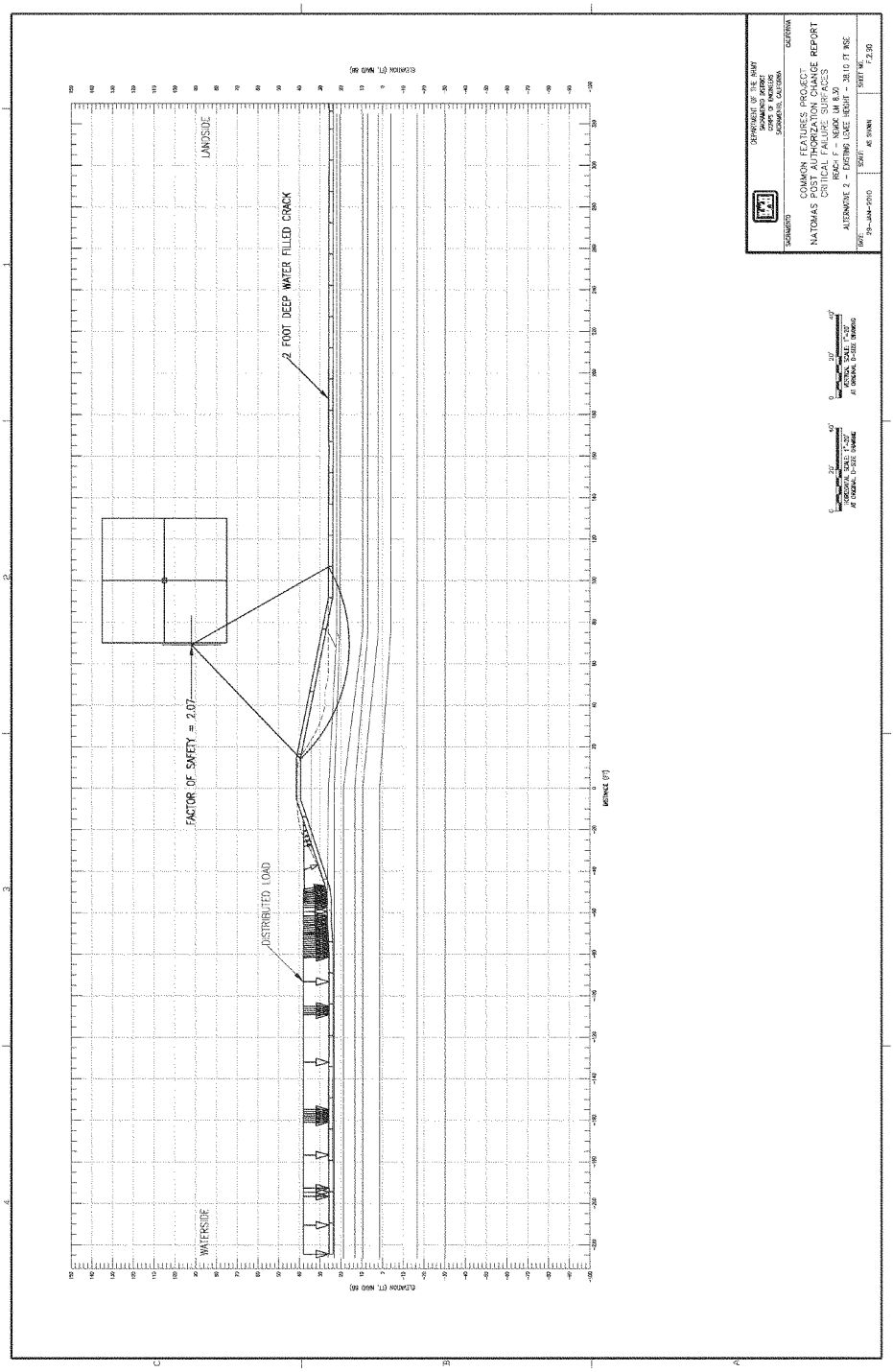
PLOT BY: LADEGAARD - Jan 28, 2010 - 11:19:23am
DRAWING: N:\2010\Common Features (SPK)\F\F285 Natomas Attachments\A - Doc. Package\Drawings Photos\NEARICF LM 8.30.dwg

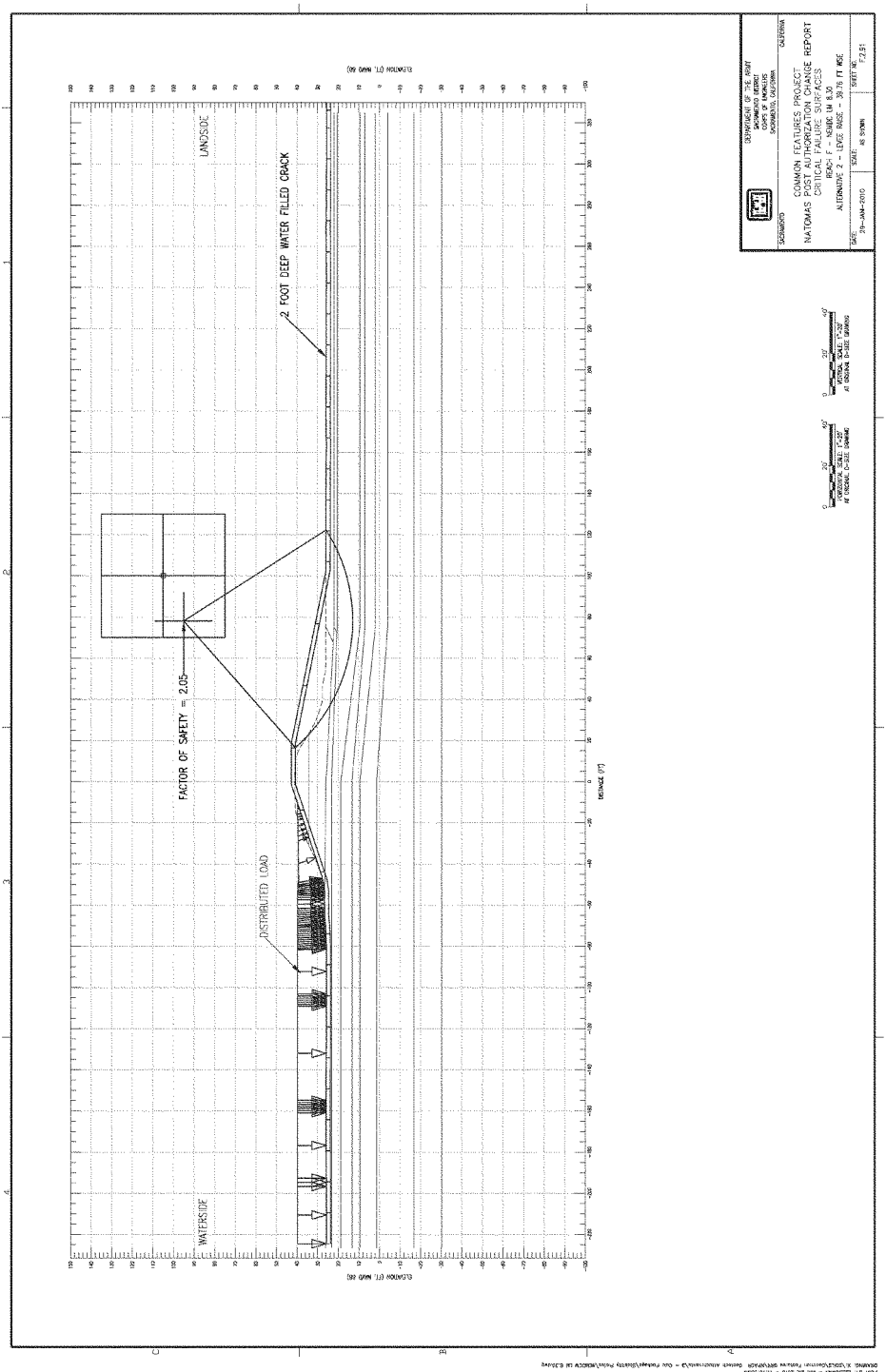

AVERAGE VERTICAL EXIT GRADIENT: (27.67-25.93)/(25.93-22) = 0.44
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
25.93
27.50
28.75
30.00
31.25
32.50
33.75
35.00
36.25
37.50
38.75
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
RIVER STA. 1000 - RIVER MILE 38.75
ALTERNATIVE 2 - LEVEE RAISE = 3.75 FT WSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.09


FACTOR OF SAFETY = 1.12
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, MODEL NO. 3
DRAWING CONSISTING - 41.42 FT MSL
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
7.2.67


WATERSIDE
LANDSIDE
FACTOR OF SAFETY = 1.87
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
ELEVATION (FT NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH F, MODEL SECTION 38
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT - 38.10 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.88


2 FOOT DEEP WATER FILLED CRACK
FACTOR OF SAFETY = 1.84
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH: NEMC 3A
ALTERNATIVE 1 - LEVEE RAISE - 38.75 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.29


2 FOOT DEEP WATER FILLED CRACK
FACTOR OF SAFETY = 2.07
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, SACRAMENTO RIVER
ALTERNATIVE 2 - EXISTING LEVEE HEIGHT + 3.810 FT WSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F-2.90


2 FOOT DEEP WATER FILLED CRACK
FACTOR OF SAFETY = 2.05
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH E, NAME RD 1
ALTERNATIVE 2 – LEVEE RAISE – 39.76 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.81

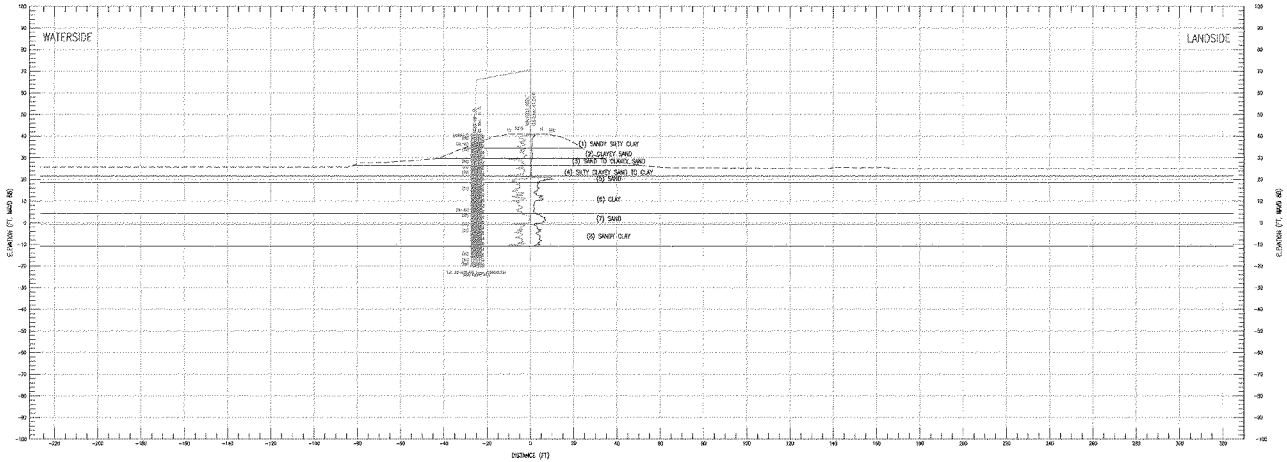
REACH G

CALCULATION PACKAGE

NATOMAS EAST MAIN DRAINAGE CANAL WEST LEVEE

(NEMDCW)

LM 7.89 – 4.25



REACH G (LM 2.82 - LM 8.27)
NATOMAS EAST MAIN DRAINAGE CANAL WEST LEVEE
ANALYSIS CROSS-SECTION (LM 5.45)

Stratum	Layer No.	Material Class Number	Hydraulic Conductivity				Effective Strength Parameters	
			Horizontal k_h (ft/day)	k_h/k_v	Vertical k_v (ft/day)	Horizontal k_h (ft/day)	Vertical k_v (ft/day)	ϕ' (deg)	γ (pcf)
WRINN_WEIR NEVADO-08-10 NEVDO-08-10	1	Sandy Silty Clay	1.0E-05	4	2.5E-06	0.1296	0.0324	30	130
	2	Clayey Sand	4.0E-05	4	1.0E-05	0.173	0.0431	28	130
	3	Sand to Clayey Sand	1.0E-03	4	2.5E-04	2.835	0.709	30	125
	4	Silty Clayey Sand to Clay	1.0E-05	4	2.5E-06	0.1823	0.0607	28	130
	5	Sand	1.0E-01	4	1.3E-01	14.175	3.543	32	130
	6	Clay	1.0E-05	10	1.0E-06	0.0284	0.00284	30	115
	7	Sand	1.0E-01	10	1.0E-02	28.350	2.835	35	130
	8	Sandy Clay	1.0E-05	10	1.0E-06	0.0284	0.00284	29	130

HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

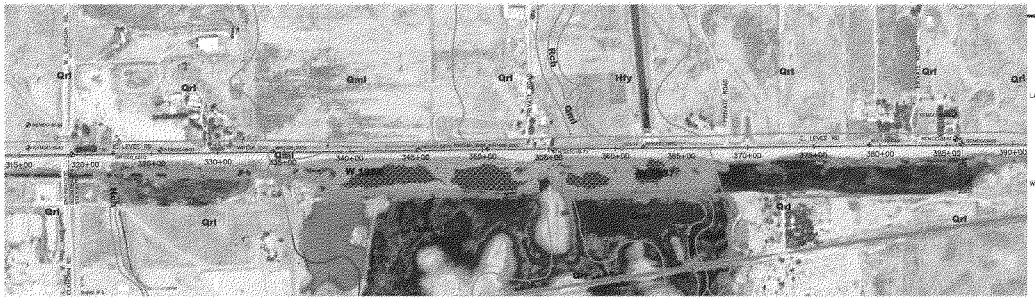
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

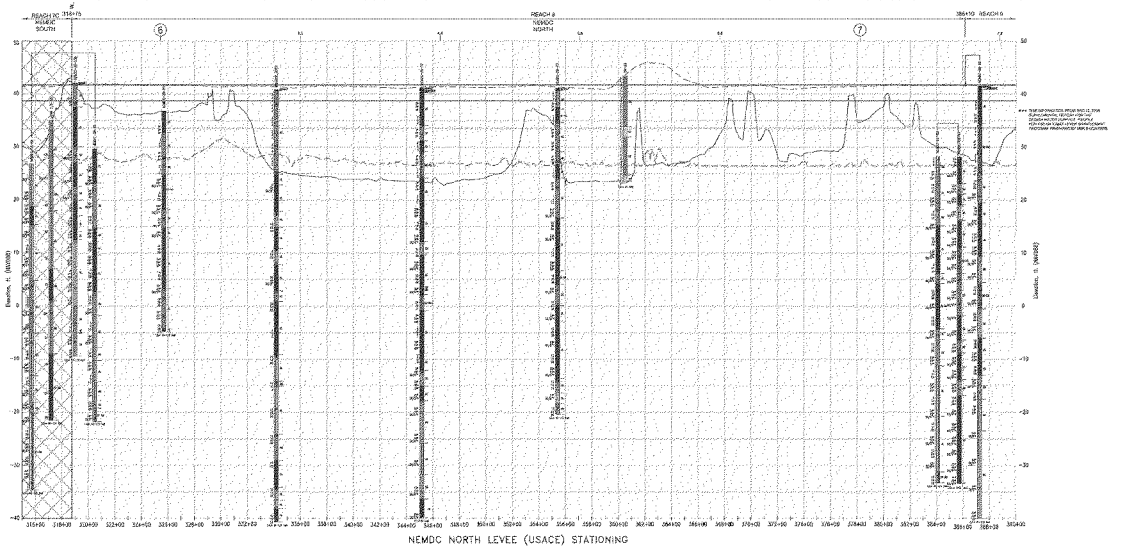
SACRAMENTO — CALIFORNIA

COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
NATOMAS EAST MAIN DRAINAGE CANAL
REACH G - LEVEE MILE 5.45

DATE:	SCALE:	SHEET NO:
29-JAN-2010	AS SHOWN	F.2.02

PLOT BY: LBROWNE — Jan 29, 2010 - 10:15:59am
DRAWING: K:\Civil\Common Features GRR\NAT\Sketch Attachments\3 - Geo Parker\Cross Section Plots\NEVADO08 LM 5.45.dwg





NEMDC NORTH LEVEE (USACE) STATIONING

DRAFT

KLEINFELDER

PLAN AND PROFILE
STATIONS 315+75 TO 390+00

2-2

Boring Location/ Surface Conditions: Levee crown, asphalt concrete
Groundwater: Groundwater not measured due to drilling method.
Method: Hollow Stem Auger (15 ft.)/Mud Rotary
Equipment: CME 75 with 140 lb. Automatic Hammer

Date Completed: 4/25/2008
Logged By: E. Ortakci
Reviewed By:
Total Depth: 61-1/2 feet
Boring Diameter: 8 inch/4 inch

Approximate Elevation: 41 feet (NAVD 88)
Approximate Northing: 2015439.66 feet
Approximate Easting: 6708492.25 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														ASPHALT CONCRETE: About 5 inches
			1	8 7 7										**Silty SAND** (SM): Brown, moist, fine sand, (Levee)
			2b 2a	4 3 4							23			Dark brown
36	5		3	2 2 3				20	7		50			**Sandy Silty LEAN CLAY** (CL-ML): Brown, moist, soft, low plasticity, fine sand, (Levee)
			4b 4a	2 4 6				24	10		43			**Clayey SAND** (SC): Brown, moist, fine sand, low plasticity fines, (Levee)
31	10		5b 5a	3 4 5										
			6b 6a	2 5 3				NP	NP		35			**Silty SAND** (SM): Brown, moist, fine to medium sand, (Levee)
26	15		7	1 1 2				23	12					**LEAN CLAY** (CL): Blue gray, moist, very soft, low plasticity, (Native)
			8b 8a	2 3 4				24	12		48			**Clayey SAND** (SC): Blue gray, moist, fine sand, low plasticity fines
21	20		9	1 4 12										
			10b 10a	21 44 50/3"				22	8		31			
16	25		11	20 25 50				25	9					**LEAN CLAY With Sand** (CL): Light brown, moist, very hard, low plasticity, fine to medium sand
			12b 12a	24 50/6"	>4.5									

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Bright People. Right Solutions.

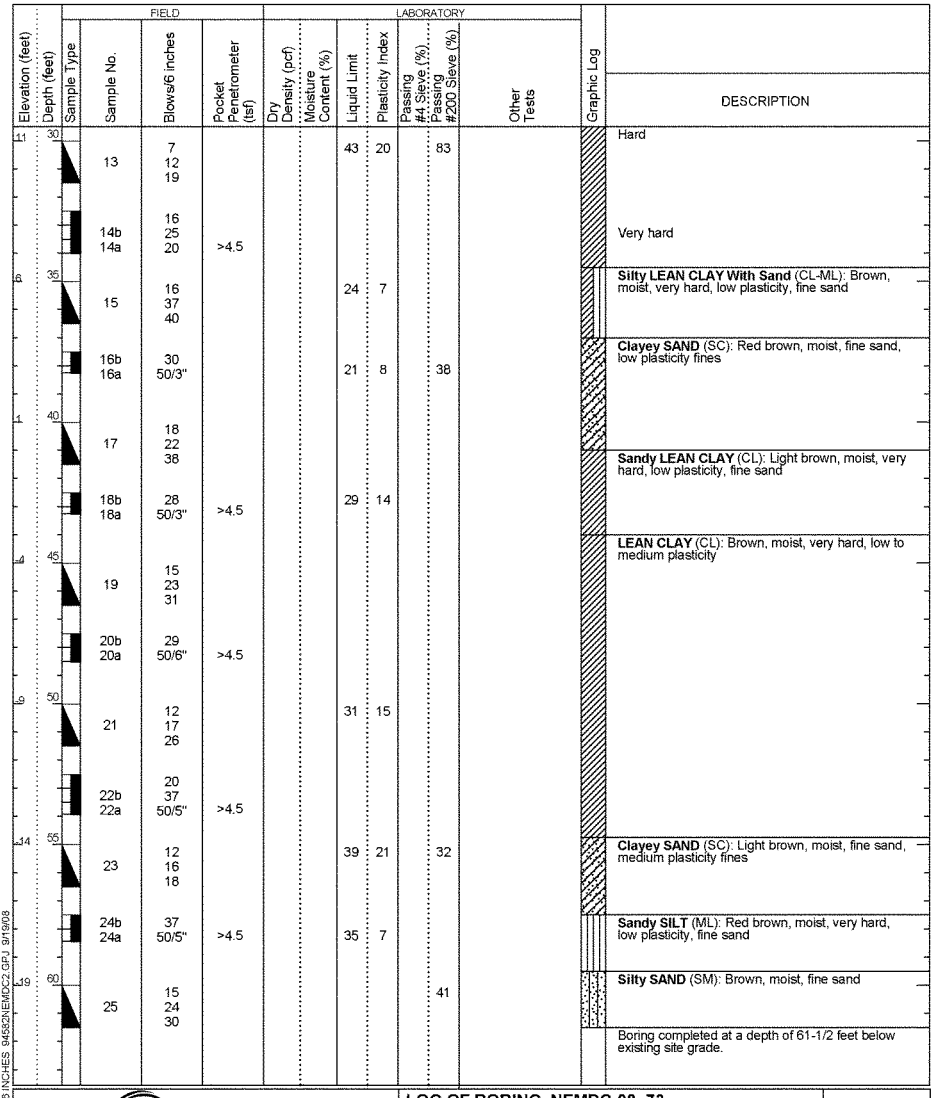
Drafted By: D. Ross
Date: 9/19/2008
Project No.: 94582NEMDC
File Number: 94582NEMDC2

LOG OF BORING NEMDC-08-73
(DRAFT)
NEMDC2

PLATE
1 of 2

P:\LOG_BLOWS PER 6 INCHES 94582\NEMDC2.GPJ 9/19/08

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PLOG_BLOWS PER 6 INCHES 94582NEMDC2.GPJ 9/19/08

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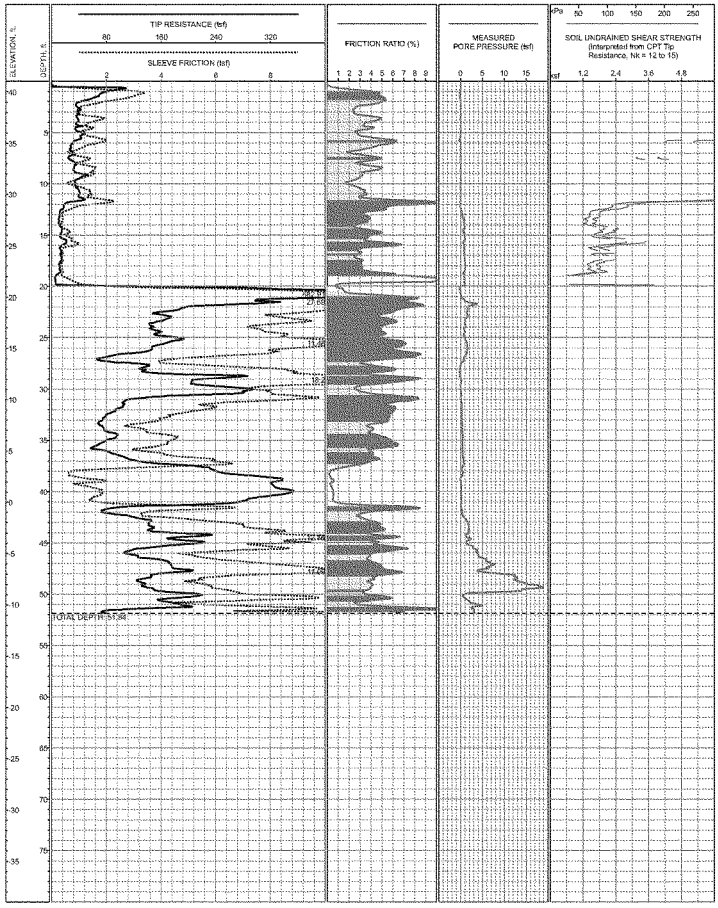
Drafted By: D. Ross
Date: 9/19/2008
Project No.: 94582NEMDC
File Number: 94582NEMDC2

LOG OF BORING NEMDC-08-73
(DRAFT)
NEMDC2

PLATE
2 of 2

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DWR Levees
Project No. 1310.016

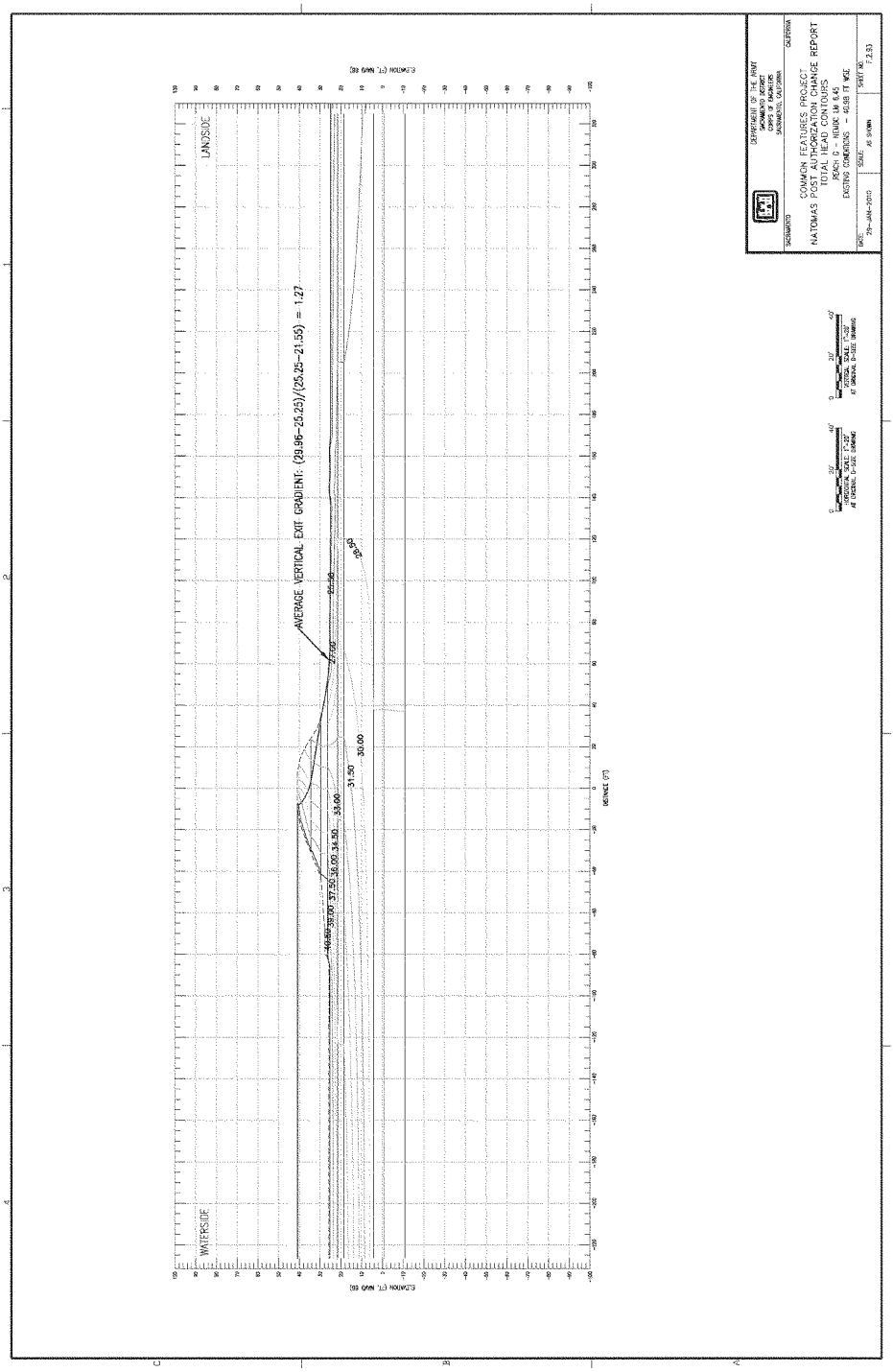


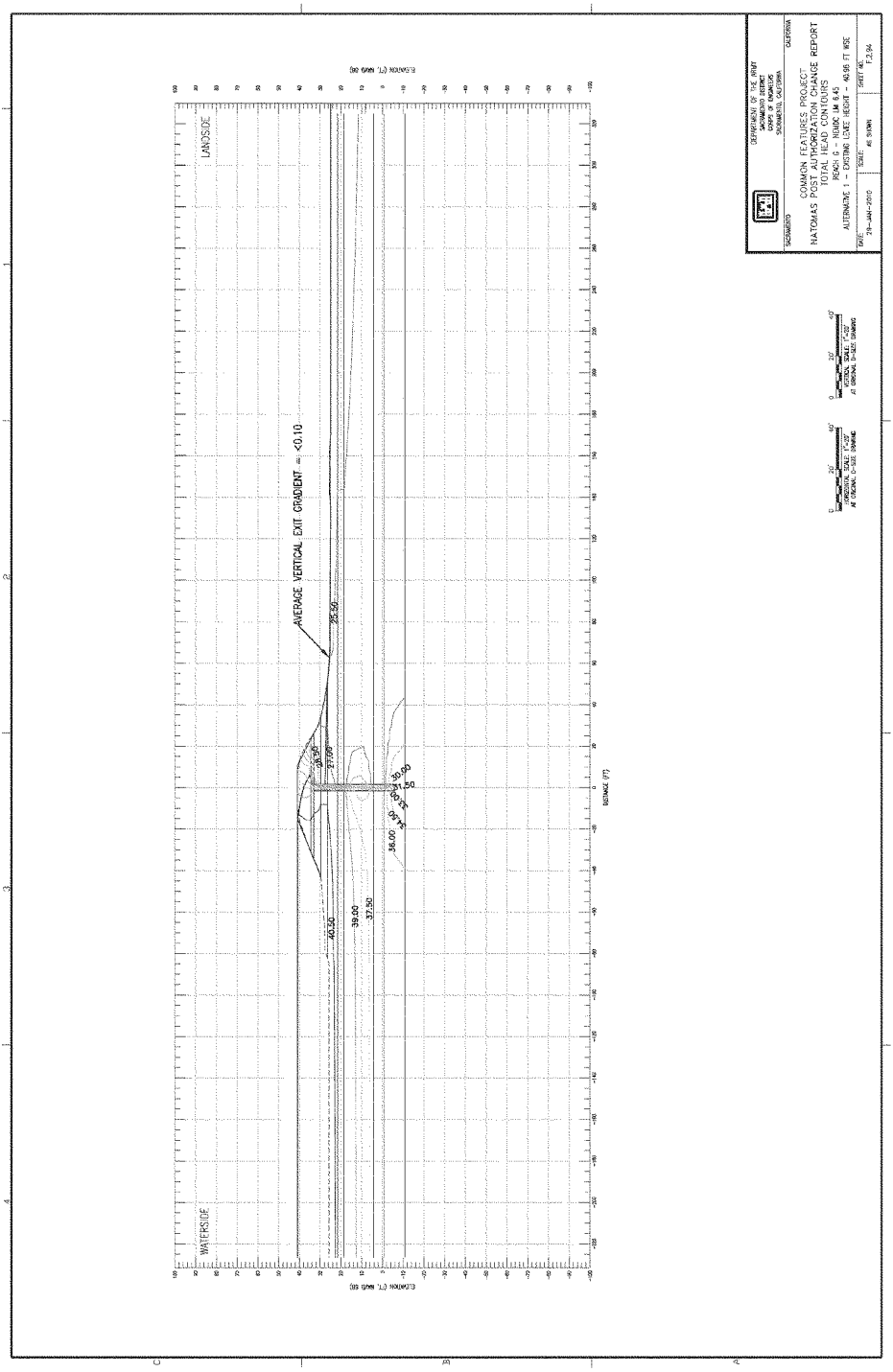
LOCATION: E6,708,483.33 N2,014,937.44 (CA SP Zn II, ft.) Lat:38.69389 Long:-121.48559 (NAD83)
SURFACE EL: 41.04ft (NAVD 88)
COMPLETION DEPTH: 51.84ft
TEST DATE: 10/4/2007

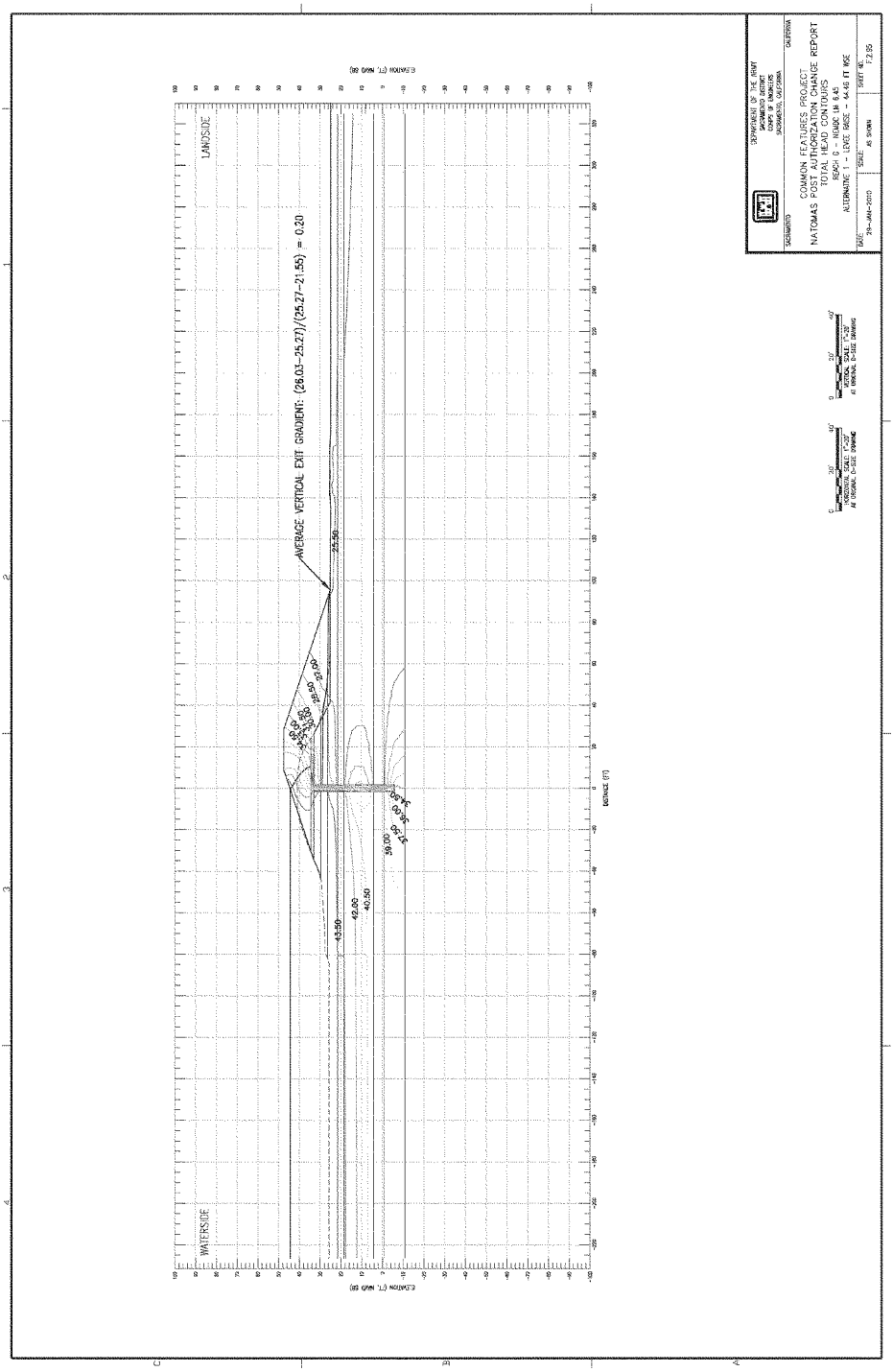
CONE: F7.5CKEW2/B 163
PERFORMED BY: Fugro Consultants
OPERATOR: R. Norris
STATIONING: 334+74.35 Left 4.75
REVIEWED BY: M. Freitas

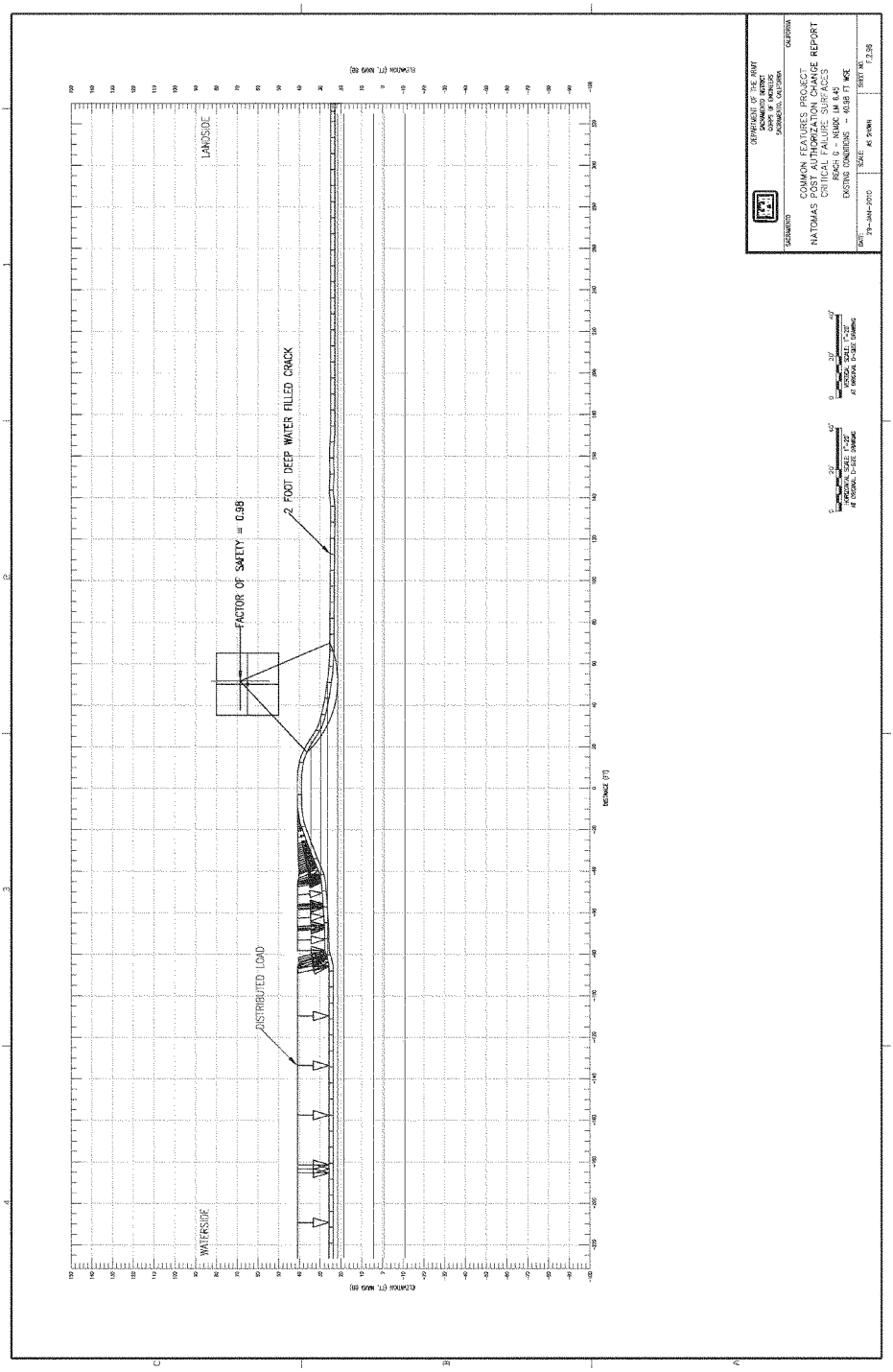
LOG OF WR1000_050C
NEMDC West Study Area

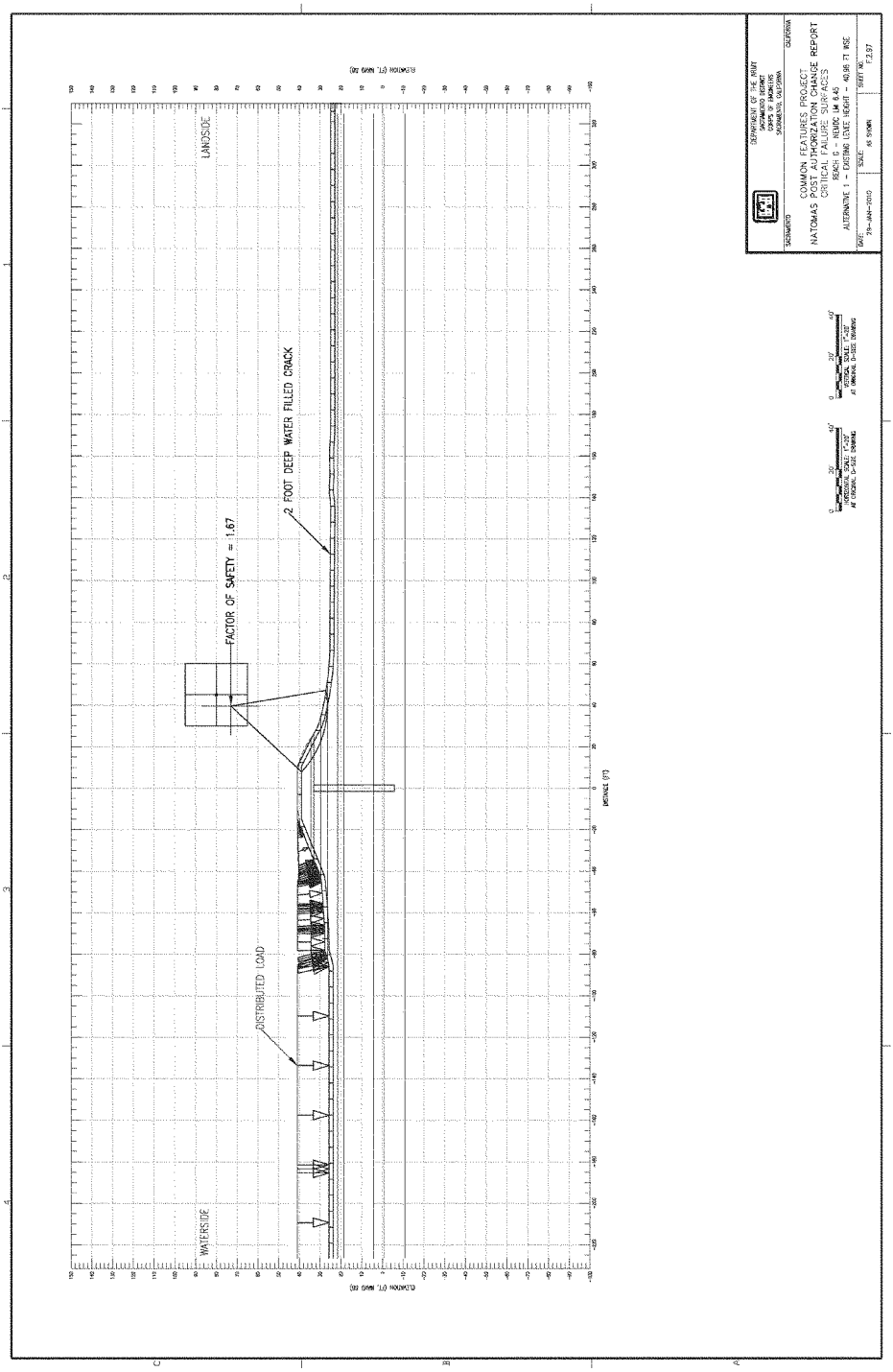
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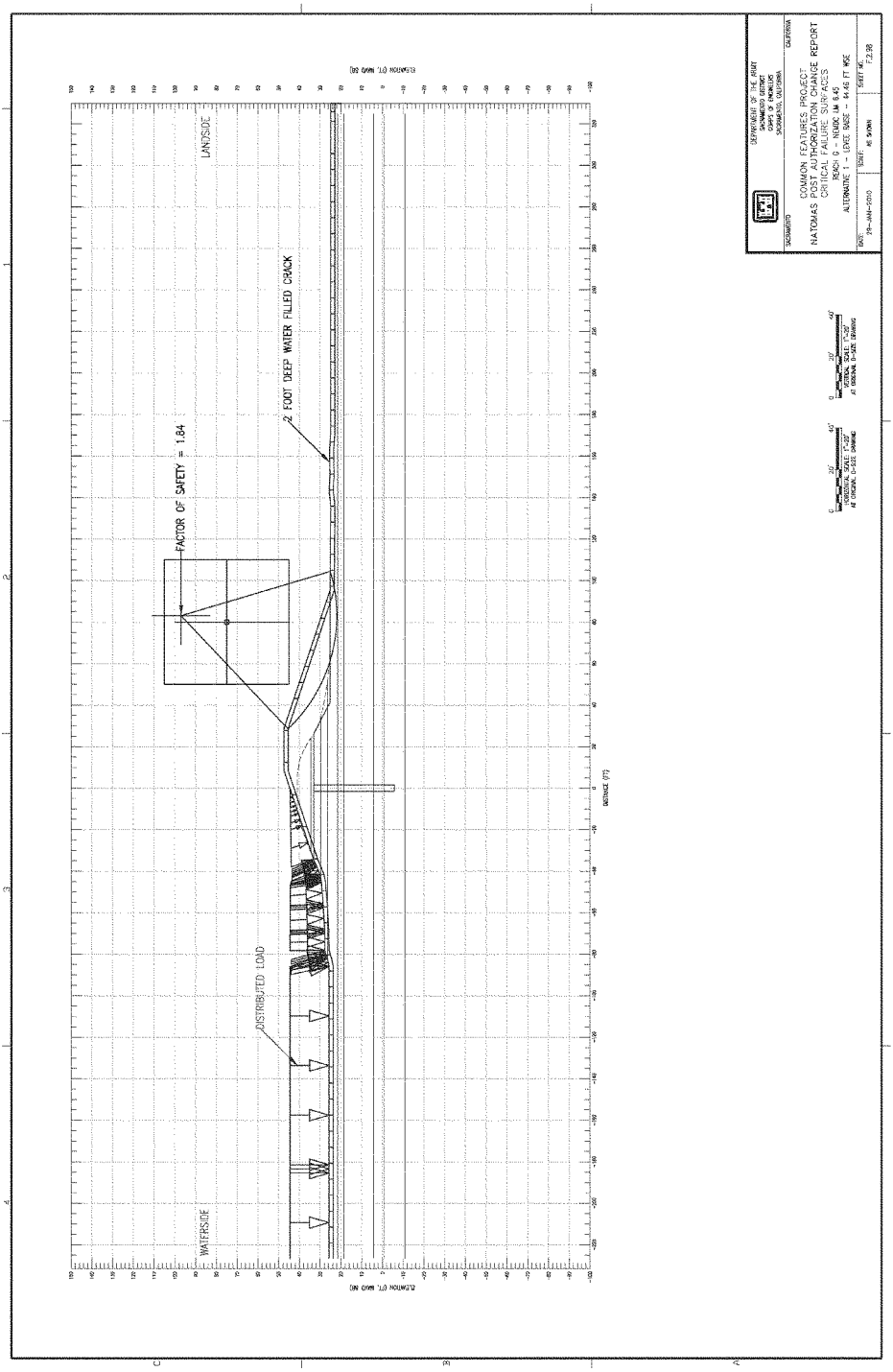

AVERAGE VERTICAL EXIT GRADIENT: (29.96-25.25)/(25.25-21.55) = 1.27
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C - HIGH WATER = 40.68 FT MSL
EXISTING CONDITIONS
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.53


AVERAGE VERTICAL EXIT GRADIENT = <0.10
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH C - NODE M-43
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 40.96 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.94


AVERAGE VERTICAL EXIT GRADIENT: (26.03-25.27)/(25.27-21.55) = 0.20
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A, RIVER MILE 64.46
ALTERNATIVE 1 - LEVEE RAISE - 64.46 ET AGE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.95


WATERSIDE
LANDSIDE
FACTOR OF SAFETY = 0.98
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH C, RIVER MILE 44.8 TO 46.2
EXISTING CONDITIONS
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.39


DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH E, RIVER MILE 44.5
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT - 40.96 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.97
LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 1.67
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)


FACTOR OF SAFETY = 1.84
2 FOOT DEEP WATER FILLED CRACK
LANDSIDE
WATERSIDE
DISTRIBUTED LOAD
ELEVATION OF MWD (ft)
DISTANCE (ft)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
CRITICAL FAILURE SURFACES
REACH 2, RIVER MILE 64.46
ALTERNATIVE 1 - LEVEE RAISE - 64.46 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.28

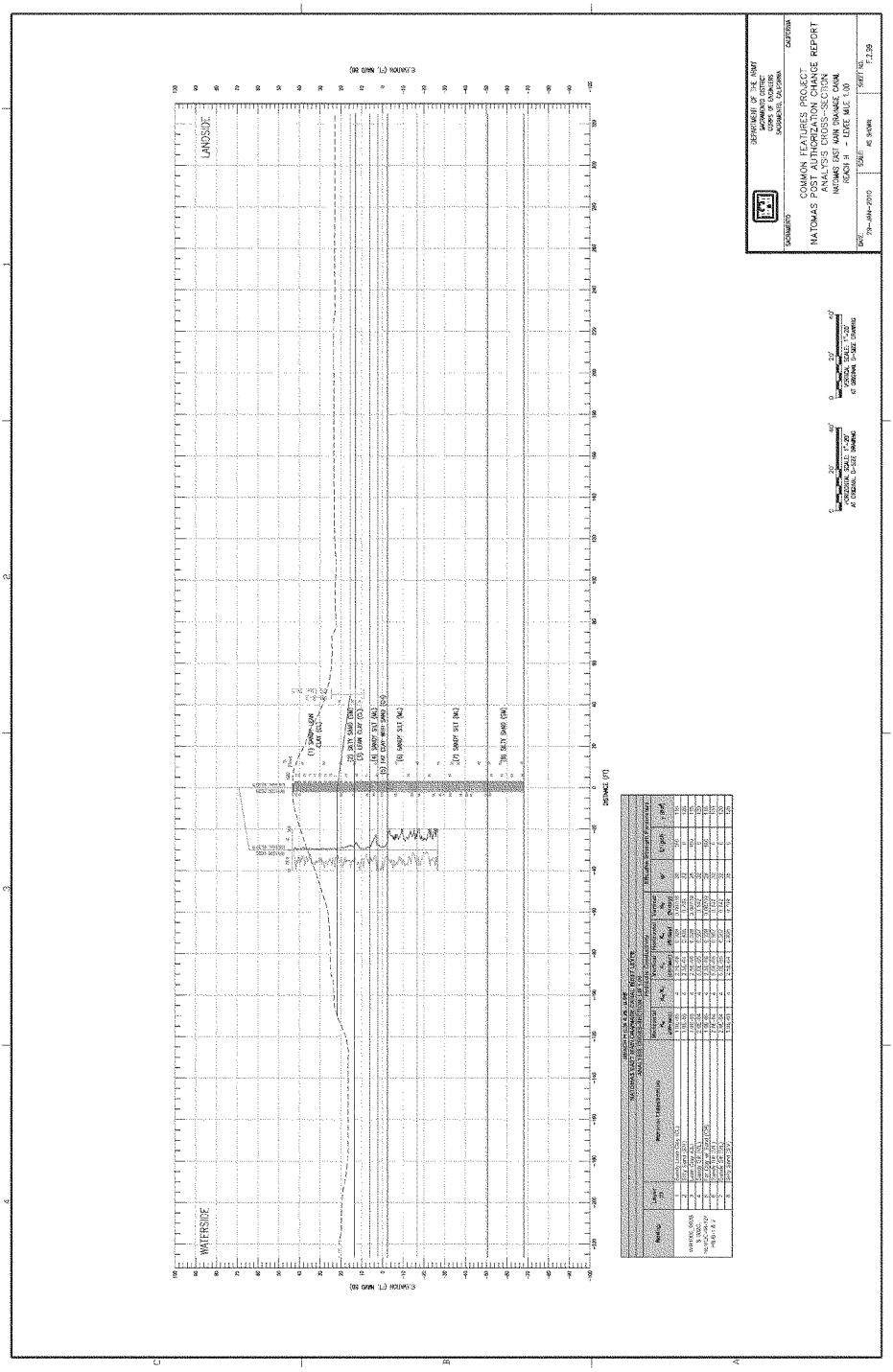
REACH H

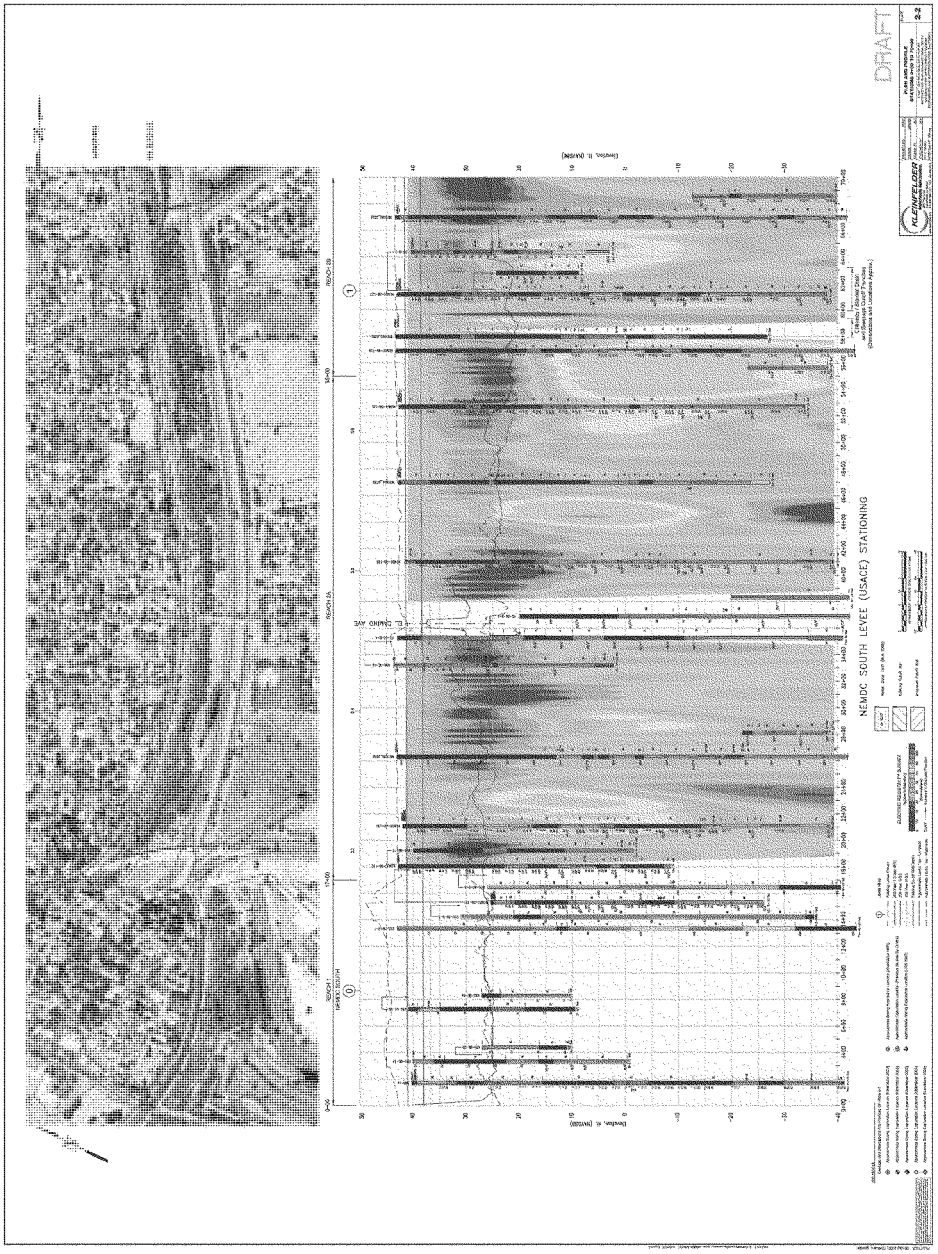
CALCULATION PACKAGE

NATOMAS EAST MAIN DRAINAGE CANAL WEST LEVEE

(NEMDCW)

LM 4.25 – 0.00


WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
(1) SANDY LEAN CLAY (CL)
(2) SILTY SAND (SM)
(3) SOFT LEAN CLAY (CL)
(4) SOFT SILTY SAND WITH CLAY (SC)
(5) SOFT SILTY SAND (SM)
(6) SANDY SILT (ML)
(7) SANDY SILT (ML)
(8) SILTY SAND (SM)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
NATOMAS EAST MAIN DRAINAGE CANAL
REACH H - LEVEE MILE 1.00
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.99


NEMDC SOUTH LEVEE (USACE) STATIONING
E. CHANO AVE
DRAFT

DATE STARTED	DATE COMPLETED	GROUND ELEVATION	ELEVATION BASIS	TOTAL DEPTH OF BORING
5/1/07	5/3/07	43.29 ft	Survey crew	111.5 ft
DRILLING CONTRACTOR		**DRILLER'S NAME**	**HELPER'S NAME**	**TOTAL DEPTH OF FILL**
Westex		Chris Minor	J. Figuroa	22.5 ft
DRILLING METHOD		**DRILL RIG MAKE AND MODEL**		**CONSULTANT COMPANY**
0-30' 8" HSA, 31.5'-111.5' Rotary Wash		CME 550		Fugro West
DRILL BIT SIZE AND TYPE (HOLE DIAMETER)		**DRILLING ROD TYPE AND DIAMETER**		**FIELD LOGGER**
8" HSA, 4-3/8" Core Bit		HQ Core 94mm, NWJ 67mm		Gopalan Vishnan
☒ VERTICAL ☐ INCLINED		**CASING TYPE, DIAMETER, INSTALLATION DEPTH**		**FIELD LOG REVIEWER**
		10" HSA to 25'		Duston Marlow
SAMPLER TYPE(S)		**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP**		**HAMMER EFFICIENCY**
SPT(1.375"), MC(2"), Shelby(2.87" ID), Punch Core(2.25")		CME, swing arm automatic, 140 lbs / 30-inch drop		72%
BOREHOLE BACKFILL OR COMPLETION		**GROUNDWATER READING: DURING DRILLING**		**AFTER DRILLING (DATE-TIME)**
See the termination note		N/A due to rotary wash drilling method		

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	0		7 inches of Asphalt.												
	1		CLAYEY SAND (SC); medium dense; dark olive brown (2.5Y 3/3); moist; 80% fine to medium sand; 20% fines; (FILL).		1	56	6 5 5	10	12						S01A_001_003S
	2														
40	3		SANDY LEAN CLAY (CL); dark yellowish brown (10YR 3/4); moist; 57% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 43% fine to medium sand; (FILL).		2	72	3 6 8	14	17						S02A_003_004S
	4														
	5				3	67	4 5 5	10	12					57	S03A_005_006S
	6														
	7														
35	8		Color changes to dark brown (7.5YR 3/3) at 7.8'.		4	22	3 4 5	9	11						S04A_007_008S
	9														
	10		Color changes to pale yellow (5Y 7/3) and dark yellowish brown (10YR 4/4) at 10.2'.		5	39	2 4 5	9	11						S05A_010_011S
	11														
	12														
30	13		Color changes to dark yellowish brown (10YR 4/4) and very dark gray (10YR 3/1) at 12.8'.		6	39	2 5 5	10	12						S06A_013_014S
	14														
	15														
	16		Color changes to light olive brown (2.5Y 5/4), 62% fines, 38% fine to medium sand, trace coarse grained sand at 15.4'.		7	67	2 4 5	9	11					62	S07A_015_016S
	17														
	18				8	61	3 5 5	10	12						S08A_008_009S
25	19														
	20														

Final Report Version 5/20/2008

Borehole Location: Crest of the Levee
Coordinates: North 1,987,865.97 East 6,713,288.82
Levee Station or Milepost: STA: 51+27; OFFSET: 5.6 Left
GPS: Latitude -121.46977 Longitude 38.62039
Channel / River Name / Feature: Natomas East Main Drainage Canal
County: Sacramento

LOG OF BORING
WR1000_002B
Sheet 1 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	REMARKS
	20				9	50	3 3 3	6	7						S09A_020_021S
	21														
	22		(BASE OF FILL).												
	23		SILTY SAND (SM); dense; brown (10YR 4/3); moist; 50% fine to medium sand; 50% fines; trace clay. (NATIVE).		10	100	9 11 12	23			61			50	S10B_023_024M S10A_023_024M
20	24														
	25														
	26		Color change to dark yellowish brown (10YR 4/3) at 25.3'.		11	100	6 14 13	27	32						S11A_025_026S
	27														
	28				12	67	11 21 30	51		4.5+P					S12A_028_029M
15	29		LEAN CLAY (CL); hard; light yellowish brown (2.5Y 6/4); moist; 85% medium dry strength, no dilatancy, medium toughness fines; 15% fine sand.												
	30				13	83	5 14 22	36	43	4.5+P	28	42	22	85	S13A_030_031S
	31														
	32					0									Drill tool changed from auger to punch core at 31.5' depth No Recovery 31.5' - 35'
10	33														
	34														
	35		LEAN CLAY with Sand (CL); stiff; pale brown (10YR 6/3); moist; 80% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 20% fine sand.		14	83	2 3 6	9	11	2.0P					S14A_035_036S
	36														
	37					0									No Recovery 36.5' - 40'
	38														
5	39		SANDY SILT (ML); very dense; brown (7.5YR 5/4); moist; 51% low plasticity, low dry strength, slow dilatancy, low toughness fines; 49% fine to medium sand; weak cementation.		15	33									S15A_038_039P
	40		Color changes to olive brown (2.5Y 4/3) at 40.0'.		16	50	11 26 41	67	80					51	S16A_040_041S
	41														
	42		FAT CLAY with Sand (CH); hard; pale olive (5Y 6/3); moist; 80% high dry strength, no dilatancy, high toughness fines; 20% fine sand.												
0	43				17	100				4.0P					S17A_043_044P
	44														
	45														

Final Report Version 5/20/2008

Borehole Location: Crest of the Levee
Coordinates: North 1,987,865.97 East 6,713,286.82
Levee Station or Milepost: STA: 51+27; OFFSET: 5.6 Left
GPS: Latitude 121.46977 Longitude 38.62039
Channel / River Name / Feature: Natomas East Main Drainage Canal
County: Sacramento

LOG OF BORING
WR1000_002B
Sheet 2 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	REMARKS
	45														
	46				18	72	4 11 17	28	34	4.5P	44	66	38		S18A_045_046S
	47														
	48				19	98				4.0P					S19A_048_049P
-5	49		SANDY SILT (ML); very dense; olive brown (2.5Y 4/4); moist; 57% no plasticity, low dry strength, slow dilatancy, low toughness fines; 43% sand.												
	50														
	51				20	71	12 36 50/5"	86/ 11"						57	S20A_050_051S
	52														S21A_053_054P
	53				21	98									
-10	54														
	55														
	56				22	78	17 31 45	76	91	3.5P					S22A_055_056S
	57		SILTY SAND (SM); olive (5Y 5/3); moist; 70% fine sand; 30% fines.												
	58				23	43									S23A_058_059P
-15	59														
	60		SANDY SILT (ML); very dense; olive (5Y 4/3); moist; 53% no plasticity, low dry strength, slow dilatancy, low toughness fines; 47% fine sand.												
	61				24	67	6 37 50/3"	87/ 9"		4.5+P				53	S24A_060_061S
	62														S25A_062_063P
	63				25	16									
-20	64														
	65														
	66				26	78	14 22 31	53	64	1.5P					S26A_065_066S
	67										29	NP	NP		S27A_067_068P
	68		SILT with Sand (ML); olive (5Y 4/3); moist; 80% low dry strength, slow dilatancy, low toughness fines; 20% sand.		27	36				3.0P					
-25	69														
	70														

Final Report Version 5/20/2008

Borehole Location: Crest of the Levee
Coordinates: North 1,987,865.97 East 6,713,288.82
Levee Station or Milepost: STA: 51+27; OFFSET: 5.6 Left
GPS: Latitude -121.46977 Longitude 38.62039
Channel / River Name / Feature: Natomas East Main Drainage Canal
County: Sacramento

LOG OF BORING
WR1000_002B
Sheet 3 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	70		SANDY SILT (ML); very dense; light olive brown (2.5Y 5/3); moist; 64% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 36% fine sand.		28	93	11 28 50/3"	78/ 9"						64	S28A_070_071S
	71														
	72														S29A_072_073S
-30	73		LEAN CLAY with Sand (CL); hard; olive brown (2.5Y 4/3); moist; 80% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 20% fine sand.		29	20				4.0P					
	74														
	75		SILTY SAND (SM); very dense; dark olive gray (5Y 3/2); moist; 77% fine to medium sand; 23% fines.			0	17 22 22	44	53						No Recovery 75' - 76.5'
	76														
	77													23	S30A_077_078P
-35	78				30	17									
	79														
	80		SILT with Sand (ML); very dense; light olive gray (5Y 6/2); moist; 80% low dry strength, slow dilatancy, low toughness fines; 20% fine sand.		31	86	14 33 50/2"	83/ 8"		4.5+P	32	35	7	80	S31A_080_082S
	81														
	82									4.5+P					
-40	83		SILTY SAND (SM); olive gray (5Y 5/2); moist; 80% fine sand; 20% fines; weak cementation.		32	59									S32A_083_084P
	84														
	85		SILT with Sand (ML); hard; olive gray (5Y 5/2); moist; 82% low dry strength, slow dilatancy, low toughness fines; 18% fine sand.		33	100	22 37 50/3"	87/ 9"		4.5+P	37	40	12		S33A_085_086S
	86														
	87														No Recovery 86.5' - 90'
-45	88					0									
	89														
	90														
	91				34	91	23 50/5"	50/ 5"		4.0P				82	S34A_090_091S
	92		LEAN CLAY with Sand (CL); hard; olive brown (2.5Y 4/4); moist; 95% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 5% sand; trace mica.												S35A_092_093P
-50	93				35	69				4.5+P					
	94		SILTY SAND (SM); very dense; olive brown (2.5Y 4/4); moist; 63% medium sand; 37% fines.							2.0P					
	95														

Final Report Version 5/20/2008

Borehole Location: Crest of the Levee
Coordinates: North 1,987,865.97 East 6,713,288.82
Levee Station or Milepost: STA: 51+27; OFFSET: 5.6 Left
GPS: Latitude 38.62039 Longitude -121.46977
Channel / River Name / Feature: Natomas East Main Drainage Canal
County: Sacramento

LOG OF BORING
WR1000_002B
Sheet 4 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	REMARKS
	95														
	96		Color changes to olive brown (2.5Y 4/3), trace mica at 96.0'.		36	83	13 23 29	52	62	2.5P				37	S36A_095_096S
	97														S37A_097_098P
-55	98				37	36									
	99														
	100		22% fines, 78% sand at 100.0'.												
	101				38	67	11 24 27	51	61					22	S38A_100_101S
	102														S39A_102_103P
-60	103				39	29									
	104														
	105														
	106		Color changes to dark olive brown (2.5Y 3/3) at 105.4'.		40	83	12 20 31	51	61						S40A_105_106S
	107														S41A_107_108P
-65	108				41	21									
	109														
	110		24% fines, 76% sand at 110.0'.												
	111				42	50	23 25 30	55	66					24	S42A_110_111S
	112														
-70	113														
	114														
	115														
	116														
	117														
	118														
-75	119														
	120														

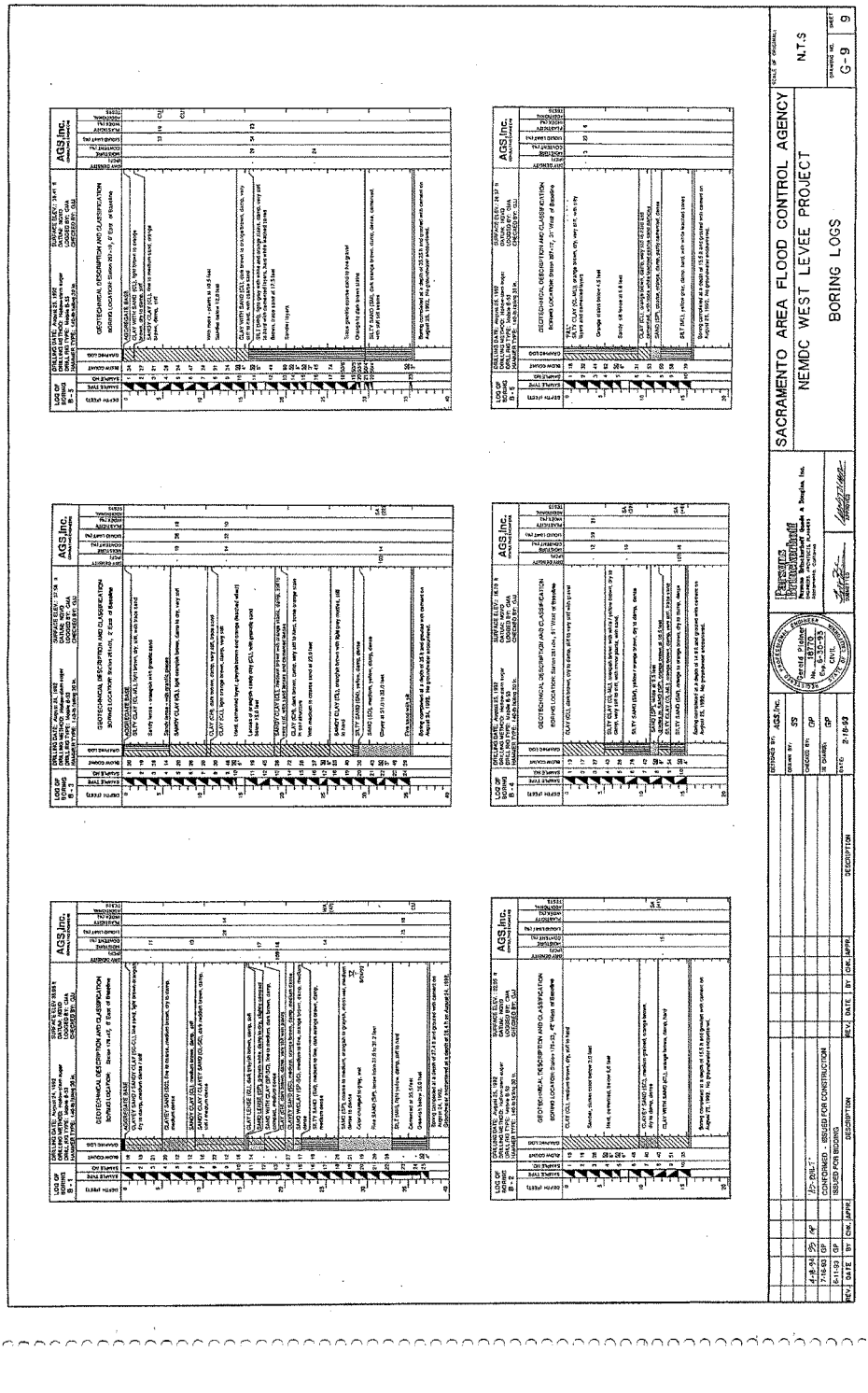
Final Report Version 5/20/2008

DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA

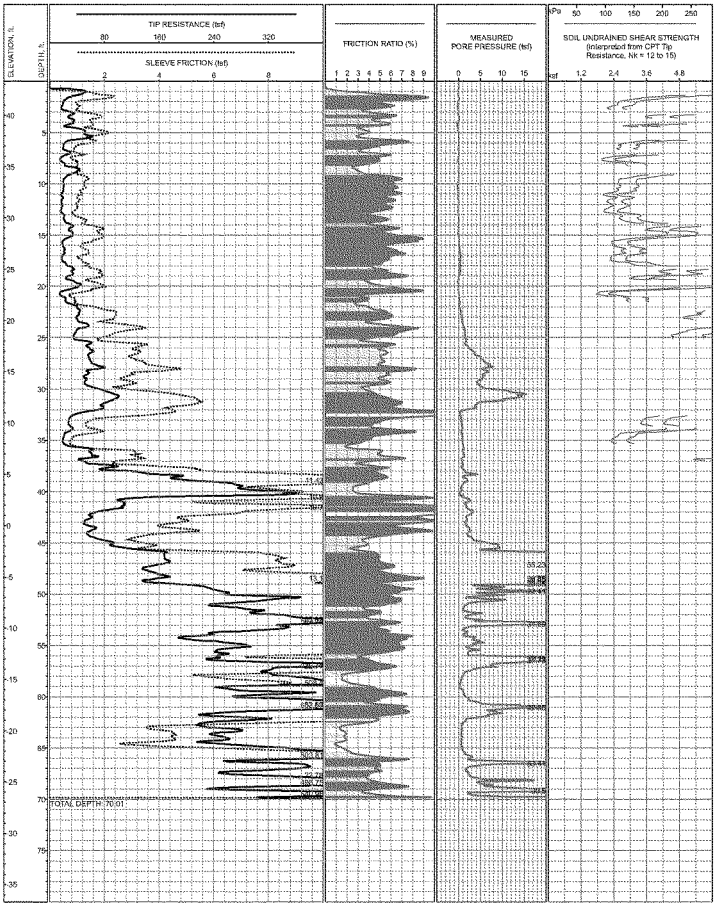
Borehole Location: Crest of the Levee
Coordinates: North 1,987,865.97 East 6,713,288.82
Levee Station or Milepost: STA: 51+27; OFFSET: 5.6 Left
GPS: Latitude 121.46977 Longitude 38.62039
Channel / River Name / Feature: Natomas East Main Drainage Canal
County: Sacramento

LOG OF BORING
WR1000_002B
Sheet 5 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations


SACRAMENTO AREA FLOOD CONTROL AGENCY
NEMDC WEST LEVEE PROJECT
BORING LOGS
N.T.S
G-9
9
Parsons Brinckerhoff
Quade & Douglas, Inc.
Harding Lawson Associates
AGS,Inc.
LOG OF BORING B-1
LOG OF BORING B-2
LOG OF BORING B-3
LOG OF BORING B-4
REV.
DATE
BY
CHK.
APPR.
DESCRIPTION
ISSUED FOR BIDDING
CONFORMED - ISSUED FOR CONSTRUCTION
7-16-93
5-11-93
4-14-93
2-18-93
DRAWN BY: SS
CHECKED BY: CP
DESIGNED BY: CP
DATE: 2-18-93
No. 18770
Exp. 6-30-95
PROFESSIONAL ENGINEER
CIVIL
STATE OF CALIFORNIA

DWR Levees
Project No. 1310.016

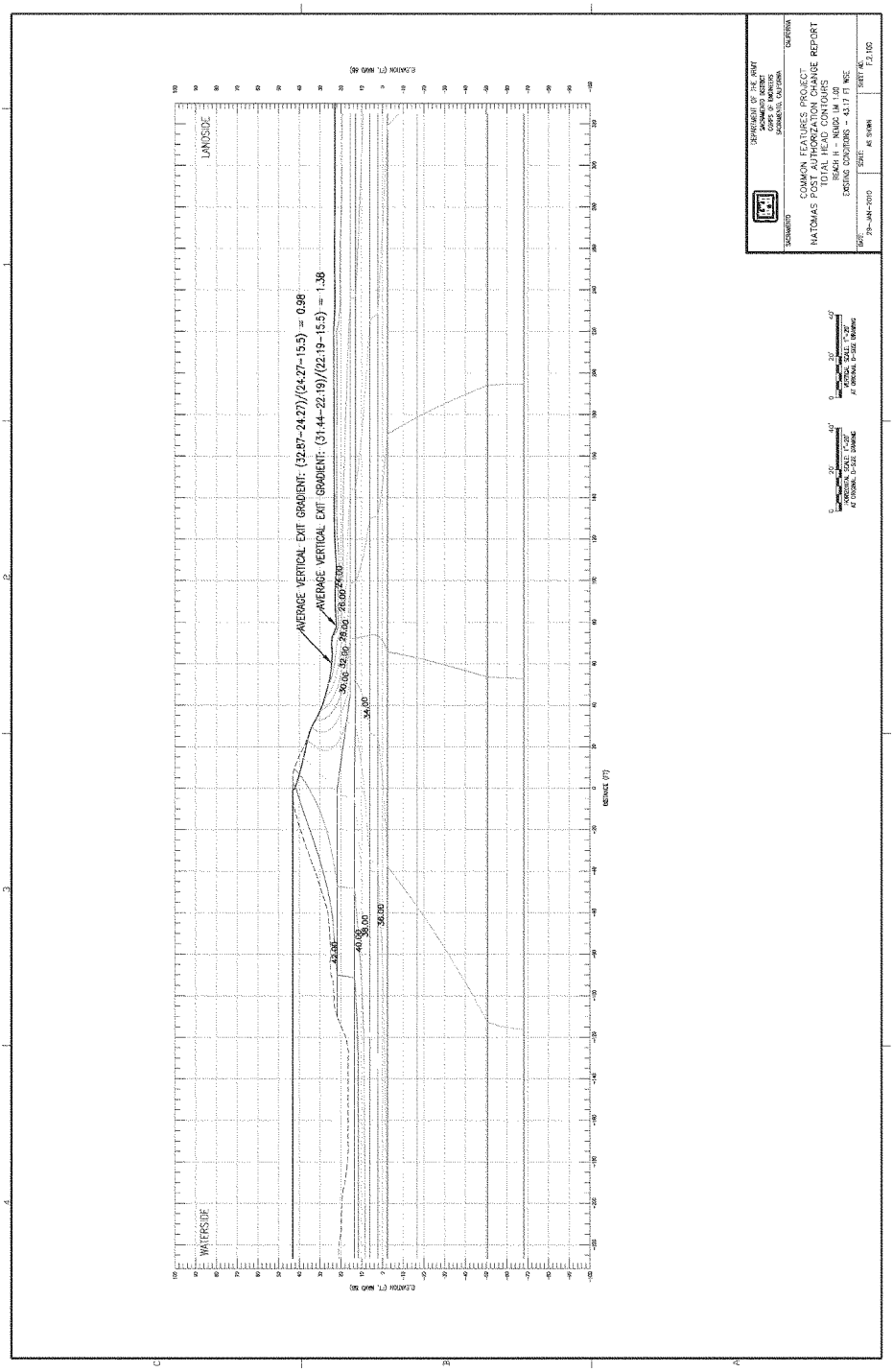


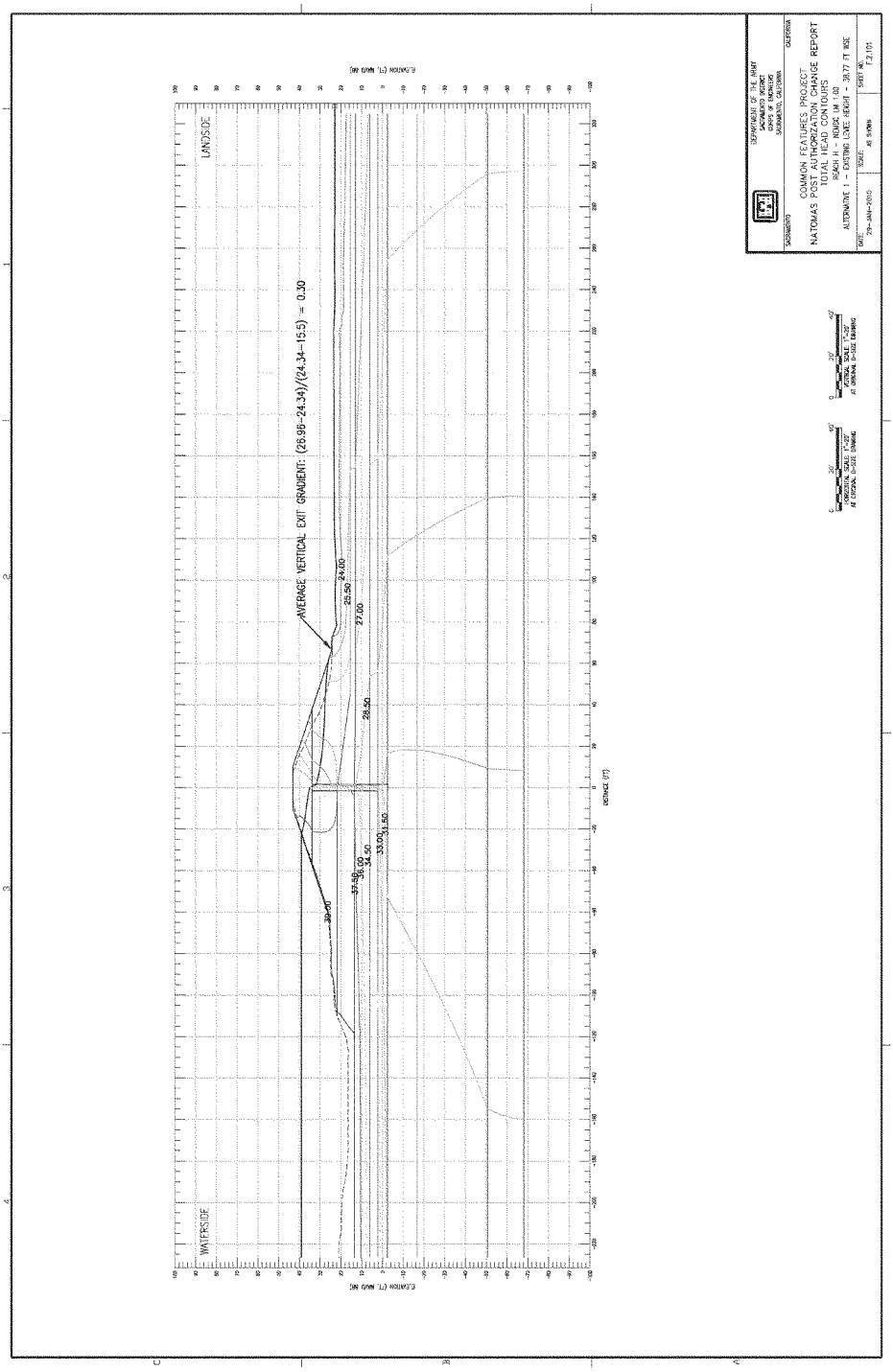
LOCATION: E6,713,290.54 N1,987,863.07 (CA SP Znll, ft.) Lat:38.61947 Long:-121.46930 (NAD83)
SURFACE EL: 43.31ft (NAVD 88)
COMPLETION DEPTH: 70.01ft
TEST DATE: 10/10/2007

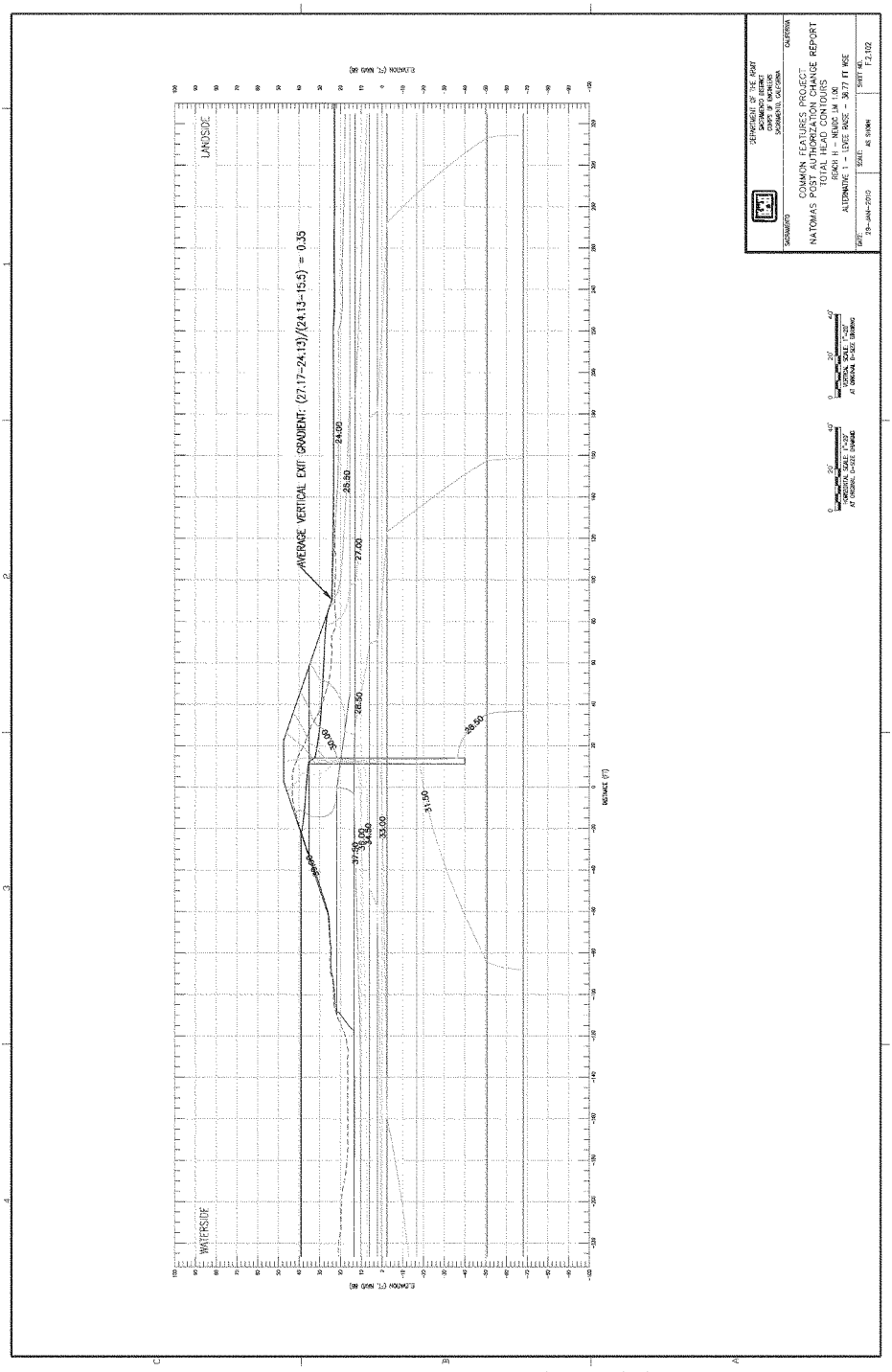
CONE: F7.5CKEW2/B 151
PERFORMED BY: Fugro Consultants
OPERATOR: D. Garza
STATIONING: 51+23.58 Left 4.39
REVIEWED BY: M. Freitas

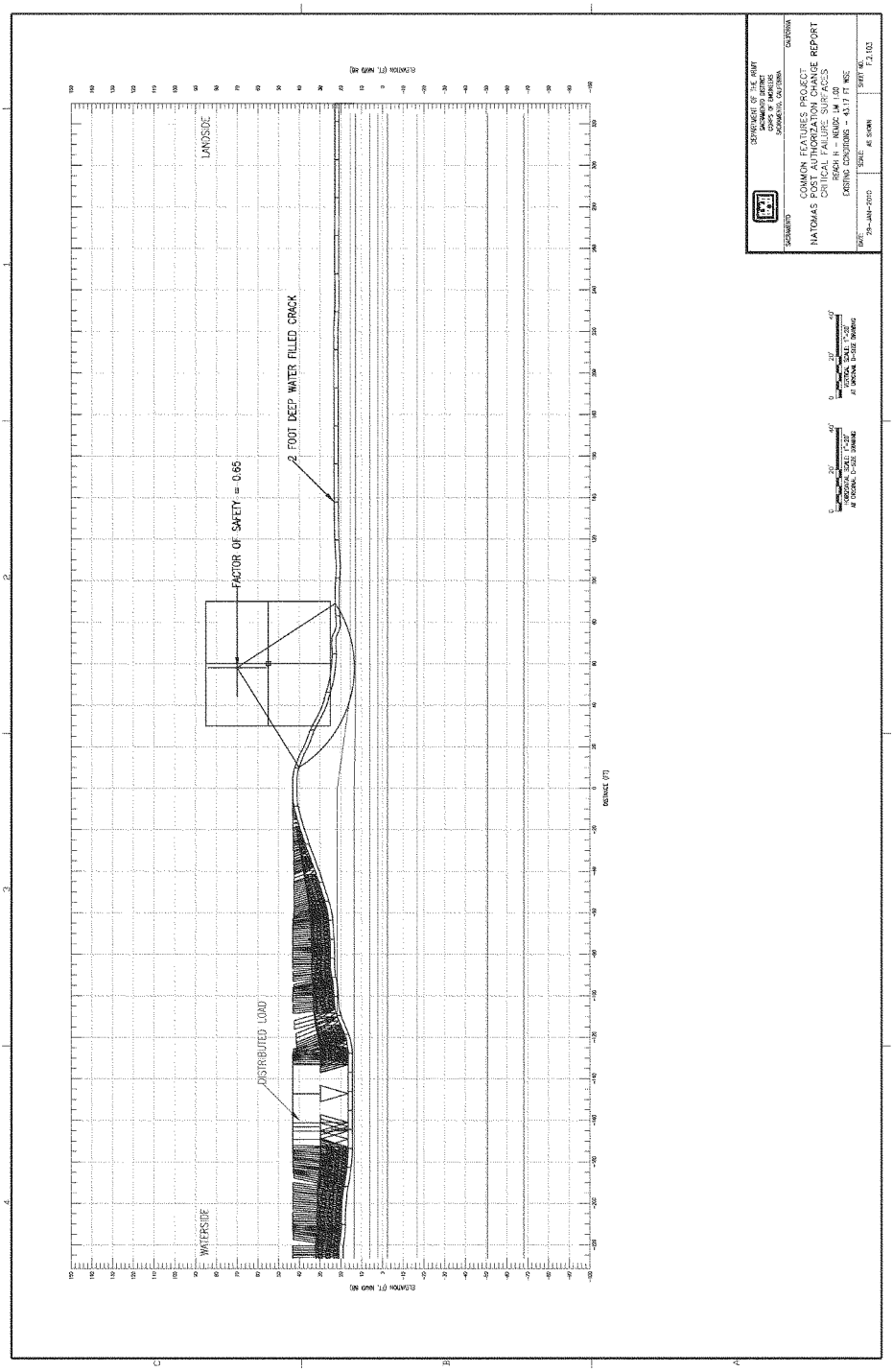
LOG OF WR1000_002C
NEMDC West Study Area

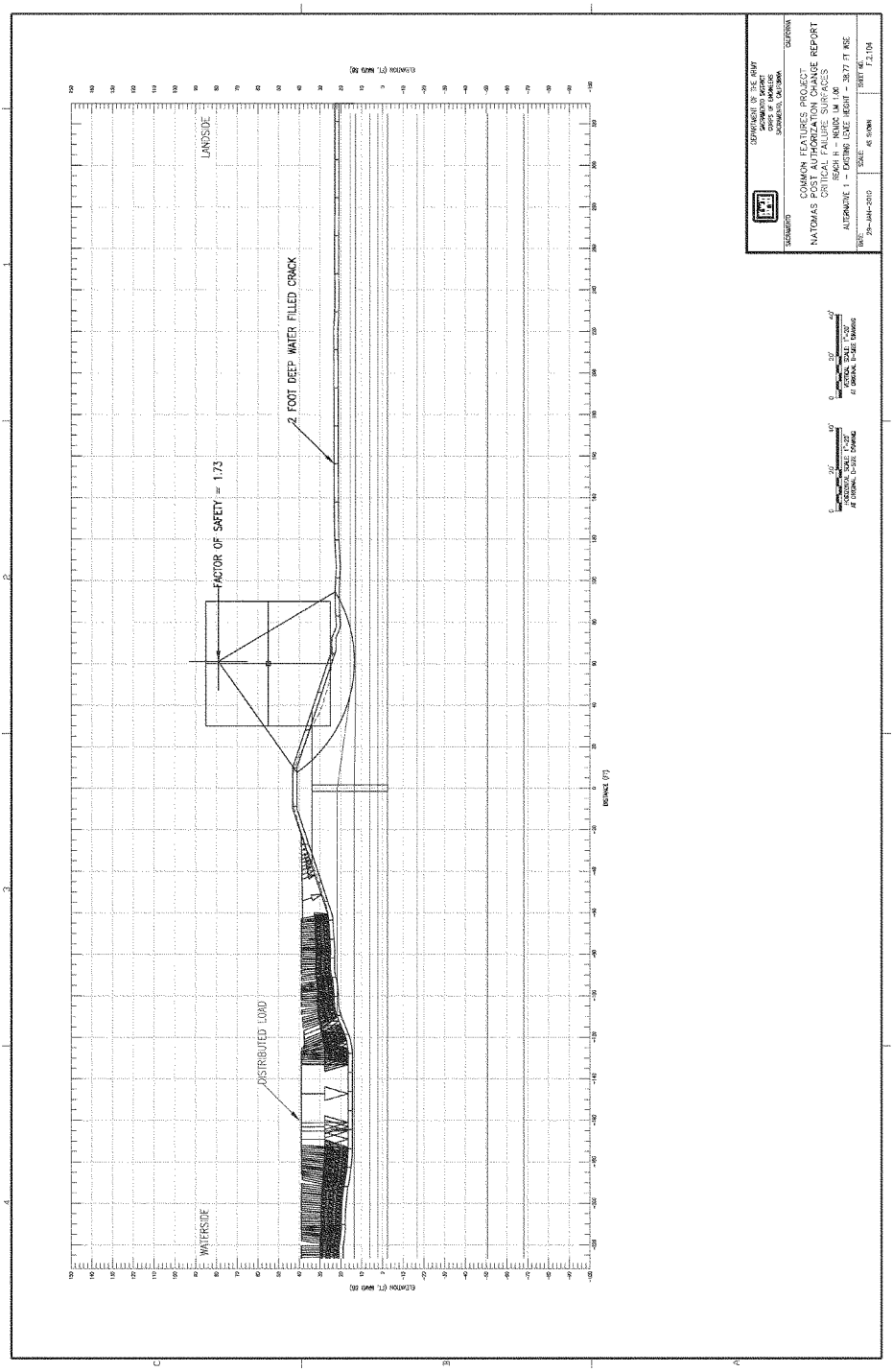
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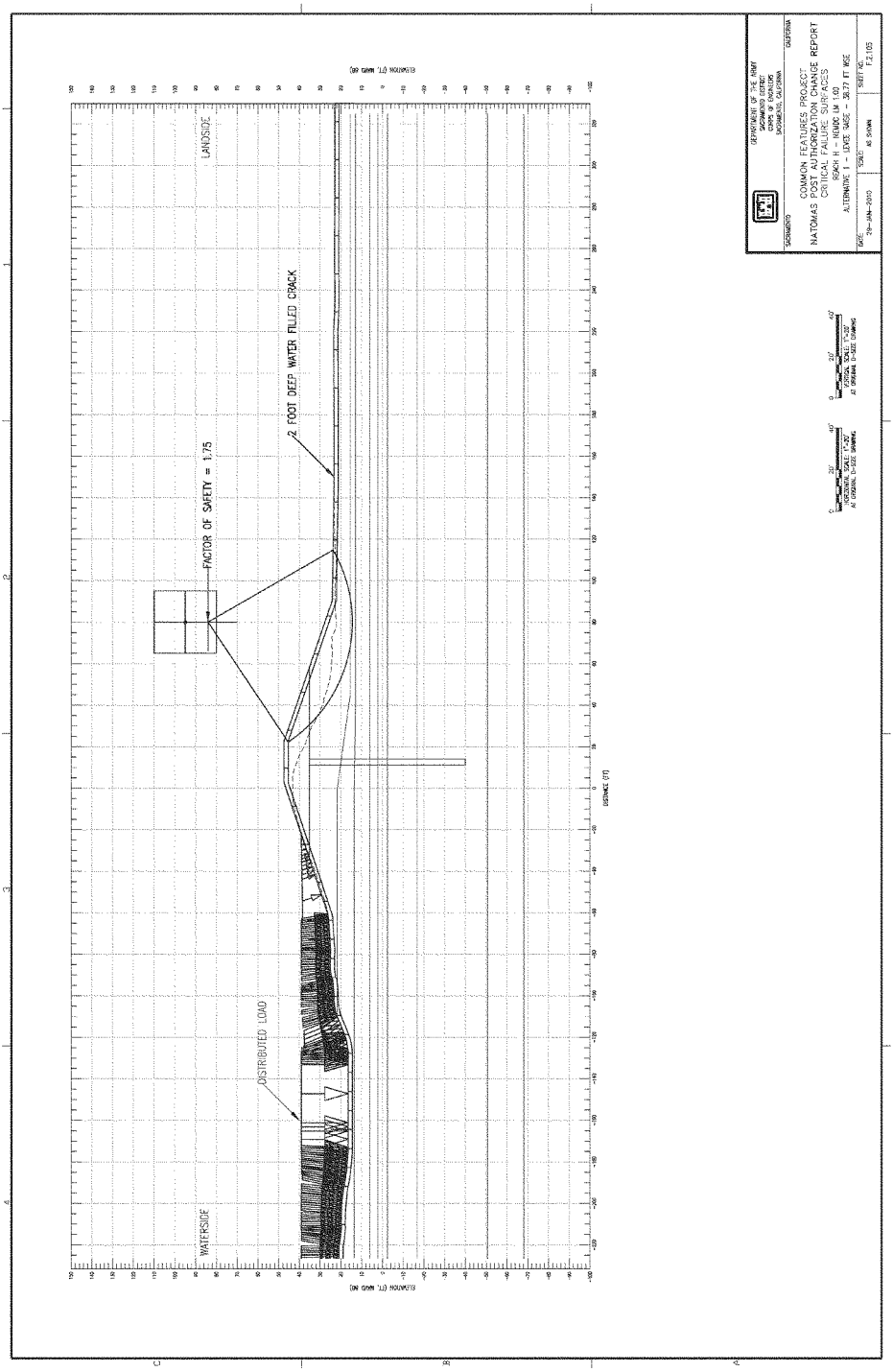

AVERAGE VERTICAL EXIT GRADIENT: (32.87-24.27)/(24.27-15.5) = 0.98
AVERAGE VERTICAL EXIT GRADIENT: (31.44-22.19)/(22.19-15.5) = 1.38
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
EXISTING CONDITIONS - 43.17 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.100


AVERAGE VERTICAL EXIT GRADIENT: (26.96-24.34)/(24.34-15.5) = 0.30
LANDSIDE
WATERSIDE
ELEVATION (FT NAVD 88)
DISTANCE (FT)
24.00
25.50
27.00
28.50
31.50
33.00
34.50
36.00
37.50
39.00
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A - RIVER MILE 60.5
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 38.77 FT MSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F.2.101


AVERAGE VERTICAL EXIT GRADIENT: (27.17-24.13)/(24.13-15.5) = 0.35
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
24.00
25.50
27.00
28.50
30.00
31.50
33.00
34.50
36.00
37.50
39.00
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH 1 - RIVER MILE 59.1
ALTERNATIVE 1 - LEVEE RAISE - 36.77 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.102


WATERSIDE
LANDSIDE
DISTRIBUTED LOAD
FACTOR OF SAFETY = 0.65
2 FOOT DEEP WATER FILLED CRACK
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, RIVER MILE 43.17 FT. WSE
EXISTING CONDITIONS
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.102


FACTOR OF SAFETY = 1.73
2 FOOT DEEP WATER FILLED CRACK
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACE ACROSS
REACH 1 - WATER SIDE
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT + 38.77 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.104


WATERSIDE
LANDSIDE
DISTRIBUTED LOAD
FACTOR OF SAFETY = 1.75
2 FOOT DEEP WATER FILLED CRACK
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
ALTERNATIVE 1 – LEVEE RAISE – 38.77 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.103

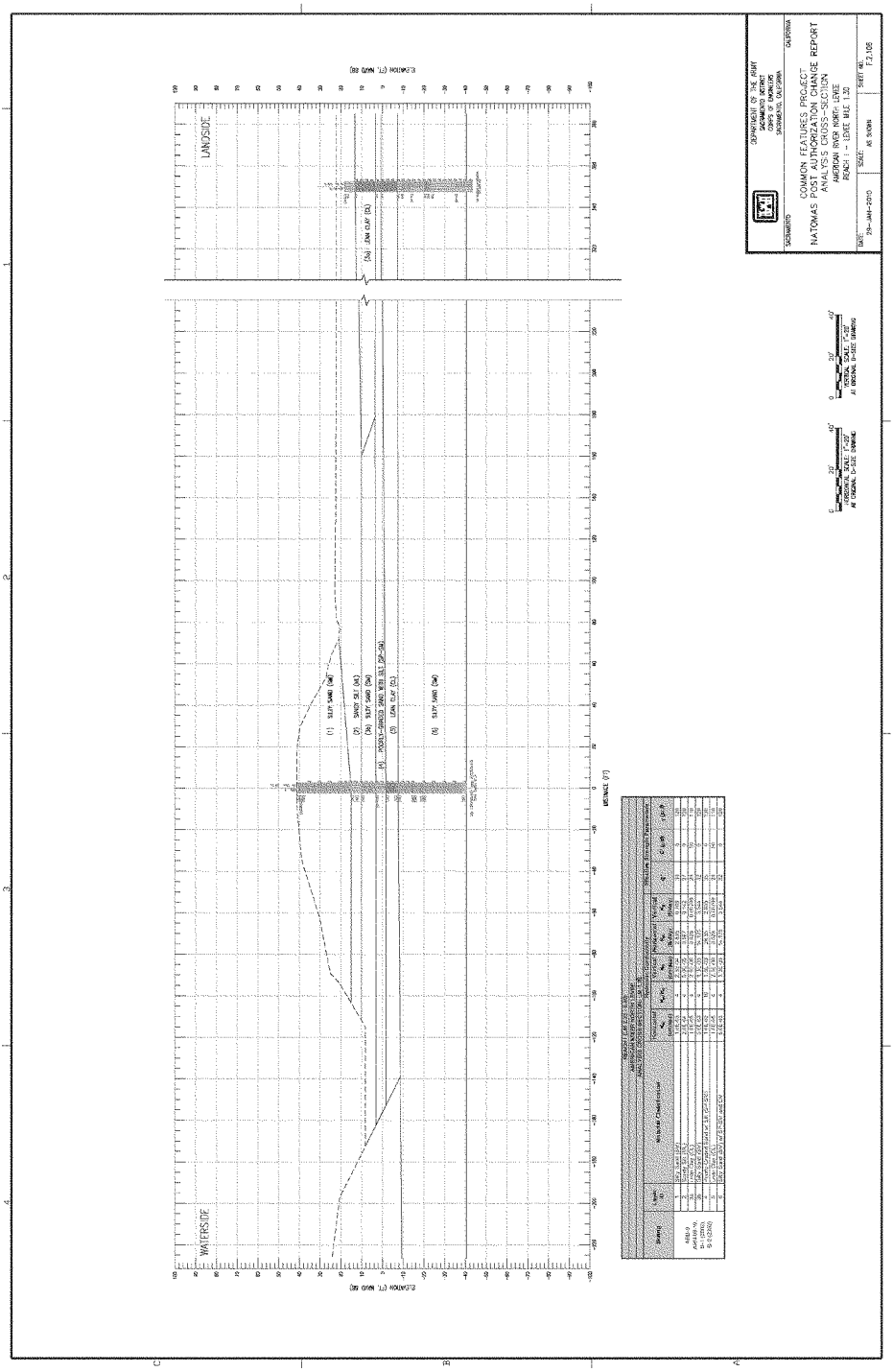
REACH I

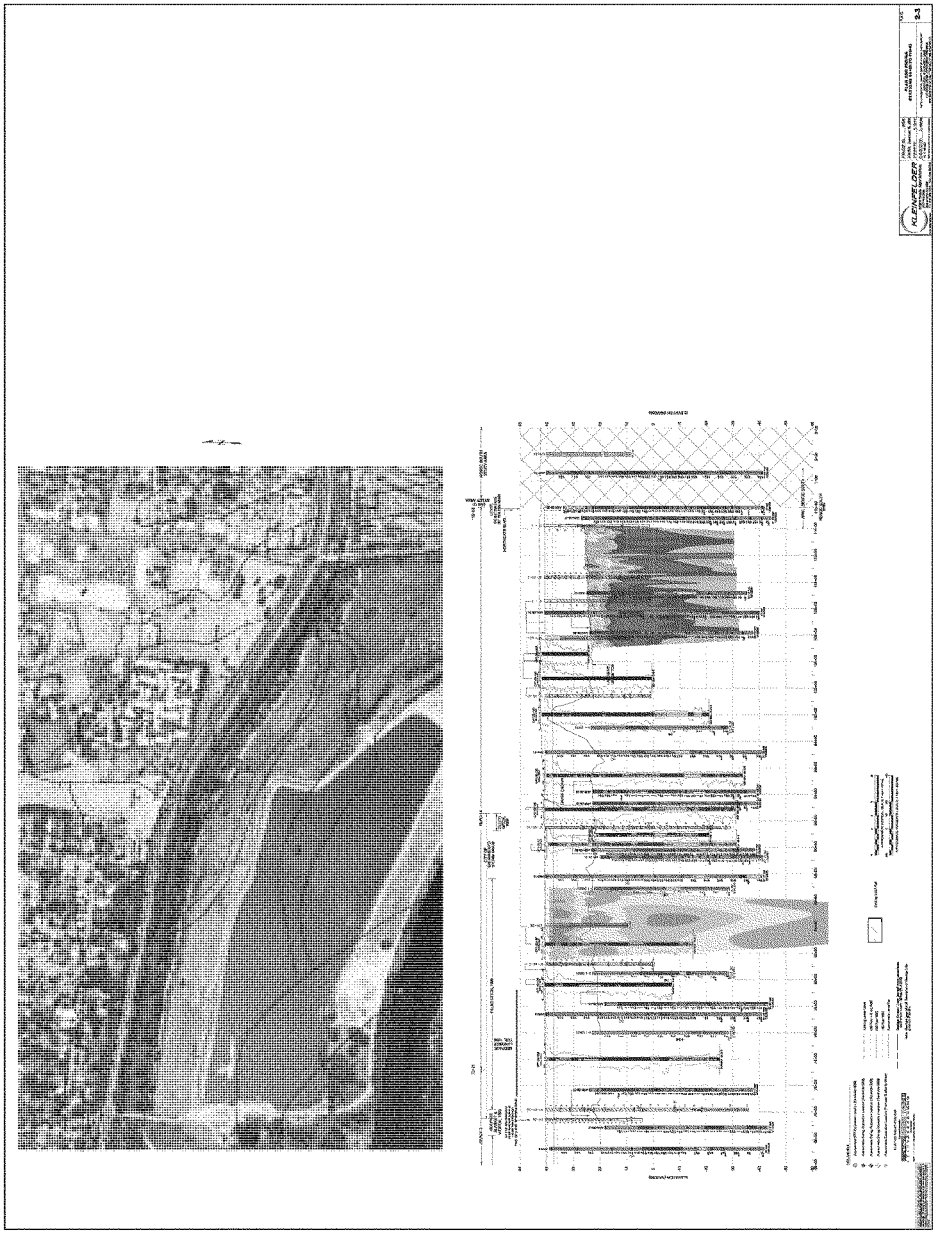
CALCULATION PACKAGE

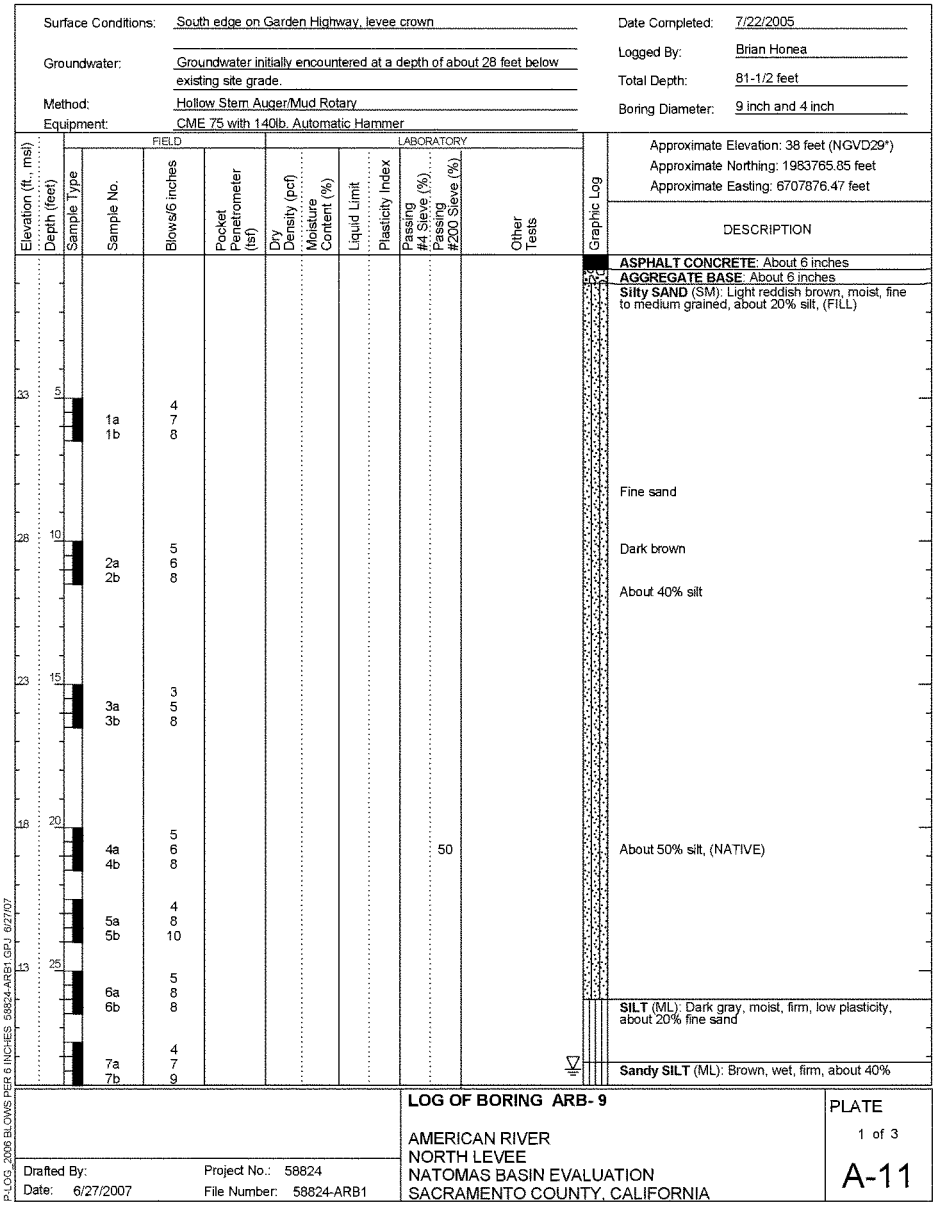
AMERICAN RIVER NORTH LEVEE

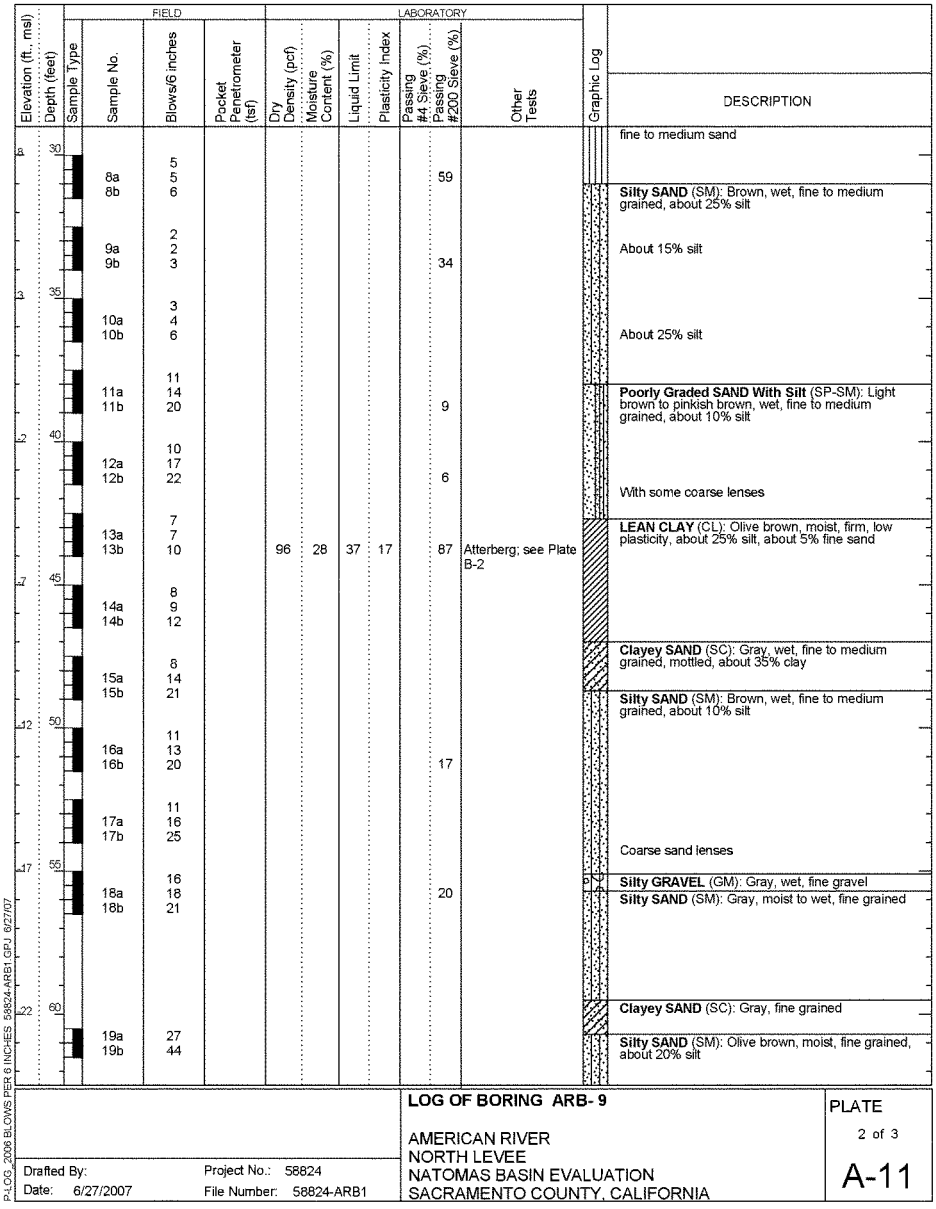
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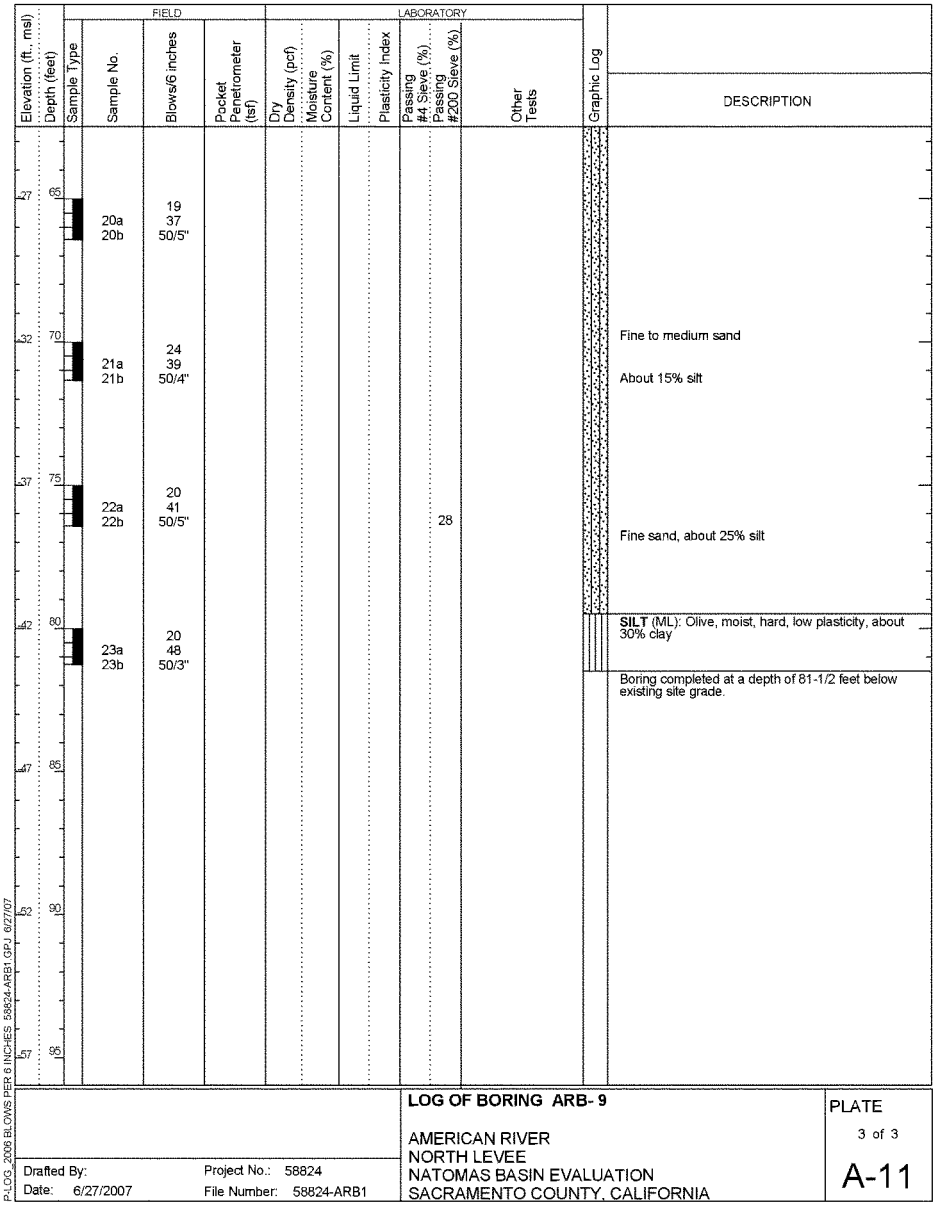
LM 2.33 – 0.00


WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
(1) SLIP, NAA (UAF)
(2) SLIP, SAND (SA)
(3) SLIP, SAND (SM)
(4) MODIFIED SAND RPD SLIP (SP-SM)
(5) SLIP, CLAY (CL)
(6) SLIP, NAA (SM)
(7) SLIP, NAA (SM)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
NORTH AMERICAN LEVEE
REACH 1 - LEVEE MILE 1.30
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.105




Surface Conditions: South edge on Garden Highway, levee crown
Groundwater: Groundwater initially encountered at a depth of about 28 feet below existing site grade.
Method: Hollow Stem Auger/Mud Rotary
Equipment: CME 75 with 140lb. Automatic Hammer
Date Completed: 7/22/2005
Logged By: Brian Honea
Total Depth: 81-1/2 feet
Boring Diameter: 9 inch and 4 inch
FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
Approximate Elevation: 38 feet (NGVD29*)
Approximate Northing: 1983765.85 feet
Approximate Easting: 6707876.47 feet
DESCRIPTION
ASPHALT CONCRETE: About 6 inches
AGGREGATE BASE: About 6 inches
Silty SAND (SM): Light reddish brown, moist, fine to medium grained, about 20% silt, (FILL)
Fine sand
Dark brown
About 40% silt
About 50% silt, (NATIVE)
SILT (ML): Dark gray, moist, firm, low plasticity, about 20% fine sand
Sandy SILT (ML): Brown, wet, firm, about 40%
1a 4
1b 8
2a 5
2b 8
3a 3
3b 8
4a 5
4b 8
50
5a 4
5b 10
6a 5
6b 8
7a 4
7b 9
PLOG_2006 BLOWS PER 6 INCHES 58824-ARB1.GPJ 6/27/07
Drafted By:
Date: 6/27/2007
Project No.: 58824
File Number: 58824-ARB1
LOG OF BORING ARB- 9
AMERICAN RIVER
NORTH LEVEE
NATOMAS BASIN EVALUATION
SACRAMENTO COUNTY, CALIFORNIA
PLATE
1 of 3
A-11


FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
fine to medium sand
Silty SAND (SM): Brown, wet, fine to medium grained, about 25% silt
About 15% silt
About 25% silt
Poorly Graded SAND With Silt (SP-SM): Light brown to pinkish brown, wet, fine to medium grained, about 10% silt
With some coarse lenses
LEAN CLAY (CL): Olive brown, moist, firm, low plasticity, about 25% silt, about 5% fine sand
Atterberg; see Plate B-2
Clayey SAND (SC): Gray, wet, fine to medium grained, mottled, about 35% clay
Silty SAND (SM): Brown, wet, fine to medium grained, about 10% silt
Coarse sand lenses
Silty GRAVEL (GM): Gray, wet, fine gravel
Silty SAND (SM): Gray, moist to wet, fine grained
Clayey SAND (SC): Gray, fine grained
Silty SAND (SM): Olive brown, moist, fine grained, about 20% silt
PLOG_2006 BLOWS PER 6 INCHES 58824-ARB1.GPJ 6/27/07
Drafted By:
Date: 6/27/2007
Project No.: 58824
File Number: 58824-ARB1
LOG OF BORING ARB- 9
AMERICAN RIVER
NORTH LEVEE
NATOMAS BASIN EVALUATION
SACRAMENTO COUNTY, CALIFORNIA
PLATE
2 of 3
A-11


FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
65
70
75
80
85
90
95
27
32
37
42
47
52
57
20a
20b
19
37
50/5"
21a
21b
24
39
50/4"
22a
22b
20
41
50/5"
28
23a
23b
20
48
50/3"
Fine to medium sand
About 15% silt
Fine sand, about 25% silt
SILT (ML): Olive, moist, hard, low plasticity, about 30% clay
Boring completed at a depth of 81-1/2 feet below existing site grade.
PLOG_2006 BLOWS PER 6 INCHES 58824-ARB1.GPJ 6/27/07
Drafted By:
Date: 6/27/2007
Project No.: 58824
File Number: 58824-ARB1
LOG OF BORING ARB- 9
AMERICAN RIVER
NORTH LEVEE
NATOMAS BASIN EVALUATION
SACRAMENTO COUNTY, CALIFORNIA
PLATE
3 of 3
A-11

Boring Location/ Surface Conditions: Asphalt concrete

Groundwater: Groundwater not measured due to drilling method.

Method: Hand Auger (5 ft.)/Mud Rotary

Equipment: CME 75 with 140lb. Automatic Hammer (30 inch drop)

Date Completed: 1/22/2008

Logged By: B. Honea

Reviewed By:

Total Depth: 61-1/2 feet

Boring Diameter: 4 inch

Approximate Elevation: 18 feet (NAVD88)
Approximate Northing: 1984096.33 feet
Approximate Easting: 6708081.84 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														ASPHALT CONCRETE: About 4 inches
														SILT With Sand (ML): Brown, moist, low plasticity, fine sand
13	5		1b	4 7		88	18				87			**LEAN CLAY** (CL): Brown, moist, firm, medium plasticity, fine sand
			1a	11										
			2	4 7 8				34	12			Atterberg; see Plate B-2		
8	10		3b	5 9										
			3a	12	4.5	111	16				72			
			4	3 5 6										
3	15		5b	5 12							43			**Clayey SAND** (SC): Brown, moist, fine sand
			5a	17										
			6	4 7 11				30	12			Atterberg; see Plate B-2		**LEAN CLAY** (CL): Light brown, moist, firm, low to medium plasticity
-2	20		7b	9 30										
			7a	38	4.5									Very hard
			8	2 4 4	2.0			40	16			Atterberg; see Plate B-2		Firm
-7	25		9b	4 17										**SILT With Sand** (ML): Light brown to gray, moist, very hard, fine sand
			9a	29	>4.5									
			10	4 7 12							41			**Silty SAND** (SM): Brown, moist, fine sand

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Drafted By: D. Ross
Date: 10/29/2008

Project No.: 72834ARN
File Number: 72834ARN08

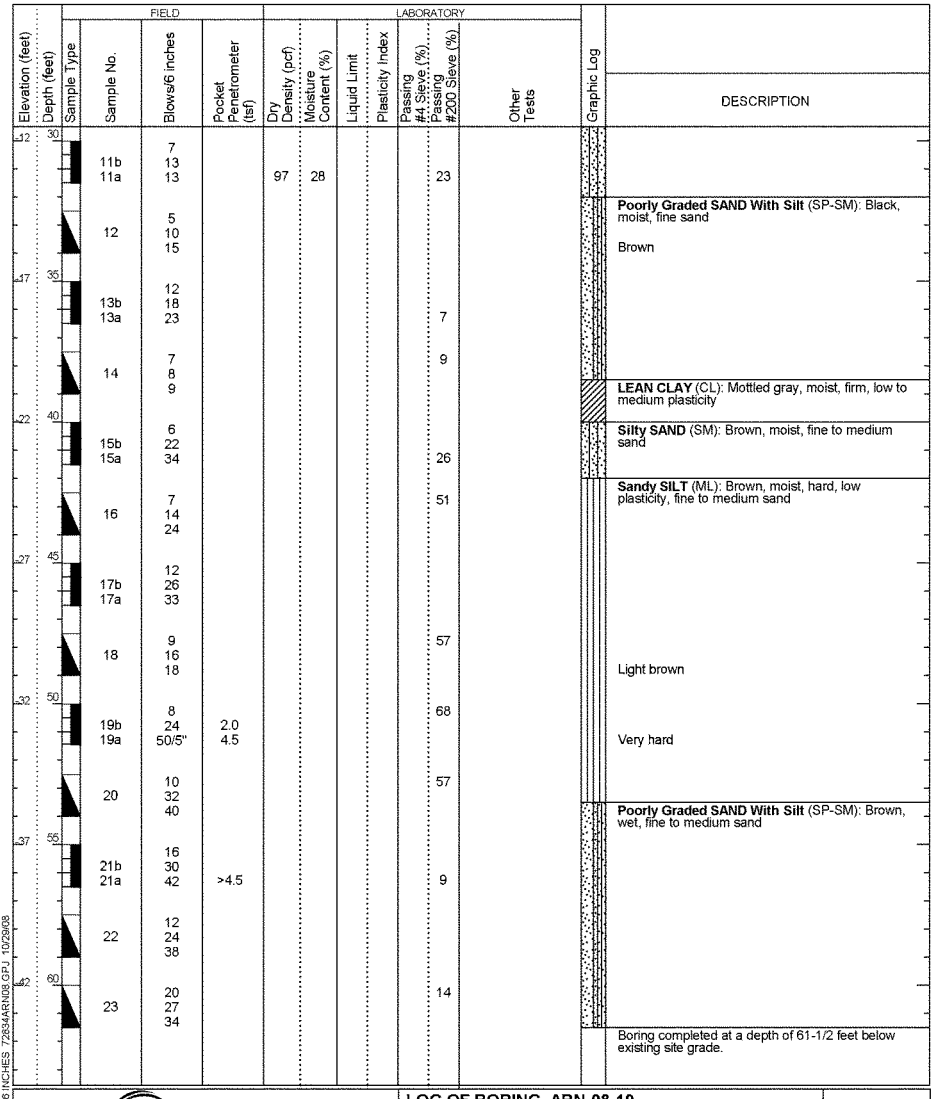
LOG OF BORING ARN-08-19
(DRAFT)

AMERICAN RIVER NORTH LEVEE
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO COUNTY, CALIFORNIA

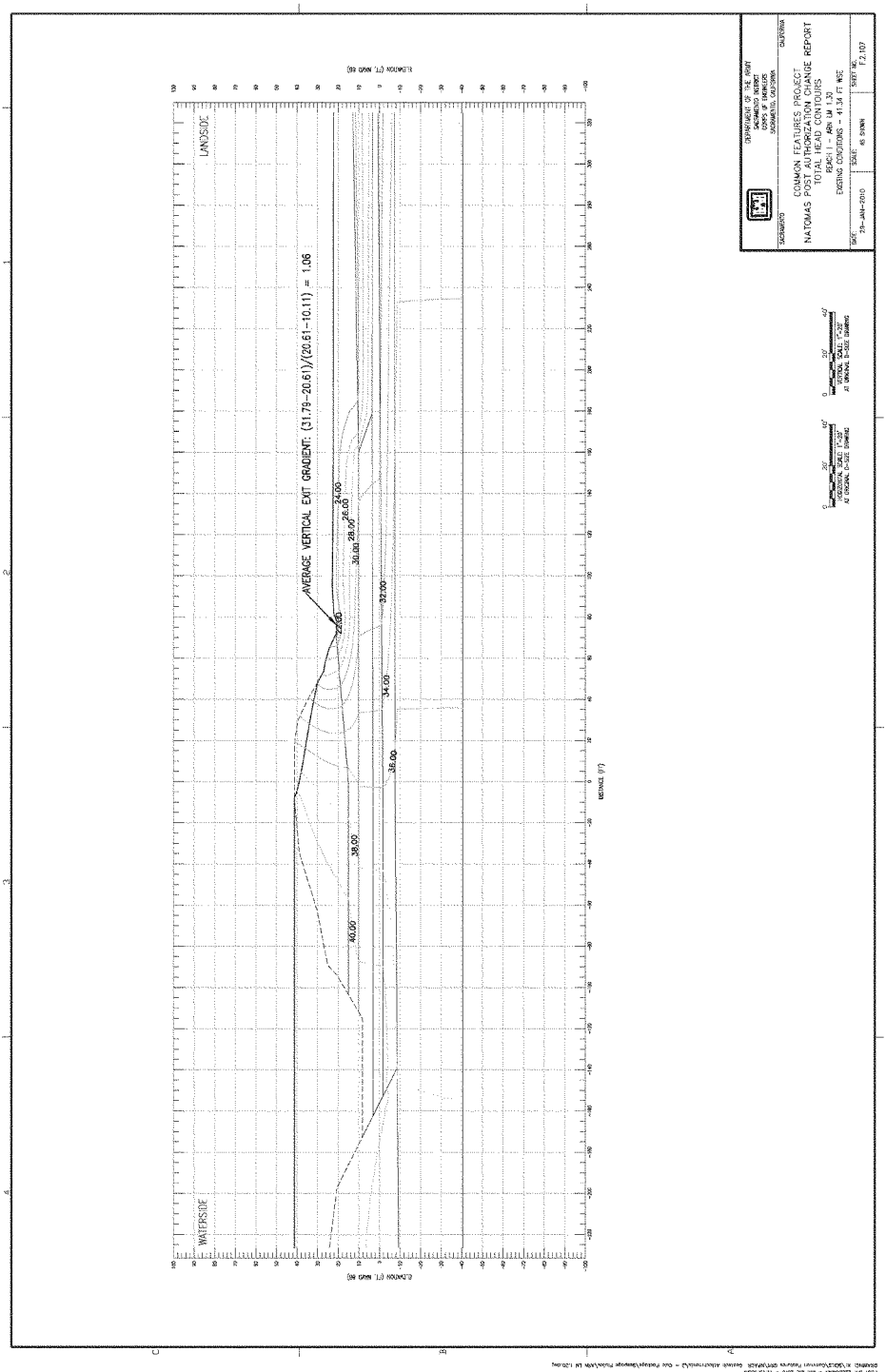
PLATE
1 of 2
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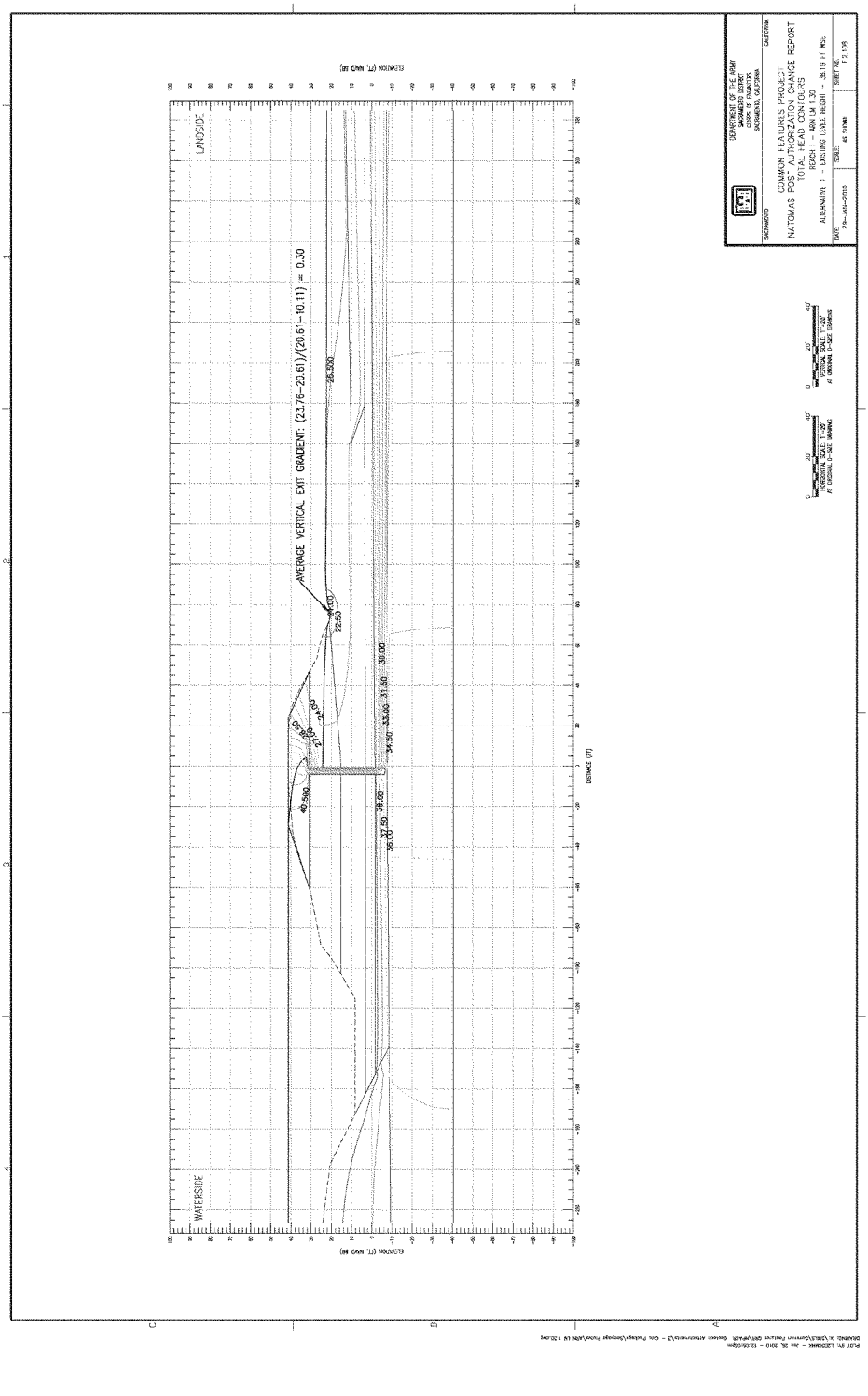
PLOG_BLOWS PER 6 INCHES 72834ARN08.GPJ 10/29/08

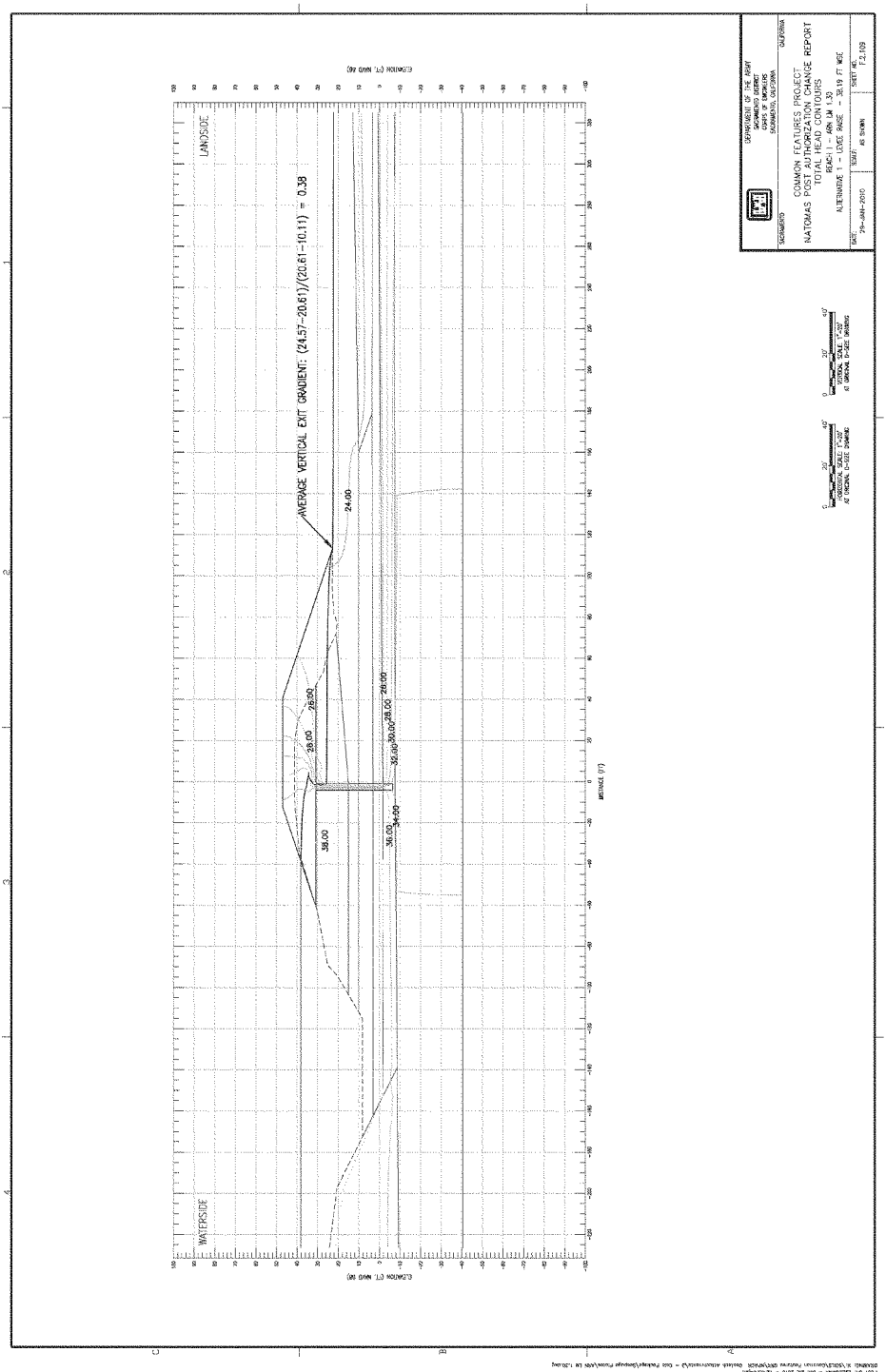
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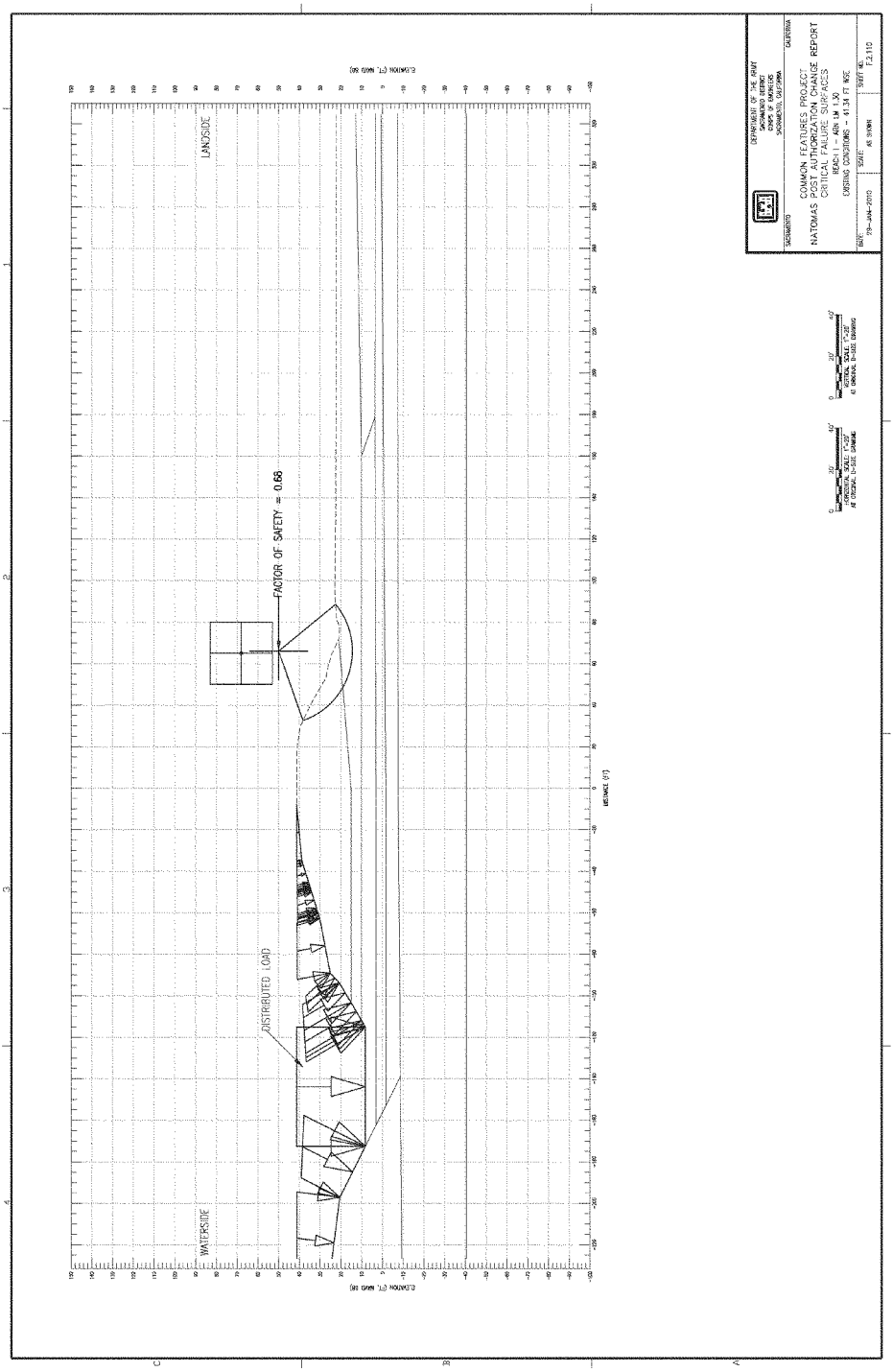


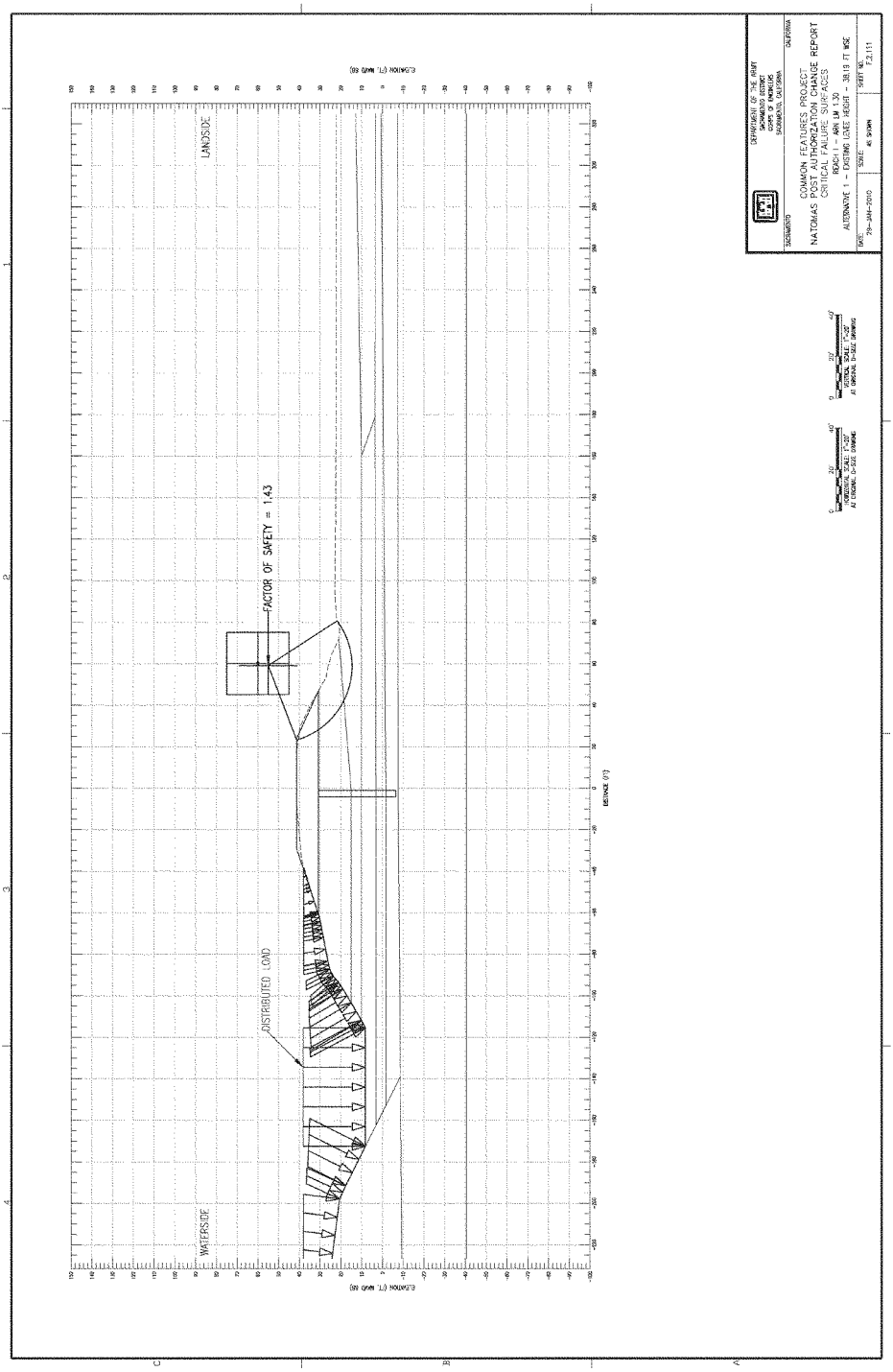
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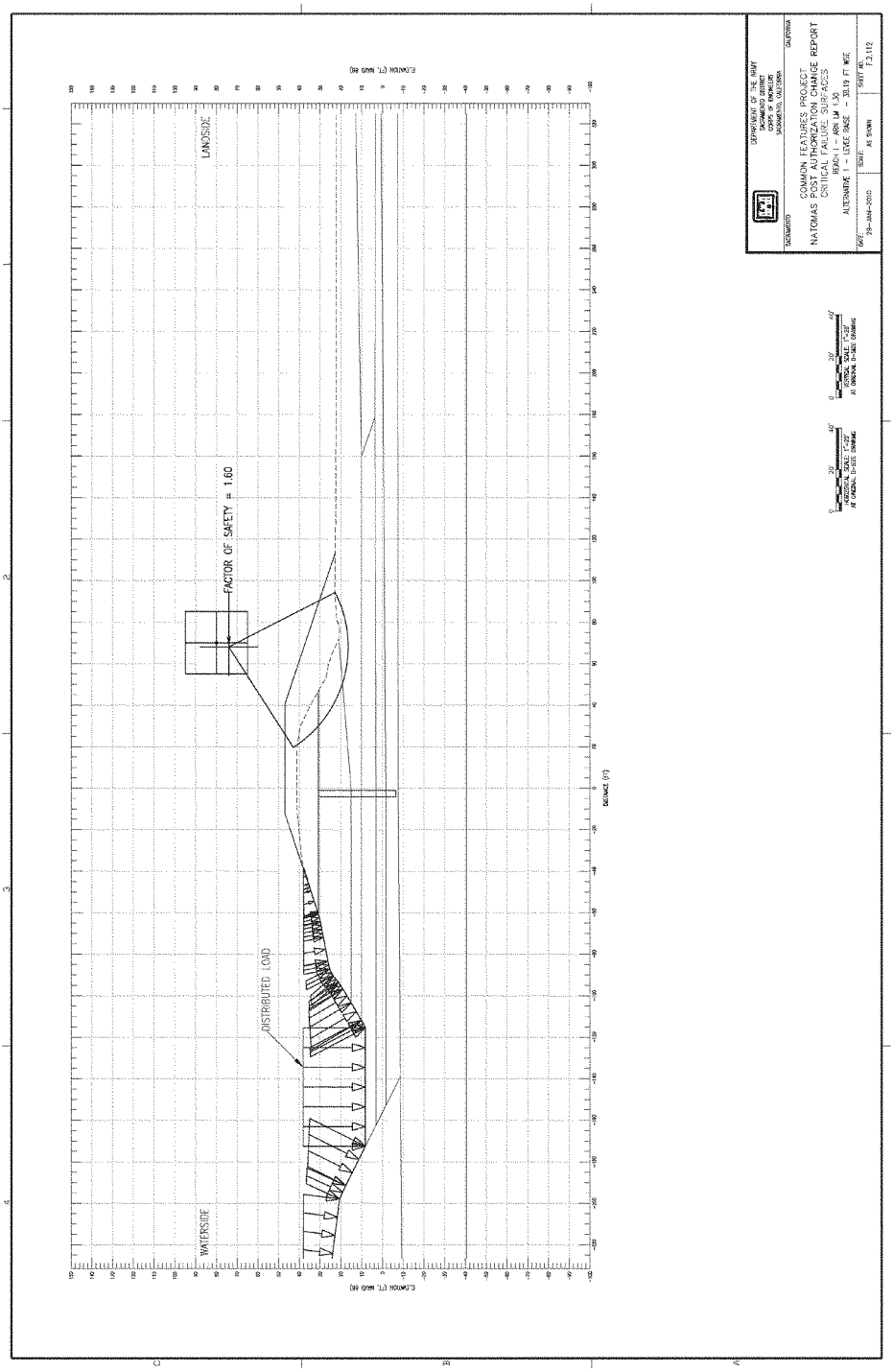

AVERAGE VERTICAL EXIT GRADIENT: (31.79-20.61)/(20.61-10.11) = 1.06
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
NATOMAS POST AUTHORIZATION CHANGE REPORT
COMMON FEATURES PROJECT
TOTAL HEAD CONTOURS
REACH 1 - AM 33.1
EXISTING CONDITIONS - 41.14 FT. WSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F2.107

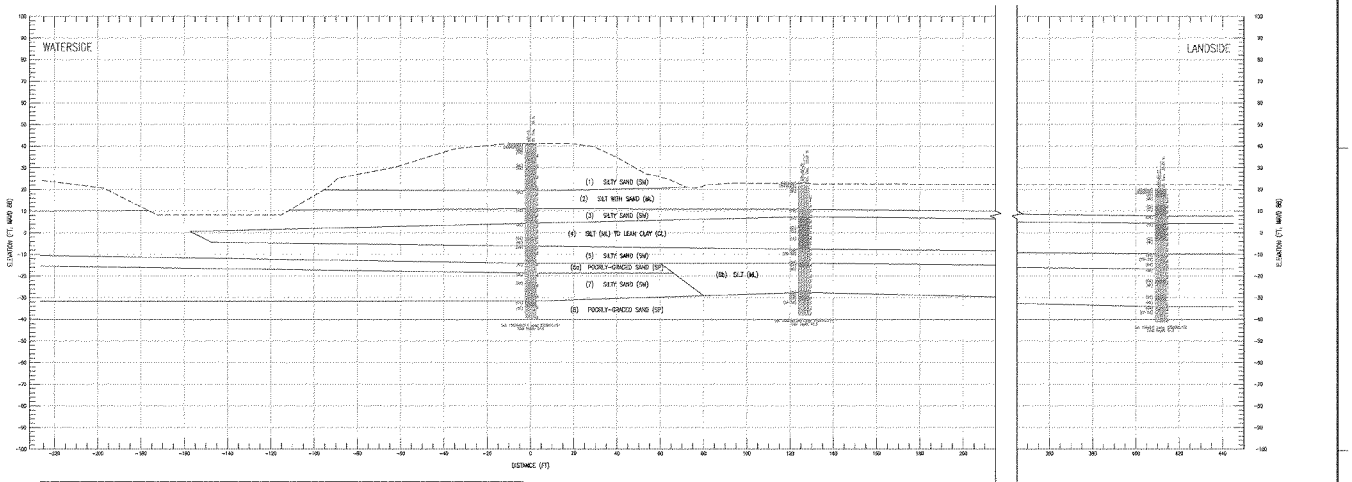

AVERAGE VERTICAL EXIT GRADIENT: (23.76-20.61)/(20.61-10.11) = 0.30
WATERSIDE
LANDSIDE
ELEVATION (FT NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH 1, AREA 30
ALTERNATIVE 1 - EXISTING LEVEE HEIGHT - 38.16 FT MSF
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.105


AVERAGE VERTICAL EXIT GRADIENT: (24.57-20.61)/(20.61-10.11) = 0.38
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
24.00
28.00
28.00
28.00
28.00
28.00
38.00
36.00
34.00
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
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SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH A, STA 10+00
ALTERNATIVE 1 – LEVEE RAISE – 32.19 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F-2.109


FACTOR OF SAFETY = 0.66
LANDSIDE
WATERSIDE
DISTRIBUTED LOAD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
LEVEE L-45A & 56
LOADING CONDITIONS - 41.14 FT. W.S.E.
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.110


FACTOR OF SAFETY = 1.43
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT MSL 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, AREA 30
ALTERNATIVE 1 – EXISTING LEVEE HEIGHT – 38.19 FT MSC
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F.2.111


FACTOR OF SAFETY = 1.60
DISTRIBUTED LOAD
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
ALTERNATIVE 1 – LEVEE RAISE – 33.19 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.112



REACH 1 (STA 2+16 – 11+00) AMERICAN RIVER NORTH LEVEE ANALYSIS CROSS-SECTION: LM 1.30											
Borehole	Layer ID	Material Description	Permeability Coefficients						Effective Strength Parameters		
			Horizontal k_H (cm/sec)	k_H/k_V	Vertical k_V (cm/sec)	Horizontal k_H (ft/day)	Vertical k_V (ft/day)		ϕ'	C' (psf)	γ (pcf)
AR14-5 AR14-5R-1 B-1 (2002), B-2 (2002)	1	Silty Sand (SM)	1.0E-03	4	2.5E-04	2.83	0.708		30	0	120
	2	Silt with Sand (ML)	2.0E-04	4	5.0E-05	0.567	0.142		30	0	120
	3	Silty Sand (SM)	1.0E-03	4	2.5E-04	2.835	0.708		30	0	120
	4	Silt (ML)/Lean Clay (CL)	1.0E-05	4	2.5E-06	0.0283	0.00709		28	50	115
	5	Silty Sand (SM)	1.0E-03	4	2.5E-04	2.84	0.708		32	0	125
	6a	Poorly-Graded Sand (SP)	1.0E-02	16	1.0E-03	28.35	2.835		35	0	125
	6b	Silt (ML)	2.0E-04	4	5.0E-05	0.567	0.142		32	0	120
	7	Silty Sand (SM)	5.0E-03	4	1.3E-03	14.18	3.54		35	0	125
	8	Poorly-Graded Sand (SP)	1.0E-02	16	1.0E-03	28.35	2.835		35	0	125

HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

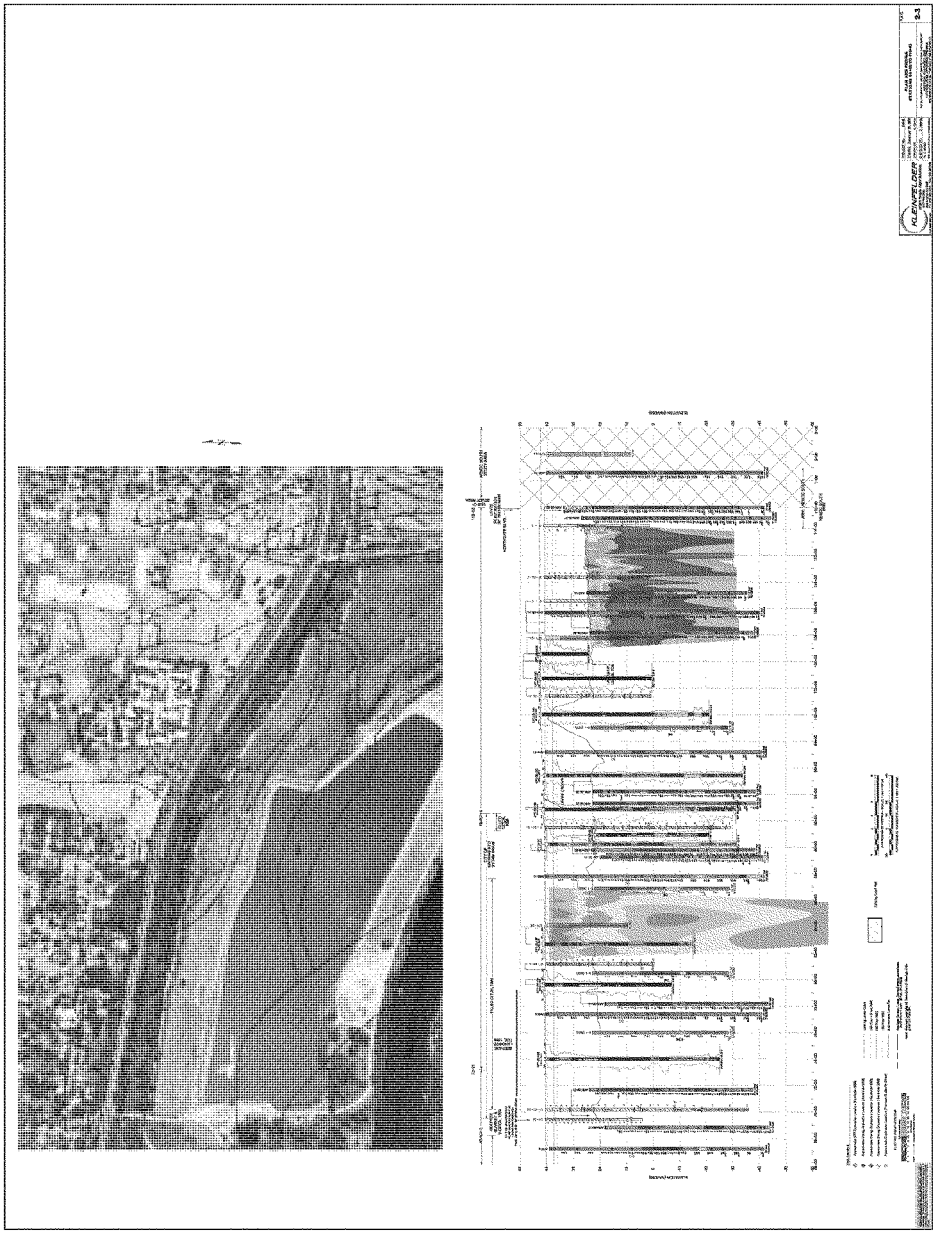
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SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO CALIFORNIA

COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
ANALYSIS CROSS-SECTION
AMERICAN RIVER NORTH LEVEE
REACH 1 – LEVEE MILE 1.30 (ALTERNATE)

DATE:	SCALE:	SHEET NO.
29-JAN-2010	AS SHOWN	F.2.113

Plot By: LBROWN – Jan 29, 2010 – 10:14:11am
Drawing: X:\SMUD\Common Features (SAFCA)\F2\F2-113 Geotech Attachments\1-3 - Geo Packet\Cross Section Plots\AR LM 1.30 (Alternate).dwg



Surface Conditions: Asphalt concrete pavement, south edge Garden Highway on levee crown

Groundwater: Groundwater initially encountered at a depth of about 30 feet below existing site grade.

Method: Hollow Stem Auger/Mud Rotary

Equipment: CME 75 with 140lb. Automatic Hammer

Date Completed: 7/21/2005

Logged By: Brian Honea

Total Depth: 81-1/2 feet

Boring Diameter: 9 inch and 4 inch

Approximate Elevation: 38 feet (NGVD29*)
Approximate Northing: 1983646.07 feet
Approximate Easting: 6708910.10 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														ASPHALT CONCRETE: About 6 inches
														AGGREGATE BASE: About 6 inches
														SILT (ML): Dark gray, moist, firm, low plasticity, about 30% fine sand, (FILL)
33	5		1a	4										**Silty SAND** (SM): Light brown, moist, fine grained, about 30% silt, (FILL)
			1b	5										
				9										
28	10			2										**SILT** (ML): Dark brown, moist, firm, (FILL)
			2a	4										**Silty SAND** (SM): Light brown, moist, fine grained, about 45% silt, (FILL)
			2b	8				NP	NP		45	Atterberg; see Plate B-2		
23	15			3										Grayish brown
			3a	6										
			3b	8										About 25% silt
18	20			3										
			4a	7										Dark brown, (NATIVE)
			4b	10										
			5a	4										**SILT With Sand** (ML): Dark brown, moist, firm, low plasticity, about 20% fine sand
			5b	6										
13	25			6										
			6a	3										
			6b	5				NP	NP		78	Atterberg; see Plate B-2		
				6										
			7a	5										
			7b	9										
				14										

FIELD | LABORATORY

Drafted By:
Date: 6/27/2007

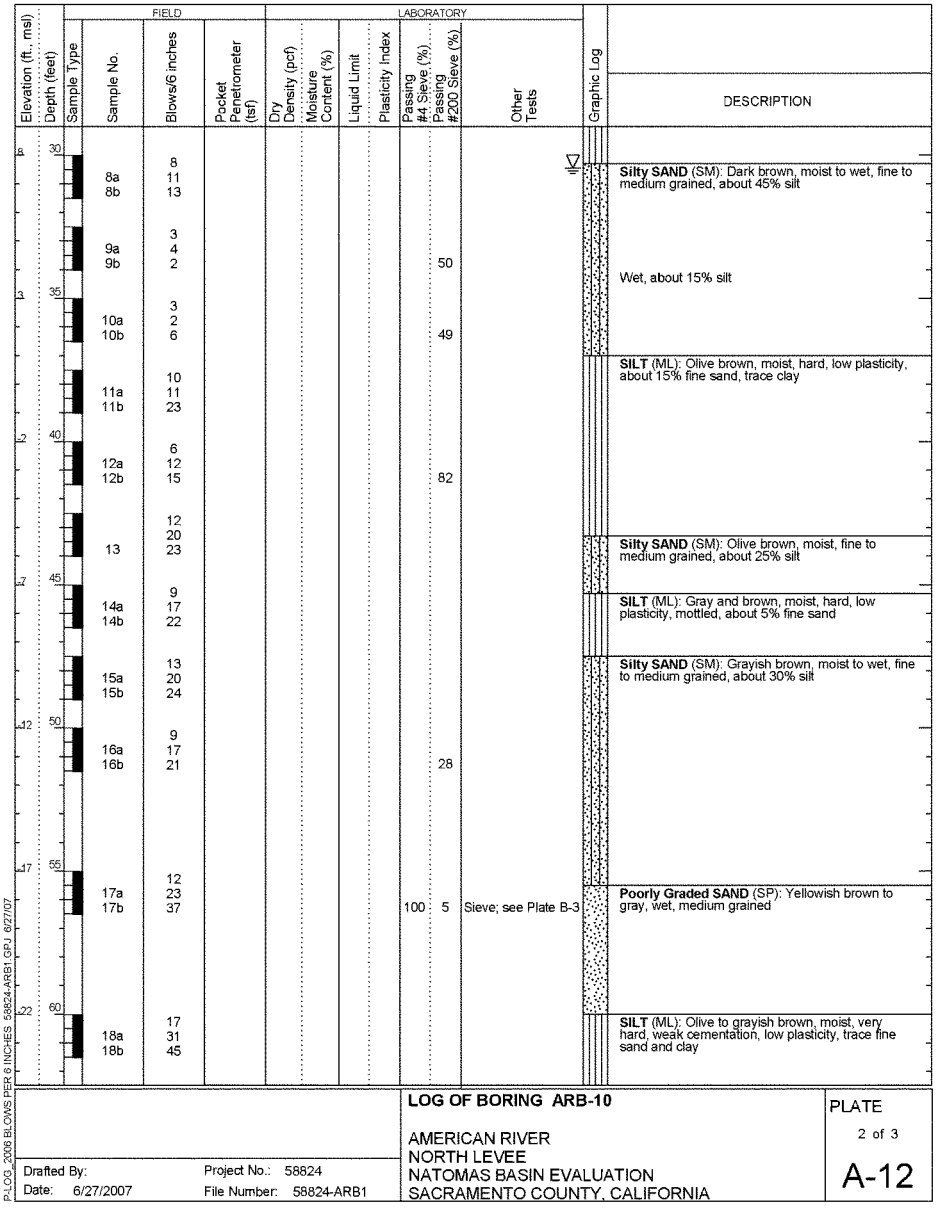
Project No.: 58824
File Number: 58824-ARB1

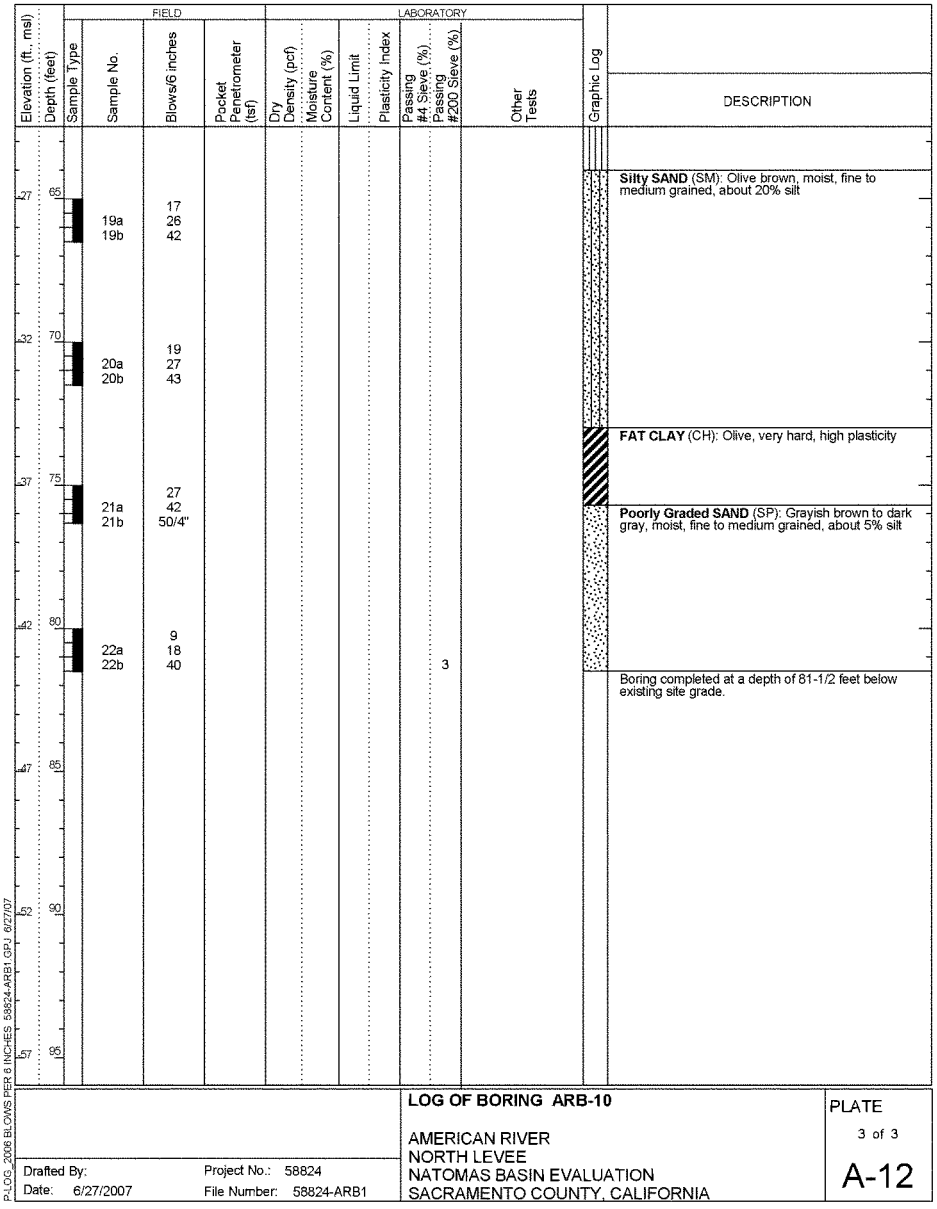
LOG OF BORING ARB-10

AMERICAN RIVER
NORTH LEVEE
NATOMAS BASIN EVALUATION
SACRAMENTO COUNTY, CALIFORNIA

PLATE
1 of 3
A-12

P:\LOG_2006 BLOWS PER 6 INCHES 58824-ARB1.GPJ 6/27/07


FIELD
LABORATORY
Elevation (ft., msl)
Depth (feet)
Sample Type
Sample No.
Blows/6 inches
Pocket Penetrometer (tsf)
Dry Density (pcf)
Moisture Content (%)
Liquid Limit
Plasticity Index
Passing #4 Sieve (%)
Passing #200 Sieve (%)
Other Tests
Graphic Log
DESCRIPTION
8a 8 11
8b 13
9a 3 4
9b 2 50
10a 3 2
10b 6 49
11a 10 11
11b 23
12a 6 12
12b 15 82
13 12 20 23
14a 9 17
14b 22
15a 13 20
15b 24
16a 9 17
16b 21 28
17a 12 23
17b 37 100 5 Sieve; see Plate B-3
18a 17 31
18b 45
Silty SAND (SM): Dark brown, moist to wet, fine to medium grained, about 45% silt
Wet, about 15% silt
SILT (ML): Olive brown, moist, hard, low plasticity, about 15% fine sand, trace clay
Silty SAND (SM): Olive brown, moist, fine to medium grained, about 25% silt
SILT (ML): Gray and brown, moist, hard, low plasticity, mottled, about 5% fine sand
Silty SAND (SM): Grayish brown, moist to wet, fine to medium grained, about 30% silt
Poorly Graded SAND (SP): Yellowish brown to gray, wet, medium grained
SILT (ML): Olive to grayish brown, moist, very hard, weak cementation, low plasticity, trace fine sand and clay
PLOG_2006 BLOWS PER 6 INCHES 58824-ARB1.GPJ 6/27/07
Drafted By:
Date: 6/27/2007
Project No.: 58824
File Number: 58824-ARB1
LOG OF BORING ARB-10
AMERICAN RIVER
NORTH LEVEE
NATOMAS BASIN EVALUATION
SACRAMENTO COUNTY, CALIFORNIA
PLATE
2 of 3
A-12



LOG OF BORING ARB-10

AMERICAN RIVER
NORTH LEVEE
NATOMAS BASIN EVALUATION
SACRAMENTO COUNTY, CALIFORNIA

Drafted By:
Date: 6/27/2007
Project No.: 58824
File Number: 58824-ARB1

PLATE
3 of 3
A-12

Boring Location/ Surface Conditions: Asphalt concrete
Groundwater: Groundwater not measured due to drilling method.
Method: Mud Rotary
Equipment: CME 75 with 140lb. Automatic Hammer (30 inch drop)

Date Completed: 1/14/2008
Logged By: B. Honea
Reviewed By:
Total Depth: 61-1/2 feet
Boring Diameter: 4 inch

Approximate Elevation: 23 feet (NAVD88)
Approximate Northing: 1983752.25 feet
Approximate Easting: 6709112.78 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														ASPHALT CONCRETE: About 3 inches **AGGREGATE BASE**: About 15 inches
														SILT With Sand (ML): Olive brown, moist
18	5			5										**SILT With Sand** (ML): Yellow brown, moist, low plasticity, fine sand
			1b	5										
			1a	8										
			2	2 4 5							75			
13	10			8										
			3b	9										
			3a	14										
			4	2 4 3							39			**Silty SAND** (SM): Yellow brown, moist, fine sand
8	15			6										
			5b	7										
			5a	13	4.0	114	16	40	24			Atterberg; see Plate B-2		**LEAN CLAY** (CL): Light brown, moist, firm, low to medium plasticity
			6	3 6 9										
3	20			12										
			7b	15										**Sandy LEAN CLAY** (CL): Mottled brown, moist, low to medium plasticity, fine to medium sand
			7a	18				27	13		62	Atterberg; see Plate B-2		
			8	4 2 3				32	15			Atterberg; see Plate B-2		**LEAN CLAY** (CL): Olive, moist, soft, low to medium plasticity
-2	25			9										
			9b	14										**Sandy LEAN CLAY** (CL): Mottled brown, moist, hard, low to medium plasticity, fine sand
			9a	22										
			10	5 5 10				30	9		63	Atterberg; see Plate B-2		

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Drafted By: D. Ross
Date: 10/29/2008
Project No.: 72834ARN
File Number: 72834ARN08

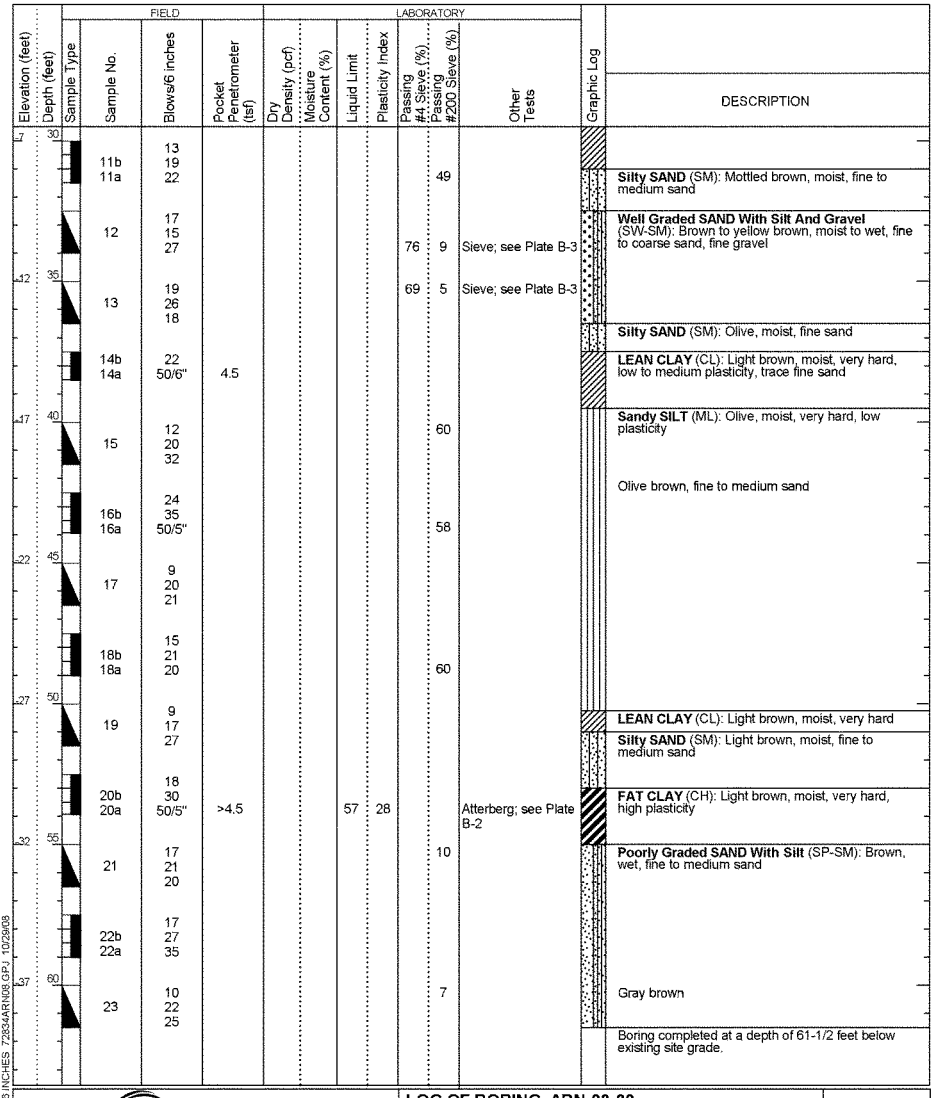
LOG OF BORING ARN-08-20
(DRAFT)

AMERICAN RIVER NORTH LEVEE
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO COUNTY, CALIFORNIA

PLATE
1 of 2
A-18

PLOG_BLOWS PER 6 INCHES 72834ARN08.GPJ 10/29/08

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Drafted By: D. Ross
Date: 10/29/2008
Project No.: 72834ARN
File Number: 72834ARN08

LOG OF BORING ARN-08-20
(DRAFT)

AMERICAN RIVER NORTH LEVEE
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO COUNTY, CALIFORNIA

PLATE
2 of 2
A-18

LOGS BLOWS PER 6 INCHES 72834ARN08.GPJ 10/29/08

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Boring Location/ Surface Conditions: Asphalt concrete
Groundwater: Groundwater not measured due to drilling method.
Method: Hand Auger (5 ft.)/Mud Rotary
Equipment: CME 75 with 140lb. Automatic Hammer (30 inch drop)

Date Completed: 1/22/2008
Logged By: B. Maddy
Reviewed By:
Total Depth: 61-1/2 feet
Boring Diameter: 4 inch

Approximate Elevation: 20 feet (NAVD88)
Approximate Northing: 1984041.00 feet
Approximate Easting: 6709099.77 feet

Elevation (feet)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														ASPHALT CONCRETE: About 3 inches
														AGGREGATE BASE: About 3 inches
														LEAN CLAY With Sand (CL): Dark brown, moist, firm, low to medium plasticity, fine sand
			1											
15	5		2					29	5		64	Atterberg; see Plate B-2		**Sandy SILT** (ML): Brown, moist, firm, low plasticity, fine sand
			3b	6										
			3a	8	2.0									
			4b	7										**LEAN CLAY With Sand** (CL): Brown, moist, firm, low to medium plasticity, fine sand
			4a	7	4.0	104	22	33	12			Atterberg; see Plate B-2		
10	10		5b	7										**Sandy LEAN CLAY** (CL): Brown, moist, firm, low to medium plasticity, fine sand
			5a	8	3.5			25	7		68	Atterberg; see Plate B-2		
			6b	6										
			6a	6							34			**Silty SAND** (SM): Dark brown, moist, fine sand
5	15		7b	5										
			7a	6							57			**Sandy LEAN CLAY** (CL): Red brown, moist, firm, low to medium plasticity
			8b	15										Very hard
			8a	16	4.5									
0	20		9b	15										
			9a	18	>4.5	112	19	35	17			Atterberg; see Plate B-2		
			10b	5										**LEAN CLAY With Sand** (CL): Red brown, moist, firm, low to medium plasticity, fine sand
			10a	9	3.0									
-5	25		11b	8										**Sandy SILT** (ML): Red brown, moist, firm, low plasticity, fine sand
			11a	13	3.0						60			
			12b	4										
			12a	13							57			

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Date: 10/29/2008
Project No.: 72834ARN
File Number: 72834ARN08

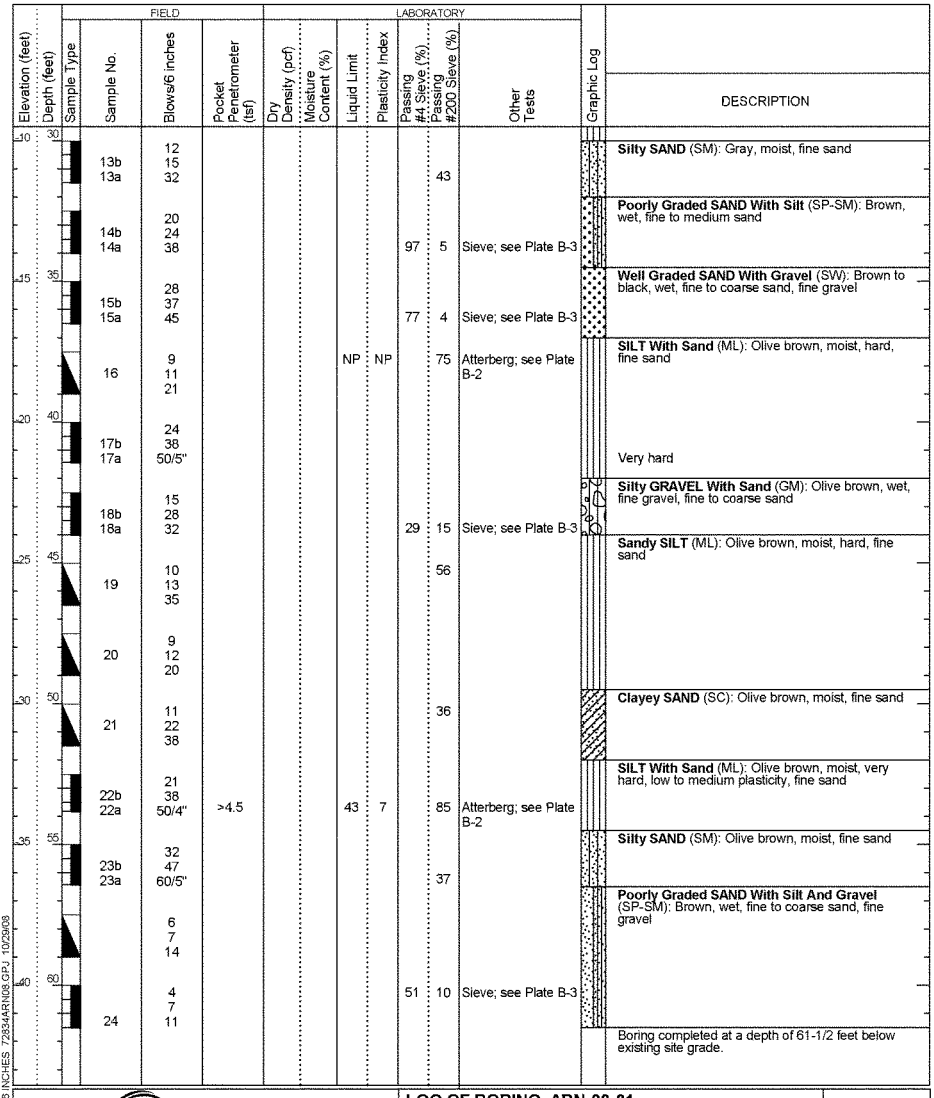
LOG OF BORING ARN-08-21
(DRAFT)

AMERICAN RIVER NORTH LEVEE
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO COUNTY, CALIFORNIA

PLATE
1 of 2
A-19

P:\LOG_BLOWS PER 6 INCHES 72834ARN08.GPJ 10/29/08

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Date: 10/29/2008
Project No.: 72834ARN
File Number: 72834ARN08

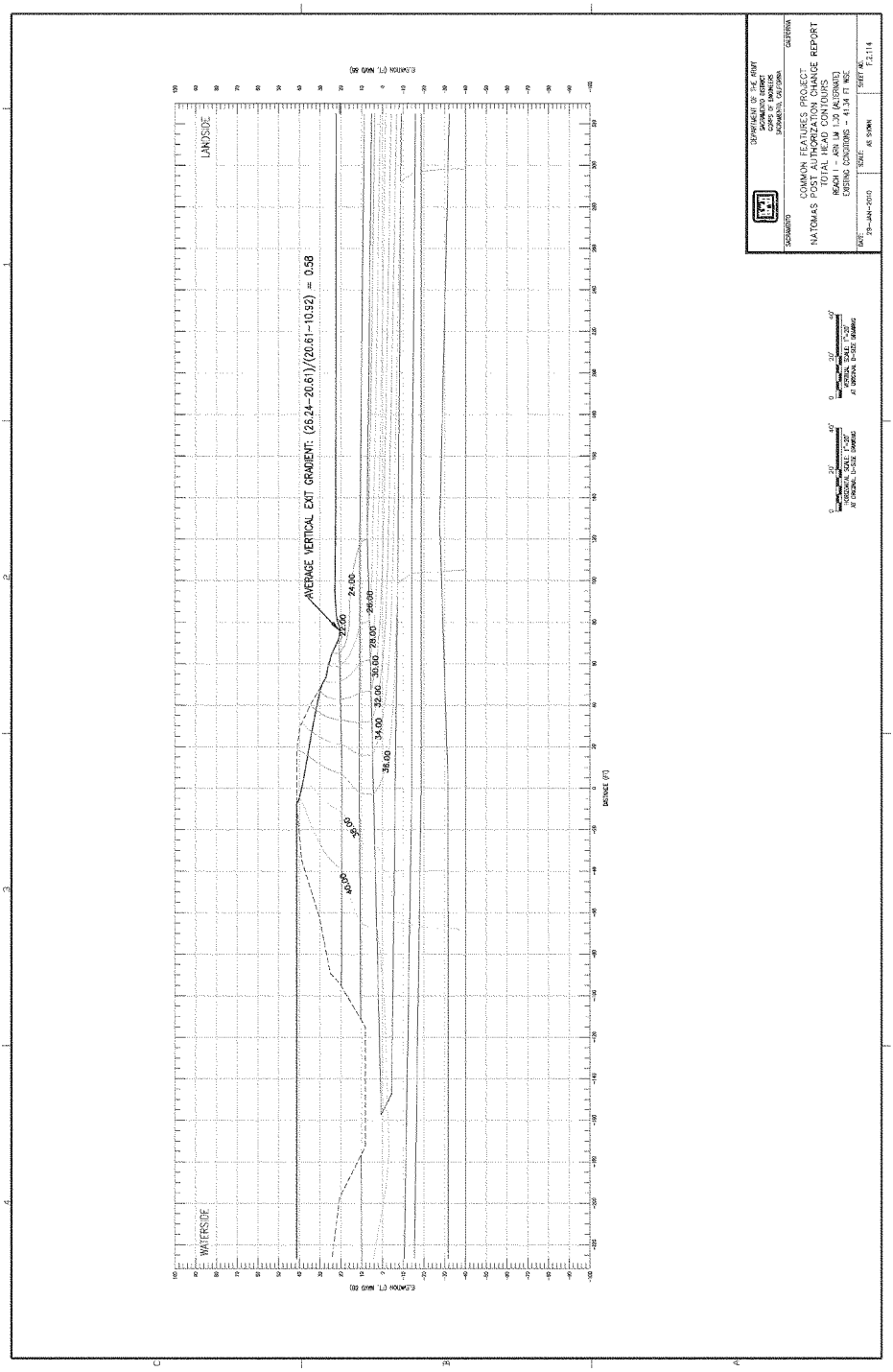
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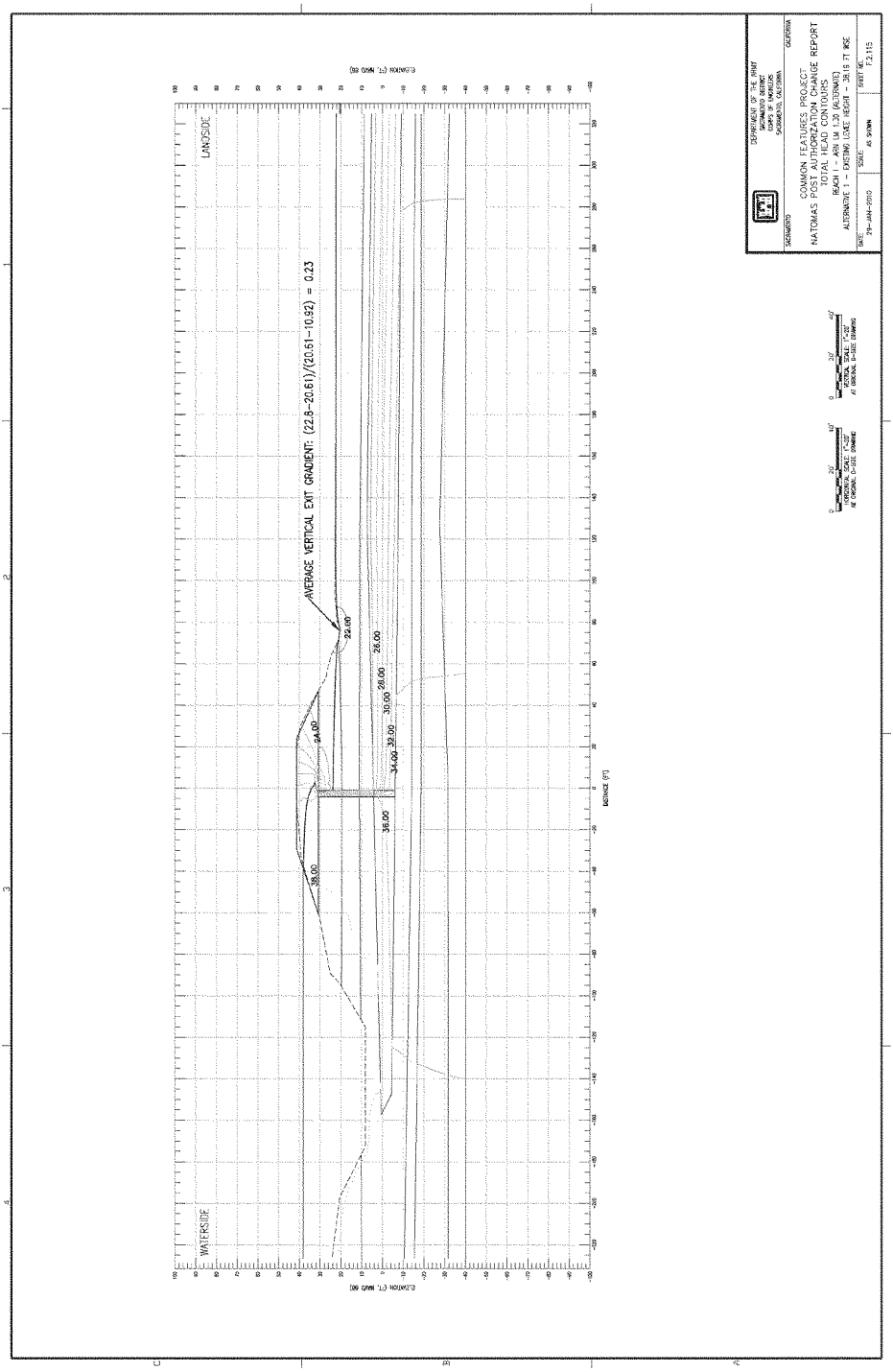
AMERICAN RIVER NORTH LEVEE
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO COUNTY, CALIFORNIA

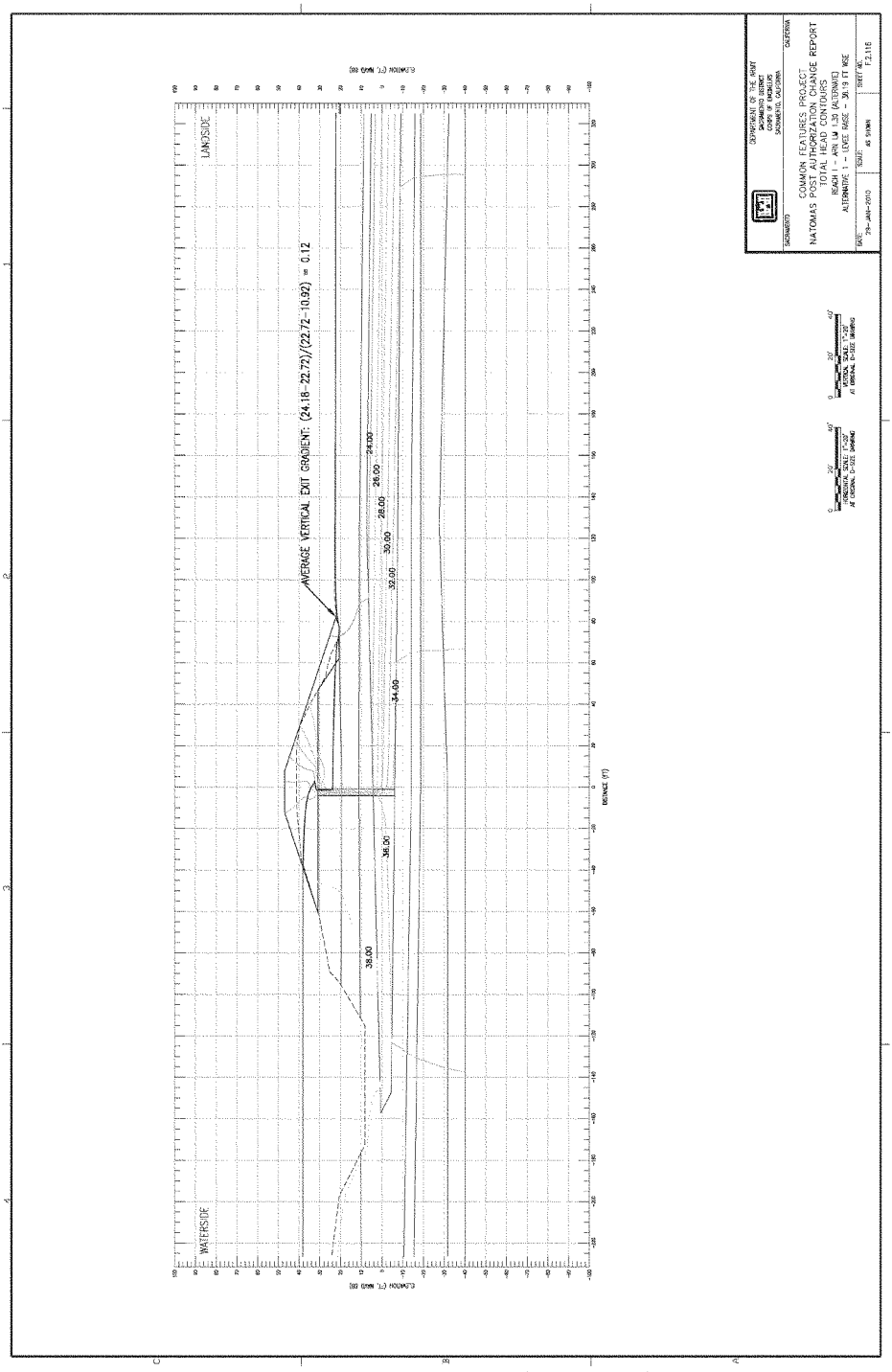
PLATE
2 of 2
A-19

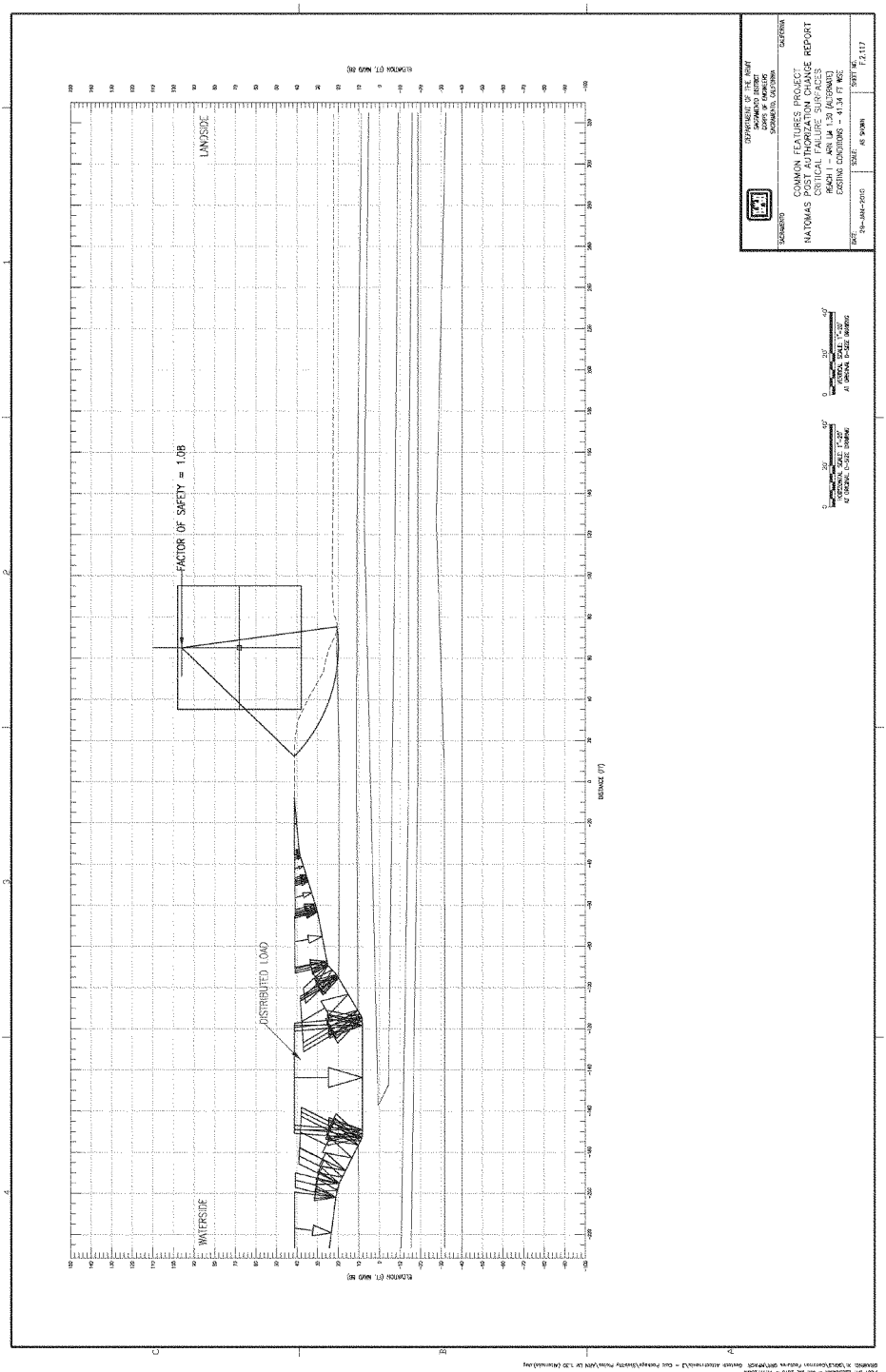
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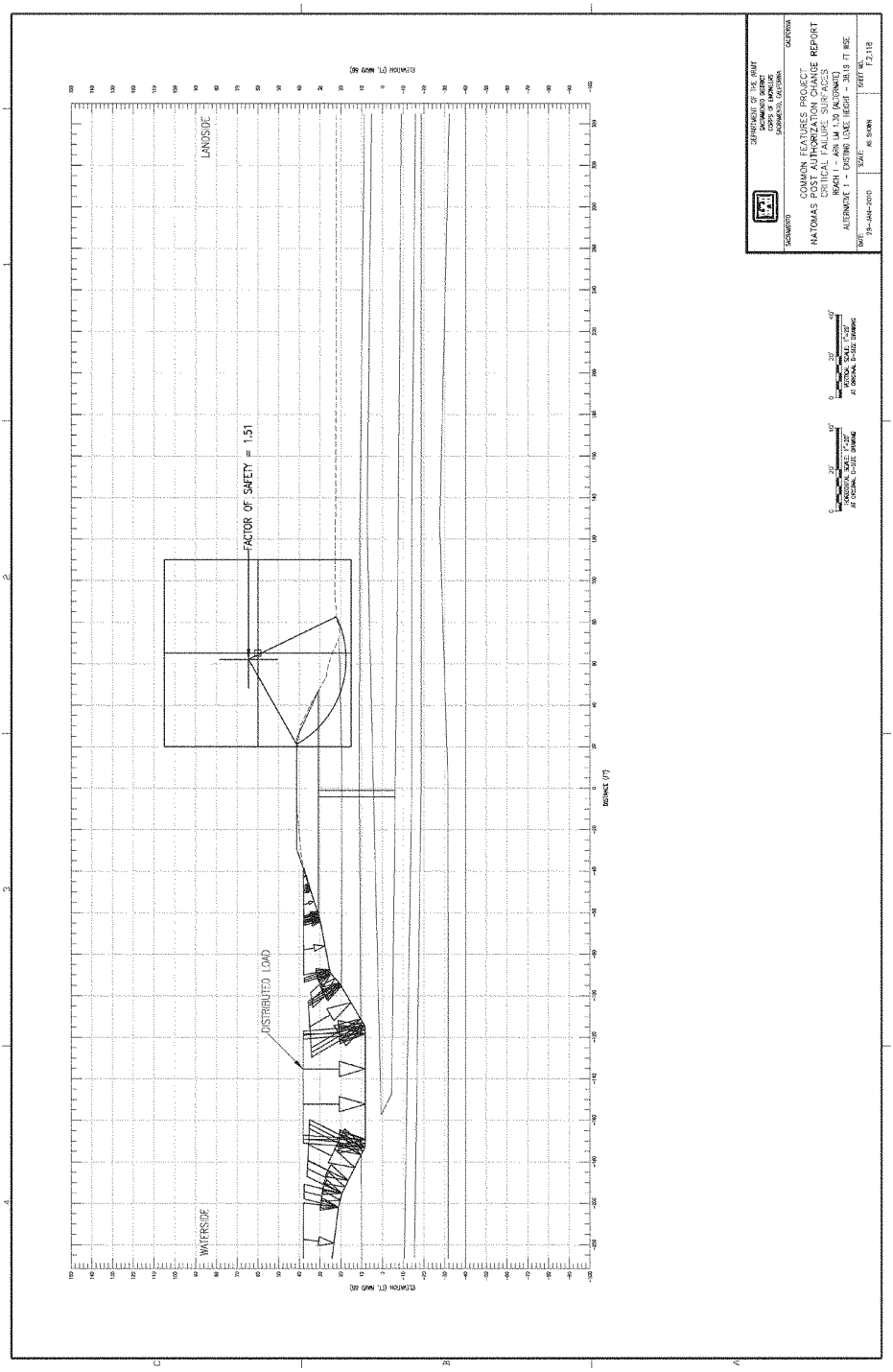
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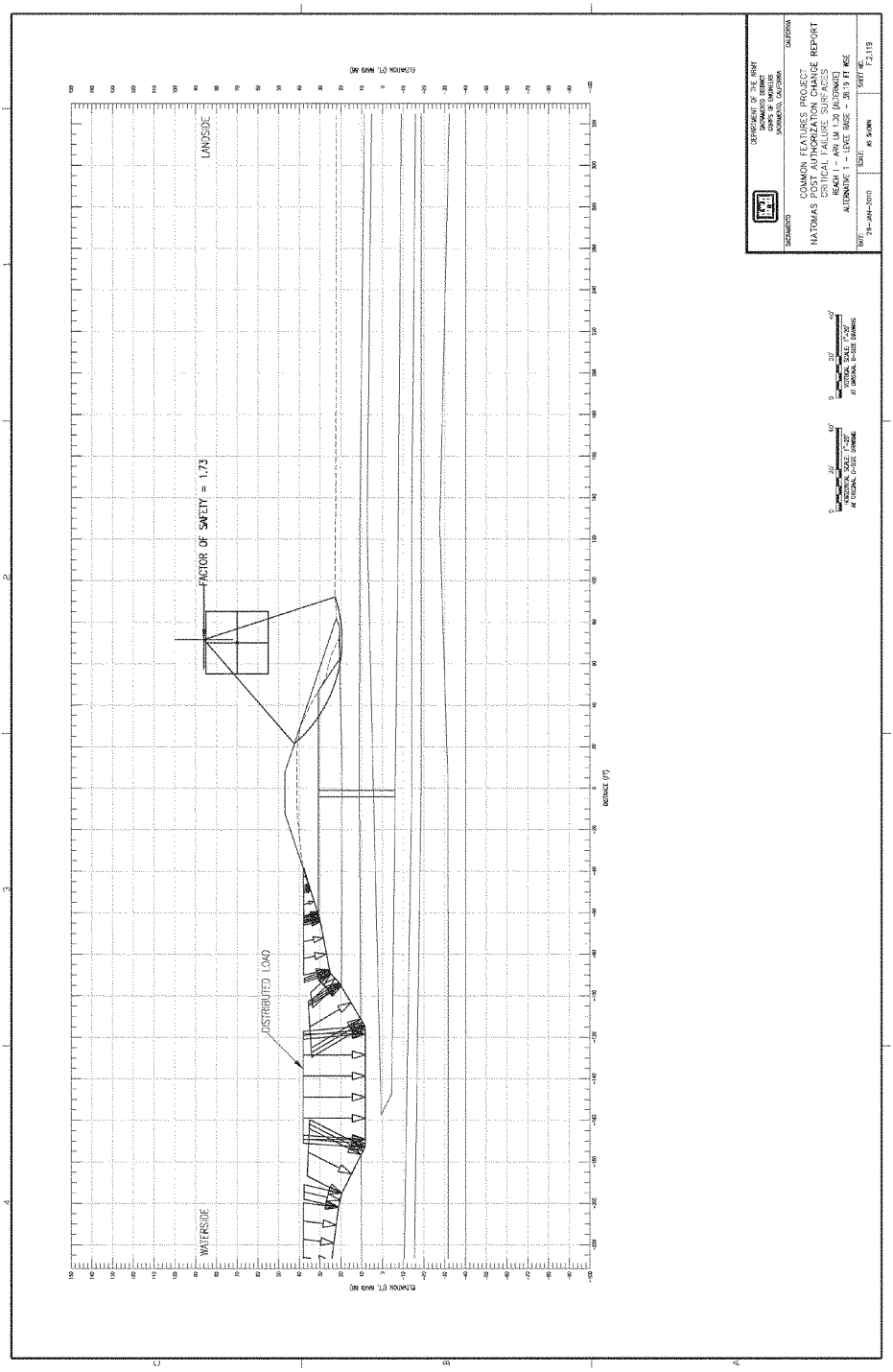

AVERAGE VERTICAL EXIT GRADIENT: (26.24-20.61)/(20.61-10.92) = 0.58
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
24.00
26.00
28.00
30.00
32.00
34.00
36.00
40.00
50.00
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOTAL HEAD CONTOURS
REACH 1 - STA 37+00 TO STA 41+00
EXISTING CONDITIONS - 41.34 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.114


AVERAGE VERTICAL EXIT GRADIENT: (22.8-20.61)/(20.51-10.92) = 0.23
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
22.80
24.00
26.00
28.00
30.00
32.00
34.00
36.00
38.00
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
REACH A, RIO LINDA LEVEE (LEVEE 13)
ALTERNATIVE 1 – EXISTING LEVEE REPORT + 3.15 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.115


AVERAGE VERTICAL EXIT GRADIENT: (24.18 - 22.72)/(22.72 - 10.92) = 0.12
LANDSIDE
WATERSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
24.00
26.00
28.00
30.00
32.00
34.00
36.00
38.00
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
REACH 1A, REACH 1B, & REACH 2
ALTERNATIVE 1 - LEVEE RAISE - 38.9 FT MSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO.: F2.116


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CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, RIO LINDA/ELVERTA LEVEE
EXISTING CONDITIONS - 41.34 FT MSL
DATE
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F2.117
LANDSIDE
WATERSIDE
FACTOR OF SAFETY = 1.08
OVO CLEARED SIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING


FACTOR OF SAFETY = 1.51
DISTRIBUTED LOAD
WATERSIDE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A, B, & C (STATIONS 0+00 TO 330+00)
ALTERNATIVE 1 – EXISTING LEVEE HEIGHT + 3.0 FT WSE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. F2.112


FACTOR OF SAFETY = 1.73
LANDSIDE
WATERSIDE
DISTRIBUTED (1:0V)
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
CRITICAL FAILURE SURFACES
REACH A AND B, SECTIONS 1 & 2
ALTERNATIVE 1 - LEVEE RAISE = 38.9 FT MSE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
F2.119

AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

NATOMAS POST AUTHORIZATION CHANGE REPORT

ENCLOSURE F3

TYPICAL GEOTECHNICAL IMPROVEMENT SECTIONS

US Army Corps of Engineers

American River Watershed
Common Features Project
Natomas Post Authorization Change Report

Improvements by Reach and Water Surface Elevation												
River Section	Reach	Subreach	LM	to	LM	500yr	200yr	100yr	50yr	25yr	10yr
SREL	A	1	18.60	-	17.61	Improvement Measures Not Required, existing cutoff wall at approximate tip elevation -7.0 ft; Levee shall be improved, as necessary, to meet minimum 3:1 landside and waterside slopes, 20ft crest width, landside maintenance road, utility corridor, and levee crest raise (if required by H&H).					
		2	17.61	-	15.50	**Alternative 1:** Levee Crest Raise with Keyed in Cutoff Wall (waterside of existing cutoff wall and within levee crest) to tip elev. -85.0 (120.0 ft deep) **Alternative 2:** Adjacent/Widened Levee Crest Raise with Waterside Keyed in Cutoff Wall to tip elev. -85.0 (120.0 ft deep)	**Alternative 1:** Waterside Hanging Cutoff Wall to tip elev. -68.5 (103.5 ft deep) **Alternative 2:** Adjacent Levee/Widened Levee Crest with Hanging Cutoff Wall (waterside of existing cutoff wall and within levee crest) to tip elev. -68.5 (103.5 ft deep)	Improvement Measures Not Required; Levee shall be improved, as necessary, to meet minimum 3:1 landside and waterside slopes, 20ft crest width, landside maintenance road, utility corridor, and levee crest raise (if required by H&H)			
	B	1	15.50	-	14.00	**Alternative 1:** Adjacent Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -4.0 (39.5ft deep) **Alternative 2:** Levee Crest Raise with 80ft Wide, 7.5ft Thick Drained Seepage Berm **Alternative 3:** Levee Crest Raise with Keyed in Cutoff Wall (waterside of existing cutoff wall and within levee crest) to tip elev. -4.0 (37.0ft deep)	**Alternative 1:** Adjacent Levee with Keyed in Cutoff Wall to tip elev. -4.0 (39.5ft deep) **Alternative 2:** 80ft Wide, 5.0ft thick Drained Seepage Berm **Alternative 3:** Keyed in Cutoff Wall (waterside of existing cutoff wall and within levee crest) to tip elev. -4.0 (37.0ft deep)	Improvement Measures Not Required; Levee shall be improved, as necessary, to meet minimum 3:1 landside and waterside slopes, 20ft crest width, landside maintenance road, utility corridor, and levee crest raise (if required by H&H).			
		2	14.00	-	13.40	**Alternative 1:** Adjacent Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -4.0 (39.5ft deep) **Alternative 3:** Levee Crest Raise with Keyed in Cutoff Wall (waterside of existing cutoff wall and within levee crest) to tip elev. -4.0 (37.0ft deep) **Alternative 4:** Levee Crest Raise with 300ft Wide, 7.5ft Thick Drained Seepage Berm	**Alternative 1:** Adjacent Levee with Keyed in Cutoff Wall to tip elev. -4.0 (39.5ft deep) **Alternative 3:** Keyed in Cutoff Wall (waterside of existing cutoff wall and within levee crest) to tip elev. -4.0 (37.0ft deep) **Alternative 4:** 300ft Wide, 7.5ft Thick Drained Seepage Berm				
		3	13.40	-	12.30	**Alternative 1:** Adjacent Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -40.0 (74.5ft deep) **Alternative 3:** Levee Crest Raise with Keyed in Cutoff Wall (waterside of existing cutoff wall and within levee crest) to tip elev. -40.0 (73.0ft deep) **Alternative 4:** Levee Crest Raise with 300ft Wide, 7.5ft Thick Drained Seepage Berm	**Alternative 1:** Adjacent Levee with Keyed in Cutoff Wall to tip elev. -40.0 (74.5ft deep) **Alternative 3:** Keyed in Cutoff Wall (waterside of existing cutoff wall and within levee crest) to tip elev. -40.0 (73.0ft deep) **Alternative 4:** 300ft Wide, 7.5ft Thick Drained Seepage Berm				
		4	12.30	-	9.00	**Alternative 5:** Levee Crest Raise with 300ft Wide, 7.5ft Thick Drained Seepage Berm with Hanging Cutoff Wall to tip elev. -39.5 (75.0ft deep) **Alternative 6:** Adjacent Levee Crest Raise with 300ft Wide, 7.5ft Thick Drained Seepage Berm with Hanging Cutoff Wall to tip elev. -39.5 (75.0ft deep)	**Alternative 5:** 300ft Wide, 7.5ft Thick Drained Seepage Berm with Hanging Cutoff Wall to tip elev. -39.5 (75.0ft deep) **Alternative 6:** Adjacent Levee with 300ft Wide, 7.5ft Thick Drained Seepage Berm with Hanging Cutoff Wall to tip elev. -39.5 (75.0ft deep)				
		5	9.00	-	8.00	**Alternative 1:** Adjacent Levee Crest Raise with Keyed in Cutoff Wall to tip elev -65.0 (100.5ft deep) **Alternative 4:** Levee Crest Raise with 300ft Wide, 7.5ft Thick Drained Seepage Berm **Alternative 7:** Levee Crest Raise with Keyed in Cutoff Wall in place to tip elev. -65.0 (96.0ft deep)	**Alternative 1:** Adjacent Levee with Keyed in Cutoff Wall to tip elev. -65.0 (100.5ft deep) **Alternative 4:** 300ft Wide, 7.5ft Thick Drained Seepage Berm **Alternative 7:** Keyed in Cutoff Wall in place to tip elev. -65.0 (96.0ft deep)				
		6	8.00	-	5.00	**Alternative 8:** Adjacent Levee Crest Raise with Hanging Cutoff Wall to tip elev. -84.0 (120.0 ft deep) and 100 ft wide by 7.5ft thick Drained Seepage Berm **Alternative 9:** Adjacent Levee Crest Raise with Hanging Cutoff Wall to tip elev. -39.0 (75.0 ft deep) and 300ft wide by 7.5ft thick Drained Seepage Berm	**Alternative 8:** Adjacent Levee with Hanging Cutoff Wall to tip elev. -84.0 (120.0 ft deep) and 100 ft by 7.5ft thick Drained Seepage Berm **Alternative 9:** Adjacent Levee with Hanging Cutoff Wall to tip elev. -39.0 (75.0 ft deep) and 300ft wide by 7.5ft thick Drained Seepage Berm				

US Army Corps of Engineers

American River Watershed
Common Features Project
Natomas Post Authorization Change Report

Improvements by Reach and Water Surface Elevation												
River Section	Reach	Subreach	LM	to	LM	500yr	200yr	100yr	50yr	25yr	10yr
	C	1	5.00	-	4.00	**Alternative 1:** Levee Crest Raise with Hanging Cutoff Wall to tip elev. -40.0 (75.0 ft deep) with 80 ft Drained Seepage Berm. **Alternative 2:** Adjacent Levee Crest Raise with Hanging Cutoff Wall to tip elev. -37.0 (75.0 ft deep).				**Alternative 1:** Hanging Cutoff Wall to tip elev. -40.0 (75.0 ft deep) with 80 ft Drained Seepage Berm. **Alternative 2:** Adjacent Levee with Hanging Cutoff Wall to tip elev. -37.0 (75.0 ft deep).	
		2	4.00	-	0.00	**Alternative 3:** Levee Crest Raise with Hanging Cutoff Wall to tip elev. -19.0 (55.0 ft deep) with 80 ft Drained Seepage Berm. **Alternative 4:** Levee Crest Raise with Hanging Cutoff Wall to tip elev. -39.0 (75.0 ft deep). **Alternative 5:** Adjacent Levee Crest Raise with Hanging Cutoff Wall to tip elev. -38.0 (75.0 ft deep)			**Alternative 3:** Hanging Cutoff Wall to tip elev. -19.0 (55.0 ft deep) with 00 ft Drained Seepage Berm. **Alternative 4:** Hanging Cutoff Wall to tip elev. -39.0 (75.0 ft deep). **Alternative 5:** Adjacent Levee with Hanging Cutoff Wall to tip elev. -38.0 (75.0 ft deep)	
NCC	D	1	4.38	-	16.06	**Alternative 1:** Levee Crest Raise with Hanging Cutoff Wall to tip elev. -38.0 (75.0 ft deep).				**Alternative 1:** Hanging Cutoff Wall to tip elev. -18.0 (55.0 ft deep).	
PGCC	E	1	16.06	-	12.55	**Alternative 1:** Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -6.0 (45.9ft deep) **Alternative 2:** Adjacent Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -6.0 (45.9ft deep)		**Alternative 1:** Keyed in Cutoff Wall to tip elev. -6.0 (45.9ft deep) **Alternative 2:** Adjacent Levee with Keyed in Cutoff Wall to tip elev. -6.0 (45.9ft deep)			
NEMDCW	F	1	12.55	-	7.89	**Alternative 1:** Levee Crest Raise with Drained Stability Berm **Alternative 2:** Levee Crest Raise with Flattened Landside Levee Slope (5H:1V) **Alternative 3:** Adjacent Levee Crest Raise with Drained Stability Berm **Alternative 4:** Adjacent Levee Crest Raise with Flattened Landside Levee Slope (5H:1V)			**Alternative 1:** Drained Stability Berm **Alternative 2:** Flattened Landside Levee Slope (5H:1V)		
	G	1	7.89	-	4.25	**Alternative 1:** Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -5.6 (38.8ft deep) **Alternative 2:** Adjacent Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -5.6 (38.8ft deep)				**Alternative 1:** Keyed in Cutoff Wall to tip elev. -5.6 (38.8ft deep) **Alternative 2:** Adjacent Levee with Keyed in Cutoff Wall to tip elev. -5.6 (38.8ft deep)	
	H	1	4.25	-	0.00	**Alternative 1:** Levee Crest Raise with Hanging Cutoff Wall to tip elev. -40.0 (75.0ft deep) with toe road raise	**Alternative 1:** Keyed in Cutoff Wall to tip elev. -5.0 (38.8ft deep)				
ARN	I	1	2.33	-	0.00	**Alternative 1:** Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -9.5 (37.4ft deep) **Alternative 2:** Adjacent/Widened Levee Crest Raise with Keyed in Cutoff Wall to tip elev. -6.5 (37.4ft deep)	**Alternative 1:** Keyed in Cutoff Wall to tip elev. -6.5 (37.4ft deep) **Alternative 2:** Adjacent/Widened Levee Crest with Keyed in Cutoff Wall to tip elev. -6.5 (37.4ft deep)				

NOTE: For design water surface elevations requiring levee crest raises the top of levee elevations are given in *NPACR Analysis Section TCL Elevation Requirements.pdf*

AMERICAN RIVER WATERSHED COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOP OF LEVEE ELEVATION REQUIREMENTS AT GEOTECHNICAL CROSS-SECTIONS

REACH A SREL LM 16.7 RM 62.60				
Crest Elevation:	40.75			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	39.92	0.83	YES	42.92
5	36.73	4.02	NO	39.73
4	34.70	6.05	NO	37.70
3	34.00	6.75	NO	37.00
2	33.45	7.30	NO	36.45
1	31.29	9.46	NO	34.29

REACH B-1, 2, 3, 4, 5 SREL LM 14.3 RM 65.00				
Crest Elevation:	40.56			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	39.99	0.57	YES	42.99
5	36.92	3.64	NO	39.92
4	34.98	5.58	NO	37.98
3	34.27	6.29	NO	37.27
2	33.72	6.84	NO	36.72
1	31.97	8.59	NO	34.97

REACH B-6 SREL LM 6.5 RM 73.00				
Crest Elevation:	42.37			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	42.40	-0.03	YES	45.40
5	41.35	1.02	YES	44.35
4	39.86	2.51	YES	42.86
3	38.97	3.40	NO	41.97
2	38.31	4.06	NO	41.31
1	36.08	6.29	NO	39.08

REACH C-1 SREL LM 4.0 RM 75.20				
Crest Elevation:	42.81			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	43.11	-0.30	YES	46.11
5	42.24	0.57	YES	45.24
4	40.86	1.95	YES	43.86
3	39.95	2.86	YES	42.95
2	39.26	3.55	NO	42.26
1	37.08	5.73	NO	40.08

AMERICAN RIVER WATERSHED COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOP OF LEVEE ELEVATION REQUIREMENTS AT GEOTECHNICAL CROSS-SECTIONS

REACH C-2 SREL LM 1.3 RM 78.00				
Crest Elevation:	44.40			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	44.44	-0.04	YES	47.44
5	43.58	0.82	YES	46.58
4	42.21	2.19	YES	45.21
3	41.26	3.14	NO	44.26
2	40.55	3.85	NO	43.55
1	38.43	5.97	NO	41.43

REACH D-1 NCC LM 3.92 RM 0.53				
Crest Elevation:	44.62			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	45.13	-0.51	YES	48.13
5	44.16	0.46	YES	47.16
4	42.76	1.86	YES	45.76
3	41.80	2.82	YES	44.80
2	41.07	3.55	NO	44.07
1	38.97	5.65	NO	41.97

REACH D-2 NCC LM 1.17 RM 3.23				
Crest Elevation:	44.85			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	45.16	-0.31	YES	48.16
5	44.23	0.62	YES	47.23
4	42.84	2.01	YES	45.84
3	41.88	2.97	YES	44.88
2	41.11	3.74	NO	44.11
1	39.00	5.85	NO	42.00

REACH E PGCC LM 15.70 RM 0.74				
Crest Elevation:	46.20			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	45.03	1.17	YES	48.03
5	43.89	2.31	YES	46.89
4	42.56	3.64	NO	45.56
3	41.56	4.64	NO	44.56
2	40.75	5.45	NO	43.75
1	38.81	7.39	NO	41.81

AMERICAN RIVER WATERSHED COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TOP OF LEVEE ELEVATION REQUIREMENTS AT GEOTECHNICAL CROSS-SECTIONS

REACH F NEMDC LM 8.30 RM 10.80				
Crest Elevation:	41.42			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	43.03	-1.61	YES	46.03
5	39.76	1.66	YES	42.76
4	38.97	2.45	YES	41.97
3	38.10	3.32	NO	41.10
2	37.24	4.18	NO	40.24
1	35.62	5.80	NO	38.62

REACH G NEMDC LM 6.45 RM 9.00				
Crest Elevation:	40.98			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	43.05	-2.07	YES	46.05
5	39.78	1.20	YES	42.78
4	38.99	1.99	YES	41.99
3	38.11	2.87	YES	41.11
2	37.25	3.73	NO	40.25
1	35.63	5.35	NO	38.63

REACH H NEMDC LM 1.0 RM 3.50				
Crest Elevation:	43.17			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	44.37	-1.20	YES	47.37
5	39.07	4.10	NO	42.07
4	37.53	5.64	NO	40.53
3	35.99	7.18	NO	38.99
2	34.93	8.24	NO	37.93
1	32.55	10.62	NO	35.55

REACH I ARN LM 1.30 RM 1.20				
Crest Elevation:	41.34			
Flood Stage	WSE	Existing Freeboard	Raise Required	WSE+3ft Levee Crest Elev.
6	43.95	-2.61	YES	46.95
5	38.19	3.15	NO	41.19
4	35.66	5.68	NO	38.66
3	35.06	6.28	NO	38.06
2	34.60	6.74	NO	37.60
1	31.24	10.10	NO	34.24

AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT

TYPICAL GEOTECHNICAL CROSS SECTIONS

GENERAL SECTION NOTES:

1. LEVEE IMPROVEMENTS SHALL BE CONSTRUCTED TO USACE MINIMUM REQUIREMENTS OF A 20 FOOT CREST WIDTH WITH 3H:1V SIDE SLOPES AND SHALL INCLUDE A 15 FOOT MAINTENANCE ROAD AND 20 FOOT UTILITY EASEMENT.
2. WATERSIDE SHEET PILE WALL 3 TIMES THE LEVEE HEIGHT DEEP SHALL BE CONSTRUCTED AS NECESSARY TO PROTECT EXISTING STRUCTURES DURING CONSTRUCTION OF LEVEE IMPROVEMENTS.
3. DEGRADE LEVEE: ½ EXISTING LEVEE HEIGHT FOR SB CUTOFF WALL. DEGRADE LEVEE: ⅓ EXSITING LEVEE HEIGHT FOR SCB/CB CUTOFF WALL.
4. CUTOFF OFF WALLS SHALL BE CONSTRUCTED WITHIN THE IMPROVED LEVEE CREST.
5. CUTOFF WALLS SHALL BE SOIL BENTONITE IF THE DEPTH IS 75 FEET OR LESS AND SOIL CEMENT BENTONITE IF THE DEPTH IS GREATER THAN 75 FEET.
6. FOR ALL "LEVEE RAISE" CROSS SECTIONS, TOP OF LEVEE ELEVATION = WATER SURFACE ELEVATION + 3 FEET. SEE "20091221 NPACR ANALYSIS SECTION TOL ELEVATION REQUIREMENTS.pdf" FOR WATER SURFACE AND TOP OF LEVEE ELEVATIONS.
7. IF LANDSIDE IRRIGATION DITCH IS PRESENT, RELOCATE AND RECONSTRUCT TO EXISTING CONDITIONS. DITCH SHALL BE LOCATED A MINIMUM OF 150 FT FROM THE LANDSIDE LEVEE TOE.
8. DRAINED SEEPAGE BERMS SHALL BE CONSTRUCTED OF A 2.0FT THICK GRAVEL LAYER UNDERLAIN BY A 0.5FT THICK SAND BASE WITH GEOTEXTILE PLACED OVER THE DRAIN.

LEGEND

- LEVEE IMPROVEMENT CONSTRUCTION LINE
- EXISTING GROUND SURFACE
- CENTERLINE/BASELINE
- EXISTING LEVEE IMPROVEMENT
- NATIVE MATERIAL
- EXISTING LEVEE FILL
- CUTOFF WALL
- ASPHALTIC CONCRETE PAVEMENT

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

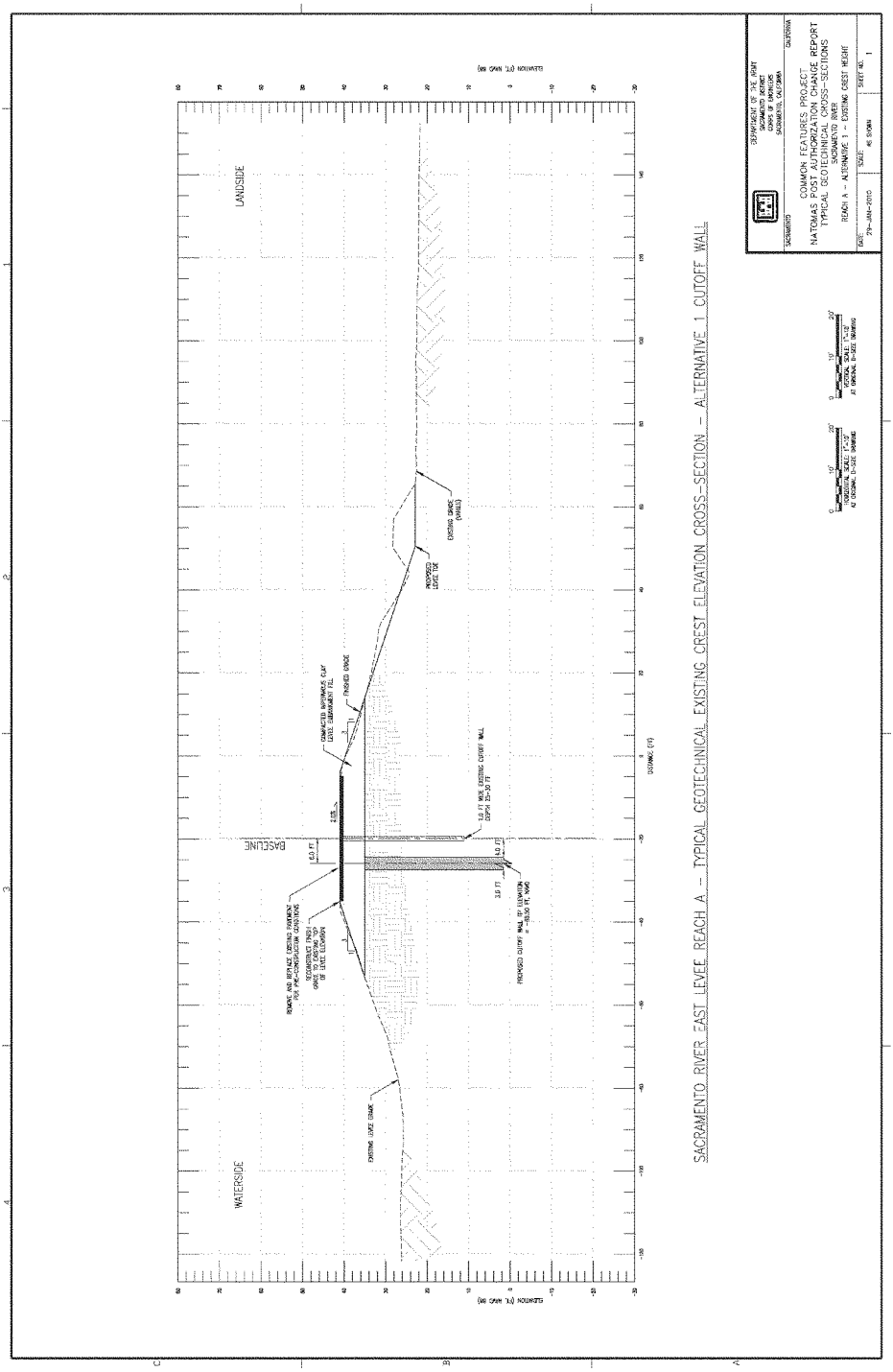
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

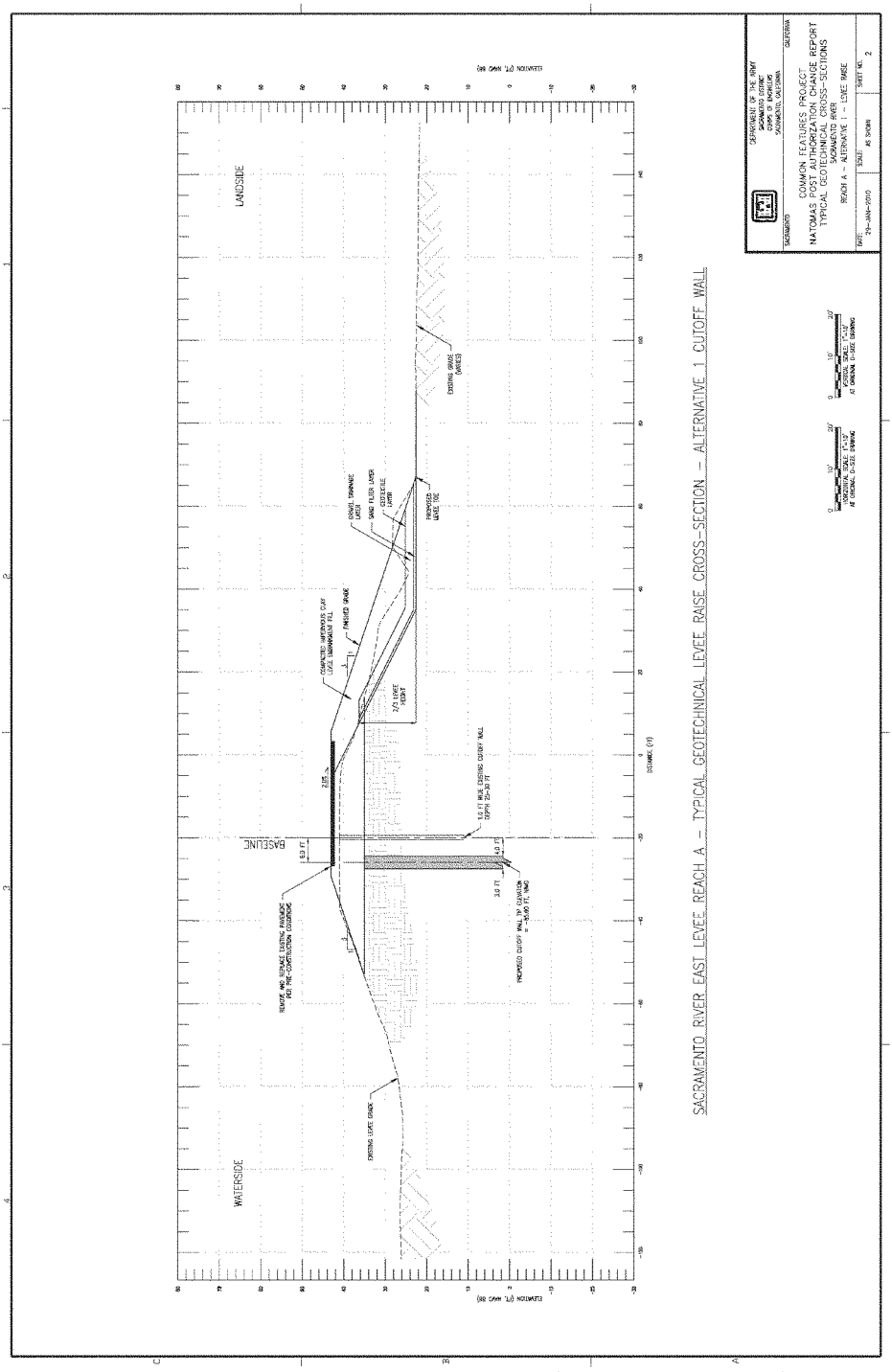
SACRAMENTO CALIFORNIA

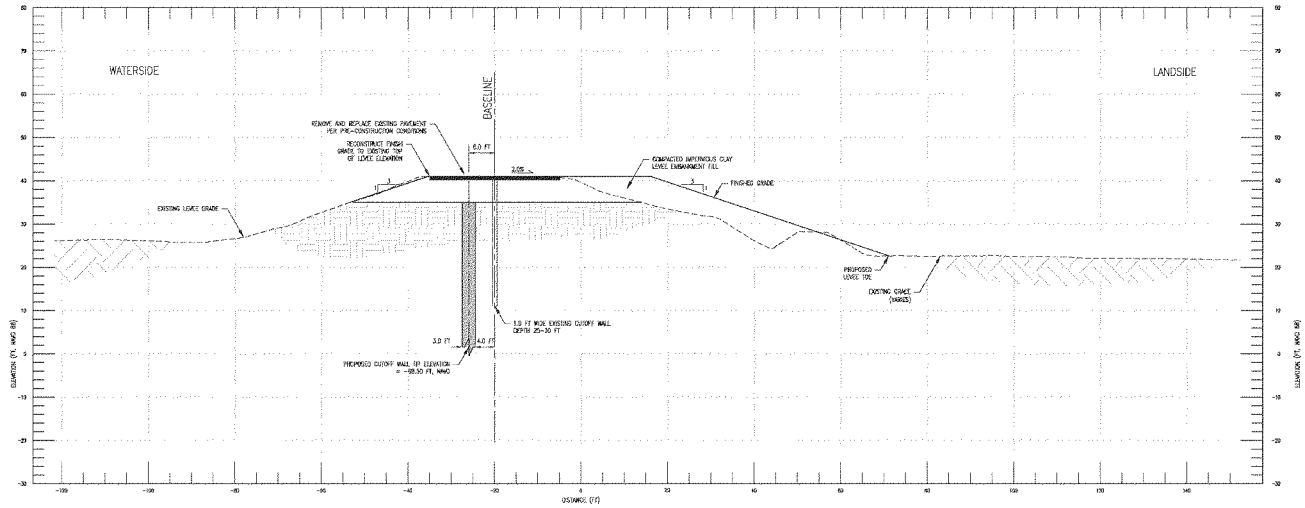
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS

TITLE SHEET AND GENERAL NOTES

DATE:	SCALE:	SHEET NO.
29-JAN-2010	AS SHOWN	NA


LANDSIDE
WATERSIDE
BASELINE
EXISTING LEVEE CREST
PROPOSED LEVEE TOE
EXISTING GRADE (TYP.)
COMPACTED IMPERVIOUS CLAY LEVEE SUBMERGED FILL
FINISHED GRADE
REMOVE AND REPLACE EXISTING PAVEMENT WITH NEW PAVEMENT STRUCTURE
RECONSTRUCT PAVED ACCESS TO MATCH NEW LEVEE ELEVATION
EXISTING LEVEE GRADE
18 FT WIDE EXISTING CUTOFF WALL DEPTH 15-30 FT
PROPOSED CUTOFF WALL TIP ELEVATION = -25.00 FT, NAVD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
SACRAMENTO RIVER EAST LEVEE REACH A – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 1 CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER EAST LEVEE
REACH A – ALTERNATIVE 1 – EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 1


SACRAMENTO RIVER EAST LEVEE REACH A – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 1 CUTOFF WALL
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
REMOVE AND SALVAGE EXISTING PAVEMENT PER PRE-CONSTRUCTION CONDITIONS
2.5
3.0 FT
3.0 FT
PROPOSED CUTOFF WALL TIP ELEVATION = -30.65 FT, NAVD
15 FT MIN. EXISTING CUTOFF WALL DEPTH ES-30 FT
2.5
2.5
2.5



SACRAMENTO RIVER EAST LEVEE REACH A – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 2 ADJACENT/WIDENED LEVEE WITH CUTOFF WALL

HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

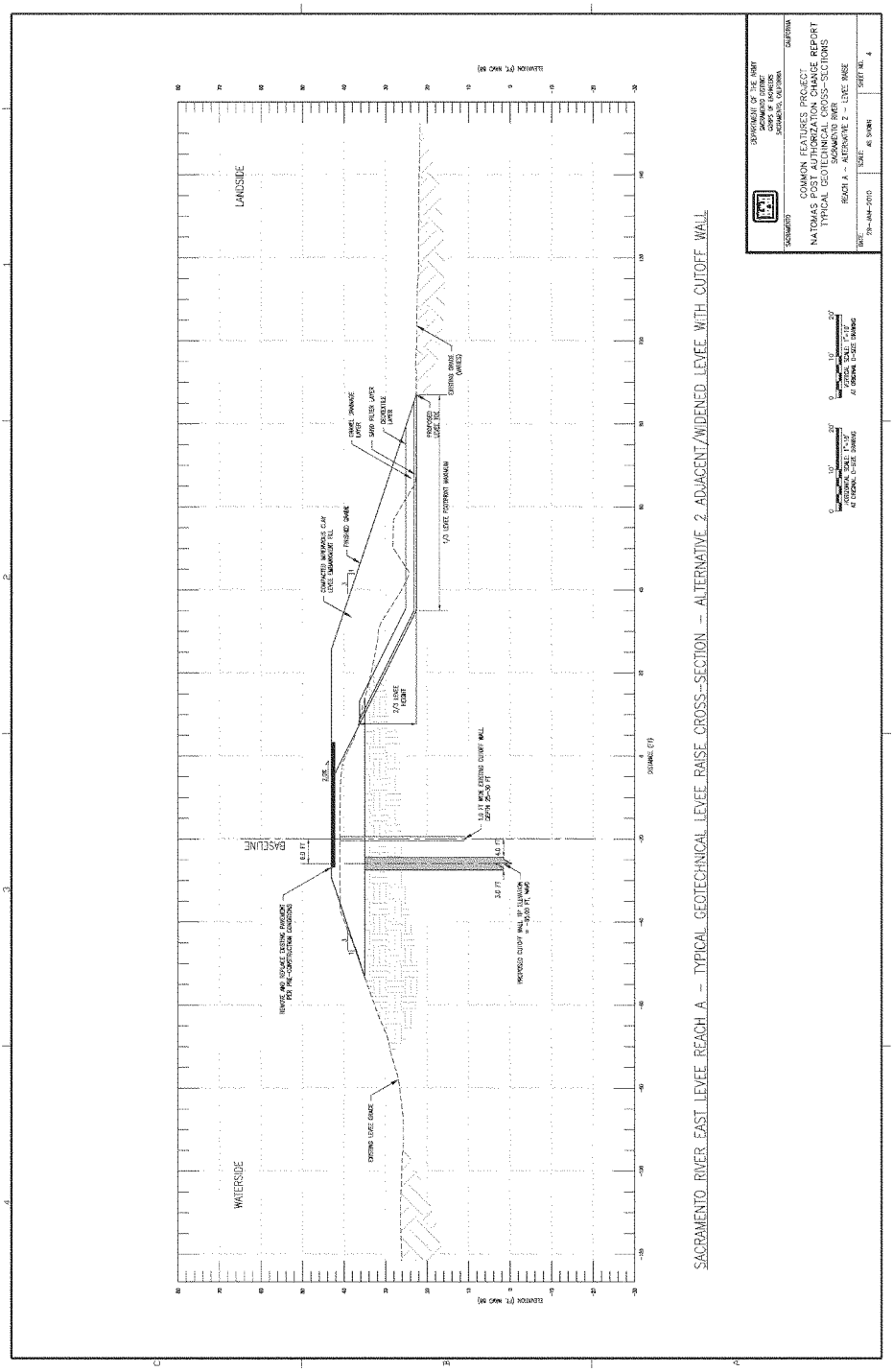
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

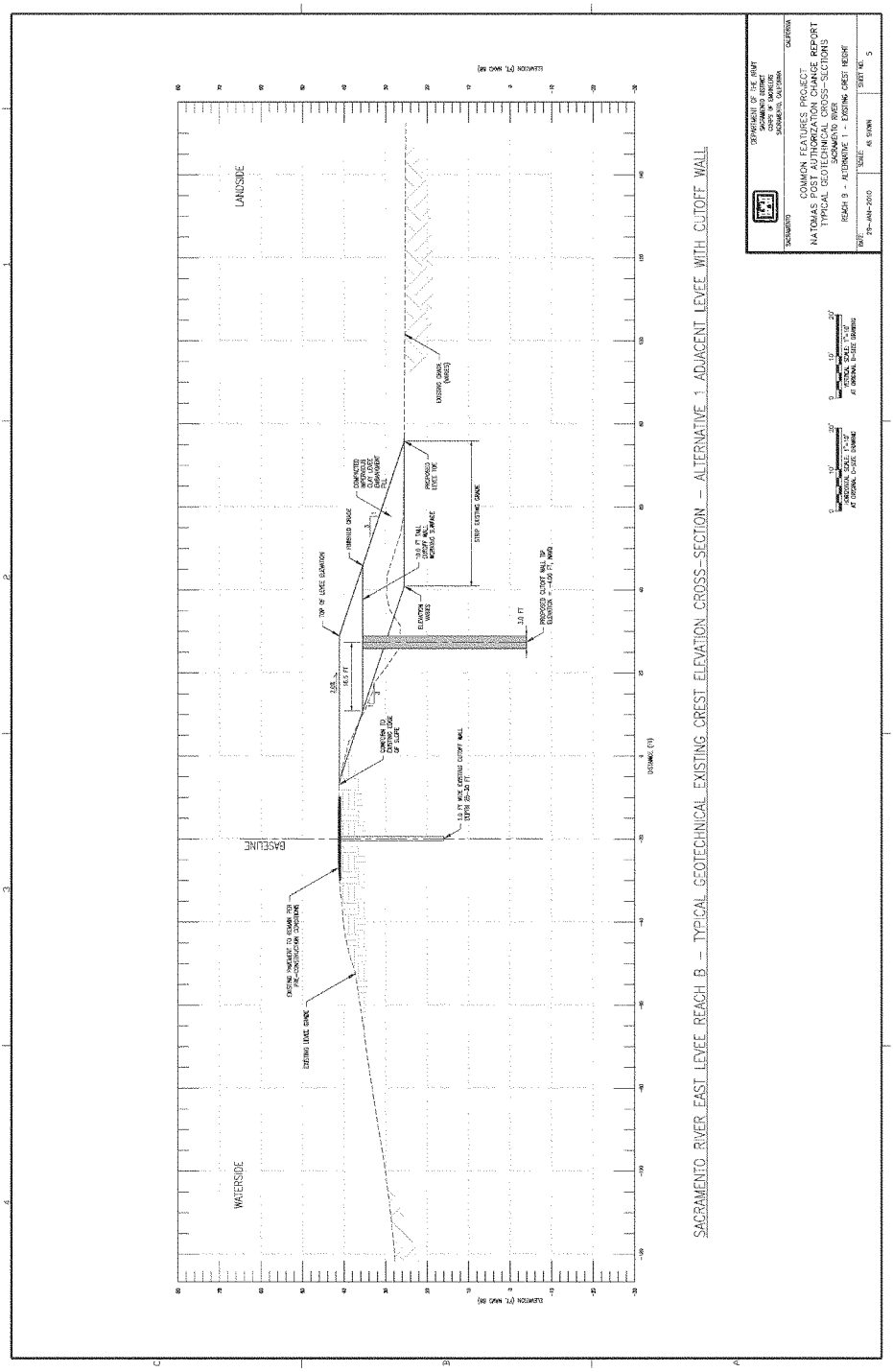
SACRAMENTO CALIFORNIA

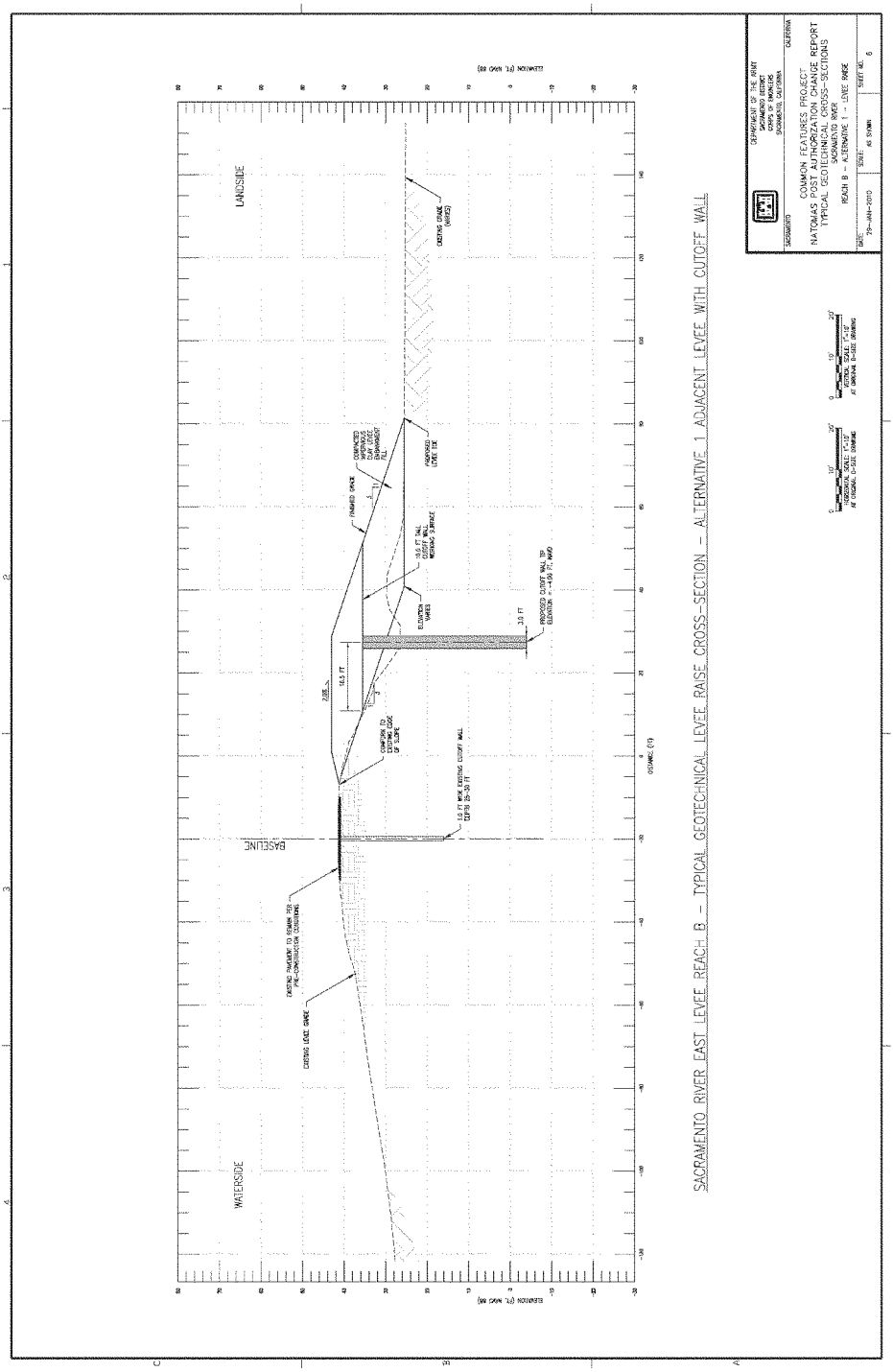
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH A – ALTERNATIVE 2 – EXISTING CREST HEIGHT

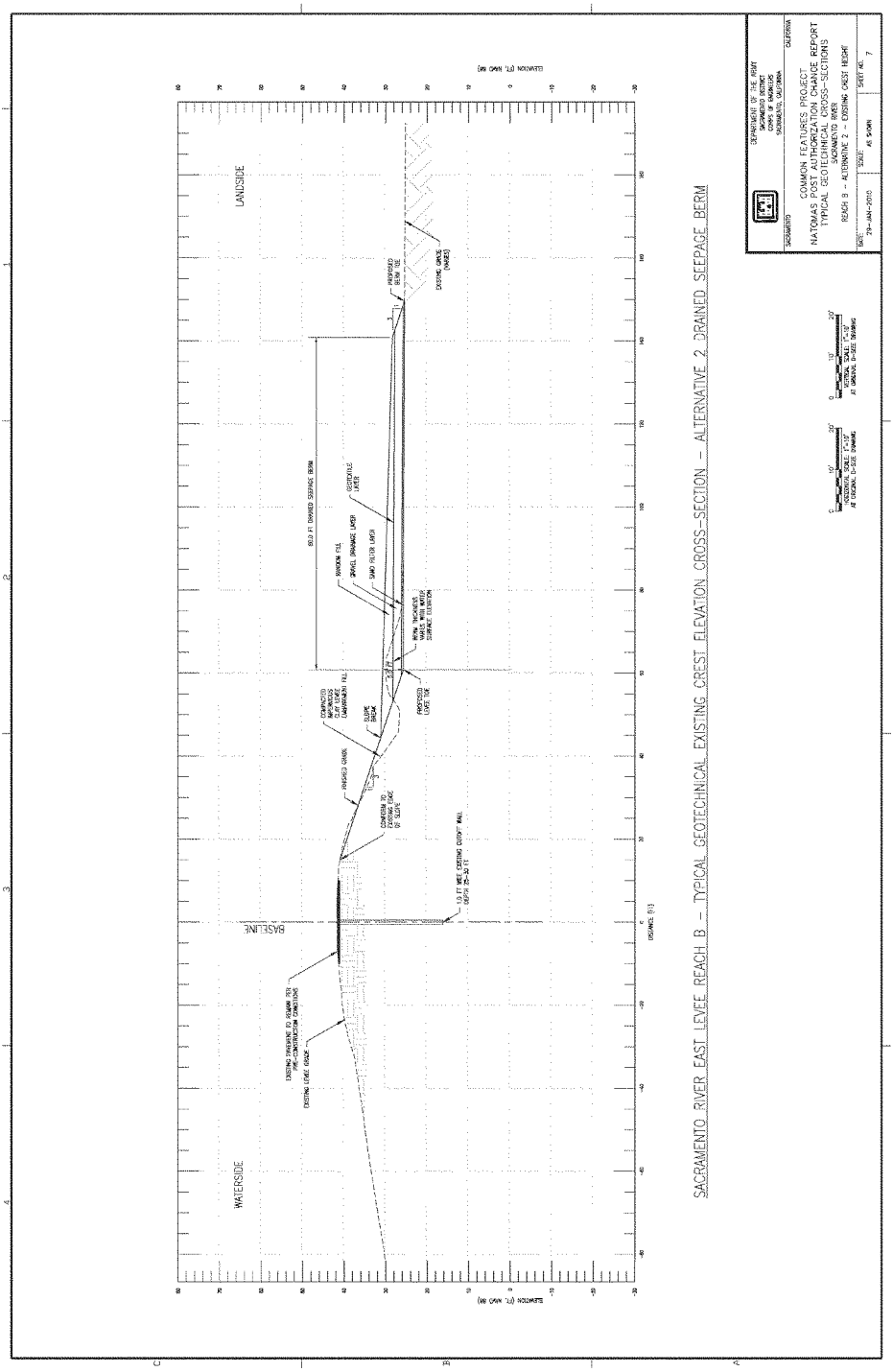
DATE:	SCALE:	SHEET NO.
29-JAN-2010	AS SHOWN	3

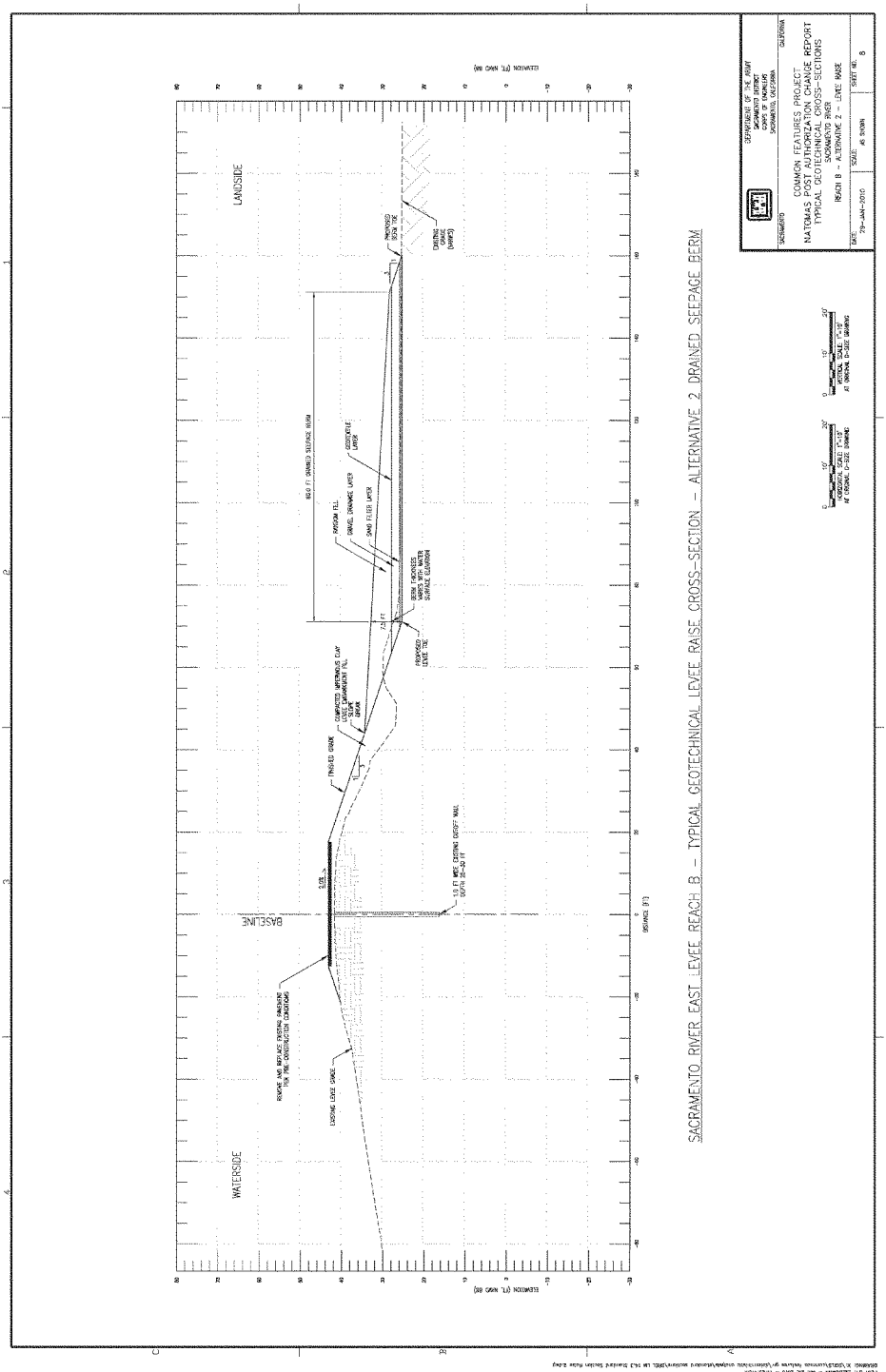
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DRAWING: X:\SAC\Common Features (pl)\Sites\Natomas and Sutter\Natomas\ Sections\CFNEL LM 10.7 Standard Section 2.dwg

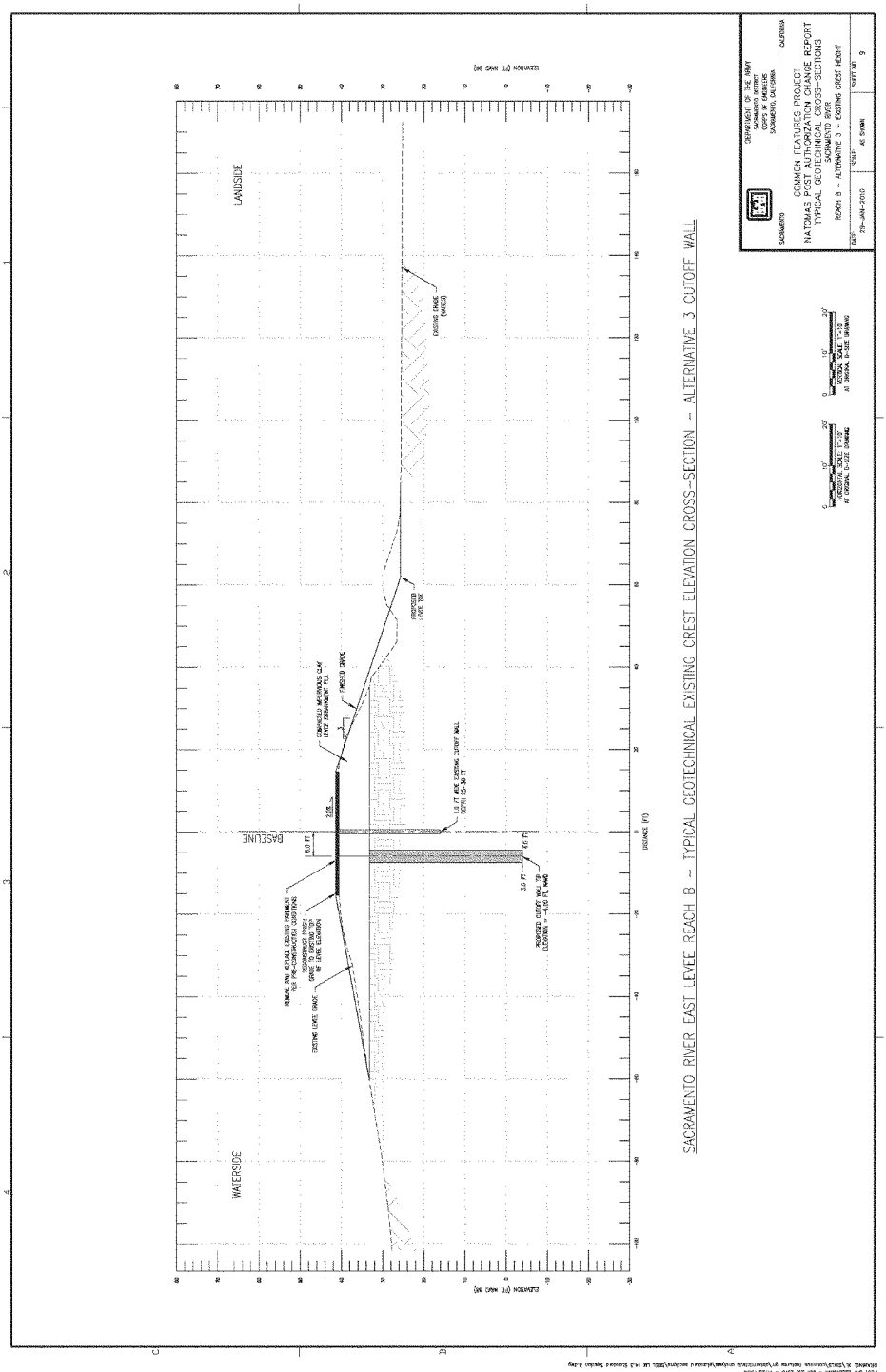

WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
REMOVE AND REPLACE EXISTING PAVEMENT PER PRE-CONSTRUCTION CONDITIONS
2.0ft
6.0 FT
3
1
COMPACTED IMPERVIOUS CLAY LEVEE SUBGRADE FILL
FINISHED GRADE
2
1
2.0ft
3
1
3(H):1(V) LEVEE PRISM
STATION (FT, NAVD 88)
ELEVATION (FT, NAVD 88)
SACRAMENTO RIVER EAST LEVEE REACH A – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 2 ADJACENT/WIDENED LEVEE WITH CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER EAST LEVEE
REACH A – ALTERNATIVE 2 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 4

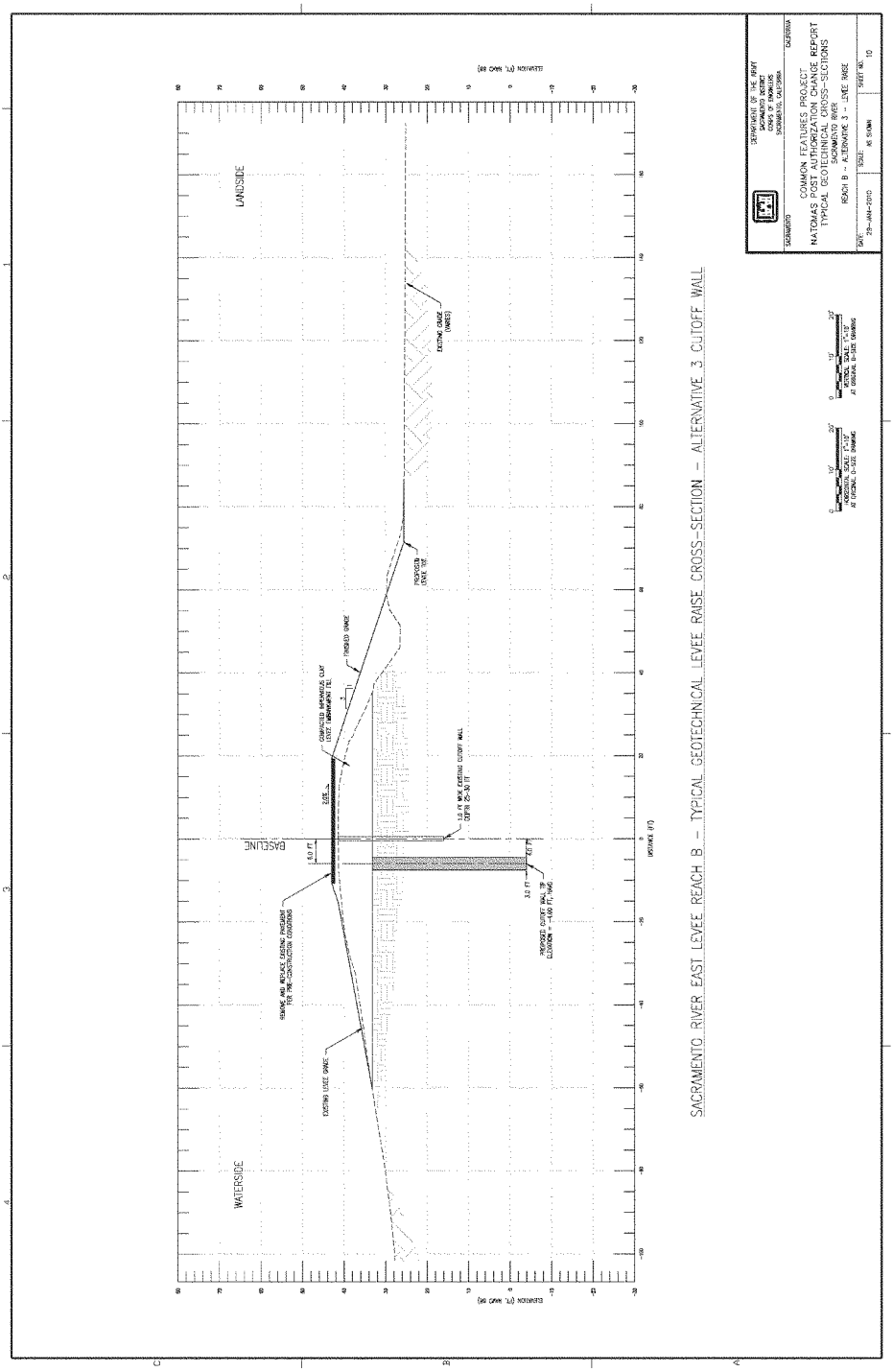

SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 1 ADJACENT LEVEE WITH CUTOFF WALL
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING GRADE
TOP OF LEVEE ELEVATION
RIPRAP GRADE
COMPACTED CLAY LEVEE ENLARGEMENT FILL
3:1
16.5 FT
10 FT
3:1
EXISTING GRADE (VARIES)
PROPOSED LEVEE TOP
STRIP EXISTING GRADE
ELEVATION VARIES
30 FT WALL DEPTH BELOW SURFACE
10 FT
PROPOSED CUTOFF WALL TOP ELEVATION +25 FT, NAVD
CENTERLINE OF CUTOFF WALL
10 FT DEEP EXISTING CUTOFF WALL ELEVATION 25 TO 35 FT
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH B - ALTERNATIVE 1 - EXISTING CREST HEIGHT
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
5

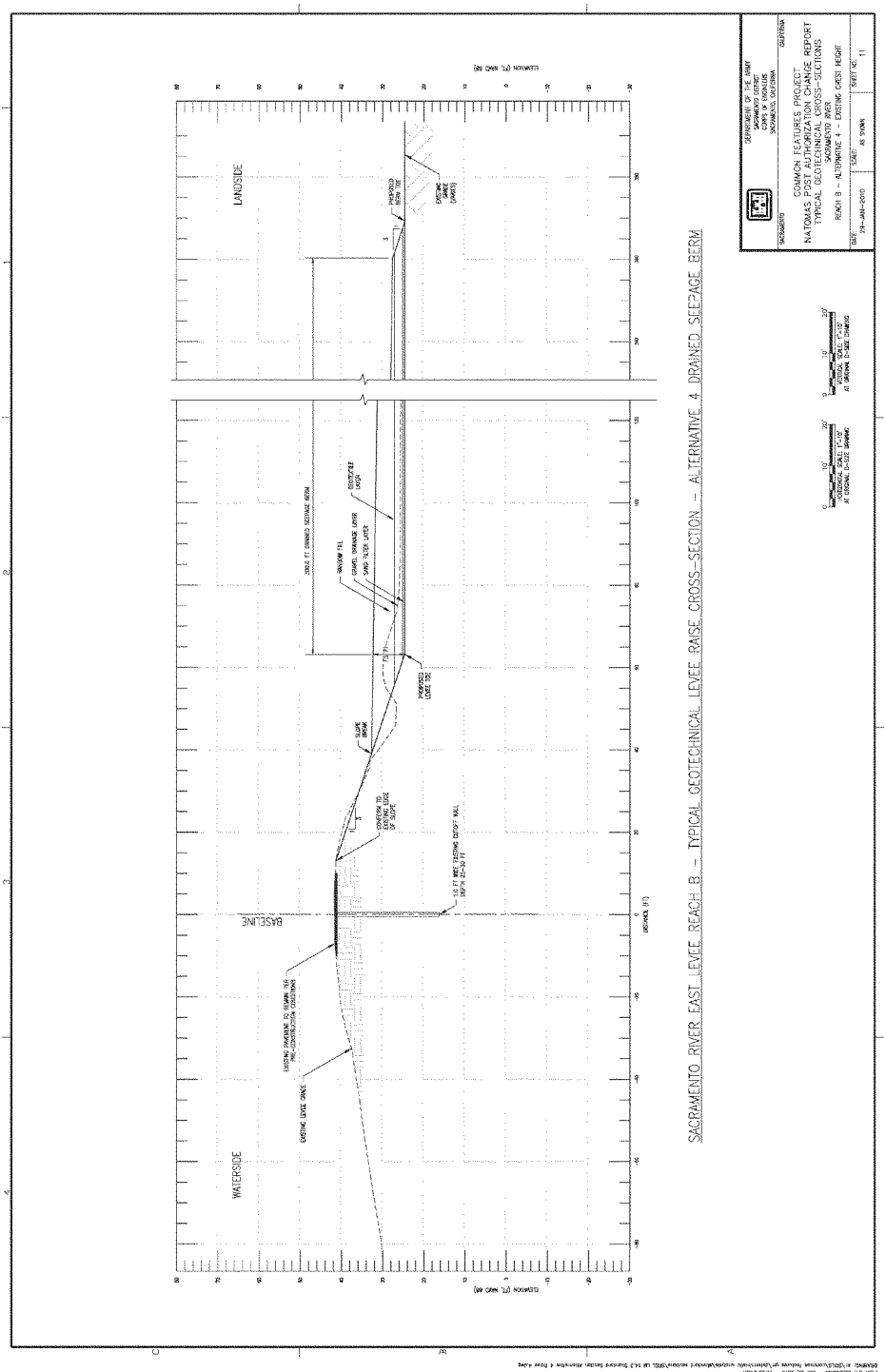

LANDSIDE
WATERSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING TRAILWAY TO REMAIN PER ALTERNATIVES 1 THROUGH 4
EXISTING GROUND
COMPACTED EARTHEN FILL
PROPOSED LEVEE TOE
EXISTING GRADE (VARIES)
16.5 FT
3 : 1
10.5 FT
ELEVATION VARIES
3.0 FT
EMBEDDED CUTOFF WALL TO ELEVATION -119.1 NAVD
16.5 FT WALL CUTOFF WALL REMOVING SEEPAGE
10 FT MIN EXISTING CUTOFF WALL DEPTH 35+-10 FT
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
SACRAMENTO RIVER EAST LEVEE REACH B - TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION - ALTERNATIVE 1 ADJACENT LEVEE WITH CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER EAST LEVEE
REACH B - ALTERNATIVE 1 - LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 6

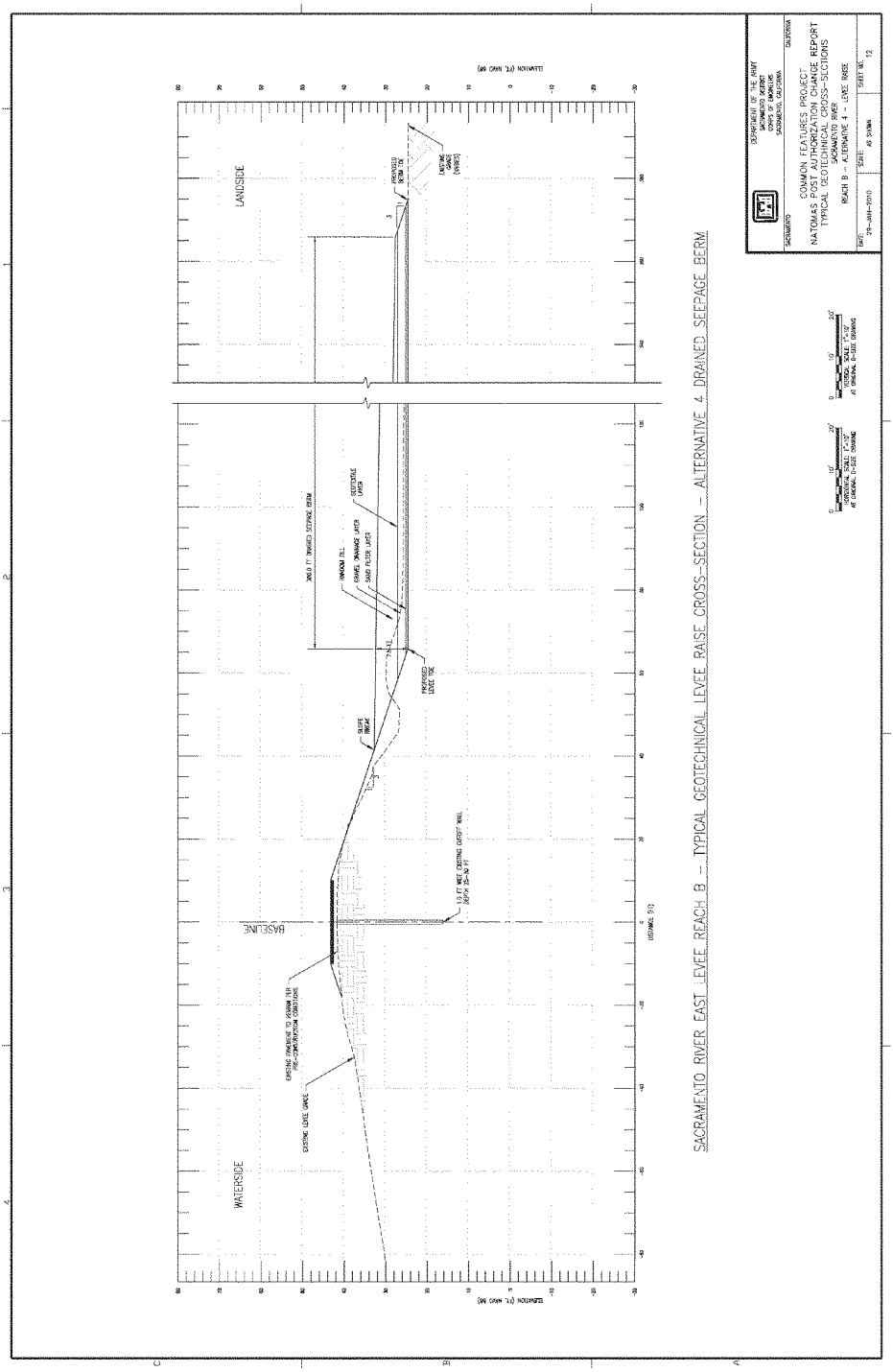

SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 2 DRAINED SEEPAGE BERM
WATERSIDE
BASELINE
LANDSIDE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
EXISTING LEVEE CREST
EXISTING LEVEE TOE
EXISTING DRAINAGE DITCH
PROPOSED CREST RAISE
COMPACTED IMPERVIOUS EARTHFILL (LANDSIDE FILL)
SLOPE BENCH
PROPOSED LEVEE TOE
PROPOSED BERM TOE
EXISTING LEVEE (VARIES)
650 FT DRAINED SEEPAGE BERM
RANDOM FILL
GRAVEL DRAINAGE LAYER
SAND FILTER LAYER
GEOTEXTILE LAYER
BERM THICKNESS VARIES WITH WATER SURFACE ELEVATION
10 FT WIDE EXISTING CUTOFF WALL DEPTH 25-30 FT
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SHEET NO. 7
REACH B - ALTERNATIVE 2 - EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN

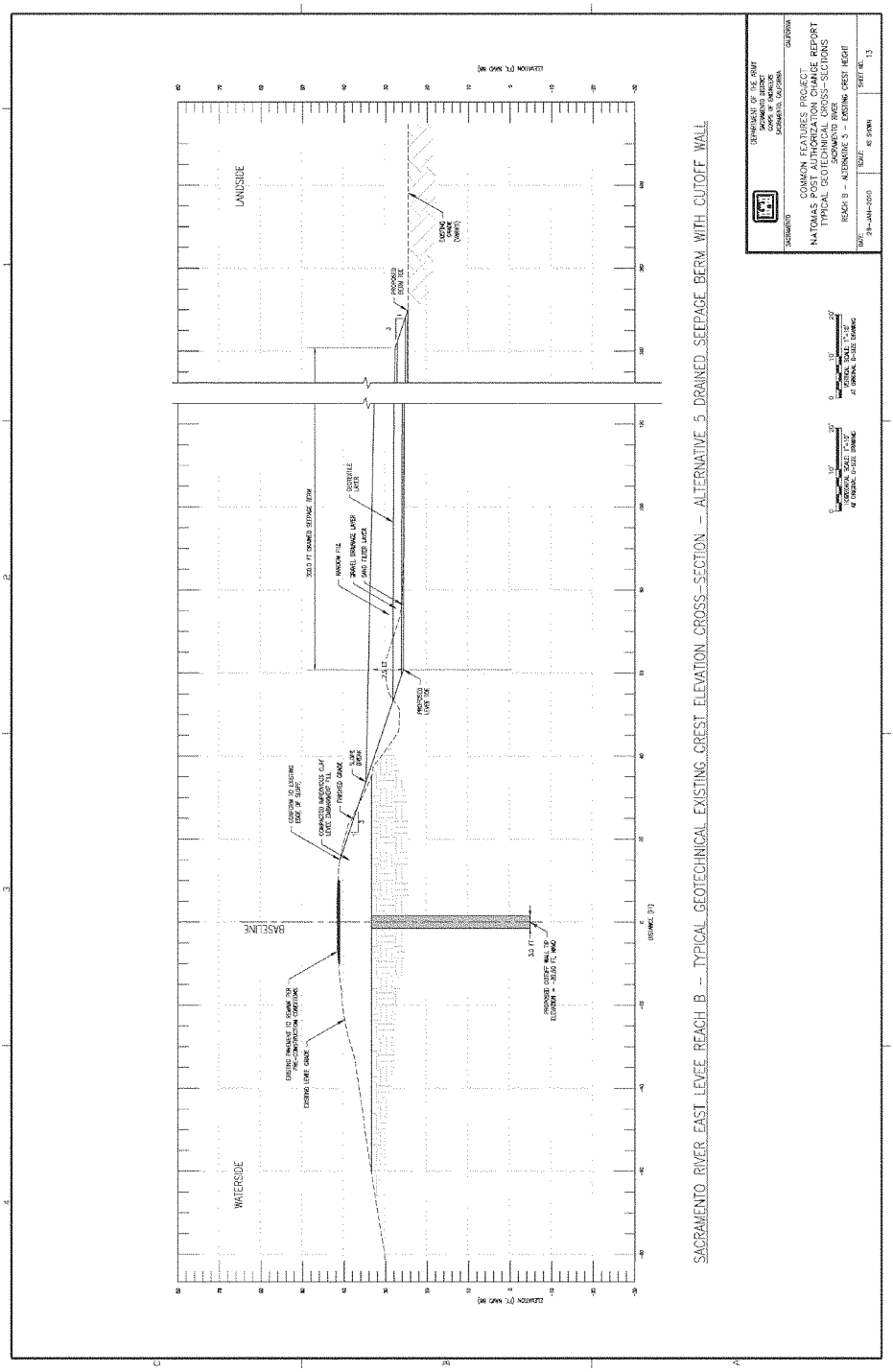

WATERSIDE
LANDSIDE
BASELINE
SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 2 DRAINED SEEPAGE BERM
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
REACH B - ALTERNATIVE 2 - LEVEE RAISE
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
29-JAN-2010
AS SHOWN
SHEET NO.
6

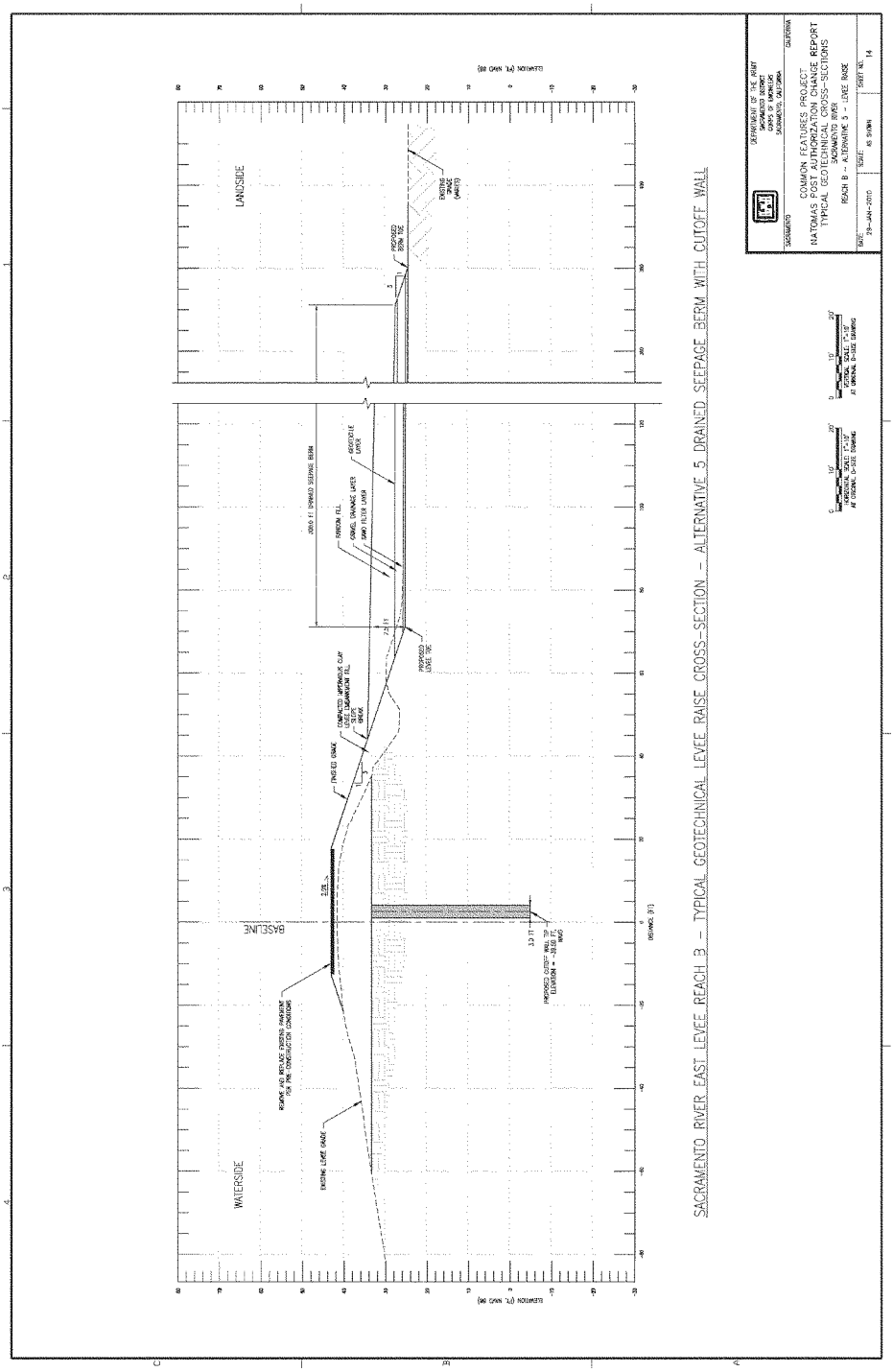

LANDSIDE
WATERSIDE
BASELINE
EXISTING LEVEE GRADE
REMOVE ANY INTERIOR EXISTING EMBANKMENT MATERIAL AND REPLACE WITH COMPACTED FILL
RECOMPACTED FINISH GRADE TO MATCH EXISTING GRADE
COMPACTED MECHANICALLY PLACED CLAY LEVEE EMBANKMENT FILL
PROPOSED GRADE
PROPOSED LEVEE TOE
EXISTING LEVEE CREST
6.0 FT
2.5 FT
1
3
~18 FT DEEP EXISTING CUTOFF WALL DEPTH 25'-36 FT
3.0 FT
16 FT
PROPOSED CUTOFF WALL TO ELEVATION +35 FT, NAVD
ELEVATION (FT), NAVD 88
DISTANCE (FT)
SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 3 CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH B – ALTERNATIVE 3 – EXISTING CREST HEIGHT
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
9

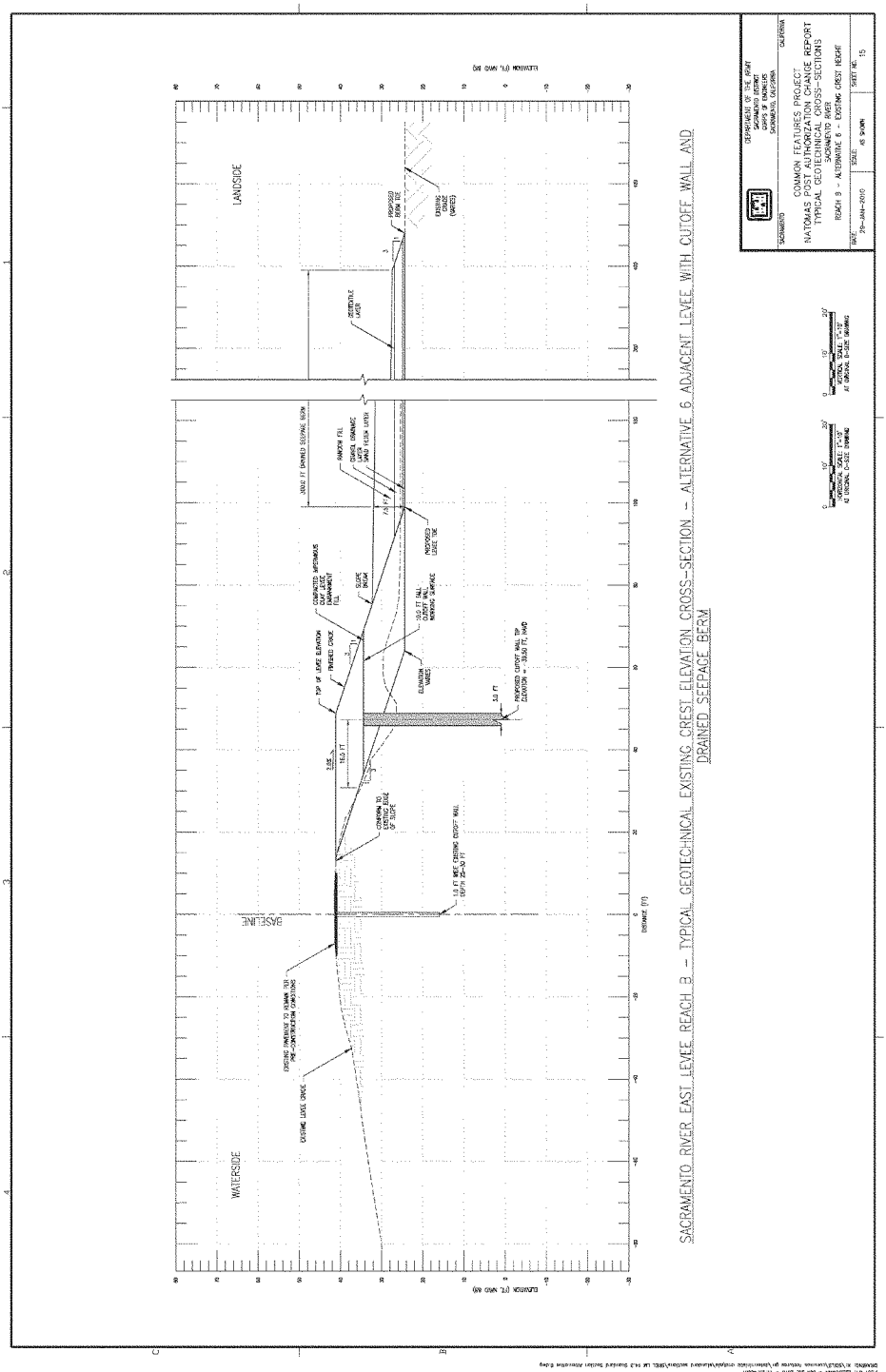

SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 3 CUTOFF WALL
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
REMOVE AND REPLACE EXISTING PAVEMENT FOR PRE-CONSTRUCTION CONDITIONS
8.0 FT
2.0%
COMPACTED IMPERVIOUS CLAY LEVEE EMBANKMENT FILL
1
1
FINISHED GRADE
PROPOSED LEVEE TOP
EXISTING GRADE (VARIES)
18.0 FT MIN. EXISTING CUTOFF WALL DEPTH 25-30 FT
3.0 FT
42.0 FT
IMPERVIOUS CUTOFF WALL ELEVATION = +4.00 FT (NAVD)
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH B – ALTERNATIVE 3 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 10

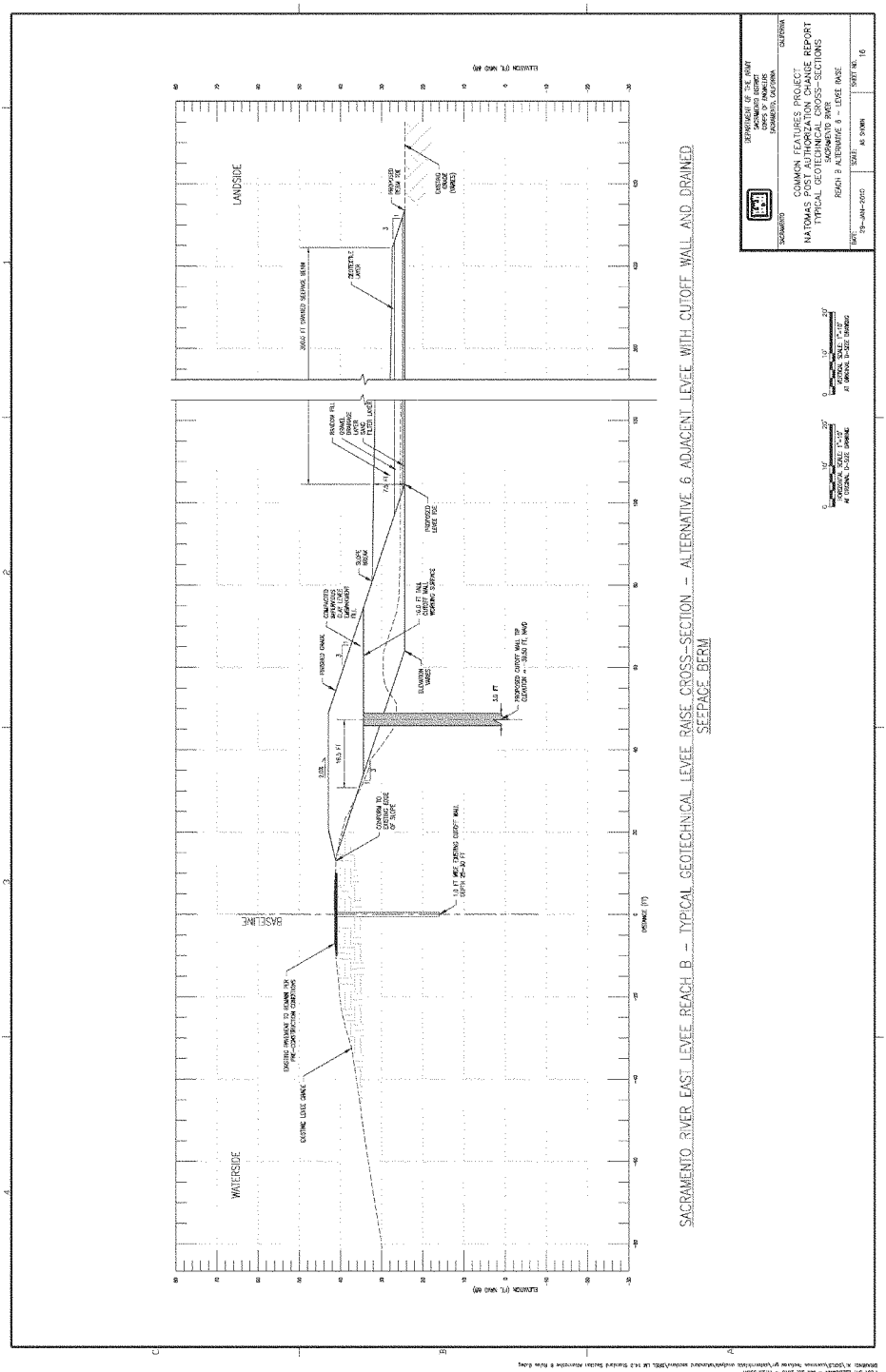

SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 4 DRAINED SEEPAGE BERM
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING DRAINAGE TO CHANNEL TOE
PROPOSED LEVEE TOE
PROPOSED LEVEE CREST
SLOPE BREAK
HORIZONTAL TO EXISTING SIDE OF SLOPE
1.0 FT MIN EXISTING CUTOFF WALL DEPTH 25-30 FT
300LB FT DRAINED SEEPAGE BERM
SHALLOW FILL
GRAVEL DRAINAGE LAYER
SAND FILTER LAYER
GEOTEXTILE FABRIC
PROPOSED BERM TOE
EXISTING LEVEE CREST (APPROX)
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
REACH B
REACH B – ALTERNATIVE 4 – EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 11

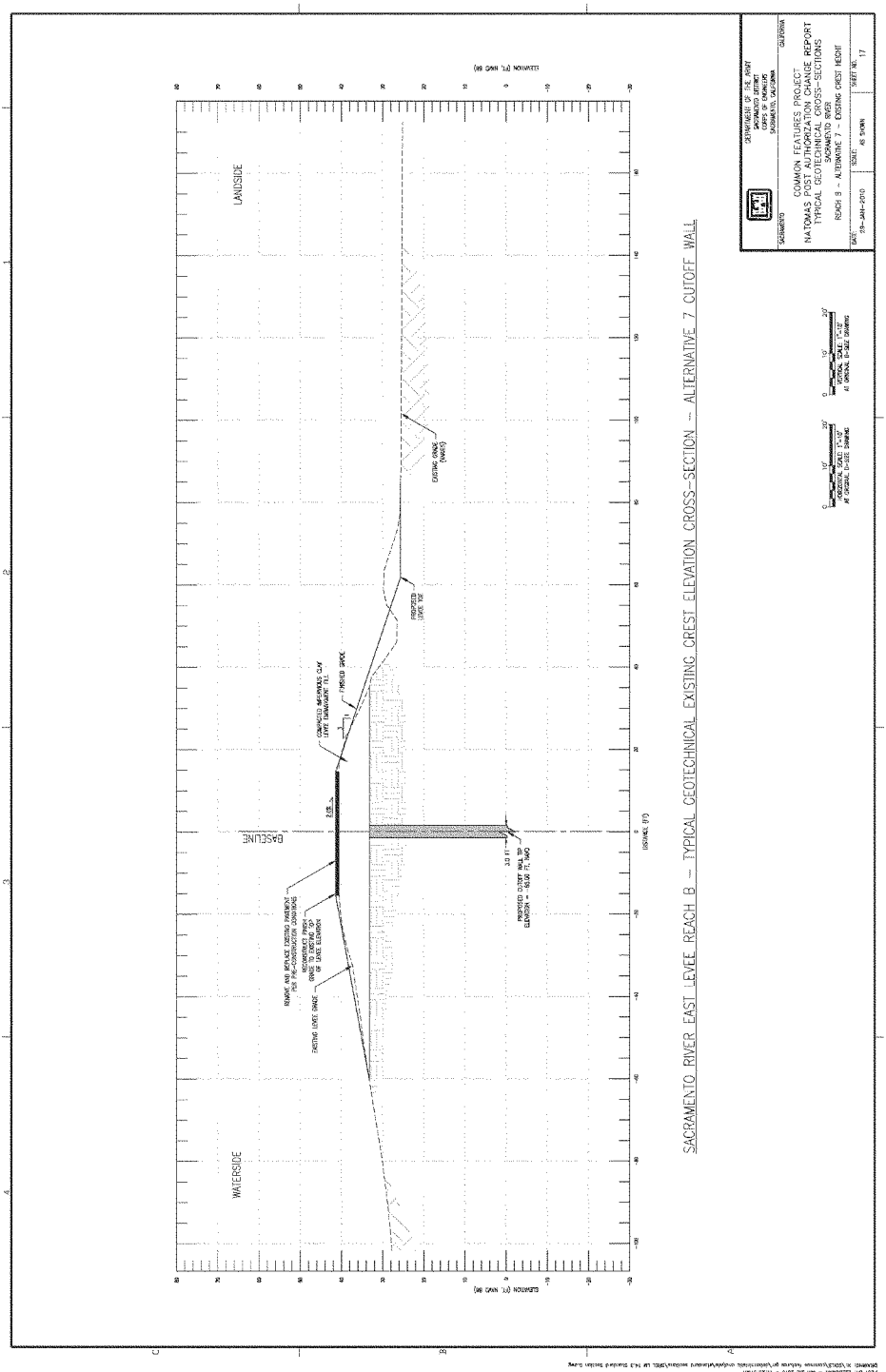

SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 4 DRAINED SEEPAGE BERM
WATERSIDE
BASELINE
LANDSIDE
EXISTING LEVEE CREST
EXISTING CHANNEL TO REMAIN TYP.
SEE CONSTRUCTION DRAWINGS
EXISTING GROUND
10.0 FT WIDE EXISTING CUTOFF WALL
DEPTH 25–34 FT
SLOPE PROTECTION
PROPOSED LEVEE TOE
2.5H:1V
3.0H:1V
PROPOSED SEEPAGE BERM TOE
PROPOSED SEEPAGE BERM CREST
300.0 FT DRAINED SEEPAGE BERM
SAND FILTER LAYER
GRAVEL DRAINAGE LAYER
SEEPAGE BERM
UNKNOWN FILL
GEOTEXTILE LAYER
EXISTING GROUND
ELEVATION (FT, NAVD 88)
STATION (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER EAST LEVEE
REACH B – ALTERNATIVE 4 – LEVEE RAISE
DATE: 28-JAN-2010
SCALE: AS SHOWN
SHEET NO. 12

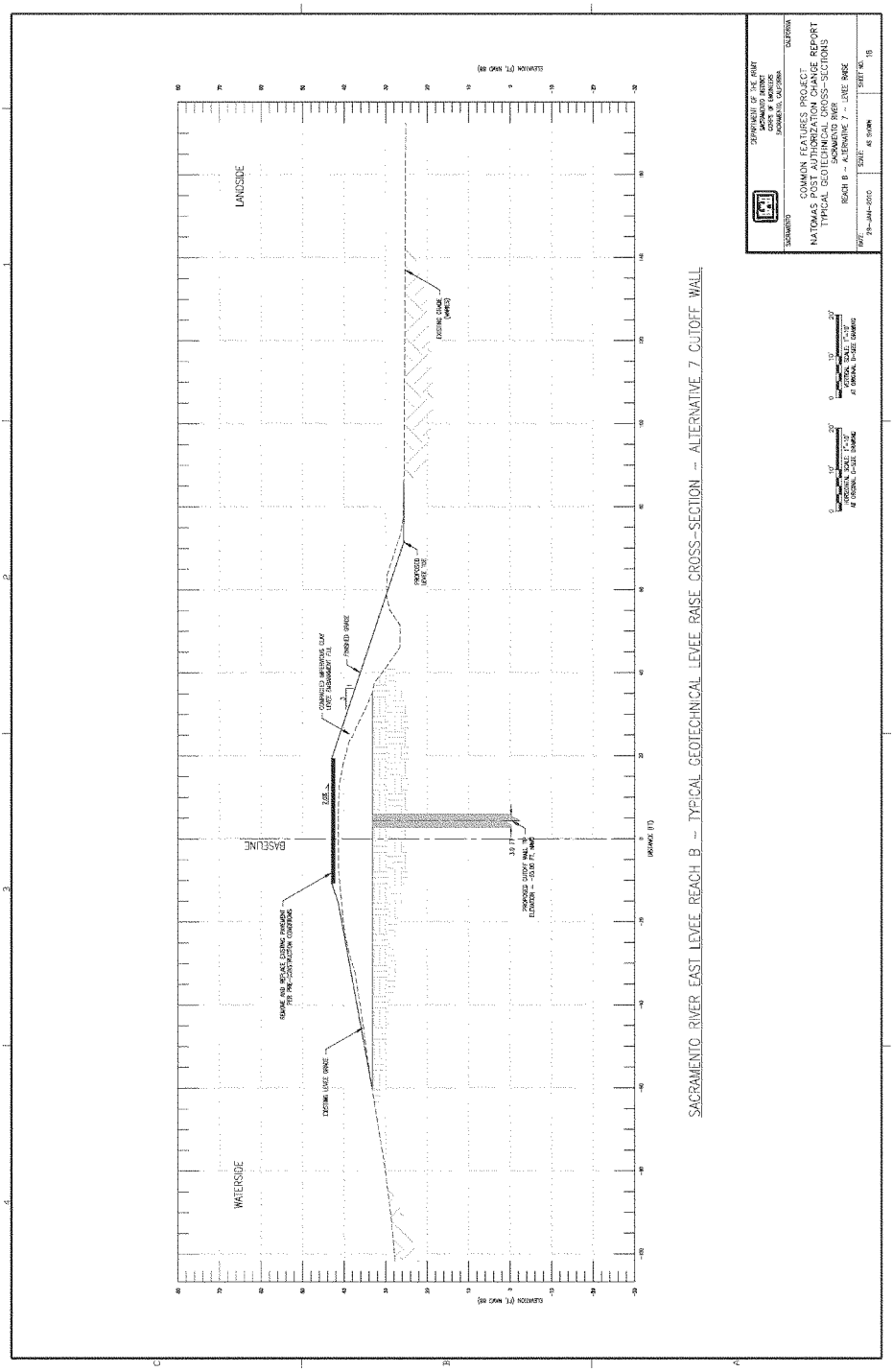

WATERSIDE
LANDSIDE
BASELINE
ELEVATION (FT, NAVD 88)
EXISTING LEVEE GRADE
EXISTING EMBANKMENT TO REMAIN
PROPOSED CUTOFF WALL TIP
EL -30.0 FT, NAVD
3.0 FT
PROPOSED CUTOFF WALL
EL -30.0 FT, NAVD
COMPACTED IMPERVIOUS CLAY LEVEE EMBANKMENT FILL
PROPOSED GRADE
3.0 FT
CONFORM TO EXISTING GRADE AT SLOPE
PROPOSED LEVEE TOE
2.5 FT
RANDOM FILL
GRAVEL DRAINAGE LAYER
SAND FILTER LAYER
GEOTEXTILE LAYER
300.0 FT DRAINED SEEPAGE BERM
EXISTING GRADE (TYPICAL)
PROPOSED BERM TOE
3
SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 5 DRAINED SEEPAGE BERM WITH CUTOFF WALL
0 50' 100' 200'
HORIZONTAL SCALE: 1"=100'
AT ORIGINAL D-SIZE DRAWING
0 10' 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER EAST LEVEE
REACH B – ALTERNATIVE 5 – EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 13

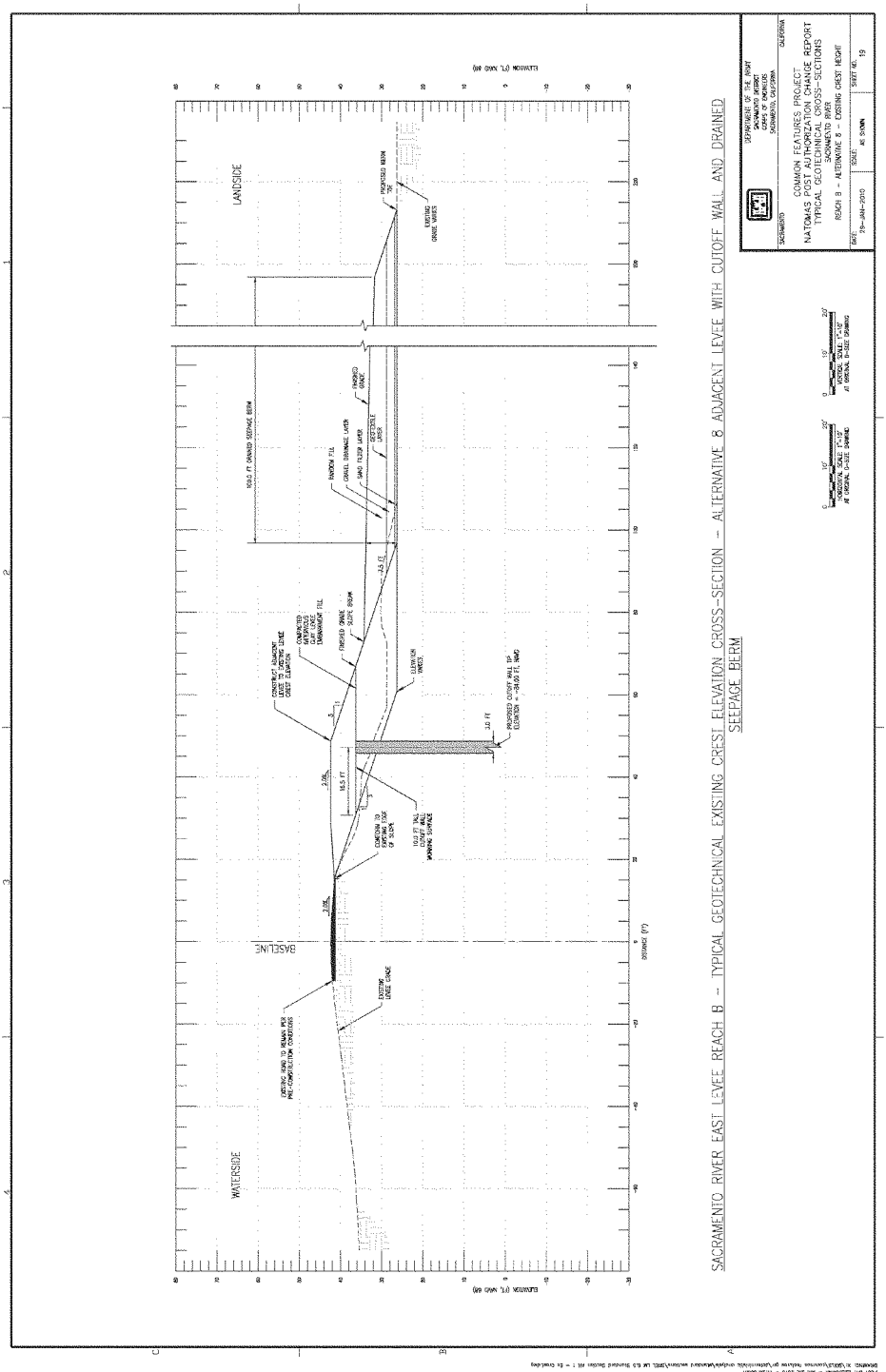

SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 5 DRAINED SEEPAGE BERM WITH CUTOFF WALL
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
REMOVE AND REPLACE EXISTING PAVEMENT PER PRE-CONSTRUCTION CONDITIONS
ENGINEERED FILL
COMPACTED IMPERVIOUS CLAY LEVEE REHABILITATION FILL
EXISTING GRADE
PROPOSED LEVEE TOP
GEOTEXTILE LAYER
GRAVEL DRAINAGE LAYER
SAND FILTER LAYER
PROPOSED SEEPAGE BERM
EXISTING GRADE (APPROX.)
PROPOSED CUTOFF WALL TO ELEVATION +30.0 FT
ELEVATION (FT, NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH B – ALTERNATIVE 5 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 14

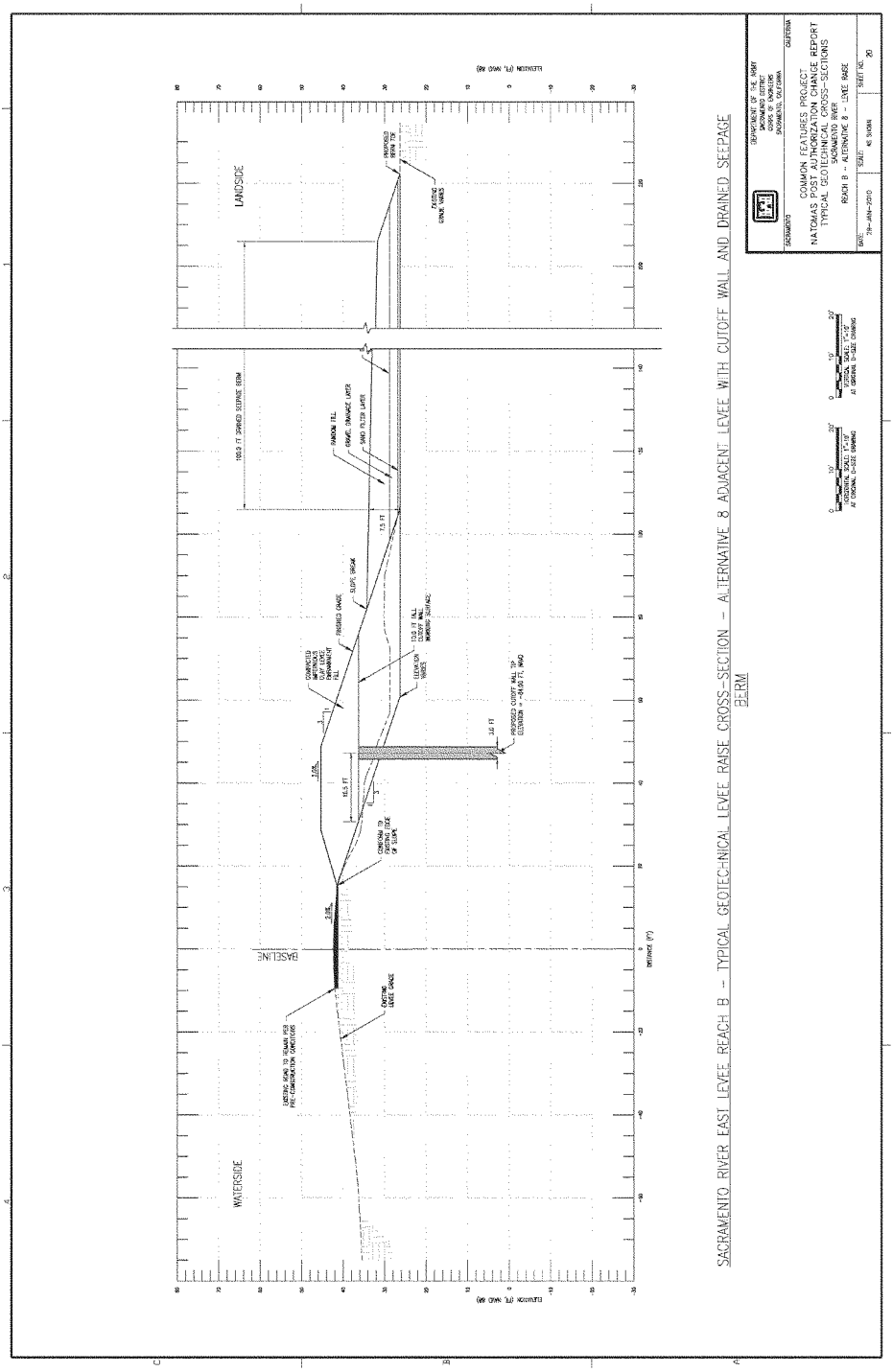

WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING EMBANKMENT TO REMAIN IN PLACE AS FOUNDATION BERM
EXISTING TOE OF SLOPE
10.0 FT WIDE EXISTING CUTOFF WALL DEPTH 25–30 FT
EXISTING TOE DRAIN
EXISTING RIVER BANK
EXISTING LEVEE CREST
TOP OF LEVEE ELEVATION
RAISED CREST
2.0%
15.0 FT
3
1
SLOPE BACKFILL
COMPACTED IMPERVIOUS EARTHEN LEVEE EMBANKMENT FILL
RANDOM FILL
DRAINED SEEPAGE BERM
MODIFIED LANDSIDE TOE
SETBACK LEVEE
EXISTING TOE DRAIN (BURIED)
PROPOSED BERM TOE
PROPOSED CUTOFF WALL TIP ELEVATION = -35.50 FT, NAVD
10.0 FT
ELEVATION VARIES
SOIL BENTONITE CUTOFF WALL WORKING SURFACE
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 6 ADJACENT LEVEE WITH CUTOFF WALL AND DRAINED SEEPAGE BERM
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER EAST LEVEE
REACH B – ALTERNATIVE 6 – EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 15

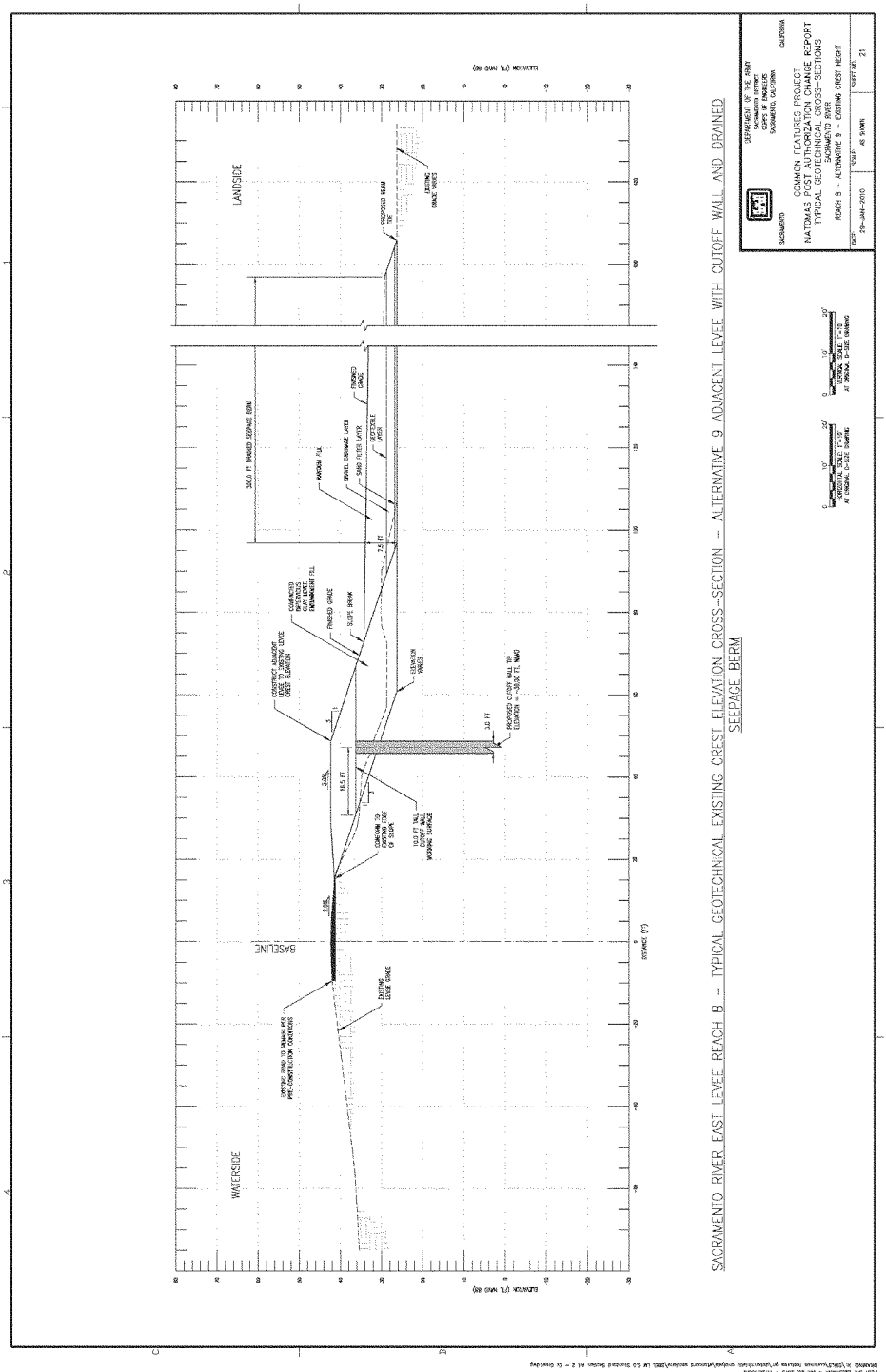

SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 6 ADJACENT LEVEE WITH CUTOFF WALL AND DRAINED SEEPAGE BERM
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING LEVEE CREST
PROPOSED CREST
PROPOSED LEVEE RISE
PROPOSED CUTOFF WALL TOP ELEVATION = +35.0 FT, NAVD
PROPOSED CUTOFF WALL TOE ELEVATION = -10.0 FT, NAVD
10.0 FT WIDE EXISTING CUTOFF WALL DEPTH 25.0 FT
10.0 FT
165.5 FT
3
3
3

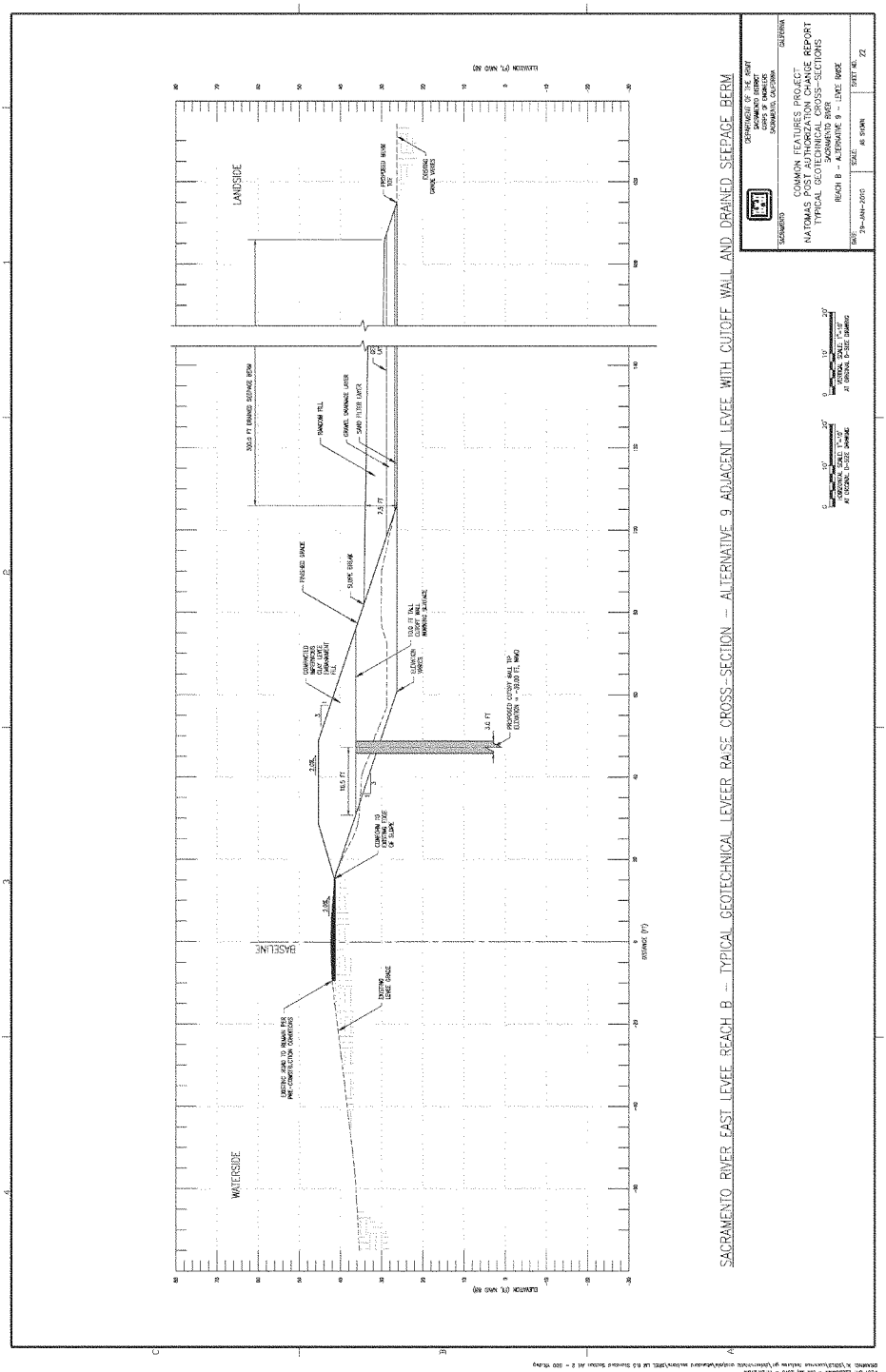

WATERSIDE
BASELINE
LANDSIDE
EXISTING LEVEE CREST
COMPACTED IMPERVIOUS CLAY LEVEE EMBANKMENT FILL
FARMING SPACE
PROPOSED LEVEE TOP
EXISTING GRADE (VARIES)
PROPOSED CUTOFF WALL TIP ELEVATION = -50.00 FT, NAVD
33.0 FT
EXISTING LEVEE GRADE
RIPRAP AND REPLACE EXISTING PROPRIETARY SACKED CONCRETE REVETMENT
RECONSTRUCT FROST-PROTECTION BENCH AT LAND ELEVATION
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
SACRAMENTO RIVER EAST LEVEE REACH B — TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION — ALTERNATIVE 7 CUTOFF WALL
HORIZONTAL SCALE: 1"=20' AT ORIGINAL D-SIZE DRAWING
VERTICAL SCALE: 1"=10' AT ORIGINAL D-SIZE DRAWING
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH B - ALTERNATIVE 7 - EXISTING CREST HEIGHT
DATE: 28-JAN-2010
SCALE: AS SHOWN
SHEET NO. 17

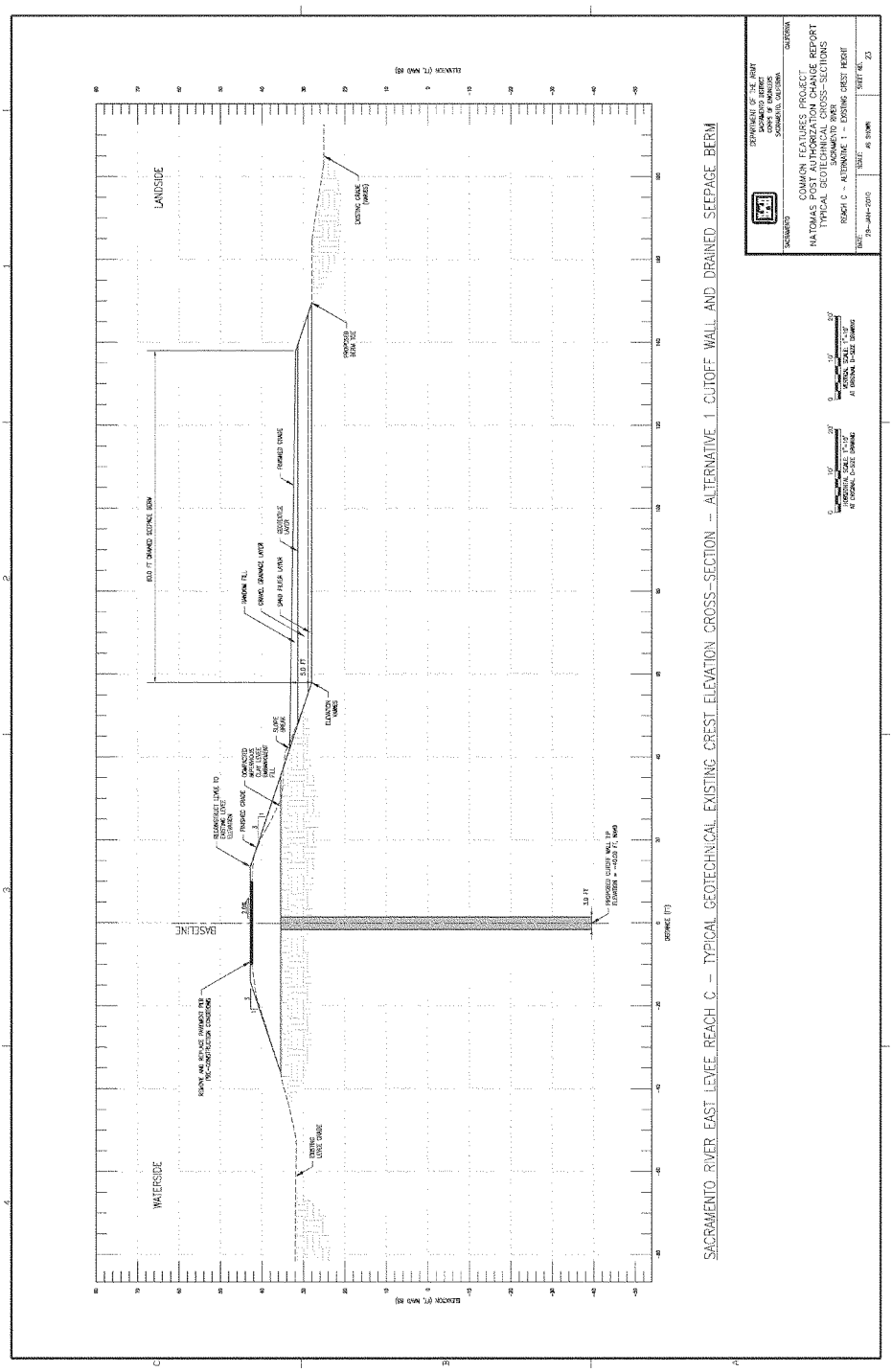

SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 7 CUTOFF WALL
LANDSIDE
WATERSIDE
BASELINE
EXISTING LEVEE GRADE
REMOVE AND REPLACE EXISTING PAVEMENT PER PRE-CONSTRUCTION CONDITIONS
COMPACTED IMPERVIOUS CLAY LEVEE EMBANKMENT FILL
FINISHED GRADE
PROPOSED LEVEE TOE
EXISTING GRADE (APPROX.)
PROPOSED CUTOFF WALL ELEVATION = -20.00 FT. NAVD
DISTANCE (FT.)
ELEVATION (FT. NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH B – ALTERNATIVE 7 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 16

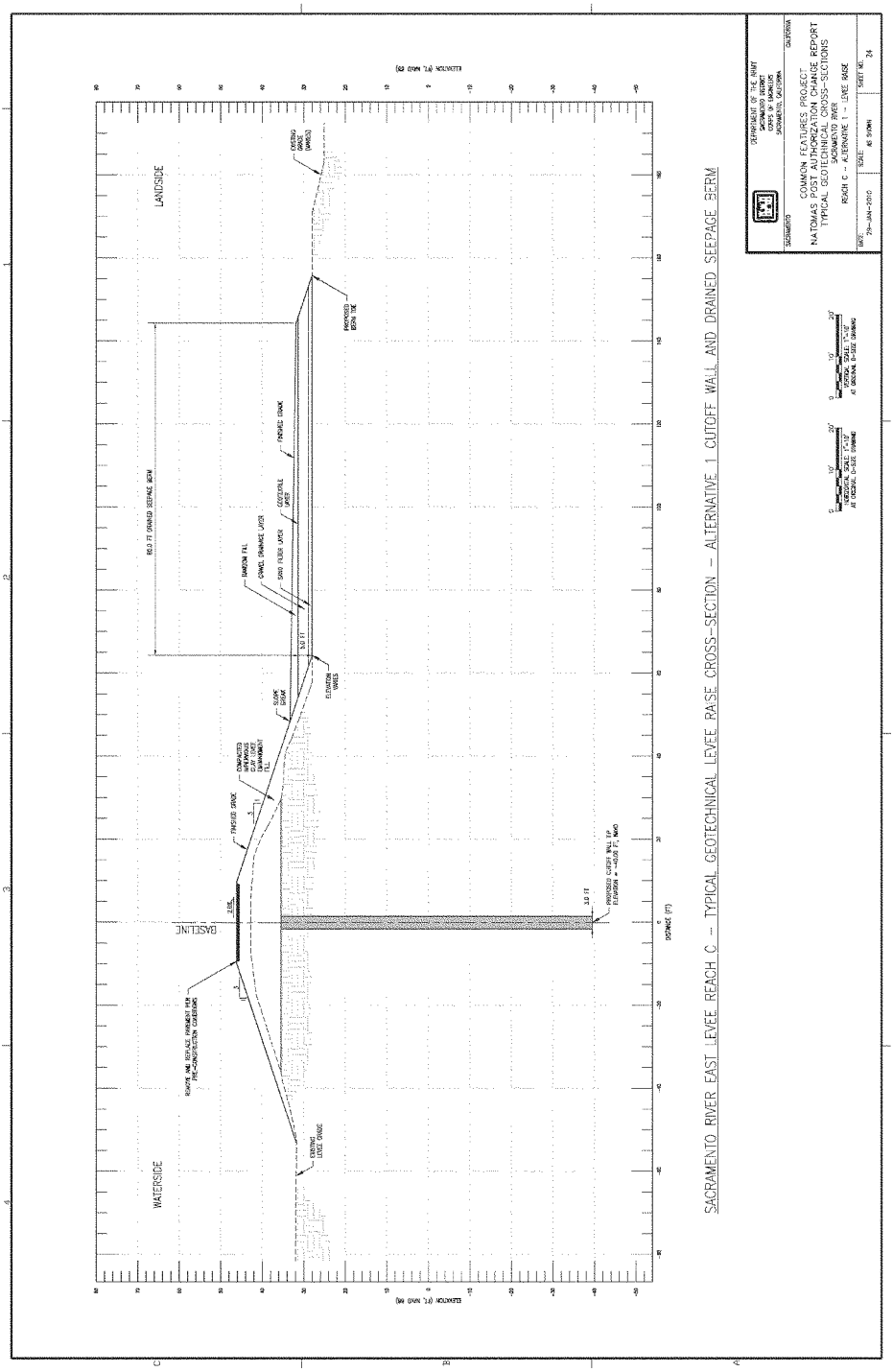

WATERSIDE
BASELINE
LANDSIDE
EXISTING LEVEE CREST
EXISTING LEVEE TOE
EXISTING GRADE WATER
PROPOSED BERM
EXISTING GRADE WATERS
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 8 ADJACENT LEVEE WITH CUTOFF WALL AND DRAINED SEEPAGE BERM
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH B – ALTERNATIVE 8 – EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 19


SACRAMENTO RIVER EAST LEVEE REACH B -- TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION - ALTERNATIVE 8 ADJACENT LEVEE WITH CUTOFF WALL AND DRAINED SEEPAGE BERM
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING ROAD TO REMAIN PER PRE-CONSTRUCTION CONDITIONS
CENTERLINE
CENTERLINE OF EXISTING TOE OF LEVEE
10.5 FT
3:1
2:1
CONNECTED DRAINAGE LAYER
FINISHED GRADE
SLOPE BREAK
RANDOM FILL
SAND FILTER LAYER
100.0 FT DRAINED SEEPAGE BERM
7.5 FT
PROPOSED CUTOFF WALL TIP ELEVATION = -34.50 FT, NAVD
44 FT
110.0 FT FULL CUTOFF WALL
LEVEE ICON MARKER
PROPOSED CREST ELEVATION
EXISTING CREST ELEVATION VARIES
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
HORIZONTAL SCALE: 1"=100'
AT ORIGINAL D-SIZE DRAWING
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER EAST LEVEE
REACH B - ALTERNATIVE 8 - LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 20

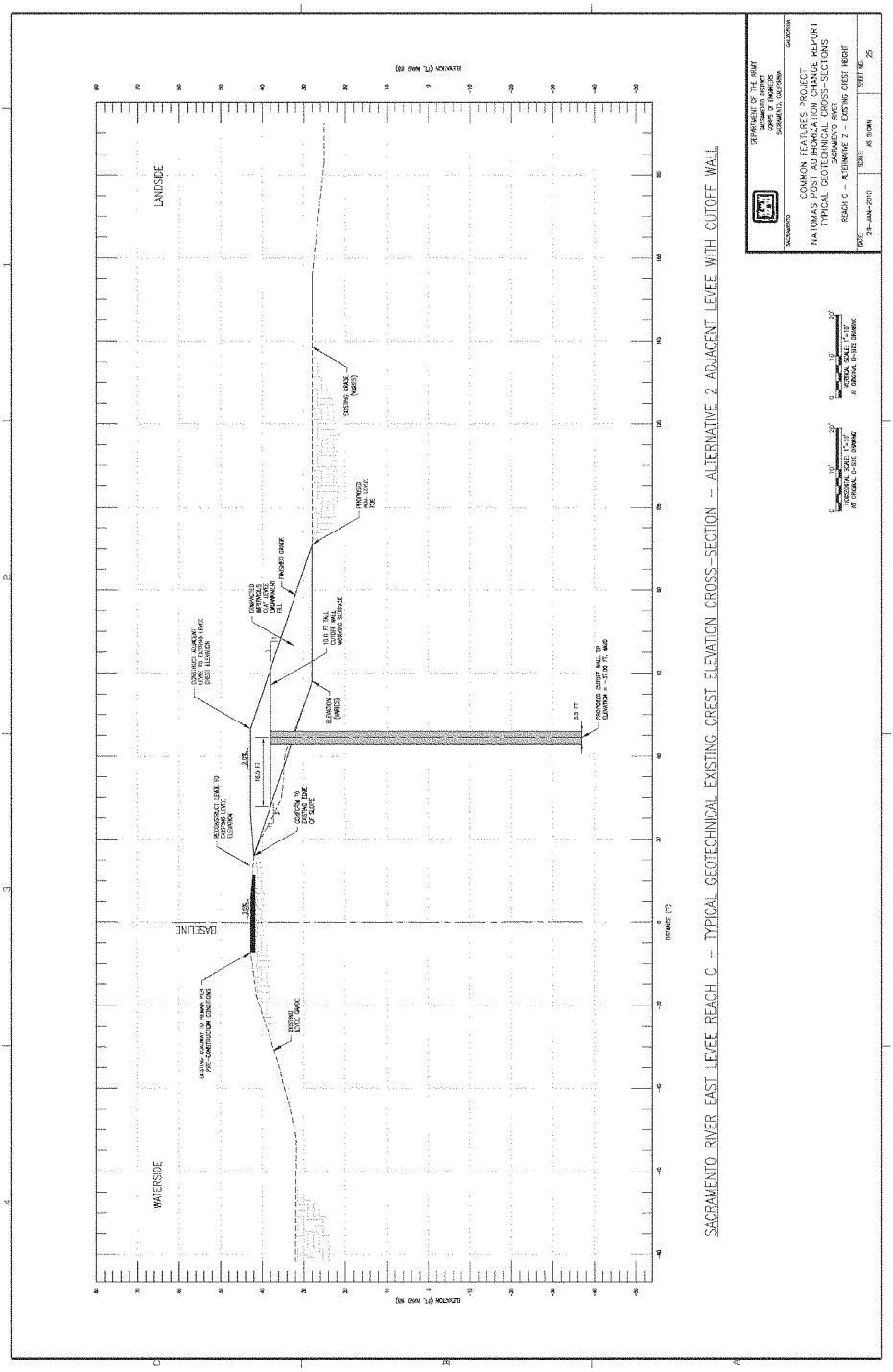

WATERSIDE
LANDSIDE
BASELINE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
SACRAMENTO RIVER EAST LEVEE REACH B -- TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION -- ALTERNATIVE 9 ADJACENT LEVEE WITH CUTOFF WALL AND DRAINED SEEPAGE BERM
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER EAST LEVEE
REACH B - ALTERNATIVE 9 - EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 21

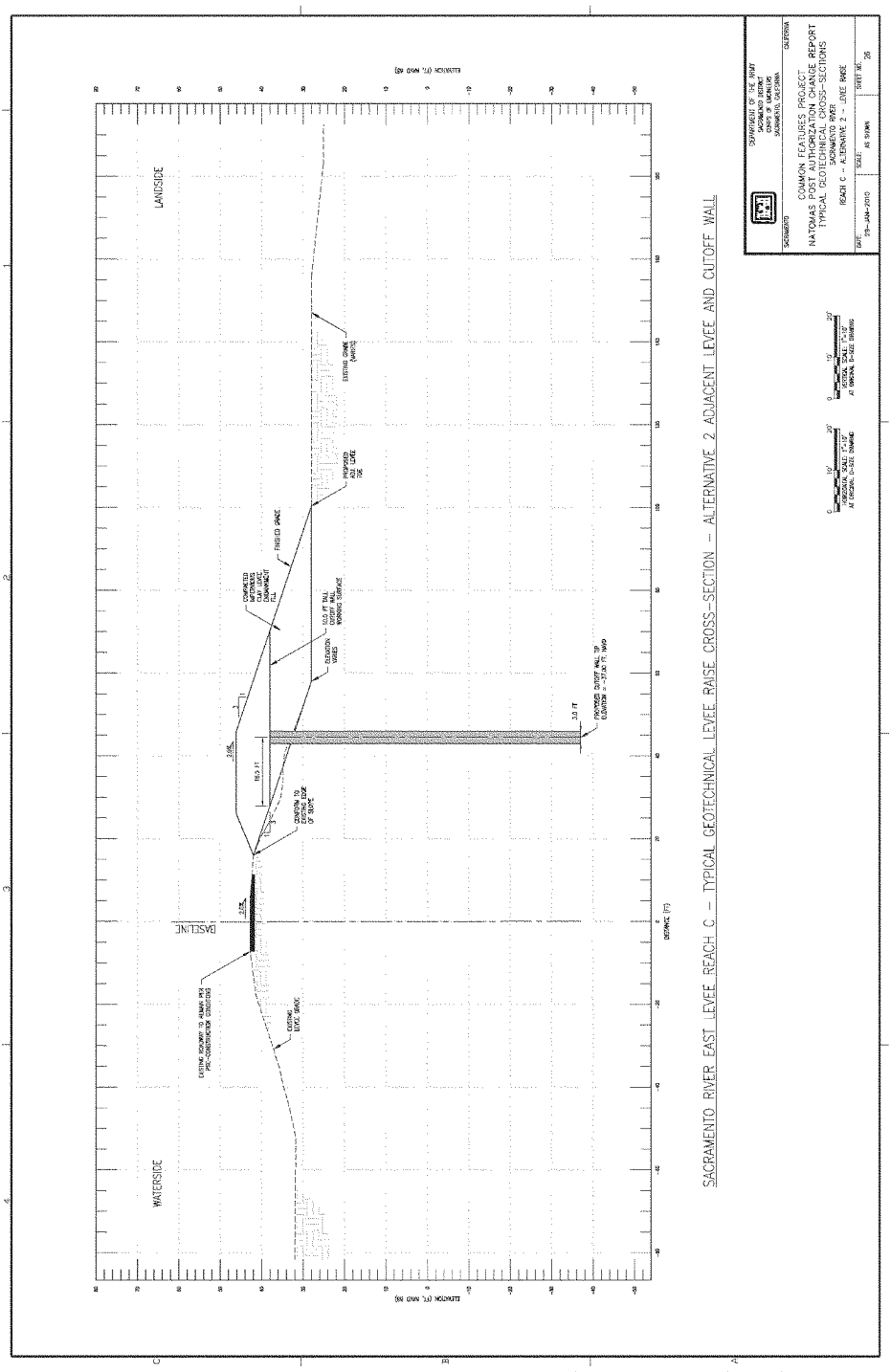

SACRAMENTO RIVER EAST LEVEE REACH B – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 9 ADJACENT LEVEE WITH CUTOFF WALL AND DRAINED SEEPAGE BERM
WATERSIDE
LANDSIDE
BASELINE
ELEVATION (FT, NAVD 88)
STATIONING (FT)
300.5 FT DRAINED SEEPAGE BERM
RANCH FILL
GRAVEL DRAINAGE LAYER
SAND FILTER LAYER
FROSTED GRADE
SLOPE BREAK
7.5 FT
CONNECTED DEEP WELLS FOR DEWATERING
TOE OF TALL VEGETATION MARKING SEEPAGE
ELEVATION VARIES
PROPOSED CUTOFF WALL TO ELEVATION = -39.0 FT, NAVD
46 FT
165 FT
CONFORM TO EXISTING SLOPE
EXISTING LEVEE GRADE
LEVEE RAISE TO REMAIN FOR PRE-CONSTRUCTION CONDITIONS
PROPOSED BERM
EXISTING LEVEE
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SHEET 1 OF 1
REACH B – ALTERNATIVE 9 – LEVEE RAISE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
22

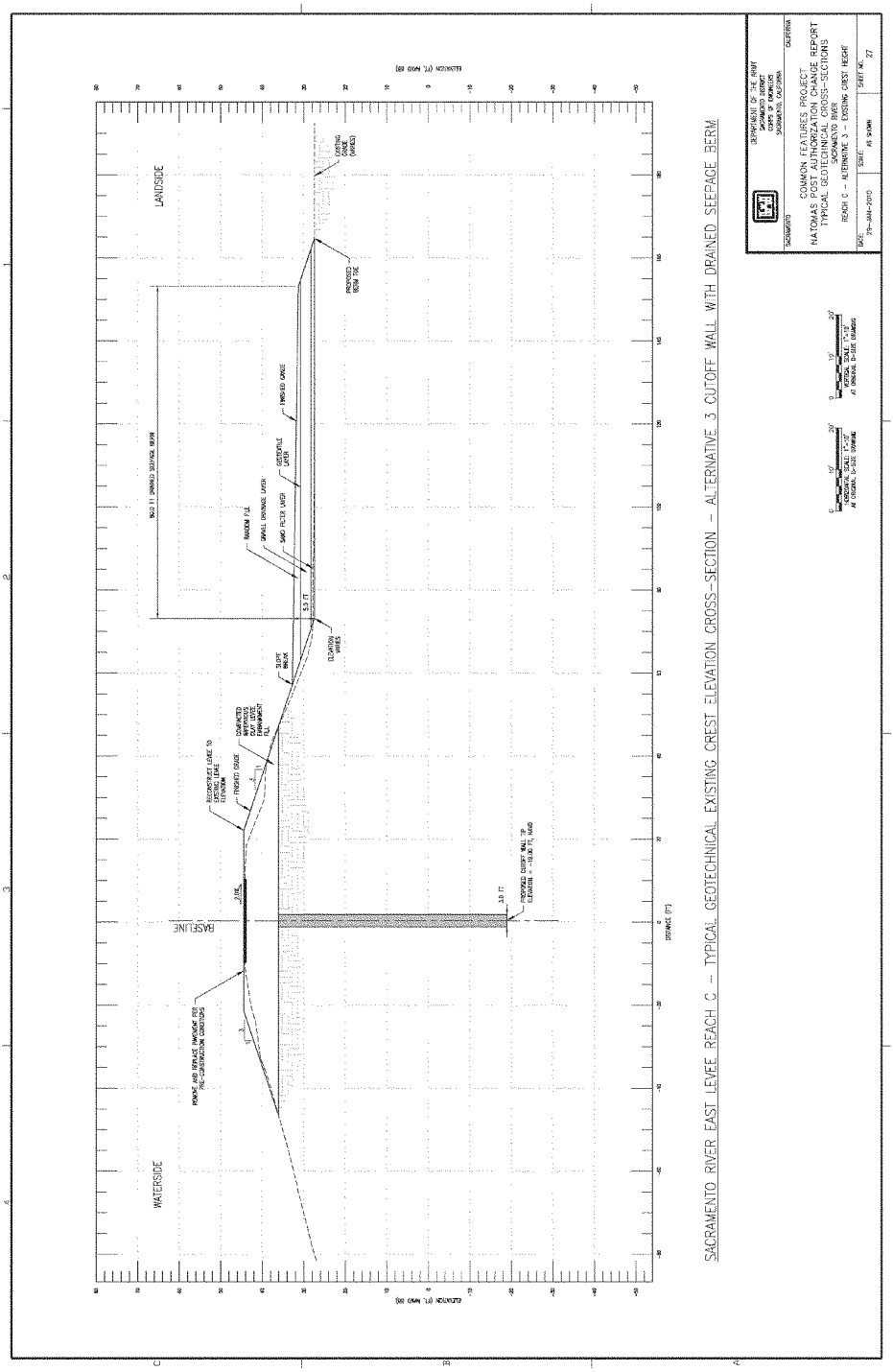

WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
REMOVE AND REPLACE PAVEMENT PER PRE-CONSTRUCTION CONDITIONS
PROPOSED GRADE
COMPACTED IMPERVIOUS EARTHFILL
SLOPE PROTECTION
SEEPAGE BERM
ELEVATION LEVELS
EXISTING CREST (RAISED)
PROPOSED SEEPAGE BERM
RAISED CREST
SEEPAGE BERM
SAND FILTER LAYER
GRAVEL DRAINAGE LAYER
IMPERVIOUS FILL
PROPOSED CUTOFF WALL TIP
ELEVATION = -40.0 Ft. NAVD
3.0 FT
5.0 FT
2.0%
3
1
ELEVATION (Ft. NAVD 88)
DISTANCE (Ft)
SACRAMENTO RIVER EAST LEVEE REACH C — TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION — ALTERNATIVE 1 CUTOFF WALL AND DRAINED SEEPAGE BERM
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH C - ALTERNATIVE 1 - EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 23

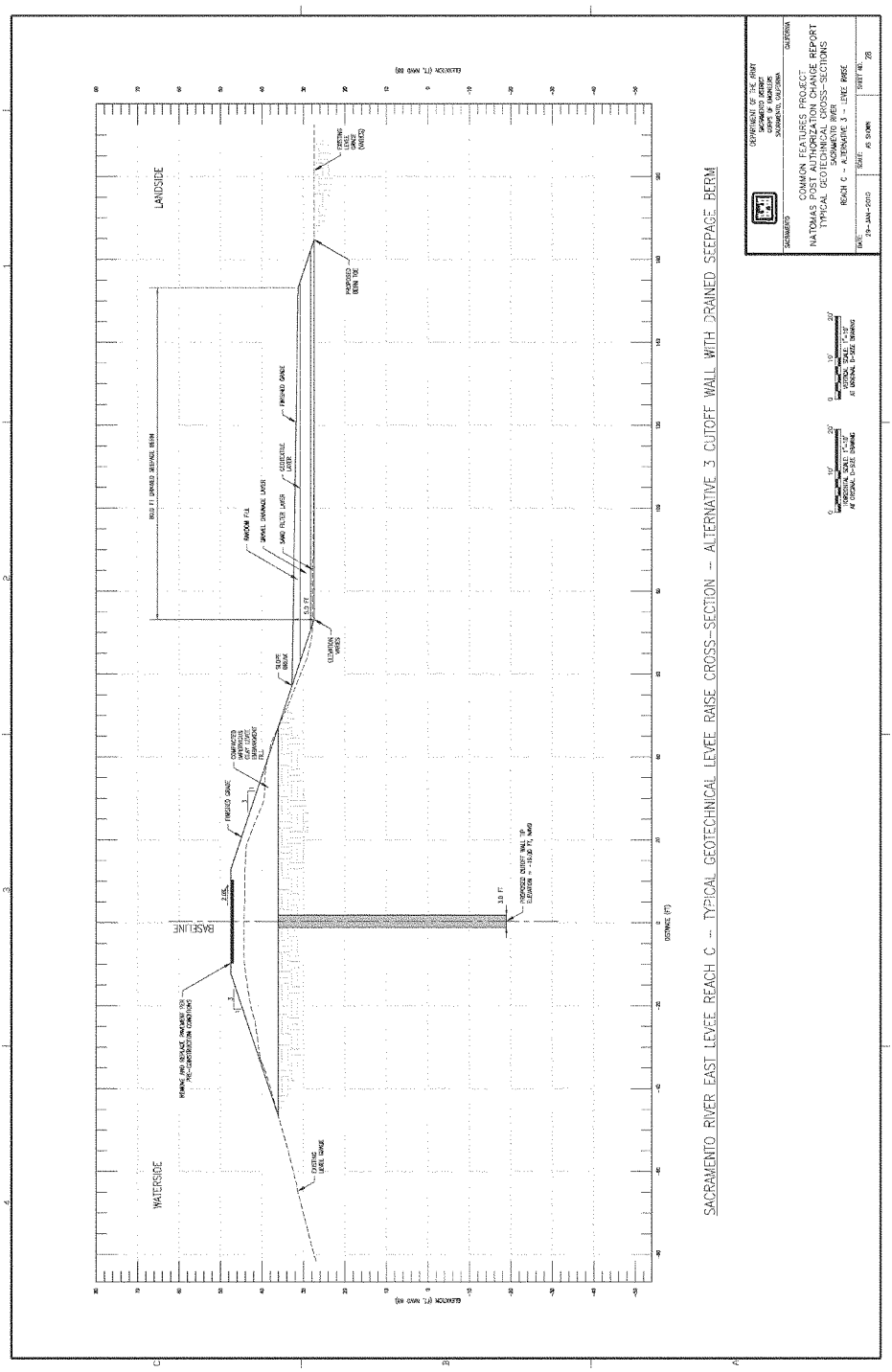


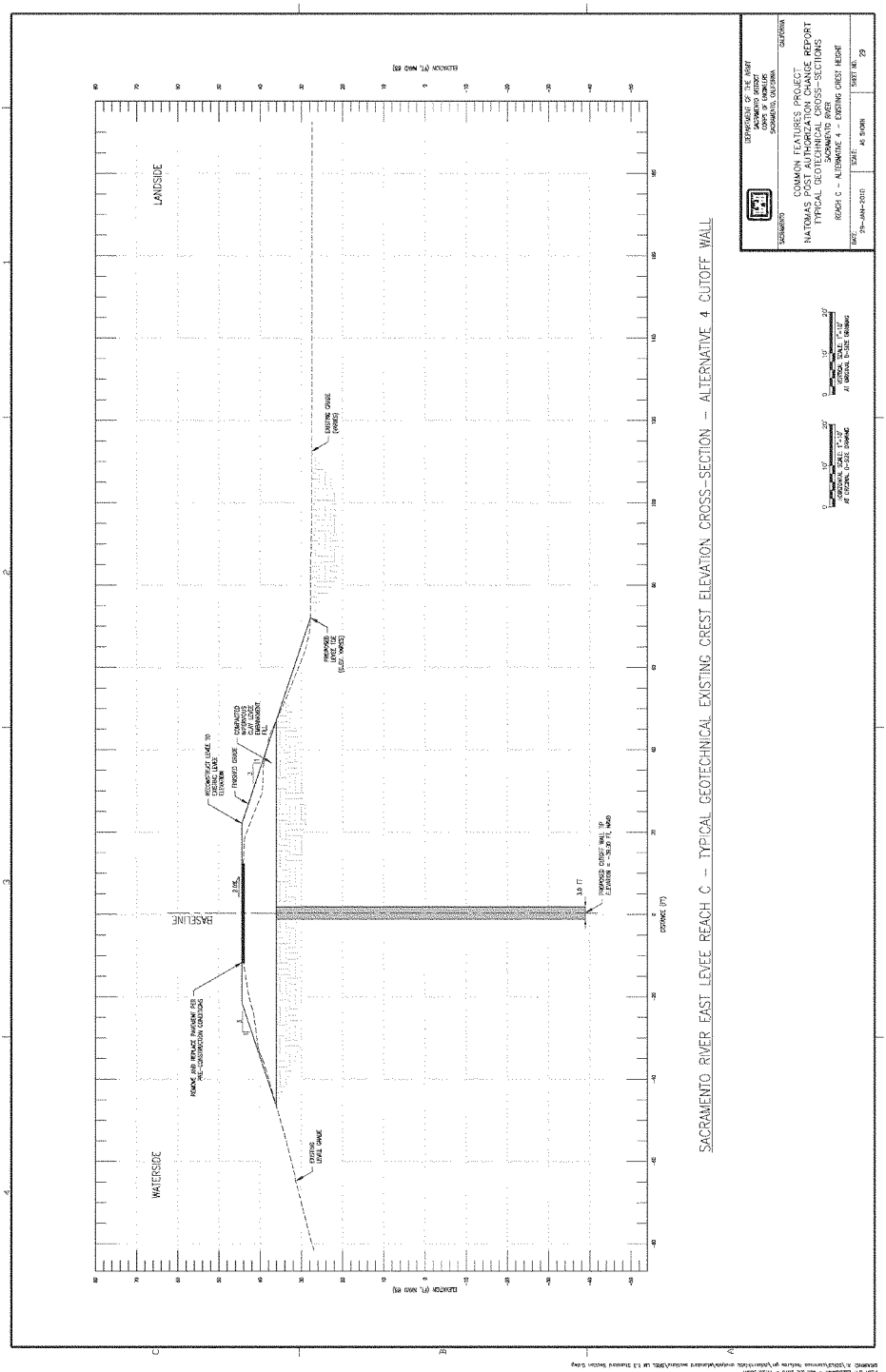
SACRAMENTO RIVER EAST LEVEE REACH C -- TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION - ALTERNATIVE 1 CUTOFF WALL AND DRAINED SEEPAGE BERM


WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING LANDSIDE TOE
EXISTING WATERSIDE TOE
EXISTING ROADWAY TO REMAIN PER PRE-CONSTRUCTION CONDITIONS
RECONSTRUCT LEVEE TO EXISTING LEVEE ELEVATION
2.0%
3.0%
60.0 FT
CONFORM TO EXISTING EDGE OF SLOPE
EXISTING LANDSIDE LOWER TO ADJACENT RIVER CREST ELEVATION
CONSTRUCT EARTHEN BERM
EARTHEN BERM (VARIES)
10.0 FT MIN. CREST WIDTH
WORKING SURFACE
CONSTRUCT SLOPE
3
1
CONCRETE CUTOFF WALL TOP ELEVATION = EXISTING GRADE
10.0 FT
PROPOSED CUTOFF WALL TOP ELEVATION = EXISTING GRADE
EXISTING GRADE (VARIES)
PROPOSED FINISHED GRADE
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
SACRAMENTO RIVER EAST LEVEE REACH C — TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION — ALTERNATIVE 2 ADJACENT LEVEE WITH CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SHEET TITLE
REACH C – ALTERNATIVE 2 – EXISTING CREST HEIGHT
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
25

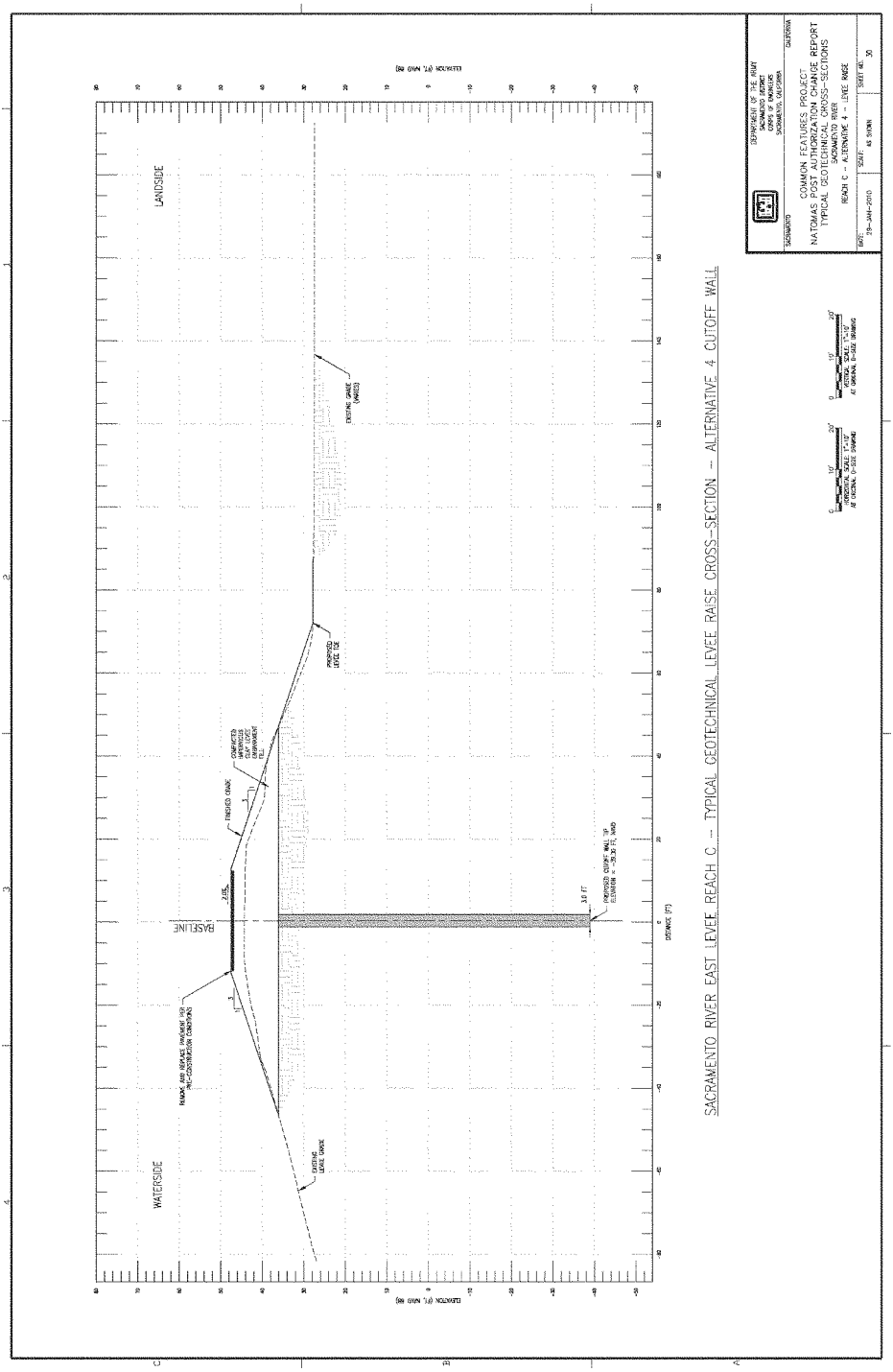

LANDSIDE
WATERSIDE
BASELINE
EXISTING LEVEE GRADE
EXISTING ROCKFILL TO REMAIN IN PLACE PRE-CONSTRUCTION CONDITIONS
EXISTING TOE DRAIN
EXISTING LEVEE CREST
PROPOSED CUTOFF WALL TOP ELEVATION = +37.0 FT NAVD
3.0 FT
PROPOSED CUTOFF WALL
EXCAVATION TO EXISTING EDGE OF SLOPE
3H:1V
2.5H:1V
165.5 FT
EXCAVATION LIMITS
50.0 FT WALL CUTOFF WALL WORKING SURFACE
COMPACTED MATERIALS TO MEET DESIGN FILL
FINISHED GRADE
PROPOSED LEVEE TOE
EXISTING GRADE (typical)
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
SACRAMENTO RIVER EAST LEVEE, REACH C – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 2 ADJACENT LEVEE AND CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH C – ALTERNATIVE 2 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO.: 26

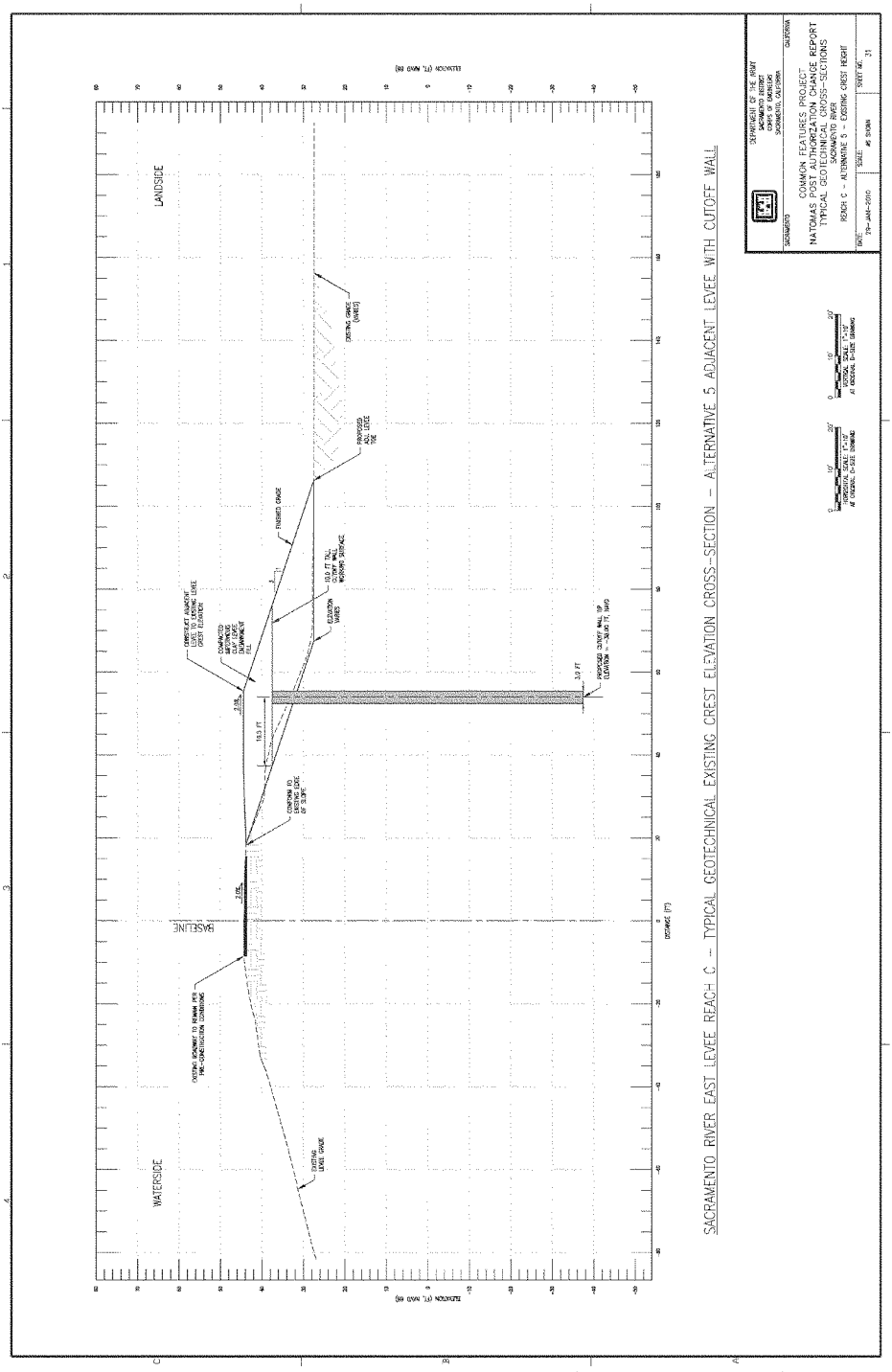

WATERSIDE
LANDSIDE
BASELINE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
EXISTING GRADE (VARIES)
PROPOSED BERM TOE
NO. 11 CRUSHED SEEPAGE BERM
RANDOM FILL
GRAVEL DRAINAGE LAYER
SAND FILTER LAYER
GEOTEXTILE LAYER
FINISHED GRADE
53.3 FT
ELEVATION VARIES
SLOPE PROTECTION
COMPACTED HYDRAULIC CLAY STATE FURNISHED FILL
DISCONTINUITY LAYER TO BEDROCK SURFACE ELEVATION
TYPICAL
REMOVE AND REPLACE PAVEMENT PER PAVEMENT RESTORATION DETAILS
1.0 FT
PROPOSED CUTOFF WALL TIP ELEVATION = -19.0 FT, NAVD
SACRAMENTO RIVER EAST LEVEE REACH C -- TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION - ALTERNATIVE 3 CUTOFF WALL WITH DRAINED SEEPAGE BERM
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH C - ALTERNATIVE 3 - EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 27


WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
RIPRAP AND BERM/ACP (WHERE NOT PROTECTED BY EXISTING REVETMENT)
3:1
FINISHED GRADE
COMPACTED IMPERVIOUS EMBANKMENT FILL
SLOPE DRAIN
EXCAVATION (WHERE)
5.0 FT
RAISED FINISHED GRADE
RAISED ROAD
RAISED BERM
RAISED TOE
ROCK FILL
GRAVEL DRAINAGE LAYER
SAND FILTER LAYER
GEOTEXTILE LAYER
FINISHED GRADE
EXISTING LEVEE CREST (VARIES)
10 FT
PROPOSED CUTOFF WALL TIP ELEVATION = -16.00 FT, NAVD
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
SACRAMENTO RIVER EAST LEVEE REACH C -- TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION -- ALTERNATIVE 3 CUTOFF WALL WITH DRAINED SEEPAGE BERM
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SHEET TITLE
REACH C - ALTERNATIVE 3 - LEVEE RAISE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
28

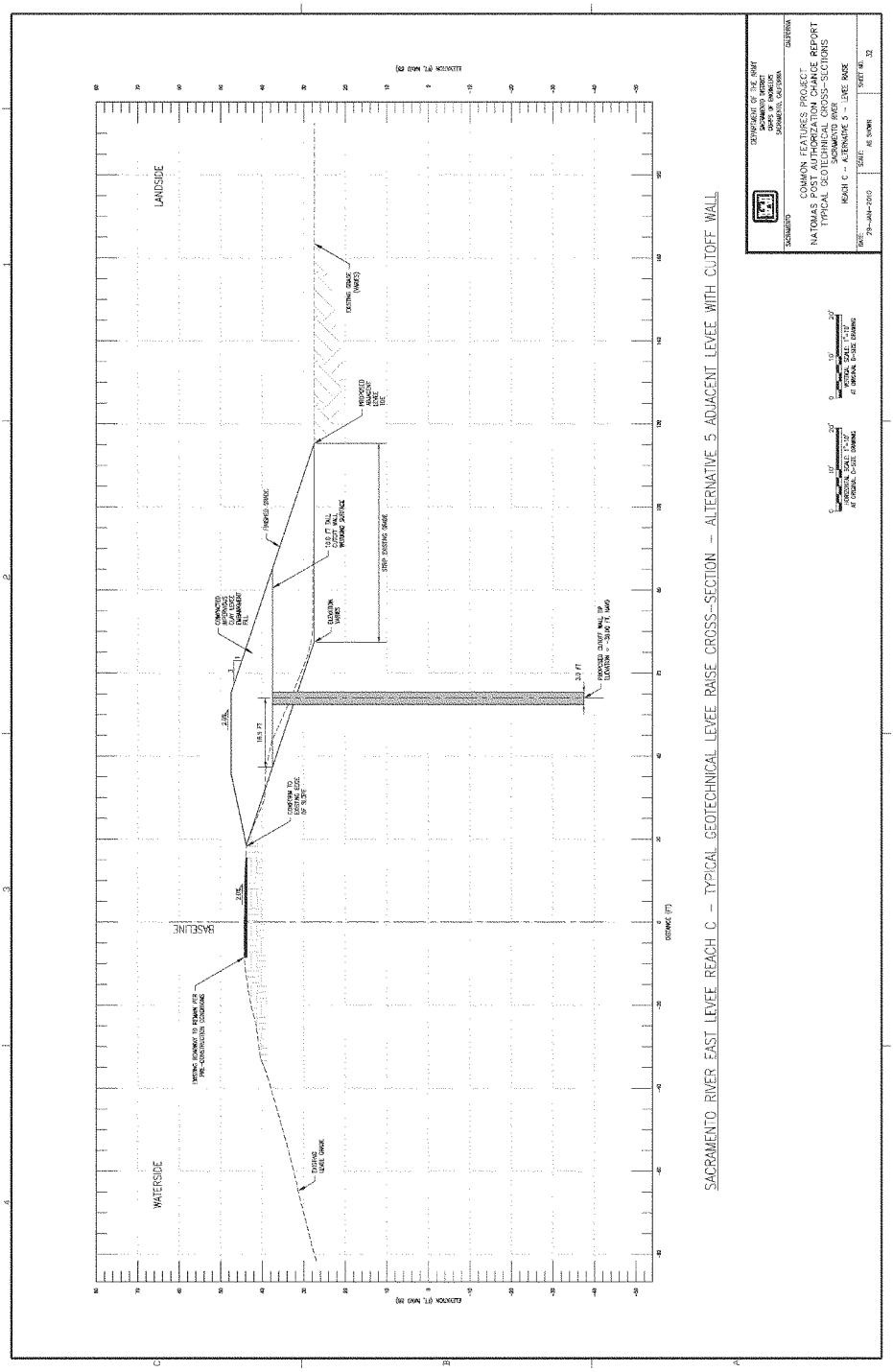


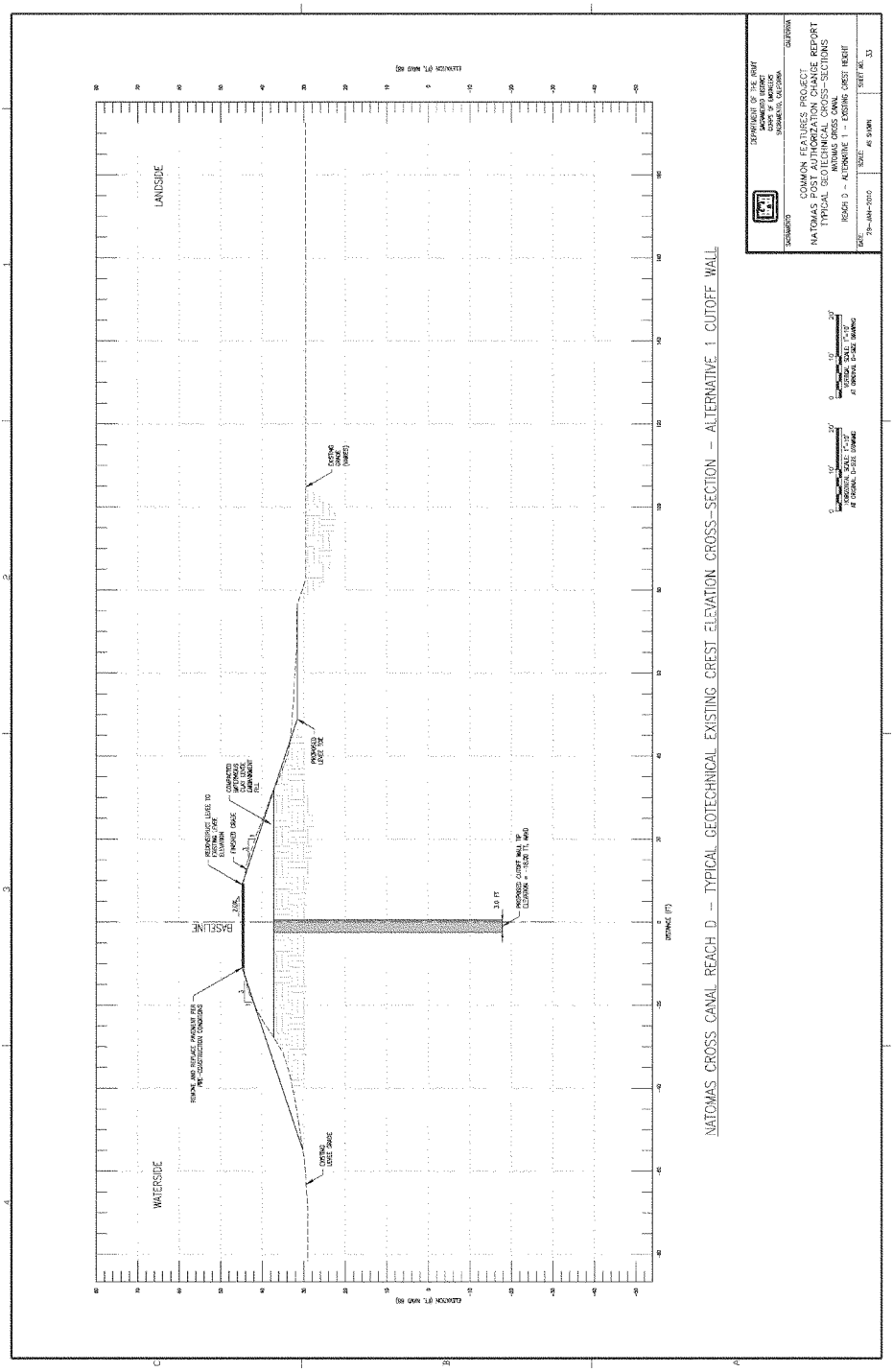
SACRAMENTO RIVER EAST LEVEE REACH C – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 4 CUTOFF WALL


WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
REMOVE AND REPLACE PAVEMENT FOR RECONSTRUCTION (TYPICAL)
FINISHED GRADE
COMPACTED IMPERVIOUS EARTHWORKS FILL
EXISTING GRADE (VARIES)
IMPROVED SOIL (TYP.)
EXISTING CUTOFF WALL TIP ELEVATION = -35.0 FT. NAVD
40 FT.
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
SACRAMENTO RIVER EAST LEVEE, REACH C — TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION — ALTERNATIVE 4 CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
SACRAMENTO RIVER
REACH C – ALTERNATIVE 4 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 30

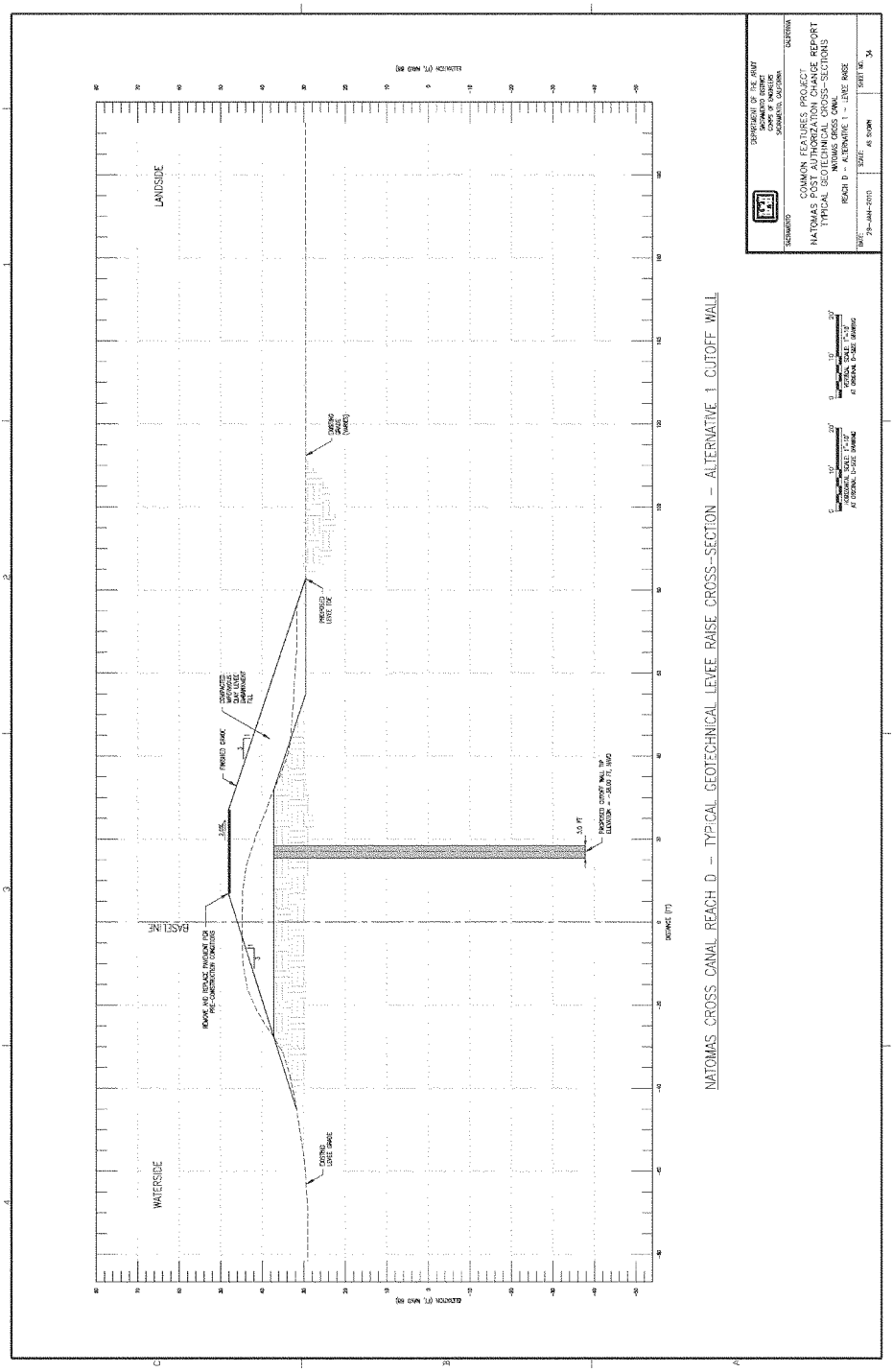


SACRAMENTO RIVER EAST LEVEE REACH C – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 5 ADJACENT LEVEE WITH CUTOFF WALL

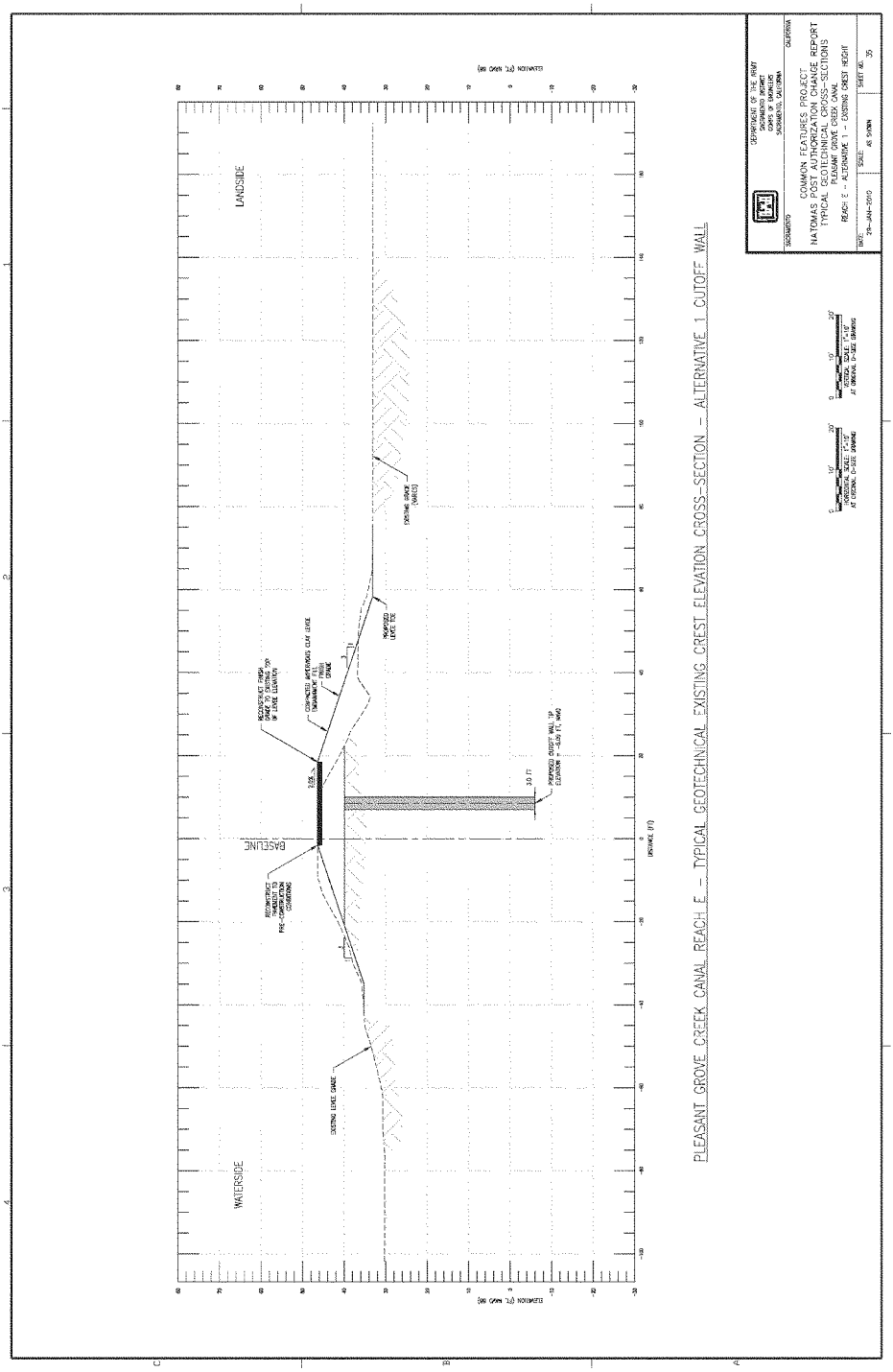

LANDSIDE
WATERSIDE
BASELINE
EXISTING LEVEE GRADE
EXISTING GRADE TO REMAIN FOR NON-OVERBUILD SEGMENT
COMPACTED BIOTECHNICAL EARTHMIXT FILL
FINISHED GRADE
110 FT TALL CUTOFF WALL WITHDRAWAL DISTANCE
ELEVATION VARIES
STRIP EXISTING GRADE
PROPOSED CONCRETE CAP SEE DETAIL
EXISTING GRADE (VARIES)
CONFORM TO EXISTING GRADE @ 3H:1V
18±1 FT
3.0 FT
PROPOSED CUTOFF WALL @ ELEVATION = -30±1 FT, NAVD
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
SACRAMENTO RIVER EAST LEVEE REACH C – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 5 ADJACENT LEVEE WITH CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
REACH C – ALTERNATIVE 5 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 32

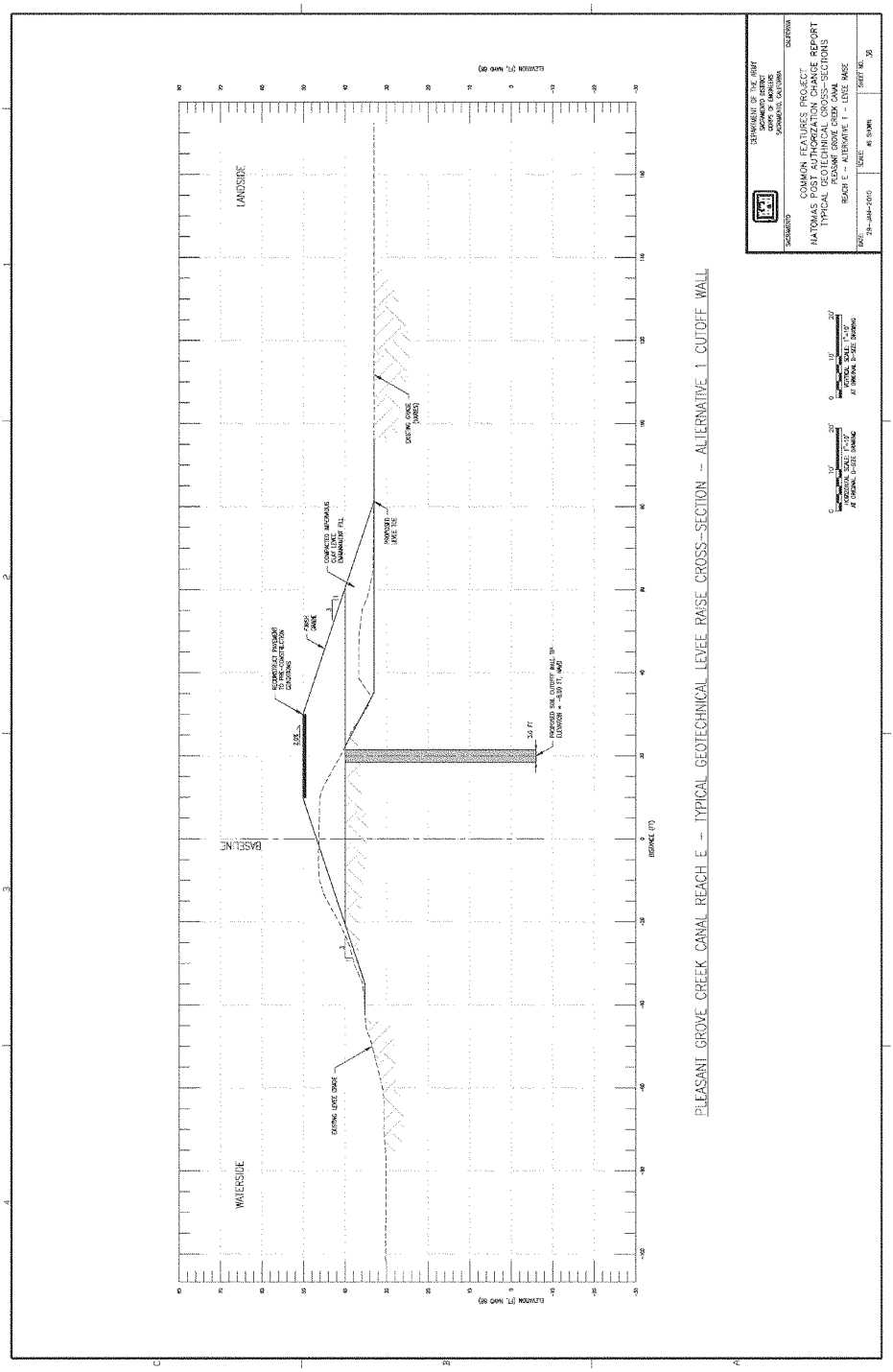


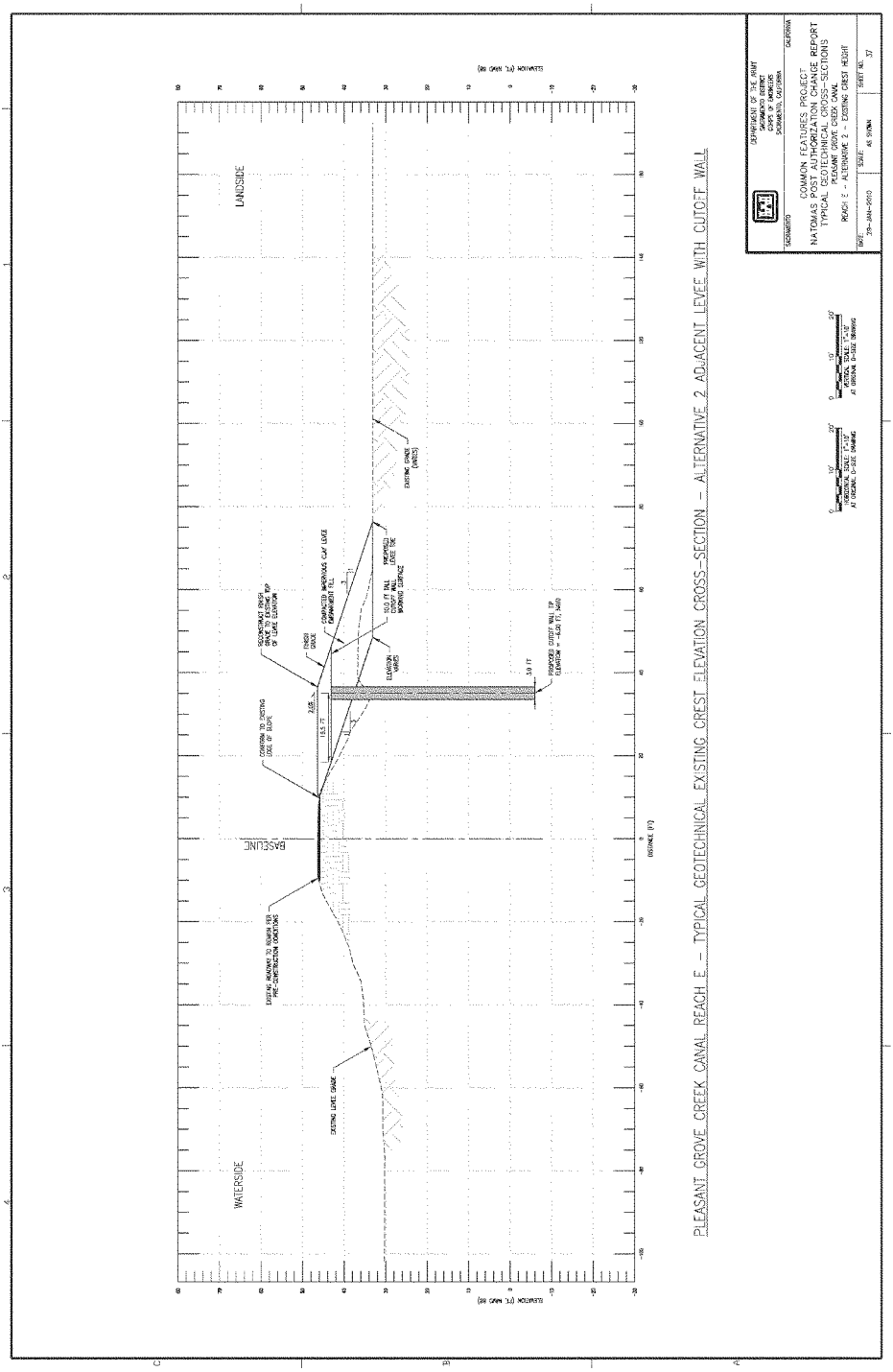
NATOMAS CROSS CANAL REACH D – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 1 CUTOFF WALL

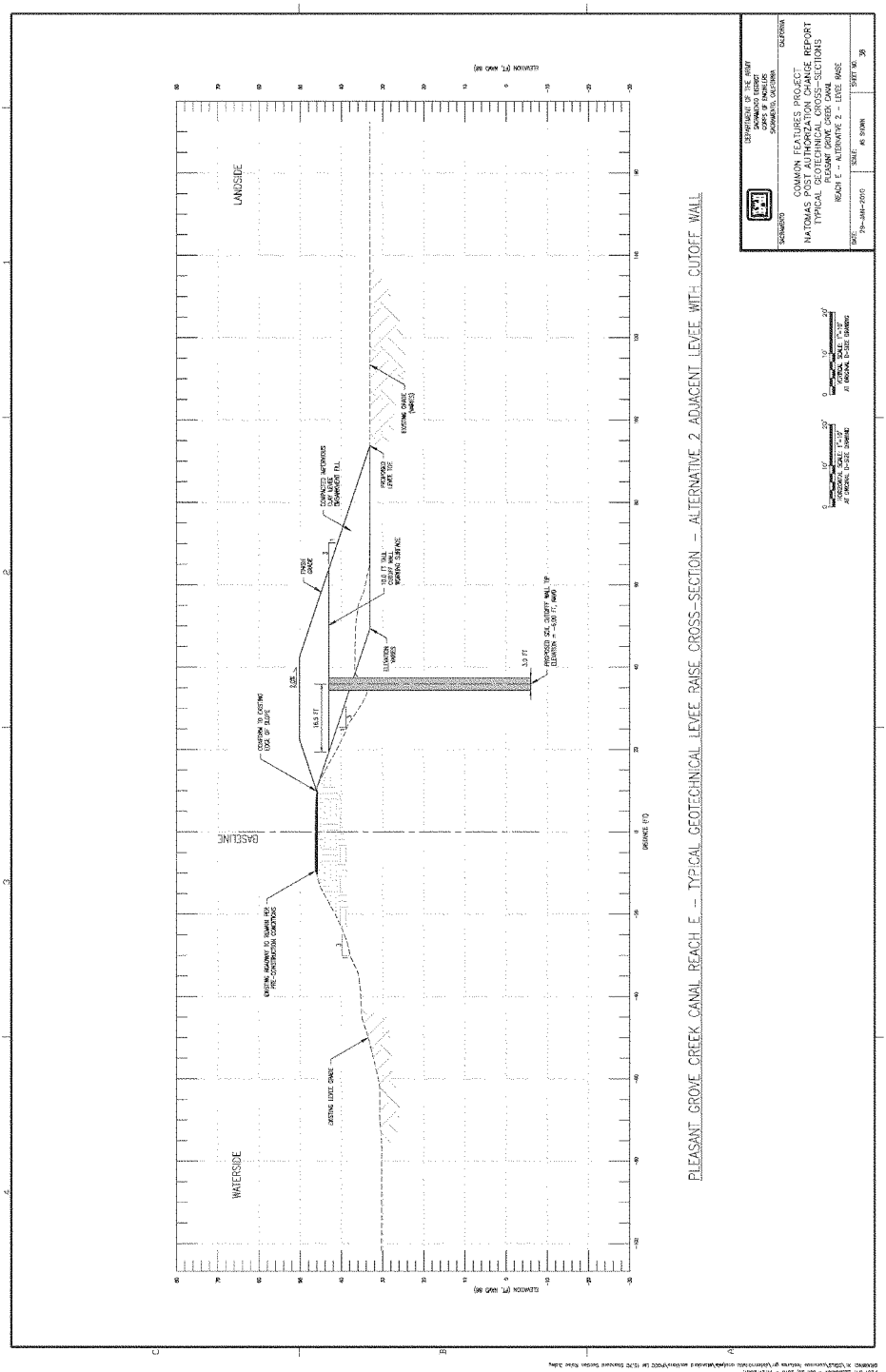


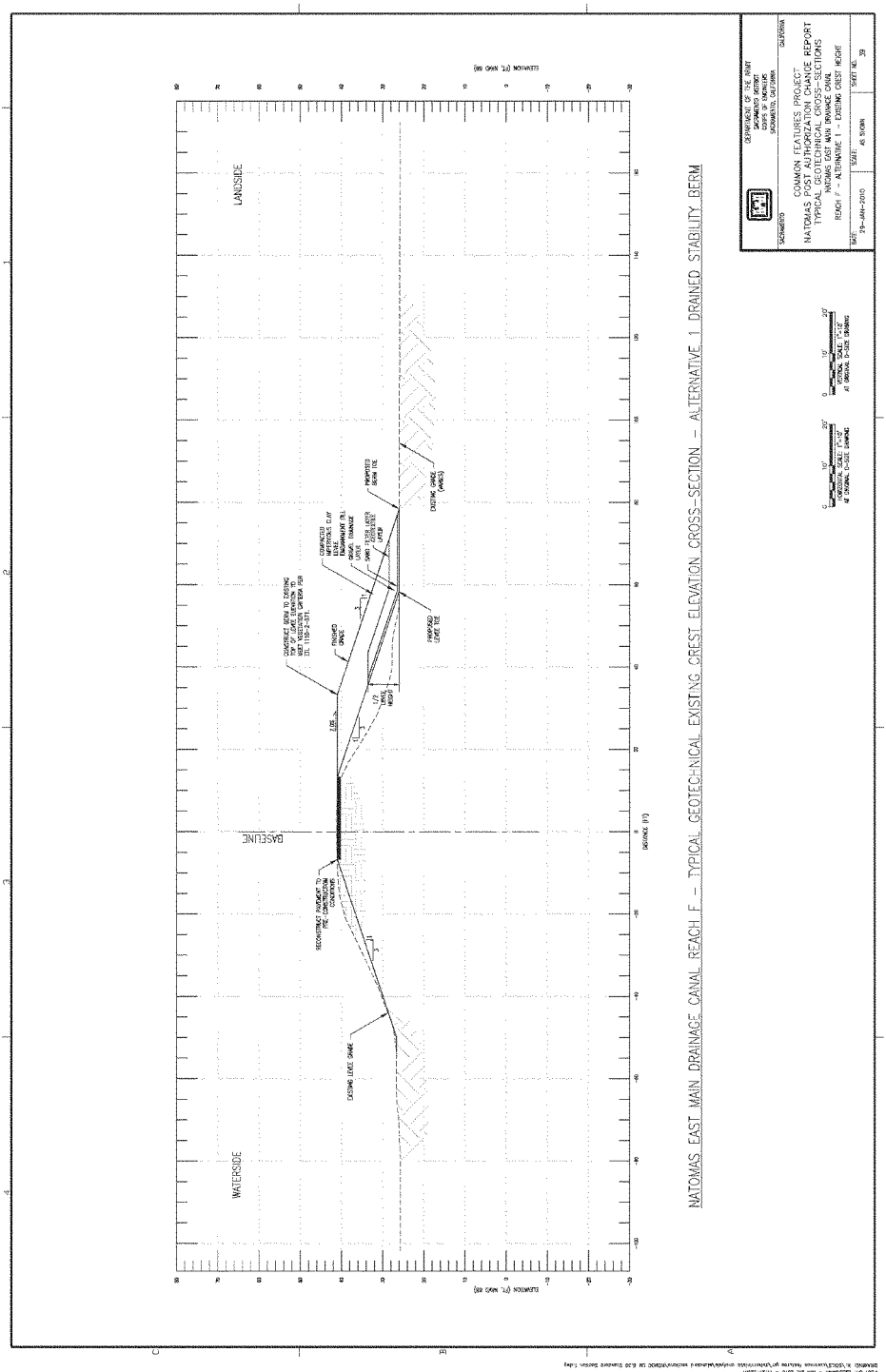
NATOMAS CROSS CANAL REACH D – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 1 CUTOFF WALL

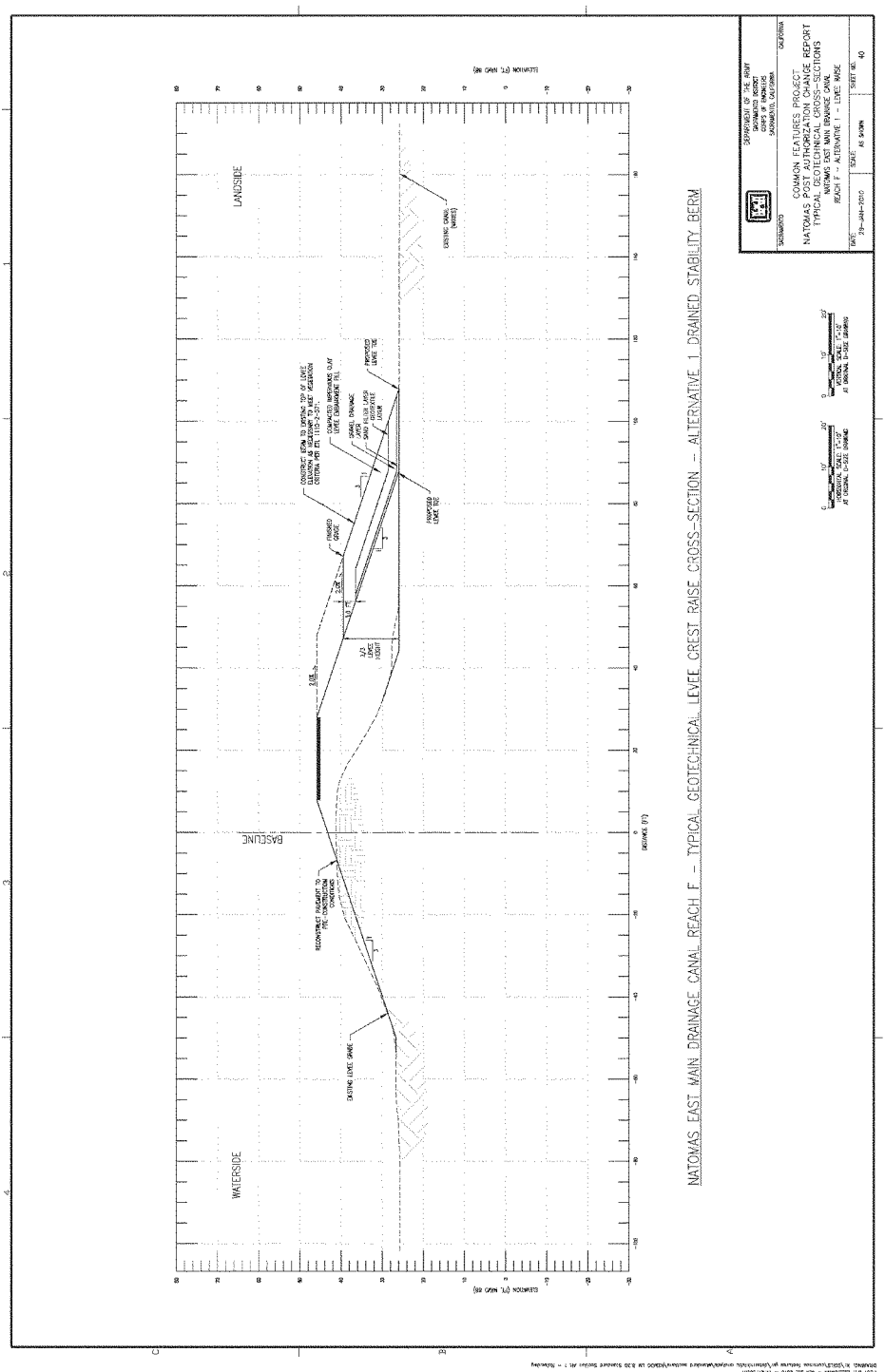

LANDSIDE
WATERSIDE
BASELINE
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
EXISTING LEVEE GRADE
RECONSTRUCT LEVEE TO PRE-CONSTRUCTION CONDITIONS
EXCAVATE LEVEE GRADE TO EXISTING TOP OF LEVEE ELEVATION
COMPACTED IMPERVIOUS CLAY LEVEE FILL
EXISTING GRADE (VARIES)
PROPOSED LEVEE TOE
30 FT
PROPOSED CUTOFF WALL TIP ELEVATION = -3.69 FT, NAVD
PLEASANT GROVE CREEK CANAL REACH E – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 1 CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
PLEASANT GROVE CREEK CANAL
REACH E – ALTERNATIVE 1 – EXISTING CREST HEIGHT
DATE: 28-JAN-2010
SCALE: AS SHOWN
SHEET NO. 35

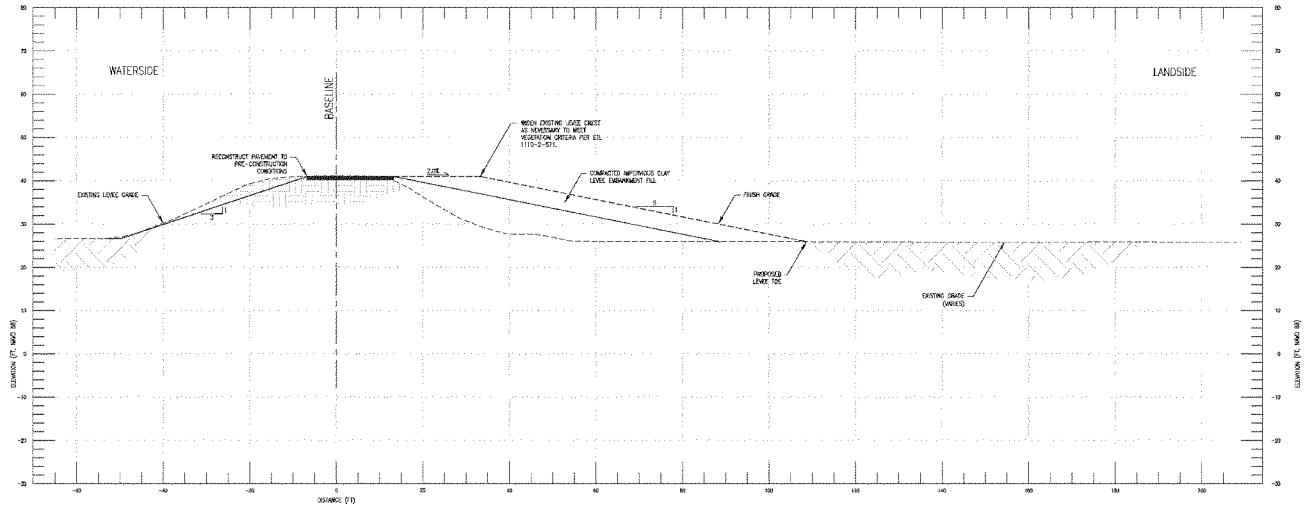

PLEASANT GROVE CREEK CANAL REACH E - TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION - ALTERNATIVE 1 CUTOFF WALL
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING GROUND SURFACE
EXISTING HYDRAULIC FILL
EXISTING LEVEE TOE
EXISTING GROUND SURFACE
EXISTING HYDRAULIC FILL
PROPOSED LEVEE TOE
PROPOSED SOIL CUTOFF WALL TIP
ELEVATION = -69.0 FT. (NAVD)
30 FT
DISTANCE (FT)
ELEVATION (FT.) NAVD 88
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
PLEASANT GROVE CREEK CANAL
REACH E - ALTERNATIVE 1 - LEVEE RAISE
DATE:
28-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
35


WATERSIDE
BASELINE
LANDSIDE
EXISTING LEVEE GRADE
EXISTING ROADWAY TO REMAIN FOR PRE-CONSTRUCTION CONDITIONS
CONFORM TO EXISTING GRADE OF LEVEE
SECONDARY RAMP GRADE TO EXISTING TOP OF LEVEE ELEVATION
ENGR. GRADE
COMPACTED IMPERVIOUS CAP LAYER
COMPACTED IMPERVIOUS FILL
150.0 FT
ELEVATION VARIES
PROPOSED SOIL-BENTONITE CUTOFF WALL
PROPOSED LEVEE TOE
EXISTING GRADE (VARIES)
PROPOSED CUTOFF WALL TIP ELEVATION = -43.0 FT, (MIN)
3.0 FT
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
PLEASANT GROVE CREEK CANAL REACH E – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 2 ADJACENT LEVEE WITH CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
PLEASANT GROVE CREEK CANAL
REACH E – ALTERNATIVE 2 – EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 37


LANDSIDE
WATERSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING GROUND SURFACE PRIOR TO CONSTRUCTION
PROPOSED CREST RAISE
COMPACTED IMPERVIOUS CLAY LEVEE EMBANKMENT FILL
EXISTING LEVEE CREST
EXISTING LEVEE SLOPE
PROPOSED SOIL CUTOFF WALL TIP ELEVATION = -4.00 FT, NAVD
3.0 FT
16.5 FT
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
PLEASANT GROVE CREEK CANAL REACH E – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 2 ADJACENT LEVEE WITH CUTOFF WALL
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
PLEASANT GROVE CREEK CANAL
REACH E – ALTERNATIVE 2 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 38


NATOMAS EAST MAIN DRAINAGE CANAL REACH F – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 1 DRAINED STABILITY BERM
WATERSIDE
BASELINE
LANDSIDE
EXISTING LEVEE GRADE
RECONTOUR PLATEAU TO PRE CONSTRUCTION CONDITIONS
EXISTING GRADE
PROPOSED LEVEE TOE
1/2 LEVEE HEIGHT
FINISHED GRADE
CONSTRUCT BERM TO CONFORM WITH ADJACENT LEVEE SEE TYPICAL SECTION DETAILS
PROPOSED RIGHT OF WAY
COMPACTED NATIVE CLAY
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH F – ALTERNATIVE 1 – EXISTING CREST HEIGHT
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
39


NATOMAS EAST MAIN DRAINAGE CANAL REACH F – TYPICAL GEOTECHNICAL LEVEE CREST RAISE CROSS-SECTION – ALTERNATIVE 1 DRAINED STABILITY BERM
WATERSIDE
BASELINE
LANDSIDE
EXISTING LEVEE GRADE
RECONSTRUCT PAVEMENT TO PRE-CONSTRUCTION CONDITIONS
FINISHED GRADE
CONSTRUCT BERM TO MATCH TOP OF LEVEE ELEVATION AS REQUIRED BY USACE REGULATION CRITERIA PER ETL 1110-2-571
COMPACTED IMPERVIOUS CLAY LEVEE EMBANKMENT FILL
GRAVEL DRAINAGE LAYER
SAND FILTER LAYER
TOPSOIL
PROPOSED LEVEE TOE
EXISTING LEVEE TOE
EXISTING GROUND (TYP.)
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH F – ALTERNATIVE 1 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 40



NATOMAS EAST MAIN DRAINAGE CANAL REACH F – TYPICAL GOETECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 2 FLATTENED LANDSIDE SLOPE

HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

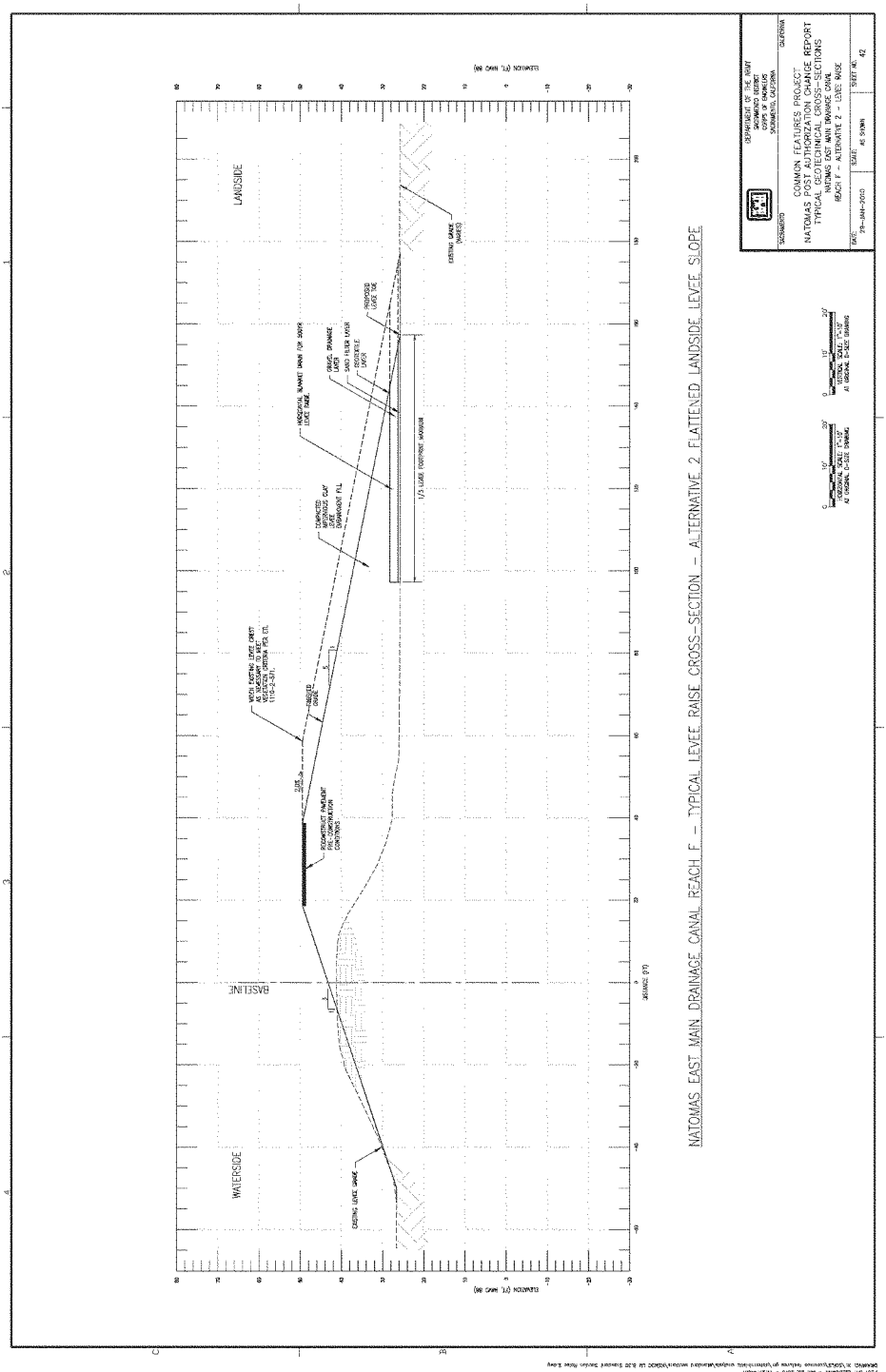
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

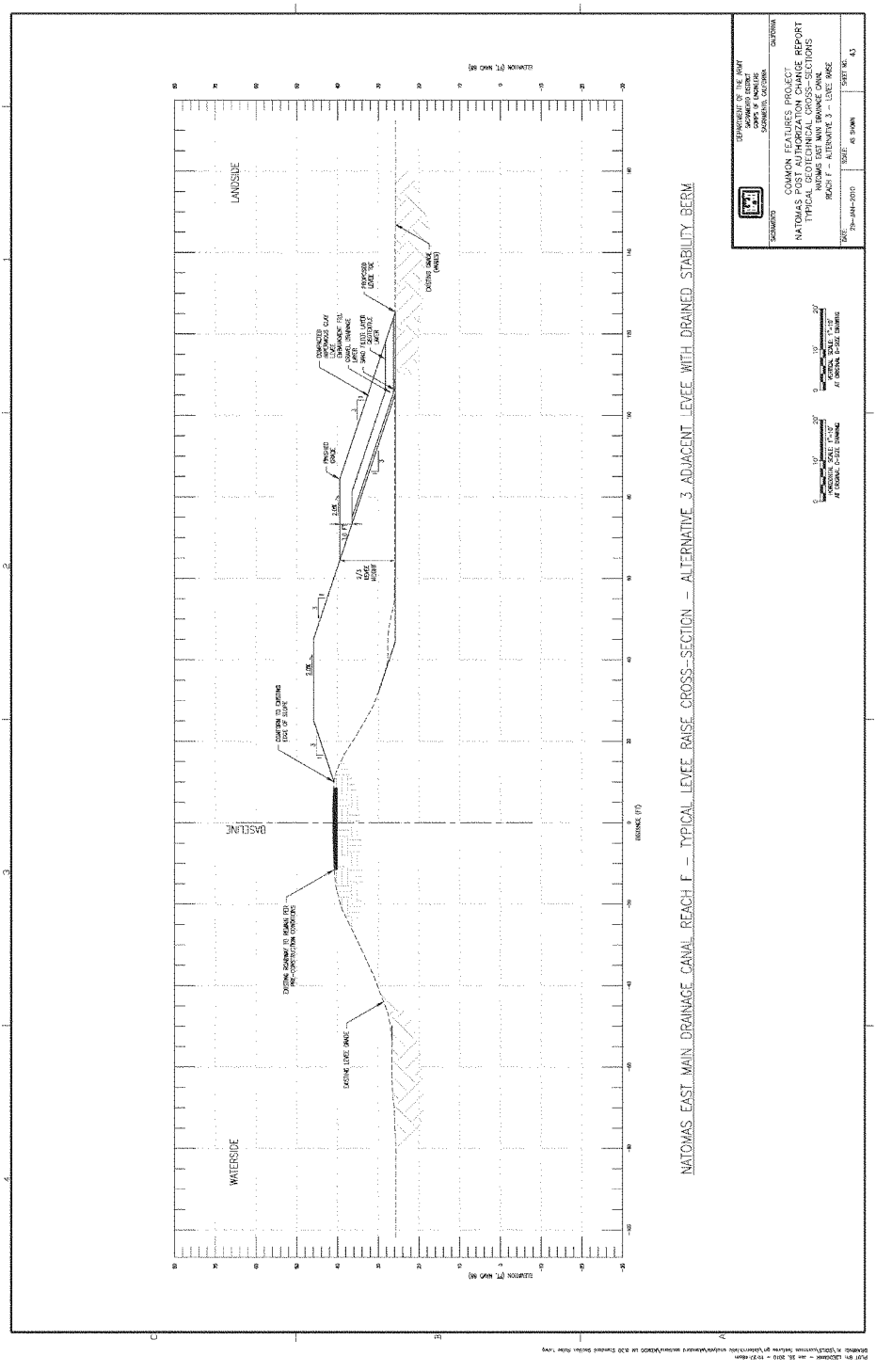
SACRAMENTO — CALIFORNIA

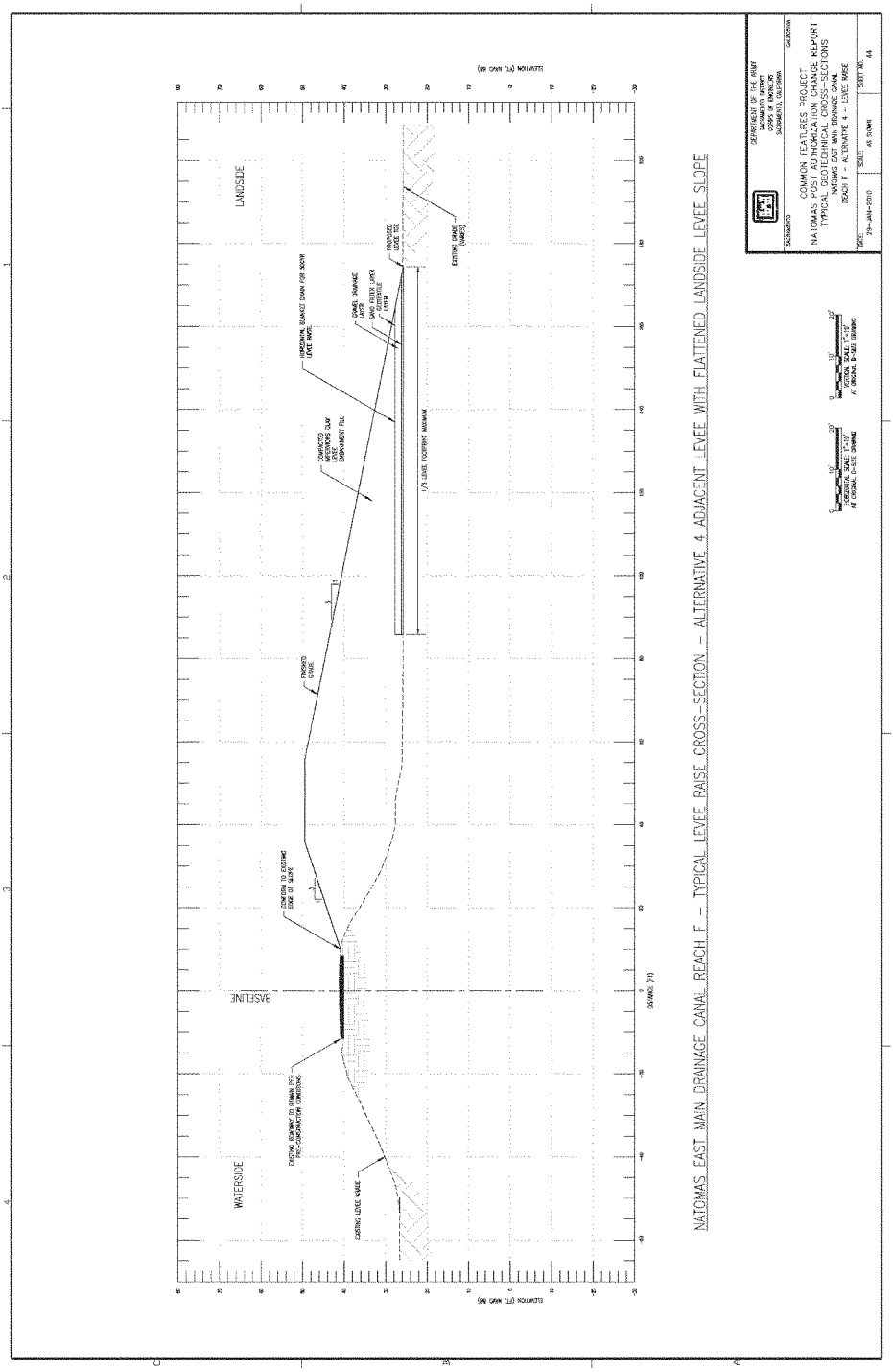
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH F – ALTERNATIVE 2 – EXISTING CREST HEIGHT

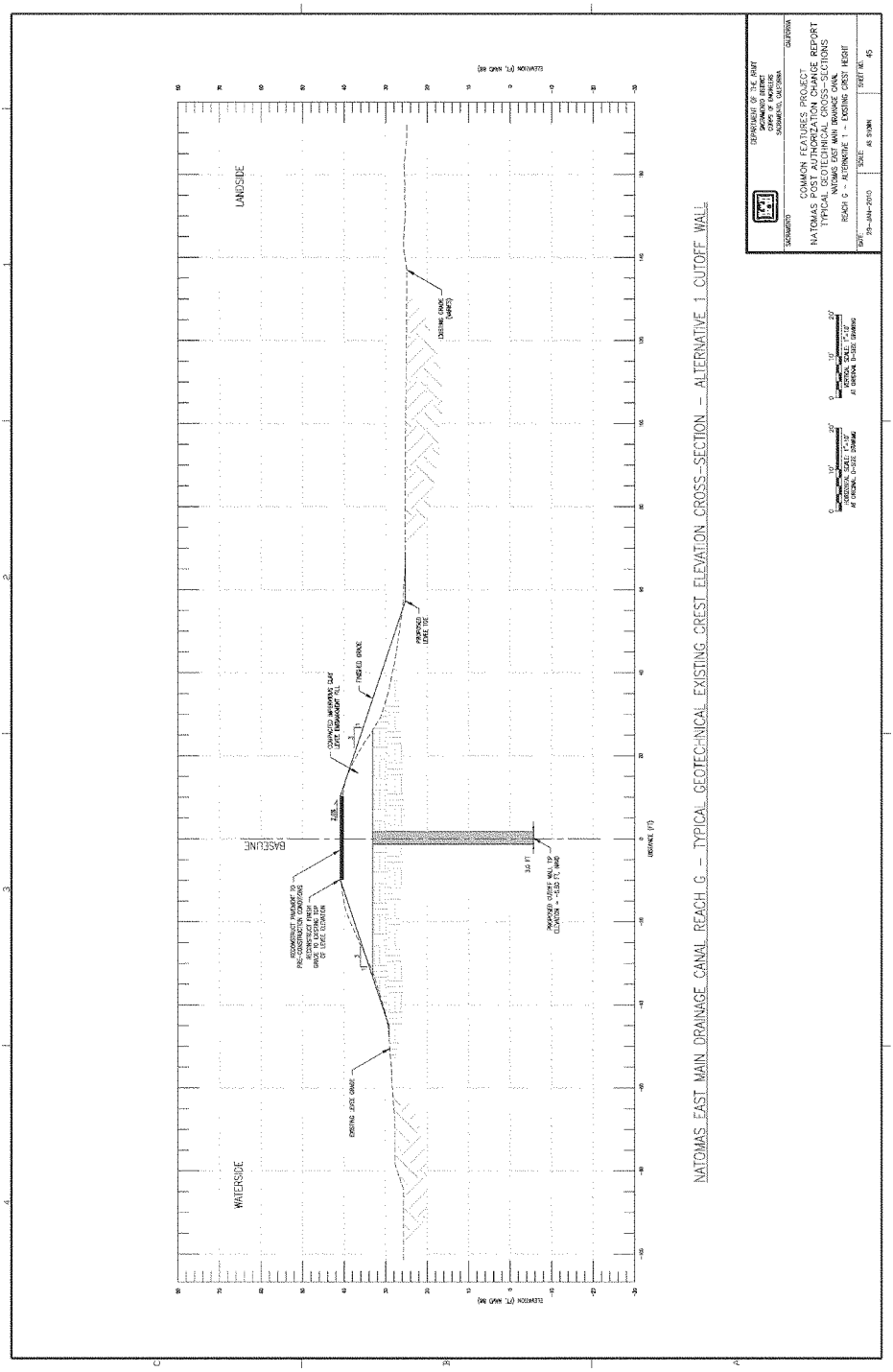
DATE:	SCALE:	SHEET NO.
29-JAN-2010	AS SHOWN	41

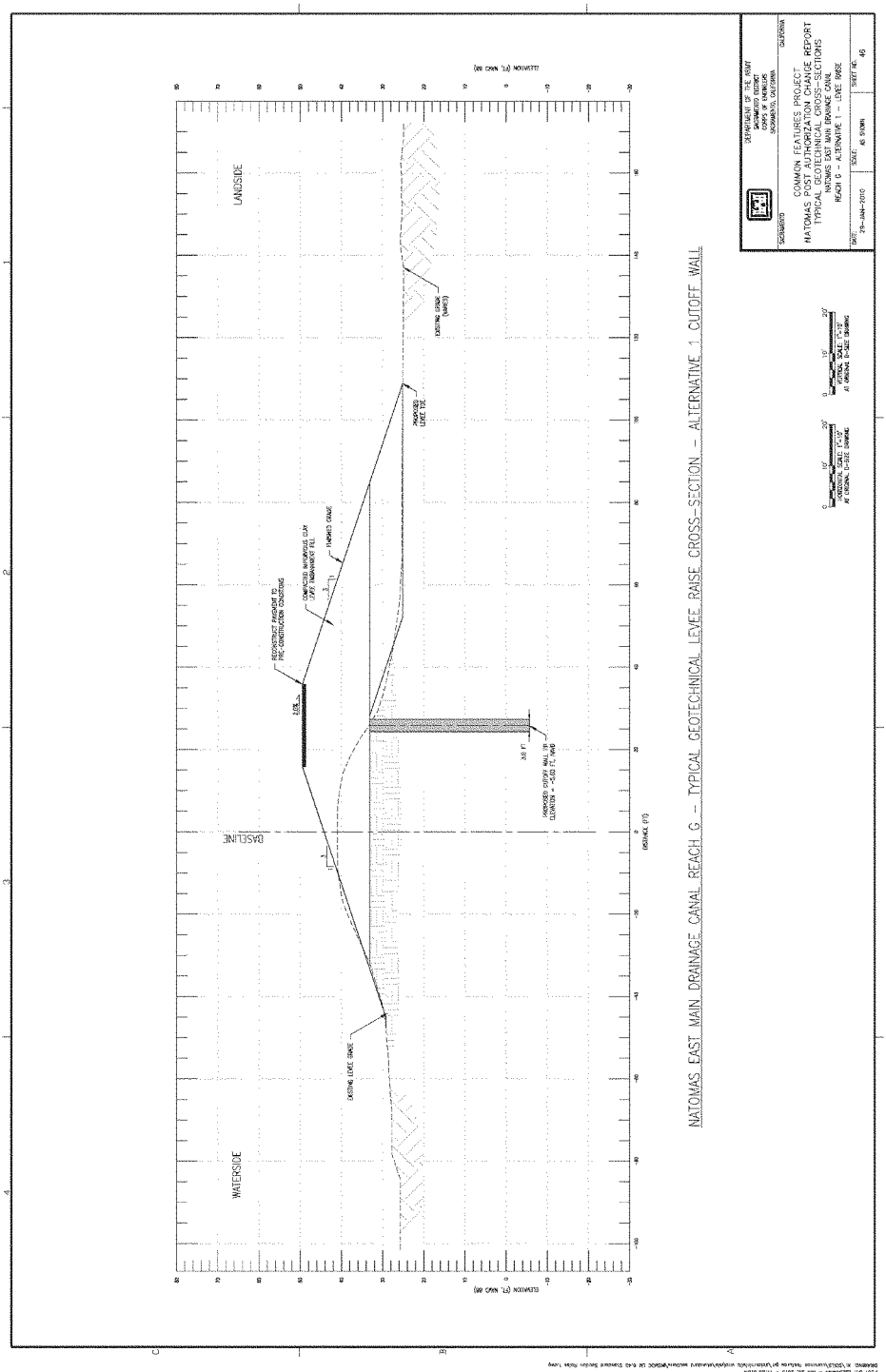
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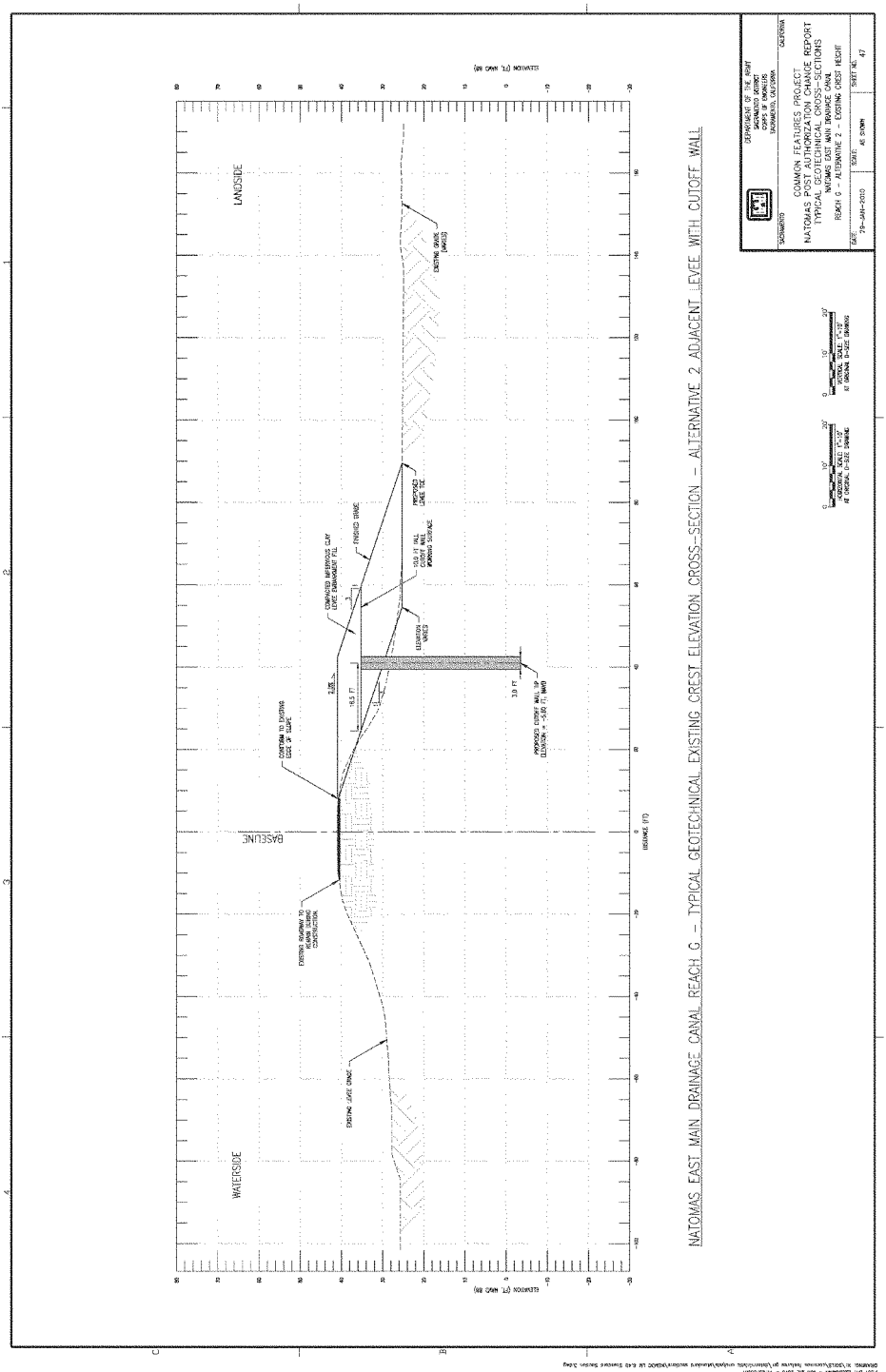

NATOMAS EAST MAIN DRAINAGE CANAL REACH F – TYPICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 2 FLATTENED LANDSIDE LEVEE SLOPE
WATERSIDE
BASELINE
LANDSIDE
EXISTING LEVEE GRADE
RECONTOUR PUMPOUT PIEZOMETER CONTROLS
LINE OF SIGHT
MATCH EXISTING LEVEE CREST ELEVATION CRITERIA PER CFR 1110-2-341.
EMBEDDED GRADE
COMPACTED CLAY LAYER DOWNWARD FILL
HORIZONTAL BLANKET DRAIN FOR SEEPAGE
GRAVEL DRAINAGE LAYER
SAND FILTER LAYER
GEOSYNTHETIC FABRIC
PROPOSED LEVEE CREST
1/3 LOSS FOOTPRINT MOVEMENT
EXISTING GRADE (VARIES)
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL SECTION/MAJOR CROSS-SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH F – ALTERNATIVE 2 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 42

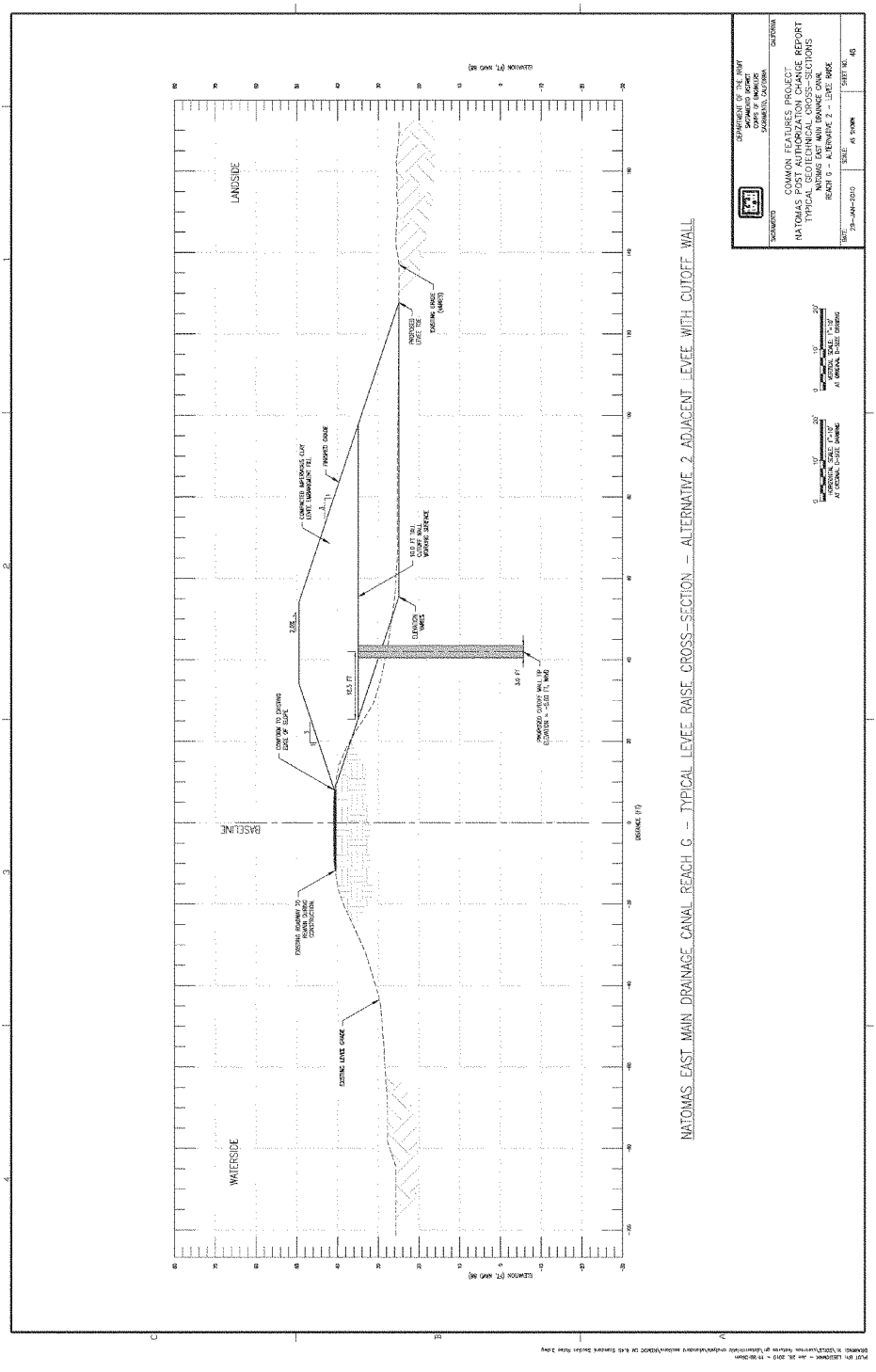

NATOMAS EAST MAIN DRAINAGE CANAL REACH F – TYPICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 3 ADJACENT LEVEE WITH DRAINED STABILITY BERM
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
EXISTING SLOPE TO REMAIN PER CONSTRUCTION RECORDS
CONFORM TO EXISTING TOE OF SLOPE
PROPOSED LEVEE TOE
EXISTING GRADE (VARIES)
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL SECTIONAL CROSS-SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH F – ALTERNATIVE 3 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 43

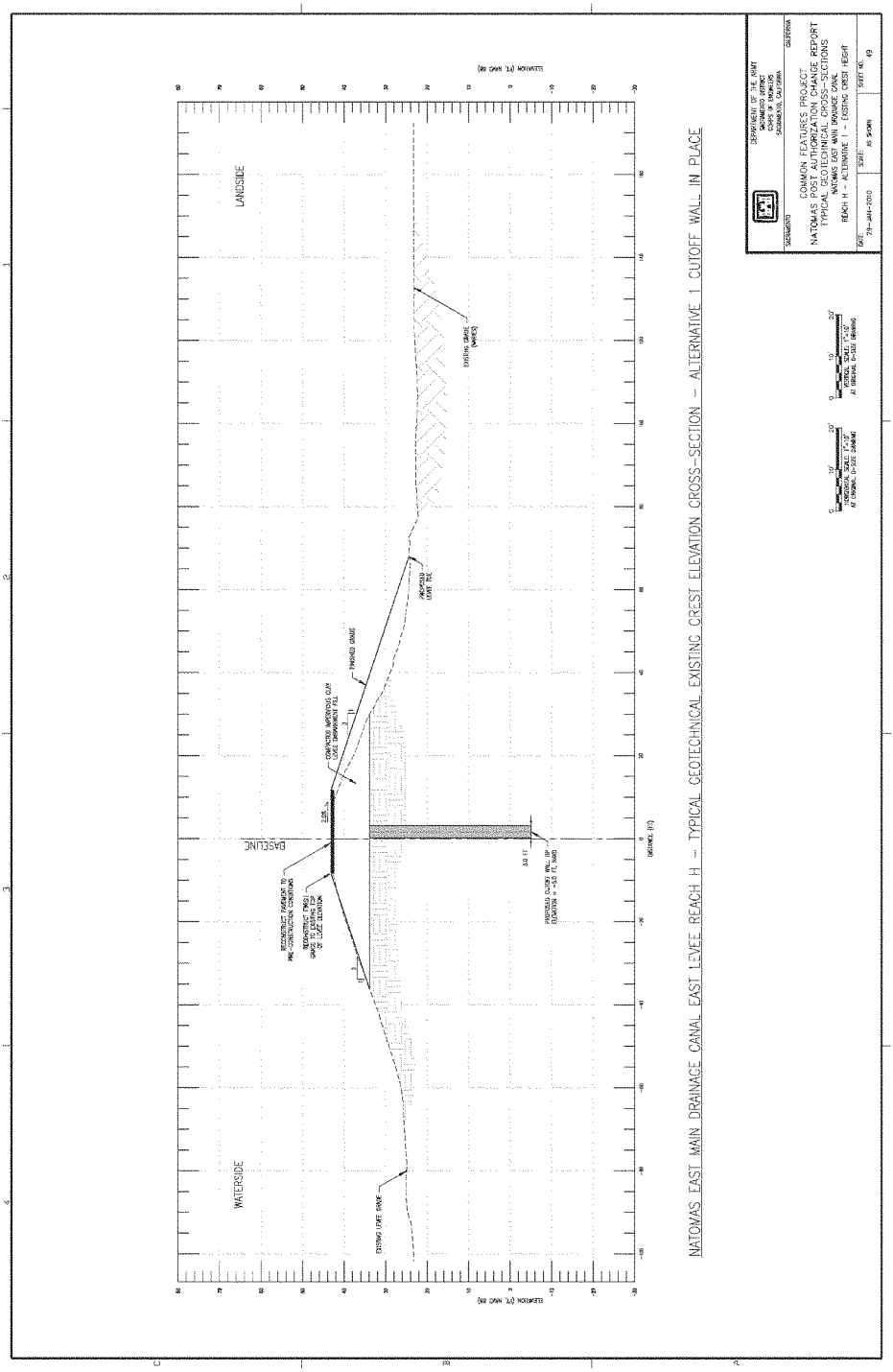

NATOMAS EAST MAIN DRAINAGE CANAL REACH F – TYPICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 4 ADJACENT LEVEE WITH FLATTENED LANDSIDE LEVEE SLOPE
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
EXISTING ROADWAY TO REMAIN PER PRE-CONSTRUCTION DRAWINGS
CONFORM TO EXISTING EDGE OF SLOPE
RAISED LEVEE
COMPACTED EARTHEN SLOPE UNDER EMBANKMENT FILL
EMBANKMENT SLOPED DOWN FOR SOME LEVEE RAISE
SAND DRAINAGE LAYER
SAND FILTER LAYER OVER GEOTEXTILE LATEX
PROPOSED LEVEE TOE
EXISTING DRAINS (TYP.)
1/3 LEVEE FOOTPRINT WIDENING
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL SECTION AND CROSS SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH F – ALTERNATIVE 4 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 44

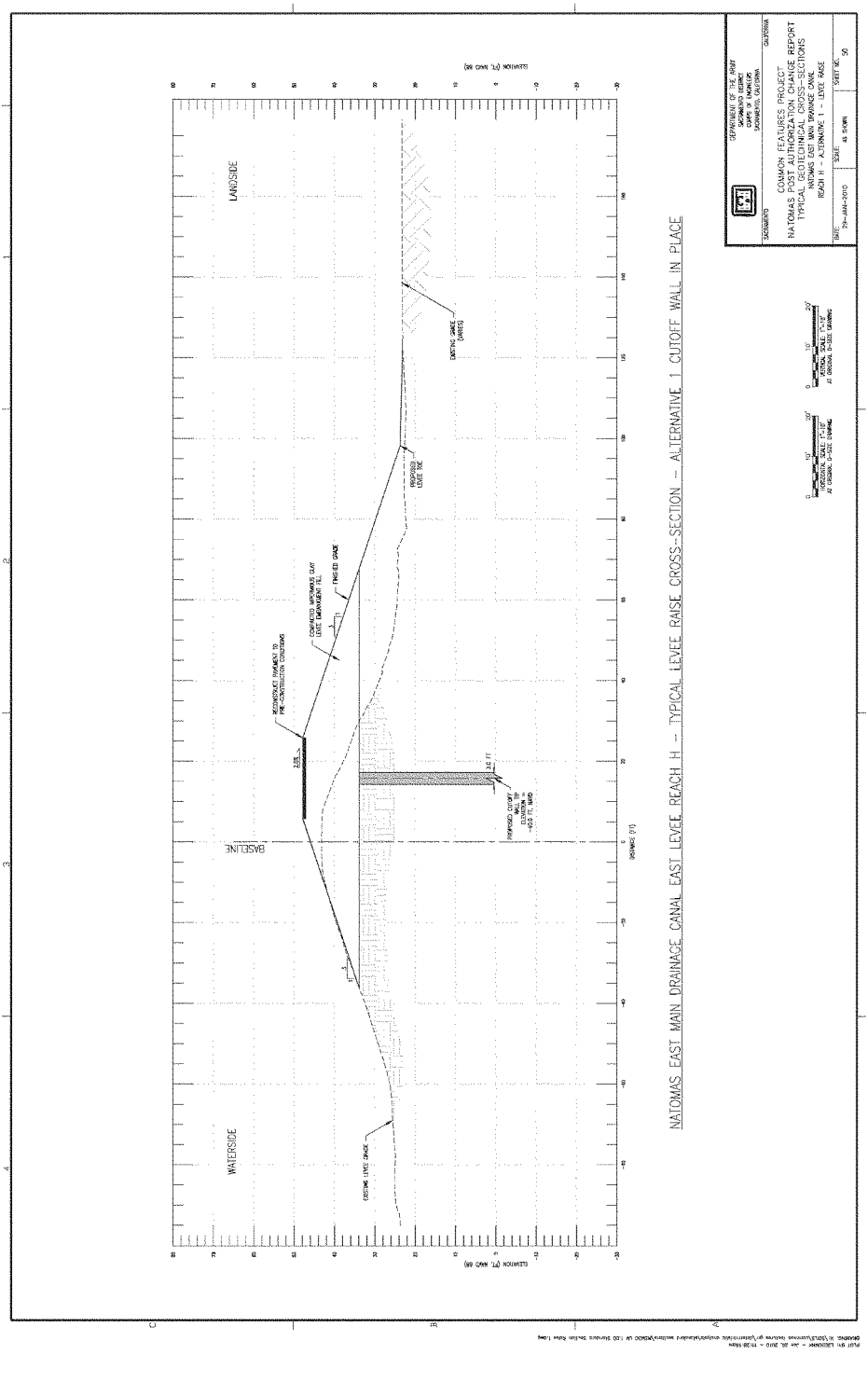

NATOMAS EAST MAIN DRAINAGE CANAL REACH G – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 1 CUTOFF WALL
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING LEVEE TOE
PROPOSED LEVEE TOE
FINISHED GRADE
COMPACTED WATERSIDE BERM
PROPOSED CUTOFF WALL TIP ELEVATION = -35.00 FT, NAVD
3.5 FT
RECONSTRUCT PARAPET TO PRE-CONSTRUCTION CONDITIONS
RECONSTRUCT FINISH GRADE TO EXISTING TOP OF LEVEE ELEVATION
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH G - ALTERNATIVE 1 - EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 45

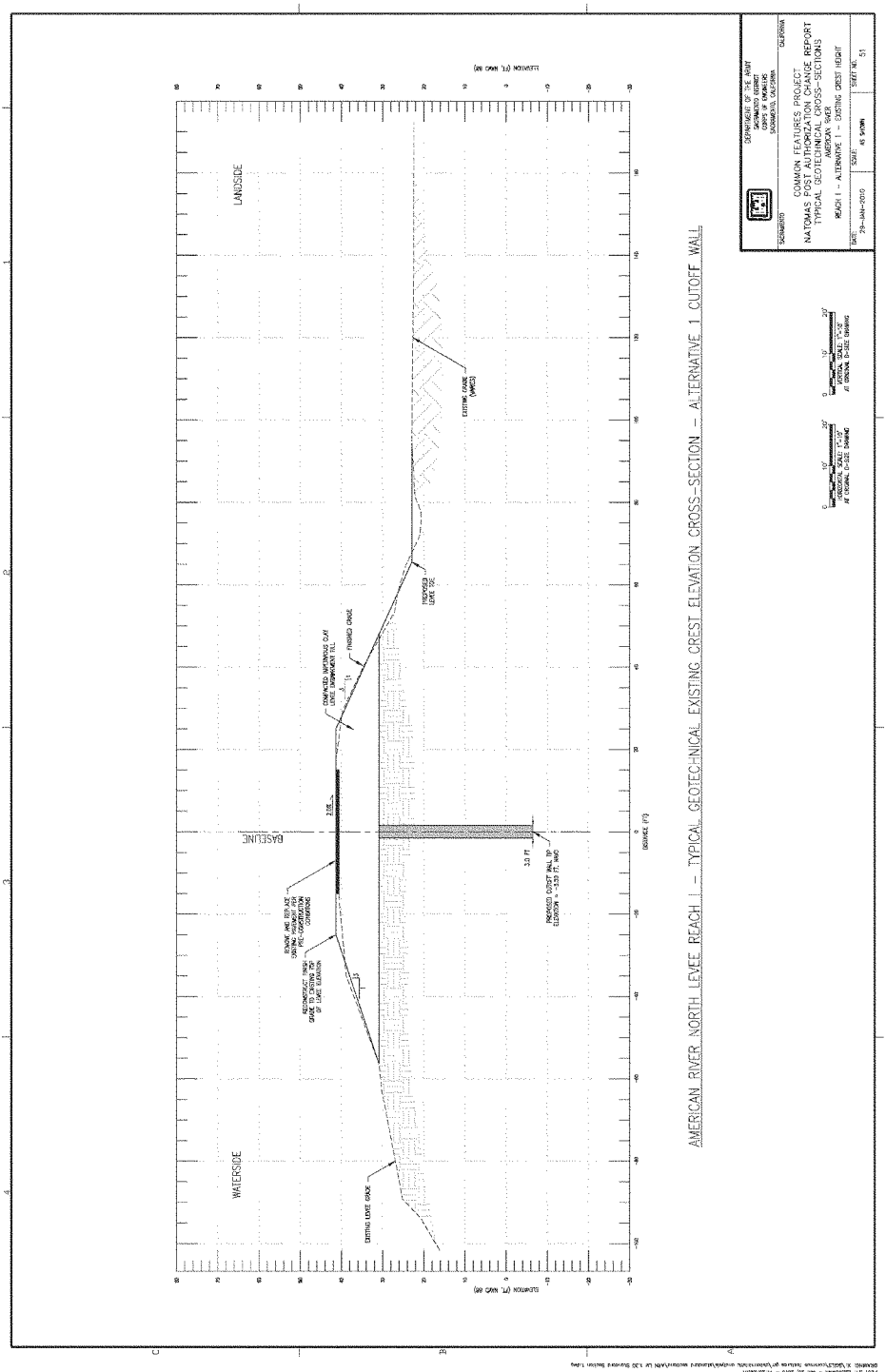

NATOMAS EAST MAIN DRAINAGE CANAL REACH G – TYPICAL GEOTECHNICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 1 CUTOFF WALL
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
PROPOSED LEVEE TOE
EXISTING GRADE (VARIES)
COMPACTED IMPERVIOUS CLAY LEVEE EMBANKMENT FILL
3
1
THICKNESS VARIES
RECONSTRUCT EMBARGO TO PRE-CONSTRUCTION CONDITIONS
LEVEE
PROPOSED CUTOFF WALL TIP ELEVATION = -3.00 FT. NAVD
3.0 FT.
ELEVATION (FT., NAVD 88)
DISTANCE (FT.)
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH G – ALTERNATIVE 1 – LEVEE RAISE
DATE:
29-JAN-2010
SCALE:
AS SHOWN
SHEET NO.
45

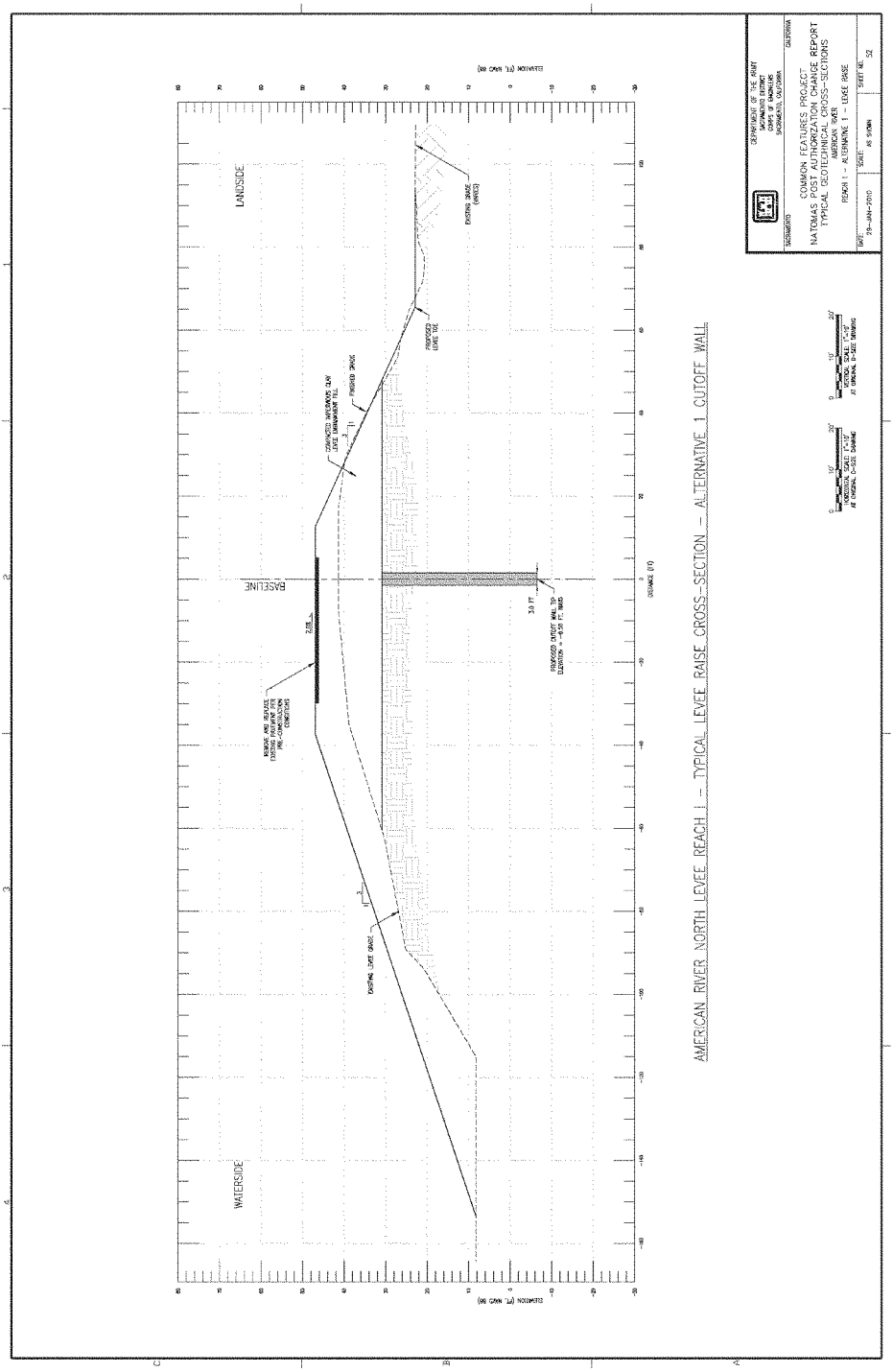

NATOMAS EAST MAIN DRAINAGE CANAL REACH G – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 2 ADJACENT LEVEE WITH CUTOFF WALL
WATERSIDE
BASELINE
LANDSIDE
EXISTING LEVEE CREST
EXISTING SEEPAGE BERM TO REMAIN UNDISTURBED DURING CONSTRUCTION
CONTOUR TO EXISTING LEVEE OR SLOPE
COMPACTED IMPERVIOUS CLAY LEVEE EMBANKMENT FILL
FINISHED GRADE
PROPOSED LEVEE TOE
SOLID FIT WALL CUTOFF WALL IMPERVIOUS SUBSURFACE
ELEVATION VARIES
3.0 FT
PROPOSED CUTOFF WALL TIP ELEVATION = -5.00 FT. NAVD
EXISTING GRADE (VARIES)
ELEVATION (FT. NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH G – ALTERNATIVE 2 – EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 47

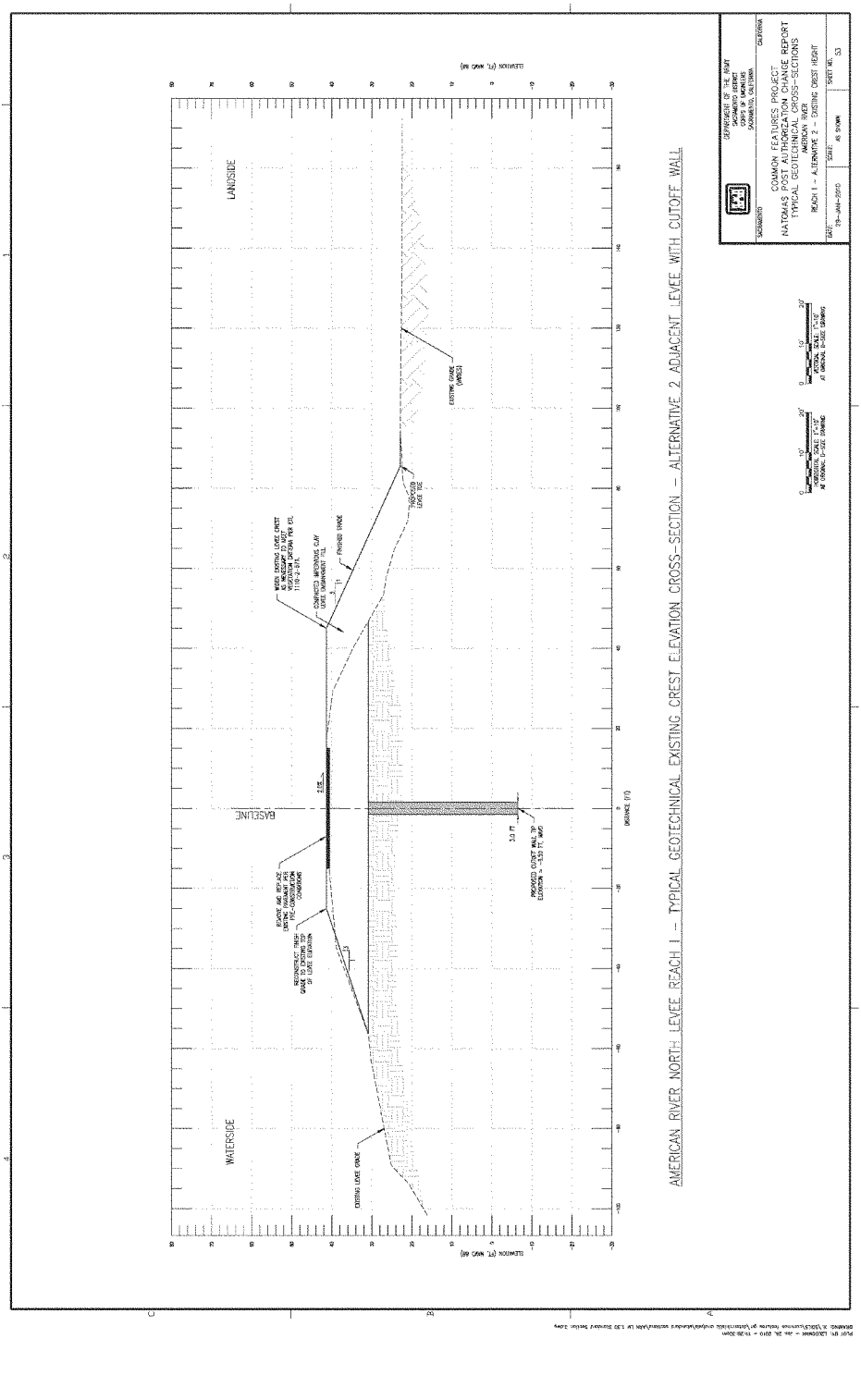

NATOMAS EAST MAIN DRAINAGE CANAL REACH G – TYPICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 2 ADJACENT LEVEE WITH CUTOFF WALL
WATERSIDE
BASELINE
LANDSIDE
EXISTING LEVEE GRADE
EXISTING ROADWAY TO REMAIN DURING CONSTRUCTION
COMPACTED IMPERVIOUS CLAY LEVEE EMBANKMENT FILL
PROPOSED GRADE
EXISTING GRADE (VARIES)
PROPOSED LEVEE TOE
SELF FILL CUTOFF WALL SHEARING SURFACE
ELEVATION VARIES
2.5H:1V
3H:1V
165 FT
10 FT
PROPOSED CUTOFF WALL TIP ELEVATION = -15.00 FT, NAVD
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL SECTIONS AND LONGITUDINAL PROFILES
NATOMAS EAST MAIN DRAINAGE CANAL
REACH G – ALTERNATIVE 2 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 45

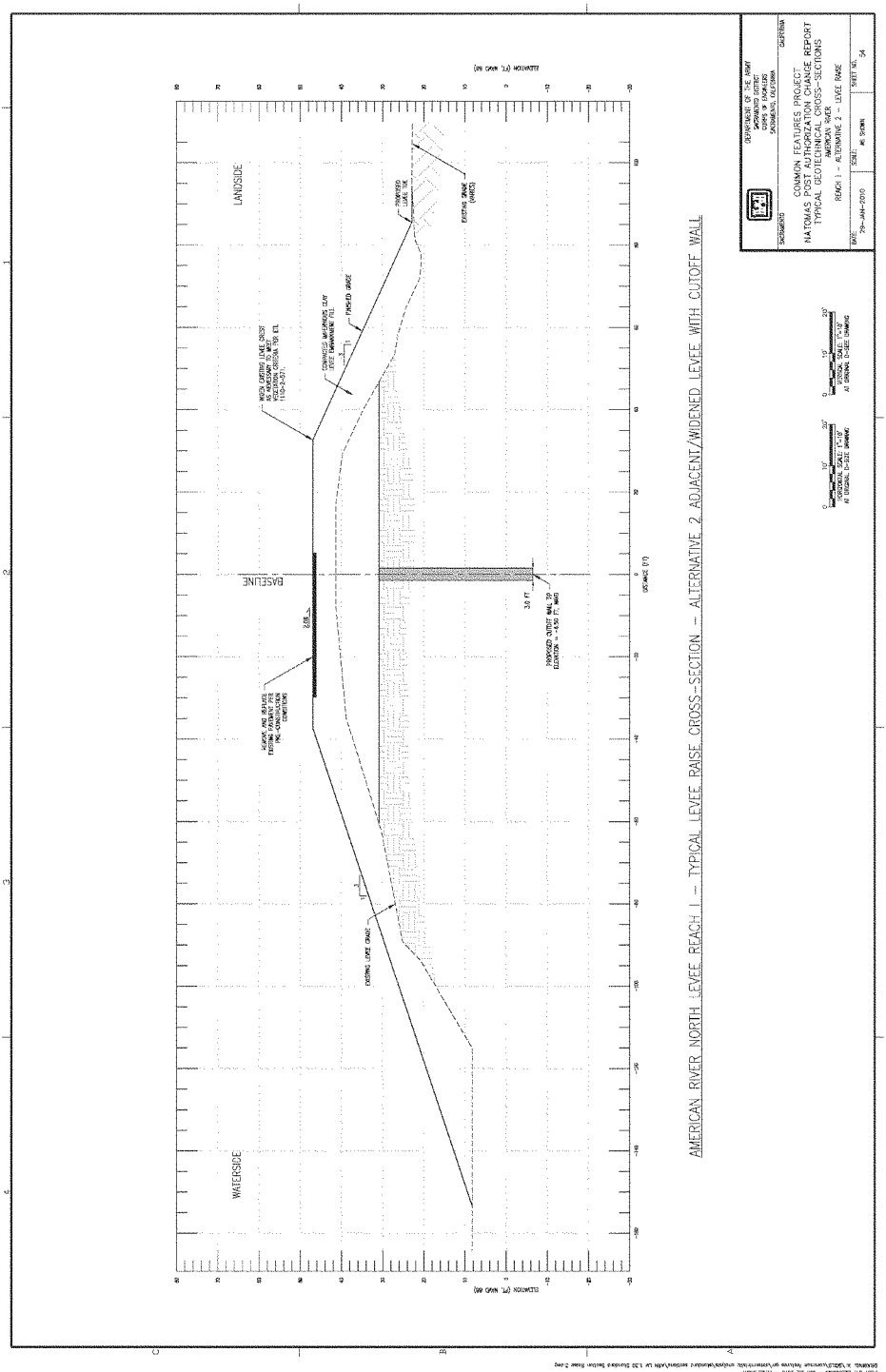

NATOMAS EAST MAIN DRAINAGE CANAL EAST LEVEE REACH H — TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION — ALTERNATIVE 1 CUTOFF WALL IN PLACE
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
RECONSTRUCT PAVEMENT TO PRE-CONSTRUCTION CONDITIONS
RECONSTRUCT LEVEE TO EXISTING CREST ELEVATION
CONSTRUCT SEEPAGE BERM
FINISHED GRADE
PROPOSED CREST
EXISTING GRADE (VARIES)
PROPOSED CUTOFF WALL TOP ELEVATION = +33 FT, NAVD
60 FT
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
NATOMAS EAST MAIN DRAINAGE CANAL
REACH H - ALTERNATIVE 1 - EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 49


NATOMAS EAST MAIN DRAINAGE CANAL EAST LEVEE REACH H -- TYPICAL LEVEE RAISE CROSS-SECTION -- ALTERNATIVE 1 CUTOFF WALL IN PLACE
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
RECONTRACT PAVEMENT TO PRE-CONSTRUCTION CONDITIONS
COMPACTED IMPORTED CLAY LEVEE EMBANKMENT FILL
FINISHED GRADE
PROPOSED LEVEE TOE
EXISTING GRADE (VARIES)
IMPROVED CUTOFF WALL TIP ELEVATION = -49.5 FT, NAVD
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL SECTIONS AND PROFILES
REACH H - ALTERNATIVE 1 - LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 50


AMERICAN RIVER NORTH LEVEE REACH I – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 1 CUTOFF WALL
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
RECONTOUR FINISH GRADE AT ELEVATION OF LEVEE CREST
REMOVE AND REPLACE SEEPAGE BERM PER GEOTECHNICAL DESIGNS
EXCAVATED WATERSIDE CLAY LINER FOR SEEPAGE FIX
FINISHED GRADE
PROPOSED LEVEE TOE
EXISTING GRADE (VARIES)
PROPOSED CREST WALL TIP ELEVATION = +33 FT. NAVD
33 FT
DISTANCE (FT)
ELEVATION (FT, NAVD 88)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
REACH I - ALTERNATIVE 1 - EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 51


AMERICAN RIVER NORTH LEVEE REACH 1 – TYPICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 1 CUTOFF WALL
WATERSIDE
LANDSIDE
BASELINE
EXISTING LEVEE GRADE
REMOVE AND REPLACE EXISTING LEVEE TO PRE-CONSTRUCTION CONDITIONS
2.0 FT.
3.0 FT.
PROPOSED CUTOFF WALL TO ELEVATION = +5.0 FT. NAVD
PROPOSED LEVEE TOE
PROPOSED GRADE
EXISTING GRADE (WARCS)
ELEVATION (FT. NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
REACH 1 – ALTERNATIVE 1 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 52


AMERICAN RIVER NORTH LEVEE REACH 1 – TYPICAL GEOTECHNICAL EXISTING CREST ELEVATION CROSS-SECTION – ALTERNATIVE 2 ADJACENT LEVEE WITH CUTOFF WALL
WATERSIDE
LANDSIDE
EASTLINK
EXISTING LEVEE GRADE
EXISTING GRADE (VARIES)
PROPOSED CREST WALL TOP ELEVATION = 43.5 FT, NAVD
3.0 FT
PROPOSED LEVEE TOE
CONCRETE MONOLITHIC CAP OVER SOUNDWALL PILE
PARAPET WALL
RECONSTRUCT THESE GRADES TO ACHIEVE TOP OF LEVEE ELEVATION
REMOVE AND REPLACE EXISTING PAVEMENT PRE-CONSTRUCTION
ELEVATION (FT, NAVD 88)
DISTANCE (FT)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
REACH 1 – ALTERNATIVE 2 – EXISTING CREST HEIGHT
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 53


AMERICAN RIVER NORTH LEVEE REACH 1 – TYPICAL LEVEE RAISE CROSS-SECTION – ALTERNATIVE 2 ADJACENT/WIDENED LEVEE WITH CUTOFF WALL
LANDSIDE
WATERSIDE
BASELINE
EXISTING LEVEE CREST
EXISTING GRADE (VARIES)
PROPOSED LEVEE TOP
PROPOSED WATERSIDE SLOPE
PROPOSED CUTOFF WALL TOP ELEVATION = +5.50 FT. NAVD
3.0 FT.
REMOVE AND REPLACE EXISTING RIPRAP AS NEEDED FOR CONSTRUCTION
REMOVE EXISTING LEVEE CREST, ROAD, AND ROADSIDE DITCH AS NEEDED FOR CONSTRUCTION
ELEVATION (FT. NAVD 88)
DISTANCE (FT.)
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
SACRAMENTO
CALIFORNIA
COMMON FEATURES PROJECT
NATOMAS POST AUTHORIZATION CHANGE REPORT
TYPICAL GEOTECHNICAL CROSS-SECTIONS
REACH 1 – ALTERNATIVE 2 – LEVEE RAISE
DATE: 29-JAN-2010
SCALE: AS SHOWN
SHEET NO. 54

DRAFT
NEMDC NORTH LEVEE (USACE) STATIONING

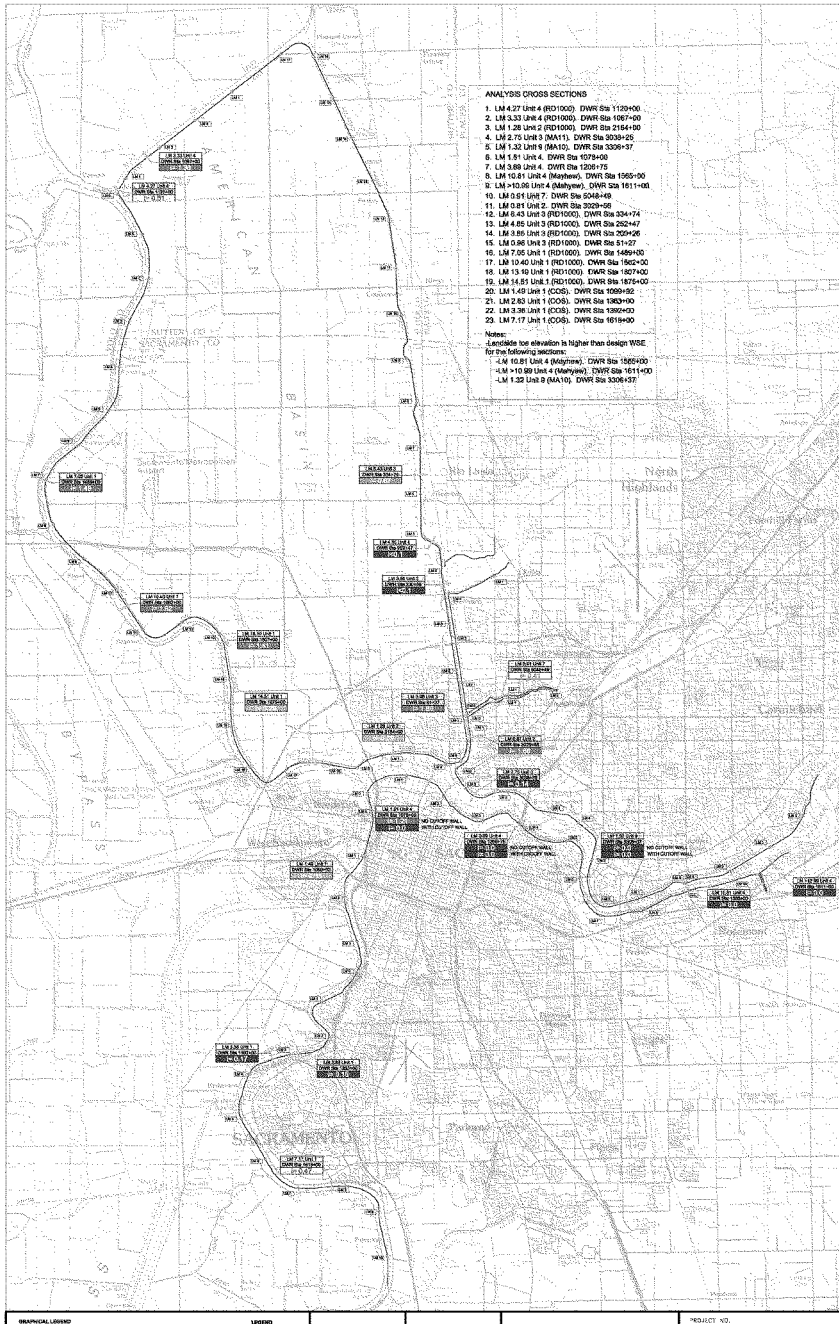
N
LANDSIDE
WATERSIDE
NEMDC NORTH LEVEE (USACE) STATIONING
DRAFT

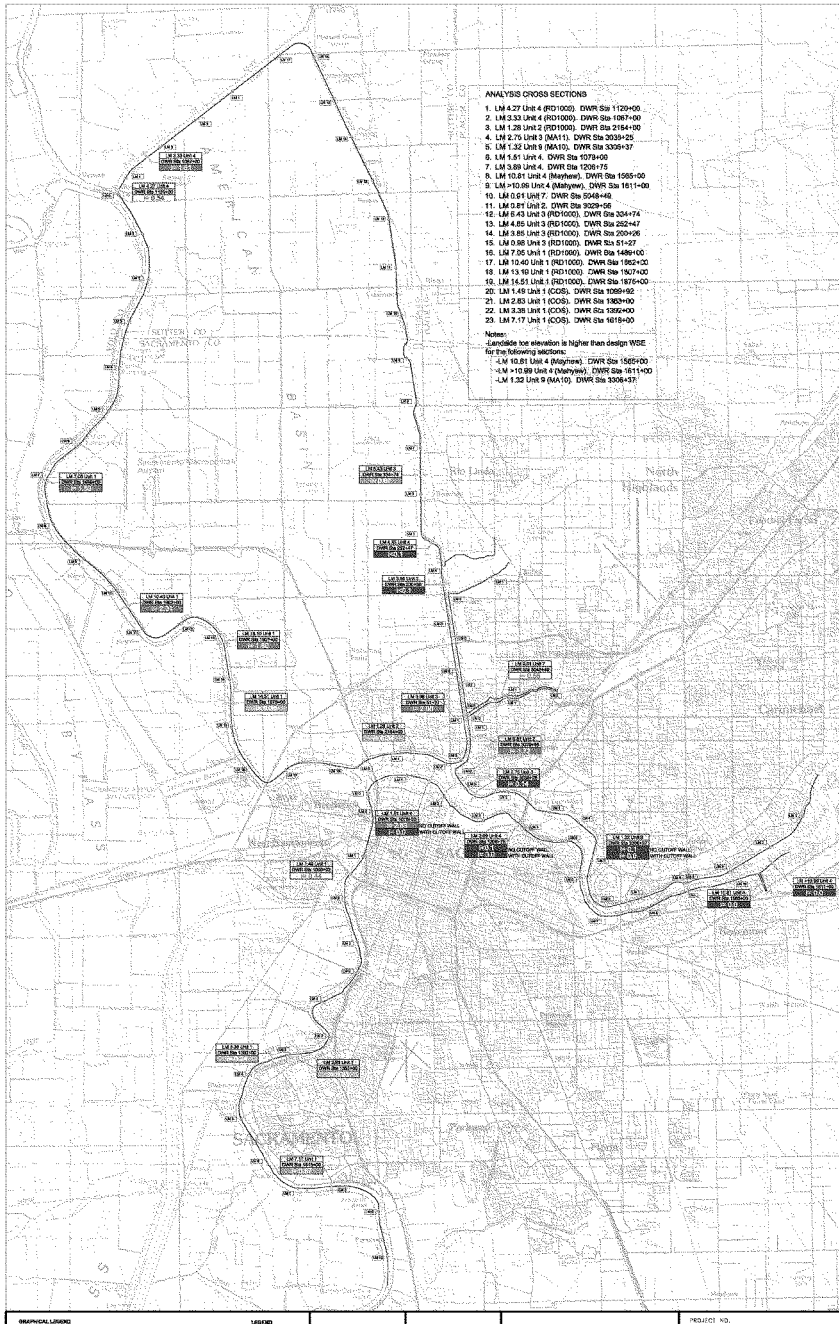
AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

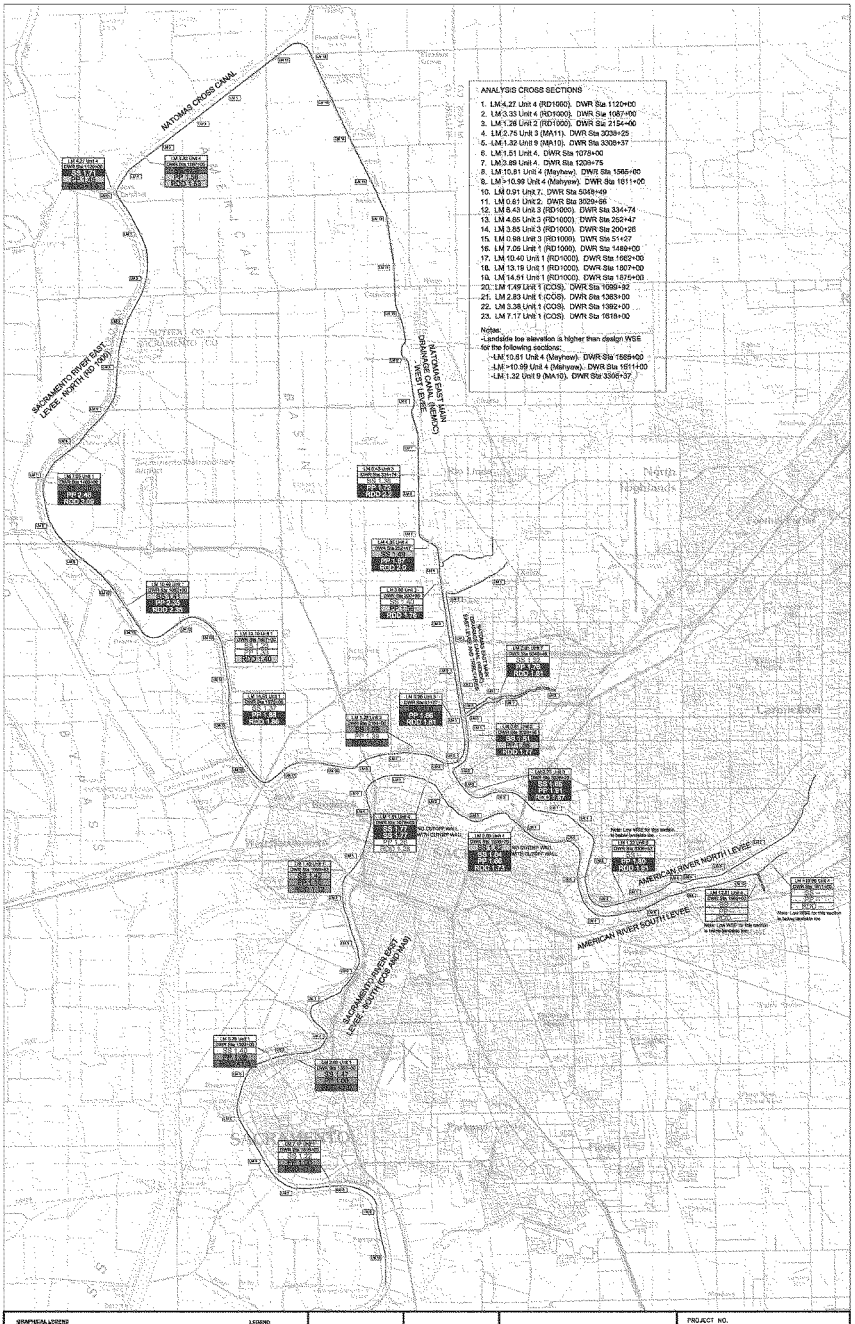
NATOMAS POST AUTHORIZATION CHANGE REPORT

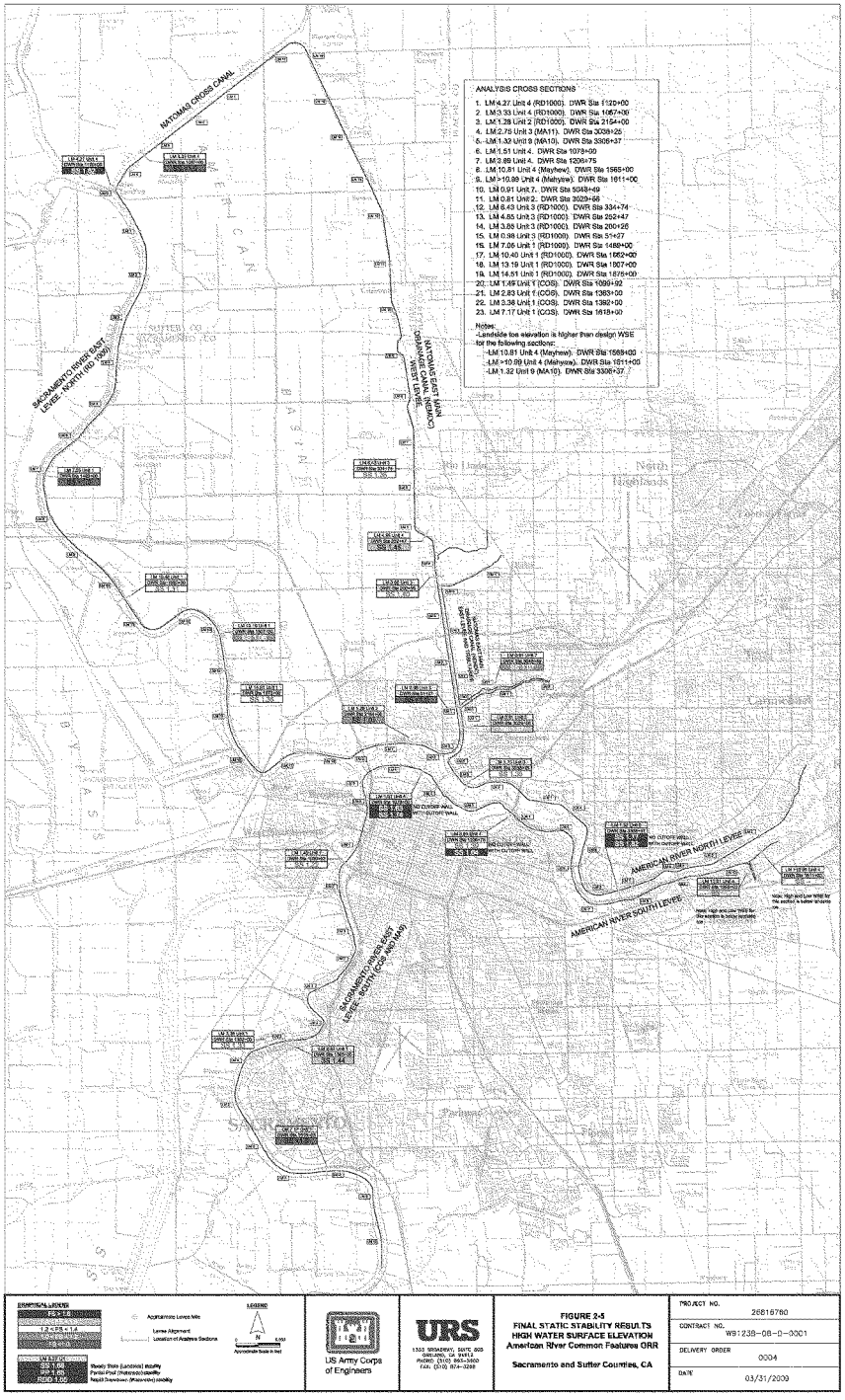
ENCLOSURE F4

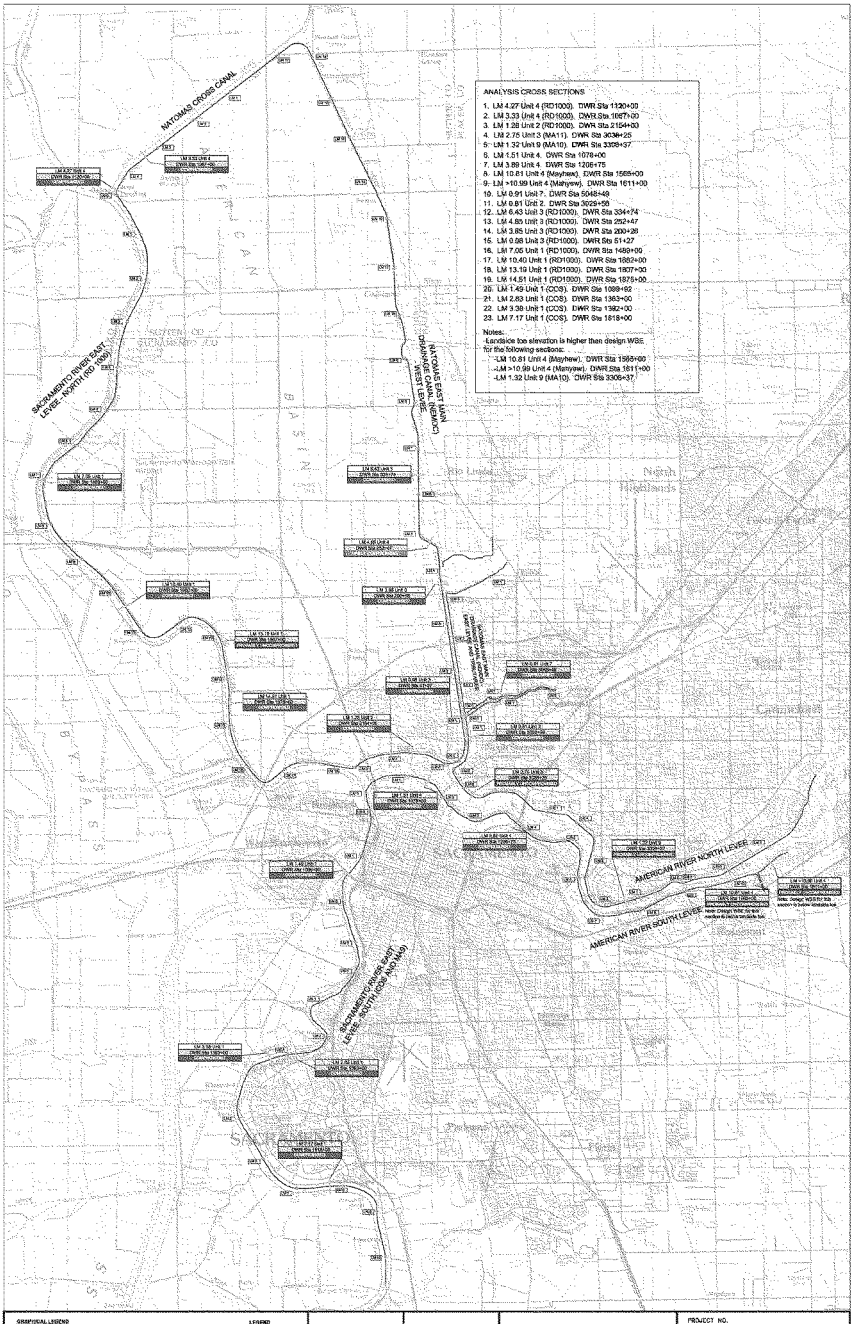
GEOTECHNICAL RISK AND UNCERTAINTY CURVES

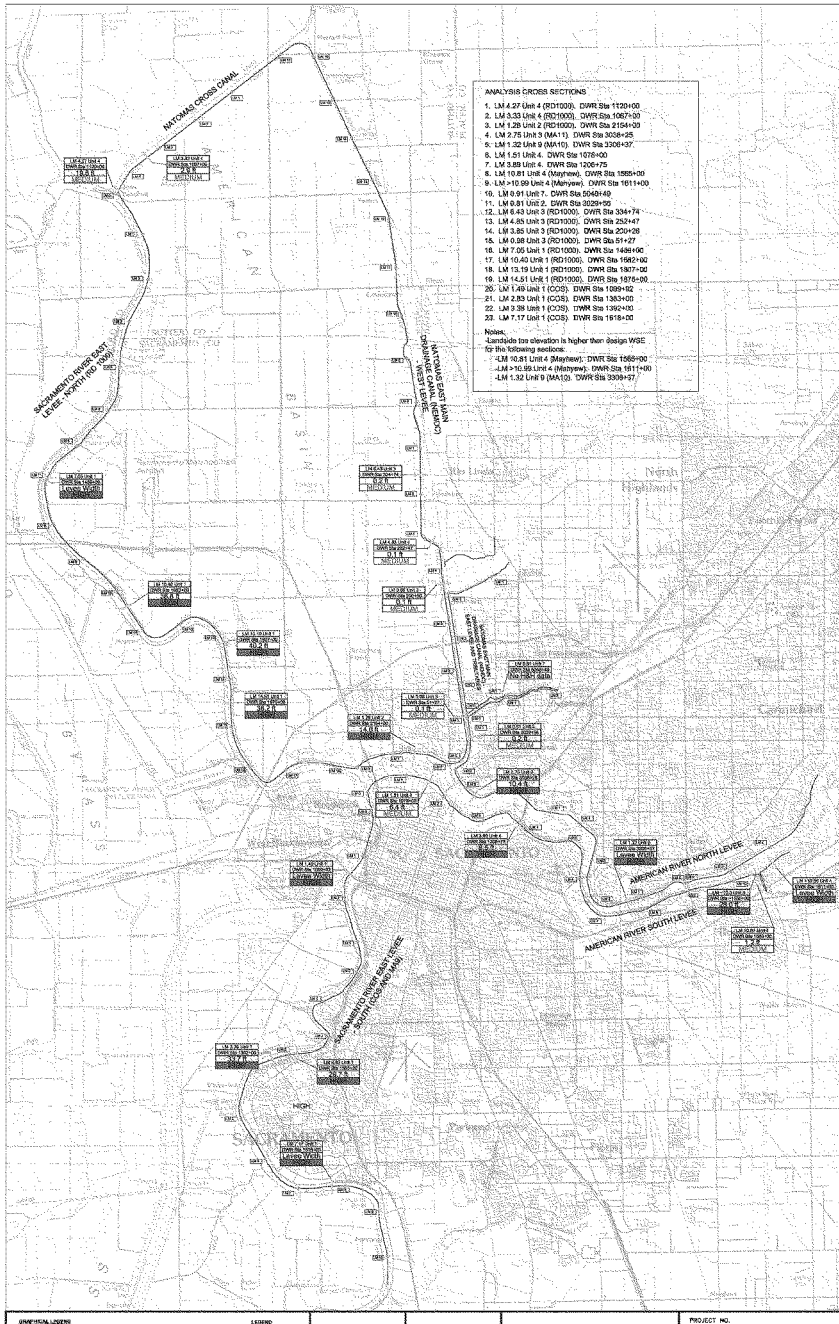

ANALYSIS CROSS SECTIONS
1. LM 4.27 Unit 4 (RD1000). DWR Sta 1129+00
2. LM 3.33 Unit 4 (RD1000). DWR Sta 1067+09
3. LM 1.28 Unit 2 (RD1000). DWR Sta 2154+00
4. LM 2.75 Unit 3 (MA11). DWR Sta 3039+25
5. LM 1.32 Unit 9 (MA10). DWR Sta 3306+37
6. LM 1.51 Unit 4. DWR Sta 1078+00
7. LM 3.89 Unit 4. DWR Sta 1206+75
8. LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
9. LM >10.99 Unit 4 (Mayhew). DWR Sta 1611+00
10. LM 0.91 Unit 7. DWR Sta 5048+49
11. LM 0.81 Unit 2. DWR Sta 3029+66
12. LM 6.43 Unit 3 (RD1000). DWR Sta 334+74
13. LM 4.85 Unit 3 (RD1000). DWR Sta 262+47
14. LM 3.85 Unit 3 (RD1000). DWR Sta 209+26
15. LM 0.96 Unit 3 (RD1000). DWR Sta 51+27
16. LM 7.05 Unit 1 (RD1000). DWR Sta 1489+00
17. LM 10.40 Unit 1 (RD1000). DWR Sta 1902+00
18. LM 13.10 Unit 1 (RD1000). DWR Sta 1827+00
19. LM 14.51 Unit 1 (RD1000). DWR Sta 1875+00
20. LM 1.49 Unit 1 (COS). DWR Sta 1099+92
21. LM 2.82 Unit 1 (COS). DWR Sta 1363+00
22. LM 3.36 Unit 1 (COS). DWR Sta 1392+00
23. LM 7.17 Unit 1 (COS). DWR Sta 1618+00
Notes:
Landside toe elevation is higher than design WSE for the following sections:
-LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
-LM >10.99 Unit 4 (Mayhew). DWR Sta 1611+00
-LM 1.32 Unit 9 (MA10). DWR Sta 3306+37
SACRAMENTO
West Sacramento
North Highlands
Natomas
Rio Linda
Elverta
Antelope
Roseville
Rocklin
Lincoln
Folsom
Citrus Heights
Orangevale
Fair Oaks
Carmichael
Parkway
Florin
Vineyard
Elk Grove
Wilton
Galt
Isleton
Walnut Grove
Courtland
Hood
Freeport
Clarksburg
Locke
Ryde
Rio Vista
Bethel Island
Discovery Bay
Byron
Tracy
Lathrop
Manteca
Ripon
Escalon
Lodi
Stockton
Linden
Lockeford
Woodbridge
Thornton
Walnut Grove
Hood
Courtland
Locke
Ryde
Isleton
Clarksburg
Freeport
Rio Vista
Bethel Island
Discovery Bay
Byron
Tracy
Lathrop
Manteca
Ripon
Escalon
Lodi
Stockton
Linden
Lockeford
Woodbridge
Thornton
NO CUTOFF WALL WITH CUTOFF WALL
GRAPHICAL LEGEND
Vertical Gradient 0.0-0.2
Vertical Gradient 0.4-0.6
Vertical Gradient 0.8-1.0
Vertical Gradient >1.0
Landside Toe Elevation Higher than Design WSE
Final Average Vertical Gradient Through Element
LEGEND
Approximate Levee Mile
Levee Alignment
Location of Analysis Sections
Approximate Scale in feet
US Army Corps of Engineers
URS
1333 BROADWAY, SUITE 800
OAKLAND, CA 94612
PHONE: (510) 893-3600
FAX: (510) 874-3268
FIGURE 2-2
FINAL SEEPAGE RESULTS
LOW WATER SURFACE ELEVATION
American River Common Features GRR
Sacramento and Sutter Counties, CA
PROJECT NO. 26816760
CONTRACT NO. W912J8-08-D-0001
DELIVERY ORDER 0004
DATE 03/31/2009

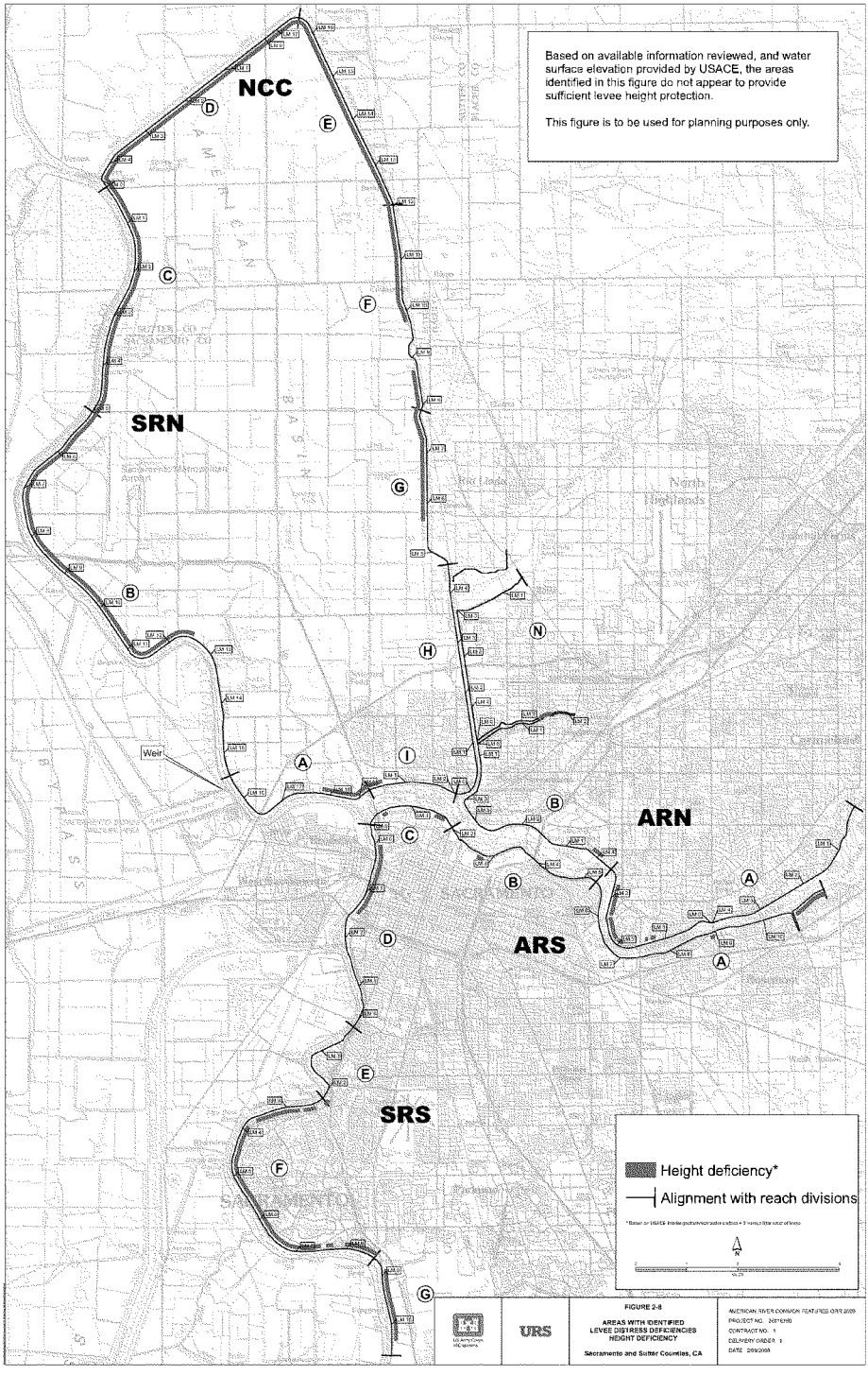

ANALYSIS CROSS SECTIONS
1. LM 4.27 Unit 4 (RD1000). DWR Sta 1129+00
2. LM 3.33 Unit 4 (RD1000). DWR Sta 1067+00
3. LM 1.28 Unit 2 (RD1000). DWR Sta 2154+00
4. LM 2.75 Unit 3 (MA11). DWR Sta 3039+25
5. LM 1.32 Unit 9 (MA10). DWR Sta 3306+37
6. LM 1.51 Unit 4. DWR Sta 1079+00
7. LM 3.89 Unit 4. DWR Sta 1206+75
8. LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
9. LM >10.99 Unit 4 (Mahyew). DWR Sta 1611+00
10. LM 0.61 Unit 7. DWR Sta 5048+49
11. LM 0.61 Unit 2. DWR Sta 3029+56
12. LM 6.43 Unit 3 (RD1000). DWR Sta 334+74
13. LM 4.85 Unit 3 (RD1000). DWR Sta 252+47
14. LM 3.85 Unit 3 (RD1000). DWR Sta 200+26
15. LM 0.98 Unit 3 (RD1000). DWR Sta 51+27
16. LSI 7.05 Unit 1 (RD1000). DWR Sta 1486+00
17. LM 10.40 Unit 1 (RD1000). DWR Sta 1962+00
18. LM 13.19 Unit 1 (RD1000). DWR Sta 1927+00
19. LM 14.51 Unit 1 (RD1000). DWR Sta 1876+00
20. LM 1.49 Unit 1 (COS). DWR Sta 1099+92
21. LM 2.83 Unit 1 (COS). DWR Sta 1383+00
22. LM 3.38 Unit 1 (COS). DWR Sta 1392+00
23. LM 7.17 Unit 1 (COS). DWR Sta 1618+00
Notes:
-Landside toe elevation is higher than design WSE for the following sections:
-LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
-LM >10.99 Unit 4 (Mahyew). DWR Sta 1611+00
-LM 1.32 Unit 9 (MA10). DWR Sta 3306+37
GRAPHICAL LEGEND
Vertical Gradient 0-1:2
Vertical Gradient 0.4-0.6
Vertical Gradient 0.6-0.8
Vertical Gradient 0.8-1.0
Section 999+00
LEVEE
Final Average Vertical Gradient Through Element
USGS
Approximate Levee Mile
Levee Alignment
Location of Analysis Sections
N
0 500
Approximate Scale In Feet
US Army Corps of Engineers
URS
1333 BROADWAY, SUITE 800
OAKLAND, CA 94612
PHONE: (510) 893-3600
FAX: (510) 874-3268
FIGURE 2-3
FINAL SEEPAGE RESULTS
HIGH WATER SURFACE ELEVATION
American River Common Features ORR
Sacramento and Sutter Counties, CA
PROJECT NO. 26817680
CONTRACT NO. W91238-08-D-0301
DELIVERY ORDER 0004
DATE 03/31/2009


ANALYSIS CROSS SECTIONS
1. LM 4.27 Unit 4 (RD1000). DWR Sta 1120+00
2. LM 3.33 Unit 4 (RD1000). DWR Sta 1067+00
3. LM 1.28 Unit 2 (RD1000). DWR Sta 2154+00
4. LM 2.75 Unit 3 (MA11). DWR Sta 3039+25
5. LM 1.32 Unit 9 (MA10). DWR Sta 3306+37
6. LM 1.51 Unit 4. DWR Sta 1078+00
7. LM 3.89 Unit 4. DWR Sta 1039+75
8. LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
9. LM 10.99 Unit 4 (Mahyew). DWR Sta 1611+05
10. LM 0.91 Unit 7. DWR Sta 5048+49
11. LM 0.61 Unit 2. DWR Sta 3029+96
12. LM 6.40 Unit 3 (RD1000). DWR Sta 334+74
13. LM 4.85 Unit 3 (RD1000). DWR Sta 252+47
14. LM 3.85 Unit 3 (RD1000). DWR Sta 290+28
15. LM 0.98 Unit 3 (RD1000). DWR Sta 51+27
16. LM 7.06 Unit 1 (RD1000). DWR Sta 1489+00
17. LM 10.40 Unit 1 (RD1000). DWR Sta 1662+00
18. LM 13.19 Unit 1 (RD1000). DWR Sta 1807+00
19. LM 14.51 Unit 1 (RD1000). DWR Sta 1875+00
20. LM 1.49 Unit 1 (COS). DWR Sta 1059+92
21. LM 2.83 Unit 1 (COS). DWR Sta 1383+00
22. LM 3.38 Unit 1 (COS). DWR Sta 1392+00
23. LM 7.17 Unit 1 (COS). DWR Sta 1618+00
Notes:
-Landside toe elevation is higher than design WSE for the following sections:
-LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
-LM 10.99 Unit 4 (Mahyew). DWR Sta 1611+00
-LM 1.32 Unit 9 (MA10). DWR Sta 3306+37
NATOMAS CROSS CANAL
SACRAMENTO RIVER EAST LEVEE - NORTH (RD 1000)
NATOMAS EAST MAIN DRAINAGE CANAL (NEMDC) - WEST LEVEE
SACRAMENTO RIVER EAST LEVEE - NORTH (COS, NEMDC)
AMERICAN RIVER NORTH LEVEE
AMERICAN RIVER SOUTH LEVEE
Natomas
North Highlands
Rio Linda
Elverta
Antelope
Roseville
Sacramento
Arden-Arcade
Carmichael
Citrus Heights
Orangevale
Fair Oaks
Folsom
Gold River
Rancho Cordova
Parkway
Florin
Elk Grove
Laguna
Vineyard
Meadowview
Pocket
Greenhaven
Freeport
Walnut Grove
Courtland
Hood
Clarksburg
Isleton
Locke
Ryde
Rio Vista
Sherman Island
Brannan Island
Andrus Island
Twitchell Island
Bethel Island
Jersey Island
Byron
Discovery Bay
Knightsen
Oakley
Antioch
Pittsburg
Bay Point
Clayton
Concord
Martinez
Pacheco
Crockett
Rodeo
Hercules
Pinole
San Pablo
Richmond
El Cerrito
Kensington
Albany
Berkeley
Emeryville
Oakland
Alameda
San Leandro
Hayward
Castro Valley
San Lorenzo
Ashland
Cherryland
Fairview
Alameda Island
Bay Farm Island
San Francisco Bay
Suisun Bay
Carquinez Strait
Suisun Marsh
Grizzly Bay
Honker Bay
Montezuma Slough
Cache Slough
Lindsey Slough
Liberty Island
Yolo Bypass
Cosumnes River
Mokelumne River
San Joaquin River
Old River
Middle River
Grant Line Canal
Tom Paine Slough
Delta Cross Channel
Georgiana Slough
Steamboat Slough
Sutter Slough
Miner Slough
Elk Slough
Cache Slough
Lindsey Slough
Barker Slough
Ulatis Creek
Alamo Creek
Morrison Creek
Laguna Creek
Elder Creek
Stone Lake
Beach Lake
Lost Slough
Dead Horse Slough
Potato Slough
Mokelumne River
Threemile Slough
Little Potato Slough
Big Break
Frank Tract
Dutch Slough
Jersey Island
Browns Island
Webb Tract
Bacon Island
Woodward Island
Roberts Island
Empire Tract
Union Island
Tyler Island
Terminous Tract
Lower Jones Tract
Upper Jones Tract
Victoria Island
Holland Tract
Quimby Island
Sherman Lake
Decker Island
Prospect Slough
Shag Slough
Lindsey Slough
Cache Slough
Ryer Island
Grand Island
Hastings Tract
Walnut Grove
Courtland
Hood
Clarksburg
Isleton
Locke
Ryde
Rio Vista
Sherman Island
Brannan Island
Andrus Island
Twitchell Island
Bethel Island
Jersey Island
Byron
Discovery Bay
Knightsen
Oakley
Antioch
Pittsburg
Bay Point
Clayton
Concord
Martinez
Pacheco
Crockett
Rodeo
Hercules
Pinole
San Pablo
Richmond
El Cerrito
Kensington
Albany
Berkeley
Emeryville
Oakland
Alameda
San Leandro
Hayward
Castro Valley
San Lorenzo
Ashland
Cherryland
Fairview
Alameda Island
Bay Farm Island
San Francisco Bay
Suisun Bay
Carquinez Strait
Suisun Marsh
Grizzly Bay
Honker Bay
Montezuma Slough
Cache Slough
Lindsey Slough
Liberty Island
Yolo Bypass
Cosumnes River
Mokelumne River
San Joaquin River
Old River
Middle River
Grant Line Canal
Tom Paine Slough
Delta Cross Channel
Georgiana Slough
Steamboat Slough
Sutter Slough
Miner Slough
Elk Slough
Cache Slough
Lindsey Slough
Barker Slough
Ulatis Creek
Alamo Creek
Morrison Creek
Laguna Creek
Elder Creek
Stone Lake
Beach Lake
Lost Slough
Dead Horse Slough
Potato Slough
Mokelumne River
Threemile Slough
Little Potato Slough
Big Break
Frank Tract
Dutch Slough
Jersey Island
Browns Island
Webb Tract
Bacon Island
Woodward Island
Roberts Island
Empire Tract
Union Island
Tyler Island
Terminous Tract
Lower Jones Tract
Upper Jones Tract
Victoria Island
Holland Tract
Quimby Island
Sherman Lake
Decker Island
Prospect Slough
Shag Slough
Lindsey Slough
Cache Slough
Ryer Island
Grand Island
Hastings Tract
Walnut Grove
Courtland
Hood
Clarksburg
Isleton
Locke
Ryde
Rio Vista
Sherman Island
Brannan Island
Andrus Island
Twitchell Island
Bethel Island
Jersey Island
Byron
Discovery Bay
Knightsen
Oakley
Antioch
Pittsburg
Bay Point
Clayton
Concord
Martinez
Pacheco
Crockett
Rodeo
Hercules
Pinole
San Pablo
Richmond
El Cerrito
Kensington
Albany
Berkeley
Emeryville
Oakland
Alameda
San Leandro
Hayward
Castro Valley
San Lorenzo
Ashland
Cherryland
Fairview
Alameda Island
Bay Farm Island
San Francisco Bay
Suisun Bay
Carquinez Strait
Suisun Marsh
Grizzly Bay
Honker Bay
Montezuma Slough
Cache Slough
Lindsey Slough
Liberty Island
Yolo Bypass
Cosumnes River
Mokelumne River
San Joaquin River
Old River
Middle River
Grant Line Canal
Tom Paine Slough
Delta Cross Channel
Georgiana Slough
Steamboat Slough
Sutter Slough
Miner Slough
Elk Slough
Cache Slough
Lindsey Slough
Barker Slough
Ulatis Creek
Alamo Creek
Morrison Creek
Laguna Creek
Elder Creek
Stone Lake
Beach Lake
Lost Slough
Dead Horse Slough
Potato Slough
Mokelumne River
Threemile Slough
Little Potato Slough
Big Break
Frank Tract
Dutch Slough
Jersey Island
Browns Island
Webb Tract
Bacon Island
Woodward Island
Roberts Island
Empire Tract
Union Island
Tyler Island
Terminous Tract
Lower Jones Tract
Upper Jones Tract
Victoria Island
Holland Tract
Quimby Island
Sherman Lake
Decker Island
Prospect Slough
Shag Slough
Lindsey Slough
Cache Slough
Ryer Island
Grand Island
Hastings Tract
GRAPHICAL SCORE
FS > 1.5
1.4 > FS > 1.4
1.3 > FS > 1.2
FS < 1.2
LEGEND
Approximate Levee Mile
Levee Alignment
Location of Analyses Sections
Approximate Scale in Feet
Weekly Stats (Landside) stability
Partial Pool (Waterside) stability
Rapid Drawdown (Waterside) stability
US Army Corps of Engineers
URS
1333 BROADWAY, SUITE 800
OAKLAND, CA 94612
PHONE: (510) 893-3600
FAX: (510) 874-3268
FIGURE 2-4
FINAL STATIC STABILITY RESULTS
LOW WATER SURFACE ELEVATION
American River Common Features GRR
Sacramento and Sutter Counties, CA
PROJECT NO. 26818760
CONTRACT NO. W912SE-08-D-0001
DELIVERY ORDER 0004
DATE 03/31/2009


ANALYSIS CROSS SECTIONS
1. LM 4.27 Unit 4 (RD1000). DWR Sta 1120+00
2. LM 3.33 Unit 4 (RD1000). DWR Sta 1057+00
3. LM 1.39 Unit 2 (RD1000). DWR Sta 2154+00
4. LM 2.79 Unit 3 (MA11). DWR Sta 2039+25
5. LM 1.32 Unit 9 (MA10). DWR Sta 3306+37
6. LM 1.51 Unit 4. DWR Sta 1078+00
7. LM 3.89 Unit 4. DWR Sta 1039+75
8. LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
9. LM >10.99 Unit 4 (Mahysw). DWR Sta 1611+00
10. LM 0.91 Unit 7. DWR Sta 5048+49
11. LM 0.81 Unit 2. DWR Sta 3023+66
12. LM 6.43 Unit 3 (RD1000). DWR Sta 334+74
13. LM 4.85 Unit 3 (RD1000). DWR Sta 252+47
14. LM 3.89 Unit 3 (RD1000). DWR Sta 200+26
15. LM 0.98 Unit 3 (RD1000). DWR Sta 51+27
16. LM 7.06 Unit 1 (RD1000). DWR Sta 1469+00
17. LM 10.40 Unit 1 (RD1000). DWR Sta 1562+00
18. LM 13.19 Unit 1 (RD1000). DWR Sta 1807+00
19. LM 14.51 Unit 1 (RD1000). DWR Sta 1876+00
20. LM 1.49 Unit 1 (COS). DWR Sta 1099+92
21. LM 2.83 Unit 1 (COS). DWR Sta 1383+00
22. LM 3.38 Unit 1 (COS). DWR Sta 1392+00
23. LM 7.17 Unit 1 (CGS). DWR Sta 1618+00
Notes:
-Landside toe elevation is higher than design WSE for the following sections:
-LM 10.81 Unit 4 (Mayhew). DWR Sta 1569+00
-LM >10.99 Unit 4 (Mahysw). DWR Sta 1611+00
-LM 1.32 Unit 9 (MA10). DWR Sta 3306+37
NATOMAS CROSS CANAL
SACRAMENTO RIVER EAST LEVEE - NORTH (RD 1000)
NATOMAS EAST MAIN DRAINAGE CANAL (NEMDC) - WEST LEVEE
SACRAMENTO RIVER EAST LEVEE - SOUTH (CO/SAC/MA)
AMERICAN RIVER NORTH LEVEE
AMERICAN RIVER SOUTH LEVEE
SYMBOLOGY & NOTES
FS > 1.0
1.0 ≥ FS ≥ 1.4
FS ≥ 1.4
LM 3.97 (D-Section)
SS 1.00
SP 1.00
RSS 1.00
Sacramento Levee Mile
Levee Alignment
Location of Analysis Sections
LEGEND
Approximate Scale in Feet
Steady State (Landside) stability
Partial Pool (Flatwater) stability
Rapid Drawdown (Waterside) stability
US Army Corps of Engineers
URS
1333 BROADWAY, SUITE 800
OAKLAND, CA 94612
PHONE: (510) 893-3600
FAX: (510) 874-3268
FIGURE 2-5
FINAL STATIC STABILITY RESULTS
HIGH WATER SURFACE ELEVATION
American River Common Features ORR
Sacramento and Sutter Counties, CA
PROJECT NO. 26816760
CONTRACT NO. W912SB-08-D-3001
DELIVERY ORDER 0004
DATE 03/31/2009


ANALYSIS CROSS SECTIONS
1. LM 4.27 Unit 4 (RD1000). DWR Sta 1130+00
2. LM 3.33 Unit 4 (RD1000). DWR Sta 1067+00
3. LM 1.28 Unit 2 (RD1000). DWR Sta 2154+00
4. LM 2.75 Unit 3 (MA11). DWR Sta 3034+25
5. LM 1.32 Unit 9 (MA10). DWR Sta 3305+37
6. LM 1.51 Unit 4. DWR Sta 1078+00
7. LM 3.89 Unit 4. DWR Sta 1206+75
8. LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
9. LM +10.99 Unit 4 (Mahyew). DWR Sta 1611+00
10. LM 0.91 Unit 7. DWR Sta 5048+49
11. LM 0.91 Unit 2. DWR Sta 3028+59
12. LM 6.43 Unit 3 (RD1000). DWR Sta 334+74
13. LM 4.85 Unit 3 (RD1000). DWR Sta 252+47
14. LM 3.85 Unit 3 (RD1000). DWR Sta 200+26
15. LM 0.98 Unit 3 (RD1000). DWR Sta 51+27
16. LM 7.05 Unit 1 (RD1000). DWR Sta 1469+00
17. LM 10.40 Unit 1 (RD1000). DWR Sta 1882+00
18. LM 13.19 Unit 1 (RD1000). DWR Sta 1807+00
19. LM 14.51 Unit 1 (RD1000). DWR Sta 1875+00
20. LM 1.45 Unit 1 (COS). DWR Sta 1089+92
21. LM 2.83 Unit 1 (COS). DWR Sta 1363+00
22. LM 3.39 Unit 1 (COS). DWR Sta 1392+00
23. LM 7.17 Unit 1 (COS). DWR Sta 1818+00
Notes:
- Levitation toe elevation is higher then design WSE for the following sections:
- LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
- LM +10.99 Unit 4 (Mahyew). DWR Sta 1611+00
- LM 1.32 Unit 9 (MA10). DWR Sta 3305+37
NATOMAS CROSS CANAL
SACRAMENTO RIVER EAST LEVEE - NORTH (RD 1000)
NATOMAS EAST MAIN DRAINAGE CANAL - WEST LEVEE (NEMDC)
AMERICAN RIVER NORTH LEVEE
AMERICAN RIVER SOUTH LEVEE
SACRAMENTO RIVER EAST LEVEE - SOUTH (RD 1000 AND MA9)
GRAPHICAL LEGEND
PROVIDES RISK REDUCTION
ACHIEVES COMPLIANCE
ACHIEVES COMPLIANCE
Potential for seismic deformation
LEGEND
Approximate Levee Mile
Levee Alignment
Location of Analysis Sections
Approximate Scale in feet
US Army Corps of Engineers
URS
1333 BROADWAY, SUITE 800
OAKLAND, CA 94612
PHONE: (510) 893-3600
FAX: (510) 874-3268
FIGURE 2-6
FINAL SEISMIC VULNERABILITY RESULTS FOR WINTER WATER SURFACE ELEVATION
American River Common Features GRR
Sacramento and Sutter Counties, CA
PROJECT NO. 26816760
CONTRACT NO. W91238-08-D-0001
DELIVERY ORDER 0004
DATE 03/31/2009


ANALYSIS CROSS SECTIONS
1. LM 4.27 Unit 4 (RD1000). DWR Sta 1120+00
2. LM 3.33 Unit 4 (RD1000). DWR Sta 1067+00
3. LM 1.28 Unit 2 (RD1000). DWR Sta 2154+00
4. LM 2.75 Unit 3 (MA11). DWR Sta 3038+25
5. LM 1.32 Unit 9 (MA10). DWR Sta 3308+57
6. LM 1.51 Unit 4. DWR Sta 1078+00
7. LM 3.89 Unit 4. DWR Sta 1206+75
8. LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
9. LM >10.99 Unit 4 (Mayhew). DWR Sta 1611+00
10. LM 0.91 Unit 7. DWR Sta 5040+40
11. LM 0.91 Unit 2. DWR Sta 3029+50
12. LM 6.43 Unit 3 (RD1000). DWR Sta 334+74
13. LM 4.85 Unit 3 (RD1000). DWR Sta 252+47
14. LM 3.85 Unit 3 (RD1000). DWR Sta 200+28
15. LM 0.98 Unit 3 (RD1000). DWR Sta 51+27
16. LM 7.00 Unit 1 (RD1000). DWR Sta 1486+00
17. LM 10.40 Unit 1 (RD1000). DWR Sta 1982+00
18. LM 13.19 Unit 1 (RD1000). DWR Sta 1907+00
19. LM 14.51 Unit 1 (RD1000). DWR Sta 1876+00
20. LM 1.49 Unit 1 (COS). DWR Sta 1099+02
21. LM 2.83 Unit 1 (COS). DWR Sta 1363+02
22. LM 3.38 Unit 1 (COS). DWR Sta 1392+00
23. LM 7.17 Unit 1 (COS). DWR Sta 1618+00
Notes:
-Landside toe elevation is higher than design WSE for the following sections.
-LM 10.81 Unit 4 (Mayhew). DWR Sta 1565+00
-LM >10.99 Unit 4 (Mayhew). DWR Sta 1611+00
-LM 1.32 Unit 9 (MA10). DWR Sta 3308+57
NATOMAS CROSS CANAL
SACRAMENTO RIVER EAST LEVEE, NORTH (RD 1000)
NATOMAS EAST MAIN DRAINAGE CANAL (NEMDC) WEST LEVEE
AMERICAN RIVER NORTH LEVEE
AMERICAN RIVER SOUTH LEVEE
SACRAMENTO RIVER EAST LEVEE, SOUTH (COS AND MAIN)
LEGEND
Approximate Levee Mile
Levee Alignment
Location of Analysis Sections
Approximate Scale in feet
Total levee erosion for two-step hydrograph
Breach Risk for two-step hydrograph (Levee or Foundation)
US Army Corps of Engineers
URS
1333 BROADWAY, SUITE 800
OAKLAND, CA 94612
PHONE: (510) 893-3600
FAX: (510) 874-3262
FIGURE 2-7
FINAL EROSION RESULTS
TWO-STEP HYDROGRAPH -
NO ARMOR OR VEGETATION
American River Common Features CRR
Sacramento and Sutter Counties, CA
PROJECT NO. 26816760
CONTRACT NO. W91238-08-D-0001
DELIVERY ORDER 0004
DATE 03/31/2009


Based on available information reviewed, and water surface elevation provided by USACE, the areas identified in this figure do not appear to provide sufficient levee height protection.
This figure is to be used for planning purposes only.
NCC
SRN
ARN
ARS
SRS
Weir
Height deficiency*
Alignment with reach divisions
FIGURE 2-8
AREAS WITH IDENTIFIED LEVEE DISTRESS DEFICIENCIES HEIGHT DEFICIENCY
Sacramento and Sutter Counties, CA
URS

Borings

Natomas Basin Levee Unit 1 Reach A (NAT A)
Sacramento River East Levee, LM 18.6 to 17.81 (RM 60.80 to 63.92) Existing Conditions
Index Point - LM 16.7 (RM 62.6)

Boring #	Blanket Thickness (ft)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Blanket Material	Blanket Kv (ft/day)	Aquifer Material	Aquifer Material Kh (ft/day)	kh/kv	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Sand Thickness (BF)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation
Sac. River East Levee Unit 1 LM 0.5 to 3.0																			
DH-2 (C)	5					CL	0.0028	SM	0.57	204					103				
2F-00-05/SPT-5 (T)	8					CL	0.0028	SP	5.7	2036					110				
2F-00-08/SPT-8 (F)	7	8	2	5	28	CL	0.0028	SP	5.7	2036	1425	946	895133	66	110	108	3	9	3
SRB 53 (C)	9					CL	0.0028	SP	5.7	2036					107				
URS071000-880+00C	9					CL	0.0028	SM/SP	0.57	204					105				
CPT-N2 (C)	12					CL	0.0028	SP	5.7	2036					110				

Material	Permeabilities: Kh		Kv		
	cm/sec	ft/day	cm/sec	ft/day	Kv/Kh
Clays(CL)	1.00E-05	0.028	1.00E-06	0.007	0.1
Silty sand (SM)	2.00E-04	0.57	2.00E-05	0.057	0.1
Poorly Graded Sand (SP)	2.00E-03	5.7	2.00E-04	0.57	0.1

UNDERSEEPAGE ANALYSI

Natomas Basin Levee Unit 1 Reach A (NAT A)
Sacramento River East Levee, LM 18.6 to 17.81 (RM 60.80 to 63.92)
Index Point - LM 16.7 (RM 62.6)
Crest width (feet) 20.00
Horizontal to vertical slope ratio 3.00

K-r = riverside permeability
K-L = landside permeability
Dbr = riverside blanket thickness
DbL = landside blanket thickness
Df = thickness of pervious foundation
Lr = length of riverside blanket
Ll = length of landside blanket

H = max.head or levee height
Hwt = head above tailwater at berm etel
HWt = head above tailwater at 1/2 berm
Ho = head above tailwater at levee toe
i-c = critical seepage gradient
Wt = berm width
i-o = seepage gradient
Cr = riverside effective length coefficient
Cl = landside effective length coefficient
L1 = riverside effective length

L2 = levee base width
Le = landside effective length
Lt = total effective length
t' = underseepage berm thickness at toe
Sc = calculated slope of underseepage berm
tu = used thickness of underseepage berm

Station	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Factor of Safety	L't	Ho	H'wt	i-o	Cr	Cl	L1	L2	Le	Lt	Hwt	t'
1.30	1425	1425	8.3	8.3	8.3	107.5	20.0	0.800	200	0	0.43	1442	15.7	15.7	1.88	1130	1130	198	114	1130	1442	NA	NA

Head = 20.00
X2 = 140

	KEKb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1425	8	107.5	1130	338	15.4	1.8474366		
	2571	8	107.5	1457	339	16.2	1.9073703	0.0320253	11.6442
	479	8	107.5	635	334	13.2	1.5894578		
	1425	11	107.5	1279	338	15.8	1.4819515	0.2429713	88.343
	1425	6	107.5	958	337	14.8	2.4677989		
	1425	8	110.5	1146	338	15.4	1.8532589	0.0000348	0.0126
	1425	8	104.5	1114	338	15.3	1.8614527		
							Total	0.275034	100

E[I] = 1.8474
Var[I]= 0.27503
sigma[I]= 0.52443
V(I) = 0.2839

E[ln I] = 0.57505
sigma [ln I] = 0.278390

I crit = 0.800
ln(I crit) = -0.22314

F(z) = 0.00207
Pr(F) = 99.79292

Head = 16.00
X2 = 140

	KEKb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1425	8	108	1130	338	12.3	1.4779477		
	2371	8	108	1457	339	13.0	1.5578065	0.0201962	11.6442
	479	8	108	635	334	10.6	1.2715662		
	1425	11	108	1279	338	12.7	1.1855612	0.155503 6	88.343
	1425	6	108	958	337	11.8	1.9742351		
	1425	8	111	1146	338	12.4	1.4825831	0.0000223	0.0126
	1425	8	104	1114	338	12.3	1.4931462		
							Total	0.1760201	100

E[I] = 1.4779
Var[I]= 0.17602
sigma[I]= 0.41955
V(I) = 0.2839

E[ln I] = 0.35190
sigma [ln I] = 0.278389

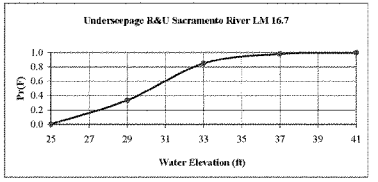
I crit = 0.800
ln(I crit) = -0.22314

F(z) = 0.01943
Pr(F) = 98.05678

Table 1 : Random Variables

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	8	2	25
Perm Ratio	1425	946	66
Pdn Sand thickness	108	3	3

Head	Elevation	Pr Seepage
4	25	0.00178
8	29	0.83570
12	33	0.84902
16	37	0.98057
20	41	0.99793



562

Head = 12.00
X2 = 140

Mean

K/Kb	z	d	X3	s	bo	I	Variance Component	Percent of Variance
1425	8	108	1130	338	9.2	1.1084608		
2371	8	108	1457	339	9.7	1.1684222	0.0115291	11.6442
479	8	108	655	334	7.9	0.9336747		
1425	11	108	1279	338	9.5	0.8897109	0.0874697	88.343
1425	6	108	958	337	8.9	1.0866763		
1425	8	111	1146	338	9.3	1.1119373	0.0000125	0.0126
1425	8	104	1114	338	9.2	1.1048596		
						Total	0.0990113	100

E[I] = 1.1085 E[ln I] = 0.06422
Var[I]= 0.09901
sigma[I]= 0.31466 sigma [ln I] = 0.278390
V(I) = 0.2839

I crit =	0.800	ln(I crit) =	-0.22314

F(z) =	0.15098
Pr(F) =	84.90206

Head = 8.00
X2 = 140

Mean

K/Kb	z	d	X3	s	bo	I	Variance Component	Percent of Variance
1425	8	108	1130	338	6.2	0.7389738		
2371	8	108	1457	339	6.5	0.7789481	0.0051241	11.6442
479	8	108	655	334	5.3	0.6357843		
1425	11	108	1279	338	6.3	0.5923806	0.0388754	88.343
1425	6	108	958	337	5.9	0.9671175		
1425	8	111	1146	338	6.2	0.7412915	0.0000056	0.0126
1425	8	104	1114	338	6.1	0.7345733		
						Total	0.0440050	100

E[I] = 0.7399 E[ln I] = -0.34124
Var[I]= 0.04401
sigma[I]= 0.20977 sigma [ln I] = 0.278390
V(I) = 0.2839

I crit =	0.800	ln(I crit) =	-0.22314

F(z) =	0.66430
Pr(F) =	33.57612

Head = 4.00
X2 = 140

Mean

K/Kb	z	d	X3	s	bo	I	Variance Component	Percent of Variance
1425	8	108	1130	338	3.1	0.3694869		
2371	8	108	1457	339	3.2	0.3894741	0.0012810	11.6442
479	8	108	655	334	2.6	0.3178916		
1425	11	108	1279	338	3.2	0.2963903	0.0097189	88.343
1425	6	108	958	337	3.0	0.4835589		
1425	8	111	1146	338	3.1	0.3706458	0.0000014	0.0126
1425	8	104	1114	338	3.1	0.3682863		
						Total	0.0110013	100

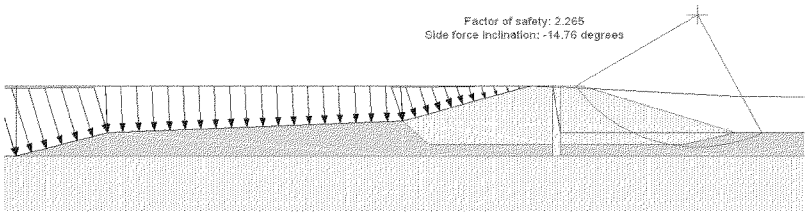
E[I] = 0.3695 E[ln I] = -1.03439
Var[I]= 0.01100
sigma[I]= 0.10489 sigma [ln I] = 0.278390
V(I) = 0.2839

I crit =	0.800	ln(I crit) =	-0.22314

F(z) =	0.95822
Pr(F) =	0.17838

STABILITY ANALYSIS

Natomas Basin Levee Unit 1 Reach A (NAT A)
Sacramento River East Levee, LM 18.6 to 17.81 (RM 60.80 to 63.92) Existing Cor
Index Point - LM 16.7 (RM 62.6)



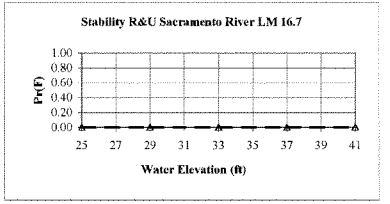
Head = 17.00
X2 = 135

Reliability Analysis of Critical Slide								
Run	Sand Φ	Clay Cohesion	Clay Φ	Sand γ	Clay γ	FS	Variance Component	Percent of Variance
Mean 1	33	50	26	125	115	2.265		
2	37	50	26	125	115	2.440	0.0552250	79.6027
3	29	50	26	125	115	1.970		
4	33	30	26	125	115	1.663	0.0018923	2.7275
5	33	70	26	125	115	1.750		
6	33	50	29	125	115	1.807	0.0119903	17.2831
7	33	50	23	125	115	1.588		
8	33	50	26	130	115	1.727	0.0001960	0.2825
9	33	50	26	120	115	1.755		
10	33	50	26	125	120	1.717	0.0000723	0.1041
11	33	50	26	125	110	1.700		
						Total	0.0693758	100

E[FS] =	2.2650	E[ln FS] =	0.81086
Var[FS]=	0.06938		
sigma[FS]=	0.26339	sigma [ln FS] =	0.115898
V(FS) =	0.1163		
FS req'd =	1.000	ln(FS req'd) =	0.00000

Beta =	6.996318
F(z) =	0.000000
Pr(f) =	0.000000

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Sand Φ	33	4	12.00
Clay Cohesion	50	20	40.00
Clay Φ	26	3	12.00
Sand γ	125	5	4.00
Clay γ	115	5	4.00

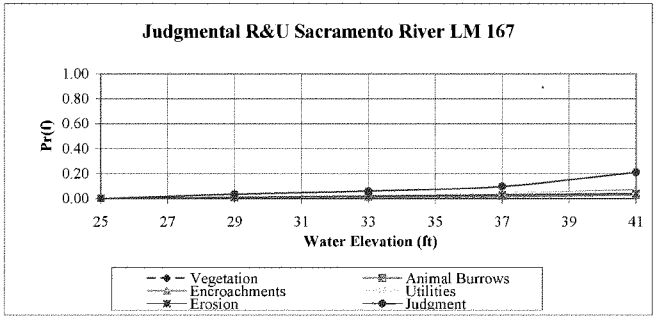


Elevation	Prf Stability
25	0.00000
29	0.00000
33	0.00000
37	0.00000
41	0.00000

Judgment Risk

Natomas Basin Levee Unit 1 Reach A (NAT A)
Sacramento River East Levee, LM 18.6 to 17.81 (RM 60.80 to 63.92) Existing Conditions
Index Point - LM 16.7 (RM 62.6)

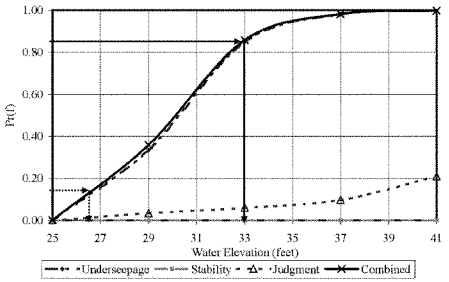
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
25	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.0000	1.00000	0.00000	1.00000	0.00000	1.000000
29	0.00500	0.99500	0.01000	0.99000	0.01000	0.99000	0.0100	0.99000	0.01000	0.99000	0.03446	0.965545
33	0.01000	0.99000	0.01200	0.98800	0.02000	0.98000	0.0200	0.98000	0.02000	0.98000	0.06039	0.939613
37	0.01500	0.98500	0.01700	0.98300	0.04000	0.96000	0.0400	0.96000	0.03000	0.97000	0.09774	0.902258
41	0.03000	0.97000	0.03000	0.97000	0.07000	0.93000	0.0600	0.94000	0.04000	0.96000	0.21037	0.789633



Combined Risk - Poor Performance
Natomas Basin Levee Unit 1 Reach A (NAT A)
Sacramento River East Levee, LM 18.6 to 17.81 (RM 60.80 to 63.92) Existing Conditions
Index Point - LM 16.7 (RM 62.6)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
25	0.00178	0.99822	0.00000	1.00000	0.00000	1.00000	0.00178	0.998216
29	0.33576	0.66430	0.00000	1.00000	0.03446	0.96554	0.35859	0.641410
33	0.84902	0.15098	0.00000	1.00000	0.06039	0.93961	0.85814	0.141862
37	0.98057	0.01943	0.00000	1.00000	0.09774	0.90226	0.98247	0.017531
41	0.99793	0.00207	0.00000	1.00000	0.21037	0.78963	0.99836	0.001635

Combined R&U Sacramento River LM 16.7



Levee Landside Toe Elev.	21 feet
Levee Crest Elev.	41 feet
15% Probability of Failure	26.5 feet
85% Probability of failure	33.0 feet

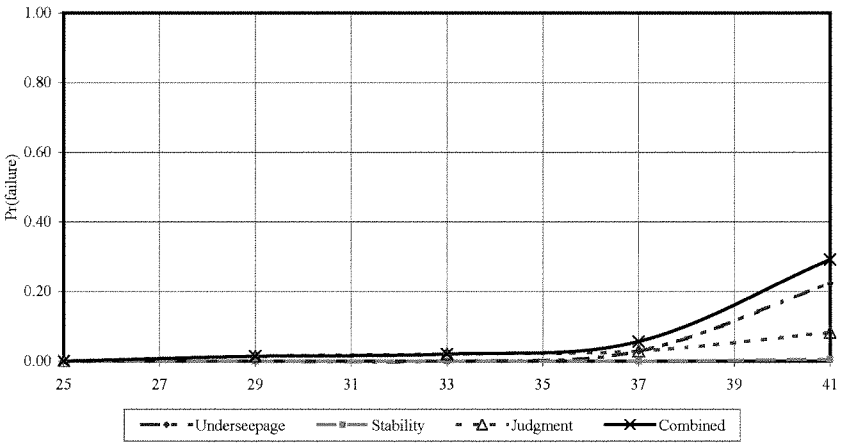
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 1 Reach A (NAT A)
Sacramento River East Levee, LM 18.6 to 17.81 (RM 60.80 to 63.92) Alternative 1 Cutoff Wall In Place
Index Point - LM 16.7 (RM 62.6)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
25	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
29	0.00000	1.00000	0.00000	1.00000	0.01407	0.98593	0.01407	0.985929
33	0.00000	1.00000	0.00000	1.00000	0.02010	0.97990	0.02010	0.979901
37	0.02824	0.97176	0.00000	1.00000	0.02892	0.97108	0.05635	0.943654
41	0.22356	0.77644	0.00536	0.99464	0.08258	0.91742	0.29149	0.708507

Combined R&U Sacramento River LM 16.7
Alternative 1 Cutoff Wall In Place



Levee Landside Toe Elev.	21 feet	
Levee Waterside Toe Elev.	25 feet	The elevations are in Datum NAVD 88
Levee Crest Elev.	41 feet	

Borings
Natomas Basin Levee Unit 1 Reach B-1 (NAT B-1)
Sacramento River East Levee, LM 15.50 to 5.00 (RM 63.92 to 74.42) Existing Conditions
Index Point LM 13.9 (RM 66.2)

Boring #	Blanket Thickness (ft)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Blanket Material	Blanket Kv (ft/day)	Aquifer Material	Aquifer Material Kh (ft/day)	kh/kv	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Sand Thickness (BF)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation
Sac. River East Levee Unit 1 LM 0.5 to 3.0																			
URS071000_718+00R	7					CL	0.0028	SM/SP	0.57	204					8				
2F-01-09 (F)	6					CL	0.0028	SP	5.7	2036					7				
CPT-00-5	25					CL	0.0028	SP	5.7	2036					12				
2F-00-03/SPT-3	26					CL	0.0028	SP	5.7	2036					14				
URS071000-732+00T	10					CL	0.0028	SM/SP	0.57	204					10				
URS071000-732+00F	9					CL	0.0028	SP	5.7	2036					22				
DH-7 (C)	7					CL	0.0028	SP	5.7	2036					24				
2F-01-12 (T)	10					CL	0.0028	SP	5.7	2036					7				
2F-01-13 (F)	6					CL	0.0028	SM/SP	0.57	204					23				
SRB-46 (C)	8	16	9	72	52	CL	0.0028	SP	5.7	2036	1623	795	632266	49	22	40	30	919	75
2F-01-15 (T)	15					CL	0.0028	SP	5.7	2036					80				
CPT-00-7 (T)	30					CL	0.0028	SP	5.7	2036					75				
CPT-N8 (C)	17					CL	0.0028	SP	5.7	2036					70				
URS071000-770+00T	25					ML	0.057	SP	5.7	100					56				
2F-00-04/SPT-4	22					CL	0.0028	SP	5.7	2036					72				
CPT-N7 (CL)	28					CL	0.0028	SP	5.7	2036					65				
SRB-49(C)	22					CL	0.0028	SP	5.7	2036					80				
CPT-00-8 (C)	19					CL	0.0028	SP	5.7	2036					80				

Permeabilities:

	Kh cm/sec	Kh ft/day	Kv cm/sec	Kv ft/day	Kv/Kh
Clays(CL)	4.00E-06	0.0112	1.00E-06	0.0028	0.25
Silt (ML)	2.00E-04	0.228	5.00E-05	0.057	0.25
Poorly Graded Sand (SP)	2.00E-03	5.7	2.00E-04	0.57	0.1
Sand, silty sand (SP, SM)	2.00E-04	0.57	2.00E-05	0.057	0.1

UNDERSEEPAGE ANALYSIS Reliability
Natomas Basin Levee Unit 1 Reach B-1 (NAT B-1)
Sacramento River East Levee, LM 15.50 to 5.00 (RM 63.92 to 74.42) Existing Conditions
Index Point LM 13.9 (RM 66.2)

Crest width (feet)		20.00	H	= max head or levee height		L2	= levee base width
Horizontal to vertical slope ratio		3.00	Hwt	= head above tailwater at berm end		Le	= landside effective length
			Hwt	= head above tailwater at 1/2 berm		Lt	= total effective length
K-r	= riverside permeability		Ho	= head above tailwater at levee toe		t'	= underseepage berm thickness at toe
K-L	= landside permeability		i-c	= critical seepage gradient		Sc	= calculated slope of underseepage berm
Dbr	= riverside blanket thickness		Wt	= berm width		tu	= used thickness of underseepage berm
DbL	= landside blanket thickness		i-o	= seepage gradient			
Df	= thickness of pervious foundation		Cr	= riverside effective length coefficient			
Lr	= length of riverside blanket		Cl	= landside effective length coefficient			
Ll	= length of landside blanket		L1	= riverside effective length			

Station	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Factor of Safety	L't	Ho	H'wt	i-o	Cr	Cl	L1	L2	Le	Lt	Hwt	t'
1.30	1623	1623	16.2	16.2	16.2	40.4	20.0	0.800	200	0	0.84	1342	15.4	15.4	0.95	1031	1031	198	114	1031	1342	NA	NA

Head = 20.00
X2 = 140

	K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1623	16	40.4	1031	338	15.1	0.9287596		
	2418	16	40.4	1258	338	15.8	0.9716157	0.0038747	1.1611
	828	16	40.4	736	335	13.7	0.8471216		
	1623	25	40.4	1273	338	15.8	0.6388292	0.3157741	94.629
	1623	8	40.4	711	335	13.6	1.7627049		
	1623	16	70.7	1364	339	16.0	0.9876985	0.0140478	4.2098
	1623	16	10.1	514	330	12.2	0.7506516		
							Total	0.3336966	100

E[I] = 0.9288 E[ln I] = -0.23742
Var[I]= 0.33370
sigma[I]= 0.57766 sigma [ln I] = 0.571871
V(I) = 0.6220

I crit = 0.800 ln(I crit) = -0.22314

F(z) =	0.50996
Pr(f) =	49.00301

Head = 16.00
X2 = 140

	K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1623	16	40	1031	338	12.1	0.7430077		
	2418	16	40	1258	338	12.6	0.777292	0.0024798	1.1611
	828	16	40	736	335	11.0	0.6776973		
	1623	25	40	1273	338	12.6	0.5110634	0.2020954	94.629
	1623	8	40	711	335	10.9	1.4101639		
	1623	16	71	1364	339	12.8	0.7901588	0.0089066	4.2098
	1623	16	10	514	330	9.7	0.6005213		
							Total	0.2135658	100

E[I] = 0.7430 E[ln I] = -0.46057
Var[I]= 0.21357
sigma[I]= 0.46213 sigma [ln I] = 0.571871
V(I) = 0.6220

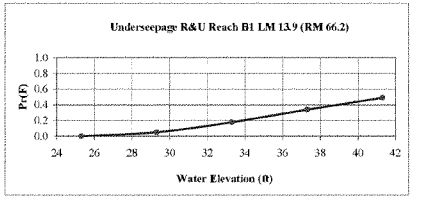
I crit = 0.800 ln(I crit) = -0.22314

F(z) =	0.66099
Pr(f) =	33.90088

Table 1: Random Variables

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	16	9	52
Perm Ratio	1623	795	49
Fdn Sand thickness	40	30	75

Head	Elevation	P/f Seepage
4	25.3	0.00226
8	29.3	0.05184
12	33.3	0.17925
16	37.3	0.33901
20	41.3	0.49004



Head = 12.00
X2 = 140

	KF/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1623	16	40	1031	338	9.0	0.5572557		
	2418	16	40	1258	338	9.5	0.582069	0.0013949	1.1611
	828	16	40	736	335	8.2	0.5082729		
	1623	25	40	1273	338	9.5	0.3832975	0.1136787	94.629
	1623	8	40	711	335	8.2	1.0576229		
	1623	16	71	1364	339	9.6	0.5926191	0.0050572	4.2098
	1623	16	10	514	330	7.3	0.450391		
							Total	0.1201308	100

E[I] = 0.5573 E[ln I] = -0.74825
Var[I]= 0.12043
sigma[I]= 0.34660 sigma [ln I] = 0.571871
V(I) = 0.6220

I crit = 0.800 ln(I crit) = -0.22314

F(z) = 0.82075
Pr(f) = 17.92508

Head = 8.00
X2 = 140

	KF/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1623	16	40	1031	338	6.0	0.3715038		
	2418	16	40	1258	338	6.3	0.388646	0.0006199	1.1611
	828	16	40	736	335	5.5	0.3388486		
	1623	25	40	1273	338	6.3	0.2555317	0.0505259	94.629
	1623	8	40	711	335	5.4	0.705082		
	1623	16	71	1364	339	6.4	0.3950794	0.0022476	4.2098
	1623	16	10	514	330	4.9	0.3002606		
							Total	0.0534915	100

E[I] = 0.3715 E[ln I] = -1.15371
Var[I]= 0.05339
sigma[I]= 0.23107 sigma [ln I] = 0.571871
V(I) = 0.6220

I crit = 0.800 ln(I crit) = -0.22314

F(z) = 0.94816
Pr(f) = 5.18452

Head = 4.00
X2 = 140

	KF/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1623	16	40	1031	338	3.0	0.1857519		
	2418	16	40	1258	338	3.2	0.194323	0.0001550	1.1611
	828	16	40	736	335	2.7	0.1694243		
	1623	25	40	1273	338	3.2	0.1277638	0.0126310	94.629
	1623	8	40	711	335	2.7	0.352541		
	1623	16	71	1364	339	3.2	0.1975397	0.0005619	4.2098
	1623	16	10	514	330	2.4	0.1501303		
							Total	0.0133479	100

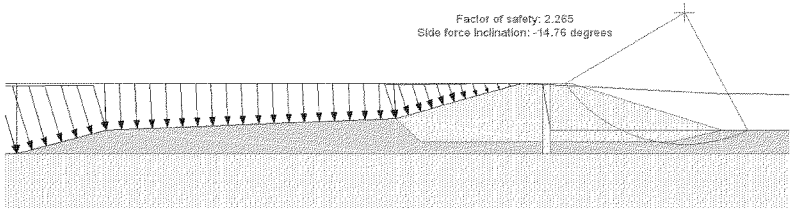
E[I] = 0.1858 E[ln I] = -1.84686
Var[I]= 0.01335
sigma[I]= 0.11553 sigma [ln I] = 0.571871
V(I) = 0.6220

I crit = 0.800 ln(I crit) = -0.22314

F(z) = 0.99774
Pr(f) = 0.22606

STABILITY ANALYSIS

Natomas Basin Levee Unit 1 Reach B-1 (NAT B-1)
Sacramento River East Levee, LM 15.50 to 5.00 (RM 63.92 to 74.42) Existing Conditions
Index Point LM 13.9 (RM 66.2)



Head = 17.00
X2 = 135

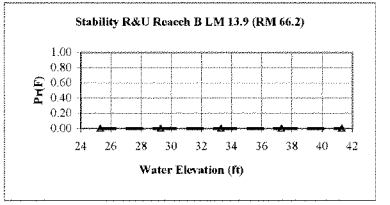
Reliability Analysis of Critical Slide								
Run	Sand Φ	Clay Cohesion	Clay Φ	Sand γ	Clay γ	FS	Variance Component	Percent of Variance
Mean 1	33	50	26	125	115	2.260		
2	37	50	26	125	115	2.440	0.0552250	79.6027
3	29	50	26	125	115	1.970		
4	33	30	26	125	115	1.663	0.0018923	2.7275
5	33	70	26	125	115	1.750		
6	33	50	29	125	115	1.807	0.0119903	17.2831
7	33	50	23	125	115	1.588		
8	33	50	26	130	115	1.727	0.0001960	0.2825
9	33	50	26	120	115	1.755		
10	33	50	26	125	120	1.717	0.0000723	0.1041
11	33	50	26	125	110	1.700		
						Total	0.0693758	100

E[FS] =	2.2600	E[ln FS] =	0.80862
Var[FS]=	0.06938		
sigma[FS]=	0.26339	sigma [ln FS] =	0.116153
V(FS) =	0.1165		
FS req'd =	1.000	ln(FS req'd) =	0.00000

Beta =	6.961696
F(z) =	0.000000
Pr(f) =	0.000000

Table 1 : Random Variables for East Bottoms

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Sand Φ	33	4	12.00
Clay Cohesion	50	20	40.00
Clay Φ	26	3	12.00
Sand γ	125	5	4.00
Clay γ	115	5	4.00

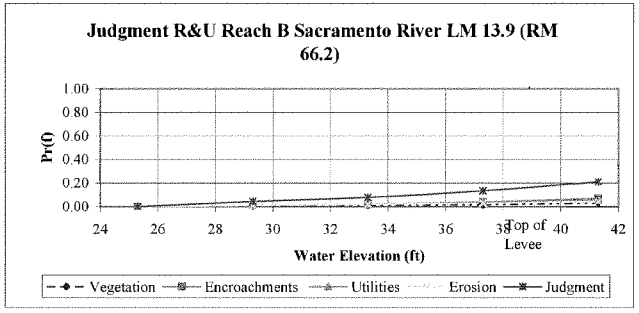


Elevation	Prf Stability
25.3	0.00000
29.3	0.00000
33.3	0.00000
37.3	0.00000
41.3	0.00000

Judgment Risk

Natomas Basin Levee Unit 1 Reach B-1 (NAT B-1)
Sacramento River East Levee, LM 15.50 to 5.00 (RM 63.92 to 74.42) Existing Conditions
Index Point LM 13.9 (RM 66.2)

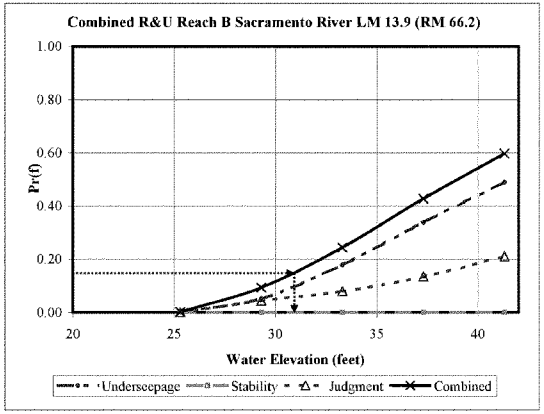
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Vegetation		Animal Burrow		Encroachments		Utilities		Erosion		Judgment	
25.3	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.0000	1.00000	0.00000	1.00000	0.00000	1.000000
29.3	0.00500	0.99500	0.01000	0.99000	0.01000	0.99000	0.0100	0.99000	0.01000	0.99000	0.04421	0.955793
33.3	0.01000	0.99000	0.01200	0.98800	0.02000	0.98000	0.0200	0.98000	0.02000	0.98000	0.07940	0.920599
37.3	0.01500	0.98500	0.01700	0.98300	0.04000	0.96000	0.0400	0.96000	0.03000	0.97000	0.13443	0.865573
41.3	0.03000	0.97000	0.03000	0.97000	0.07000	0.93000	0.0600	0.94000	0.04000	0.96000	0.21037	0.789633



Combined Risk - Poor Performance

Natomas Basin Levee Unit 1 Reach B-1 (NAT B-1)
Sacramento River East Levee, LM 15.50 to 5.00 (RM 63.92 to 74.42) Existing Conditions
Index Point LM 13.9 (RM 66.2)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
25.3	0.00226	0.99774	0.00000	1.00000	0.00000	1.00000	0.00226	0.997739
29.3	0.05184	0.94816	0.00000	1.00000	0.04421	0.95579	0.09376	0.906242
33.3	0.17925	0.82075	0.00000	1.00000	0.07940	0.92060	0.24442	0.755581
37.3	0.33901	0.66099	0.00000	1.00000	0.13443	0.86557	0.42786	0.572136
41.3	0.49004	0.50996	0.00000	1.00000	0.21037	0.78963	0.59732	0.402682



Levee Landside Toe Elev.	21.3 feet
Levee Crest Elev.	41.3 feet
15% Probability of Failure	31.3 feet
85% Probability of failure	above levee crest

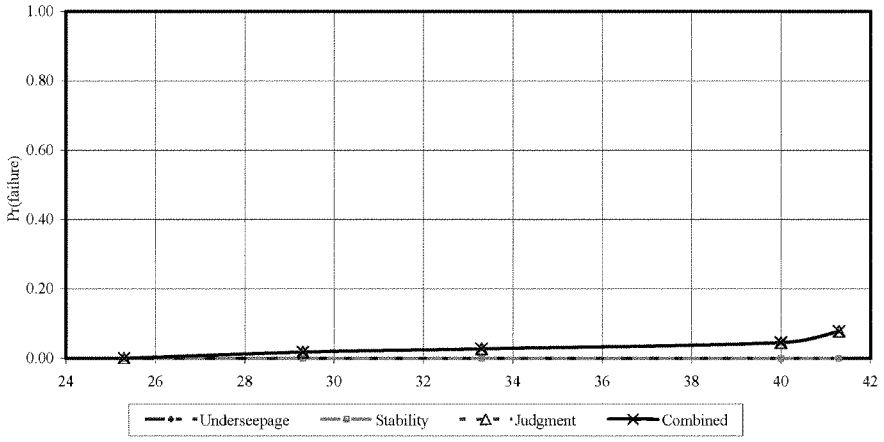
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 1 Reach B-1 (NAT B)
Sacramento River East Levee, LM 15.50 to 5.00 (RM 63.92 to 74.42) Alternative 1 Adjacent Levee with Cutoff Wall
Index Point LM 13.9 (RM 66.2)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
25.3	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
29.3	0.00000	1.00000	0.00000	1.00000	0.01785	0.98215	0.01785	0.982146
33.3	0.00000	1.00000	0.00000	1.00000	0.02725	0.97275	0.02725	0.972748
40.0	0.00000	1.00000	0.00000	1.00000	0.04507	0.95493	0.04507	0.954929
41.3	0.00000	1.00000	0.00000	1.00000	0.07794	0.92206	0.07794	0.922056

Combined R&U Reach B Sacramento River LM 13.9 (RM 66.2)
Alternative 1 Adjacent Levee with Cutoff Wall



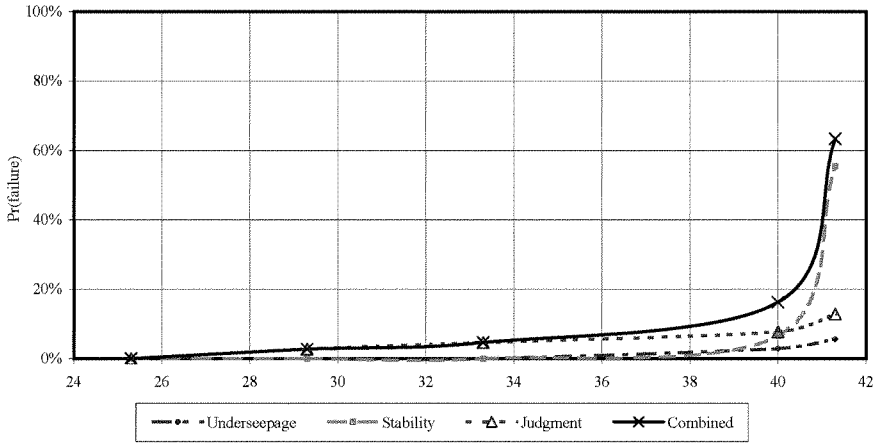
Levee Landside Toe Elev. 21.3 feet
Levee Crest Elev. 41.3 feet
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 1 Reach B-1 (NAT B)
Sacramento River East Levee, LM 15.50 to 5.00 (RM 63.92 to 74.42) Alternative 2 & 4 Drained Seepage Berm
Index Point LM 13.9 (RM 66.2)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
25.3	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
29.3	0.00000	1.00000	0.00000	1.00000	0.02721	0.97279	0.02721	0.972786
33.3	0.00000	1.00000	0.00000	1.00000	0.04614	0.95386	0.04614	0.953862
40.0	0.02924	0.97076	0.06532	0.93468	0.07706	0.92294	0.16257	0.837432
41.3	0.05618	0.94382	0.55476	0.44524	0.12808	0.87192	0.63360	0.366402

Combined R&U Reach B Sacramento River LM 13.9 (RM 66.2)
Alternative 2 Drained Seepage Berm



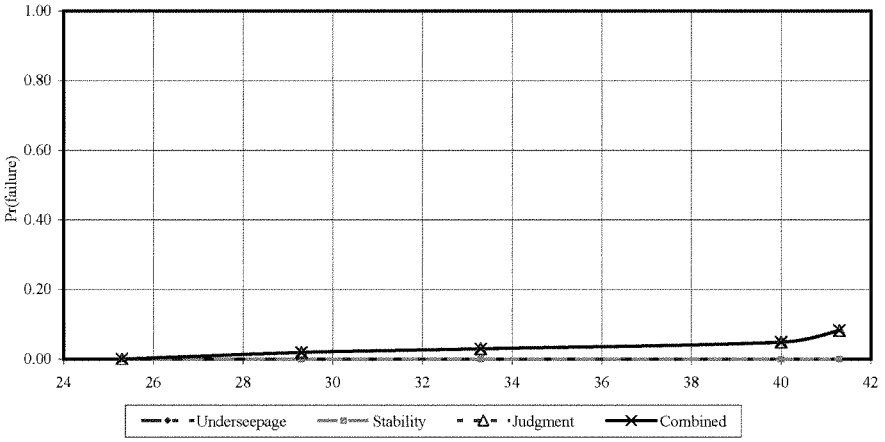
Levee Landside Toe Elev. 21.3 feet
Levee Crest Elev. 41.3 feet
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 1 Reach B-1 (NAT B)
Sacramento River East Levee, LM 15.50 to 5.00 (RM 63.92 to 74.42) Alternative 3 & 7 Cutoff Wall In Place
Index Point LM 13.9 (RM 66.2)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
25.3	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
29.3	0.00000	1.00000	0.00000	1.00000	0.01908	0.98092	0.01908	0.980917
33.3	0.00000	1.00000	0.00000	1.00000	0.02969	0.97031	0.02969	0.970310
40.0	0.00000	1.00000	0.00000	1.00000	0.04867	0.95133	0.04867	0.951334
41.3	0.00000	1.00000	0.00000	1.00000	0.08258	0.91742	0.08258	0.917423

Combined R&U Reach B Sacramento River LM 13.9 (RM 66.2)
Alternative 3 Cutoff Wall In Place



Levee Landside Toe Elev. 21.3 feet
Levee Crest Elev. 41.3 feet
The elevations are in Datum NAVD 88

BORINGS

Natomas Basin Levee Unit 1 Reach C (NAT C)
Sacramento River East Levee, LM 5.00 to 0.00 (RM 74.42 to RM 79.20) Existing Conditions Expert Elicitation
Index Point LM 1.33 (RM 78.0)

Boring #	Blanket Thickness (ft)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Blanket Material	Blanket Kv (ft/day)	Aquifer Material	Aquifer Material Kh (ft/day)	kh/kv	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Sand Thickness (BF)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation
Sac. River East Levee Unit 1 LM 0.5 to 3.0																			
URS071000-53+00R	32					CL, ML	0.057	SP	5.7	100					17				
SRB-2(T)	37					CL	0.0028	SP	5.7	2036					17				
SRE-06-6(T)	20					CL	0.0028	SP	5.7	2036					30				
SRE-6-8 (C)	15					CL	0.0028	SP	5.7	2036					20				
B00-1 (T)	19					CL	0.0028	SP	5.7	2036					23				
URS071000-70+00R	15					CL,ML	0.057	SP	5.7	100					43				
SRE-56-10(C)	16	19	8	56	41	CL	0.0028	SP	5.7	2036	1713	753	528422	44	22	29	12	161	43
URS071000-70+00T	15					CL	0.0028	SP	5.7	2036					43				
SRB-6-10 (C)	12					CL	0.0028	SP	5.7	2036					23				
SRB-6-11 (C)	17					CL	0.0028	SP	5.7	2036					24				
SRB-3 (T)	11					CL	0.0028	SP	5.7	2036					29				
SF-01-04 (R)	20					CL	0.0028	SP	5.7	2036					57				
URS071000_84+00 (C)	16					CL	0.0028	SP	5.7	2036					13				

	Permeabilities:				
	Kh		Kv		
	cm/sec	ft/day	cm/sec	ft/day	Kv/Kh
Clays(CL)	4.00E-06	0.0112	1.00E-06	0.0028	0.25
Silt (ML)	2.00E-04	0.228	5.00E-05	0.057	0.25
Poorly Graded Sand (SP)	2.00E-03	5.7	2.00E-04	0.57	0.1
Sand, silty sand (SP, SM)	2.00E-04	0.57	2.00E-05	0.057	0.1

577

UNDERSEEPAGE ANALYSIS **Reliability**

Natomas Basin Levee Unit 1 Reach C (NAT C)
Sacramento River East Levee, LM 5.00 to 0.00 (RM 74.42 to RM 79.20) Existing Conditions Expert Elicita
Index Point LM 1.33 (RM 78.0)

Crest width (feet)	20.00	H	= max head or levee height	L2	= levee base width
Horizontal to vertical slope ratio	3.00	Hwt	= head above tailwater at berm end	Le	= landside effective length
		Hwt	= head above tailwater at 1/2 berm	Lt	= total effective length
K-r = riverside permeability		Ho	= head above tailwater at levee toe (w/ berm)	t'	= underseepage berm thickness at toe
K-L = landside permeability		i-o	= critical seepage gradient	Sc	= calculated slope of underseepage berm
Dbr = riverside blanket thickness		Wt	= berm width	tu	= used thickness of underseepage berm
DbL = landside blanket thickness		i-o	= seepage gradient		
Df = thickness of pervious foundation		Cr	= riverside effective length coefficient		
Lr = length of riverside blanket		Cl	= landside effective length coefficient		
Ll = length of landside blanket		Ll	= riverside effective length		

Station	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-e	Lr	Wt	Factor of Safety	L't	Hwt	H'wt	i-o	Cr	Cl	L1	L2	Le	Lt	H'o	t'
1.30	1713	1713	19.1	19.1	19.1	29.0	18.0	0.800	160	0	1.03	1187	14.8	14.8	0.77	974	974	160	114	974	1187	NA	NA

Head = 18.00
X2 = 140

Mean

K/Kb	z	d	X3	s	bo	I	Variance Component	Percent of Variance
1713	19	29.0	974	240	14.4	0.7569301		
2467	19	29.0	1168	240	14.9	0.7836286	0.0013184	1.2042
960	19	29.0	729	239	13.5	0.7100089		
1713	27	29.0	1156	240	14.9	0.5545559	0.1069358	97.671
1713	11	29.0	749	239	13.6	1.2085766		
1713	19	41.4	1163	240	14.9	0.7820636	0.0012314	1.1247
1713	19	16.6	737	239	13.6	0.7118801		
						Total	0.1094856	100

E[I] = 0.7569 E[ln I] = -0.36592
Var[I]= 0.10949
sigma[I]= 0.33089 sigma [ln I] = 0.418177
V(I) = 0.4371

I crit = 0.800 ln(I crit) = -0.22314

P(c) = 0.53361
Pr(f) = 36.63911

Head = 15.00
X2 = 140

Mean

K/Kb	z	d	X3	s	bo	I	Variance Component	Percent of Variance
1713	19	29	974	240	12.6	0.630775		
2467	19	29	1168	240	12.4	0.6521905	0.0009156	1.2042
960	19	29	729	239	11.8	0.5916741		
1713	27	29	1156	240	12.4	0.4621299	0.0742610	97.671
1713	11	29	749	239	11.4	1.0071472		
1713	19	41	1163	240	12.4	0.6517197	0.0008552	1.1247
1713	19	17	737	239	11.8	0.5932334		
						Total	0.0760317	100

E[I] = 0.6308 E[ln I] = -0.54824
Var[I]= 0.07603
sigma[I]= 0.27574 sigma [ln I] = 0.418177
V(I) = 0.4371

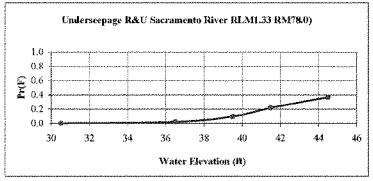
I crit = 0.800 ln(I crit) = -0.22314

P(c) = 0.78154
Pr(f) = 21.84359

Table 1 : Random Variables

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	19	8	43
Perm Ratio	1713	753	44
Fdn Sand thickness	29	12	43

Head	Elevation	Pr[Seepage
3	30.5	0.00000
9	36.5	0.02281
12	39.5	0.09492
15	41.5	0.21846
18	44.5	0.36539



Head = 12.00
X2 = 149

	K/Kb	z	d	X3	s	hs	I	Variance Component	Percent of Variance
Mean	1713	19	29	974	240	9.6	0.50462		
	2467	19	29	1168	240	10.0	0.5217524	0.0005860	1.2042
	960	19	29	729	239	9.6	0.4733392		
	1713	27	29	1156	240	9.9	0.5697039	0.0475270	97.671
	1713	11	29	749	239	9.1	0.5057177		
	1713	19	41	1163	240	9.9	0.5213757	0.0005473	1.1247
	1713	19	17	737	239	9.1	0.4745868		
							Total	0.0486603	100

E[I] = 0.5046 E[ln I] = -0.77139
Var[I]= 0.04866
sigma[I]= 0.22059 sigma [ln I] = 0.418177
V(I) = 0.4371

		P(z) =	0.80598
I crit =	0.860	Pr(I) =	9.49232

ln(I crit) = -0.22314

Head = 9.00
X2 = 140

	K/Kb	z	d	X3	s	hs	I	Variance Component	Percent of Variance
Mean	1713	19	29	974	240	7.2	0.378465		
	2467	19	29	1168	240	7.5	0.3913143	0.0003296	1.2042
	960	19	29	729	239	6.8	0.3550044		
	1713	27	29	1156	240	7.5	0.2772779	0.0267330	97.671
	1713	11	29	749	239	6.8	0.6042883		
	1713	19	41	1163	240	7.5	0.3910318	0.0003079	1.1247
	1713	19	17	737	239	6.8	0.3559301		
							Total	0.0273714	100

E[I] = 0.3785 E[ln I] = -1.05907
Var[I]= 0.02737
sigma[I]= 0.16544 sigma [ln I] = 0.418177
V(I) = 0.4371

		P(z) =	0.97719
I crit =	0.860	Pr(I) =	2.28056

ln(I crit) = -0.22314

Head = 3.00
X2 = 140

	K/Kb	z	d	X3	s	hs	I	Variance Component	Percent of Variance
Mean	1713	19	29	974	240	2.4	0.126155		
	2467	19	29	1168	240	2.5	0.1304381	0.0000366	1.2042
	960	19	29	729	239	2.3	0.1183348		
	1713	27	29	1156	240	2.5	0.092426	0.0029704	97.671
	1713	11	29	749	239	2.3	0.2014294		
	1713	19	41	1163	240	2.5	0.1303439	0.0000342	1.1247
	1713	19	17	737	239	2.3	0.1186467		
							Total	0.0030413	100

E[I] = 0.1262 E[ln I] = -2.15768
Var[I]= 0.00304
sigma[I]= 0.05515 sigma [ln I] = 0.418177
V(I) = 0.4371

		P(z) =	1.00000
I crit =	0.860	Pr(I) =	0.00019

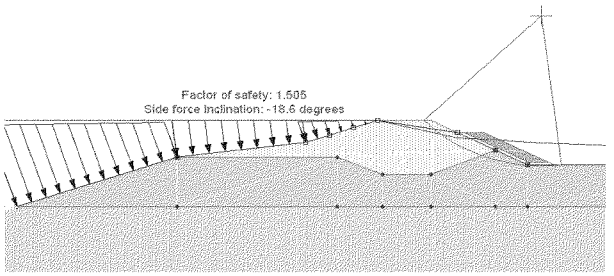
ln(I crit) = -0.22314

STABILITY ANALYSIS

Natomas Basin Levee Unit 1 Reach C (NAT C)

Sacramento River East Levee, LM 5.00 to 0.00 (RM 74.42 to RM 79.20) Existing Conditions Expert Elicitation

Index Point LM 1.33 (RM 78.0)



Head = 17.00

X2 = 135

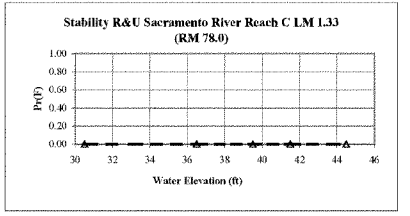
	Reliability Analysis of Critical Slide						Variance Component	Percent of Variance
	Run	Sand Φ	Clay Cohesion	Clay Φ	Sand γ	Clay γ	FS	
Mean	1	33	50	26	125	115	1.505	
	2	37	50	26	125	115	1.569	0.0041603
	3	29	50	26	125	115	1.440		19.5737
	4	33	30	26	125	115	1.464	0.0018490	8.6994
	5	33	70	26	125	115	1.550	
	6	33	50	29	125	115	1.626	0.0151290	71.1811
	7	33	50	23	125	115	1.380	
	8	33	50	26	130	115	1.490	0.0001000	0.4705
	9	33	50	26	120	115	1.510	
	10	33	50	26	125	120	1.508	0.0000160	0.0753
	11	33	50	26	125	110	1.500	
							Total	0.0212543	100

E[FS] =	1.5050	E[ln FS] =	0.40412
Var[FS]=	0.02125		
sigma[FS]=	0.14579	sigma [ln FS] =	0.096643
V(FS) =	0.0969		
FS req'd =	1.000	ln(FS req'd) =	0.00000

Beta =	4.181595
F(z) =	0.000014
Pr(f) =	0.001447

Table 1 : Random Variables for East Bottoms

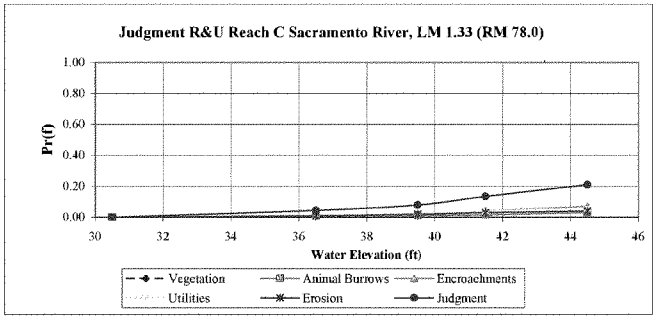
Parameter	Expected Value	Standard Deviation	Coefficient of Variation %
Sand Φ	33	4	12.00
Clay Cohesion	50	20	40.00
Clay Φ	26	3	12.00
Sand γ	125	5	4.00
Clay γ	115	5	4.00



Elevation	Prf Stability
30.5	0.00000
36.5	0.00000
39.5	0.00000
41.5	0.00000
44.5	0.00001

Judgment Risk
Natomas Basin Levee Unit 1 Reach C (NAT C)
Sacramento River East Levee, LM 5.00 to 0.00 (RM 74.42 to RM 79.20) Existing Conditions Expert Elicitation
Index Point LM 1.33 (RM 78.0)

	Pr(f)	R			Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
30.5	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.0000	1.00000	0.00000	1.00000	0.00000	1.000000
36.5	0.00500	0.99500	0.01000	0.99000	0.01000	0.99000	0.0100	0.99000	0.01000	0.99000	0.04421	0.955793
39.5	0.01000	0.99000	0.01200	0.98800	0.02000	0.98000	0.0200	0.98000	0.02000	0.98000	0.07940	0.920599
41.5	0.01500	0.98500	0.01700	0.98300	0.04000	0.96000	0.0400	0.96000	0.03000	0.97000	0.13443	0.865573
44.5	0.03000	0.97000	0.03000	0.97000	0.07000	0.93000	0.0600	0.94000	0.04000	0.96000	0.21037	0.789633



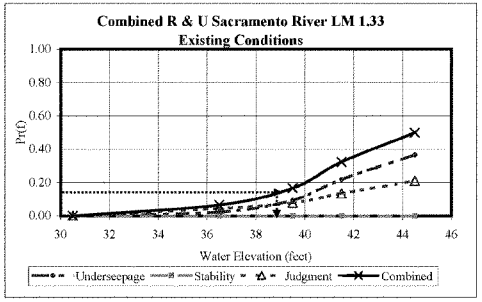
Combined Risk

Natomas Basin Levee Unit 1 Reach C (NAT C)

Sacramento River East Levee, LM 5.00 to 0.00 (RM 74.42 to RM 79.20) Existing Conditions Expert Elicitation

Index Point LM 1.33 (RM 78.0)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
30.5	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	0.999998
36.5	0.02281	0.97719	0.00000	1.00000	0.04421	0.95579	0.06600	0.933996
39.5	0.09492	0.90508	0.00000	1.00000	0.07940	0.92060	0.16679	0.833212
41.5	0.21846	0.78154	0.00000	1.00000	0.13443	0.86557	0.32352	0.676484
44.5	0.36639	0.63361	0.00001	0.99999	0.21037	0.78963	0.49969	0.500311



Levee Waterside Toe Elev.	30.5 feet
Levee Crest Elev.	44.5 feet
15% Probability of Failure	38.8 feet
85% Probability of failure	above levee crest

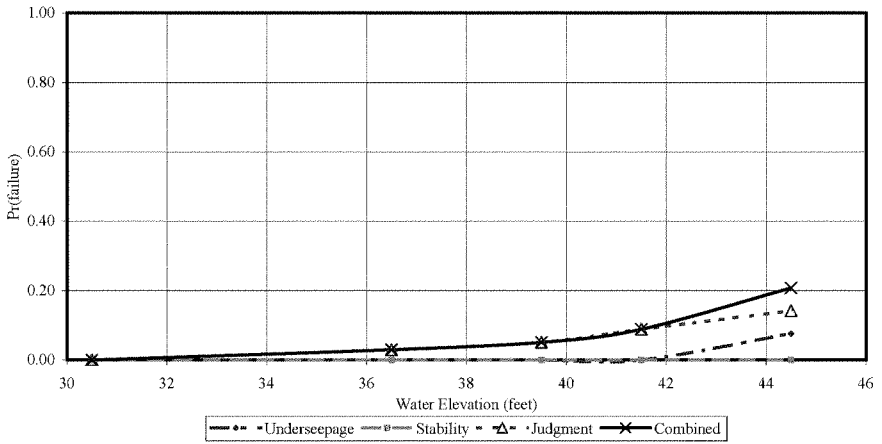
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 1 Reach C (NAT C)
Sacramento River East Levee, LM 5.00 to 0.00 (RM 74.42 to RM 79.20) Alternative 1 & 3 Drained Seepage Berm and Cutoff Wall In Place
Index Point LM 1.33 (RM 78.0)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
30.5	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
36.5	0.00000	1.00000	0.00000	1.00000	0.02967	0.97033	0.02967	0.970330
39.5	0.00000	1.00000	0.00000	1.00000	0.05100	0.94900	0.05100	0.948996
41.5	0.00000	1.00000	0.00000	1.00000	0.08901	0.91099	0.08901	0.910986
44.5	0.07626	0.92374	0.00000	1.00000	0.14198	0.85802	0.20741	0.792586

Combined Geotechnical Risk and Uncertainity - LM 1.33
Alternative 1 & 3 Drained Seepage Berm and Cutoff Wall In Place



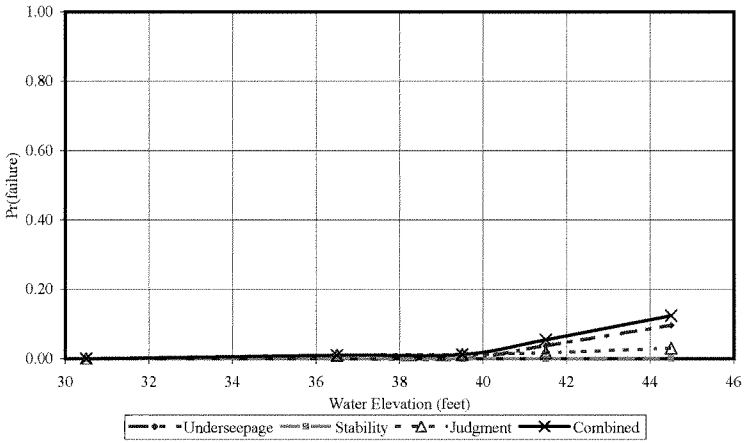
Levee Waterside Toe Elev. 30.5 feet
Levee Crest Elev. 44.5 feet
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 1 Reach C (NAT C)
Sacramento River East Levee, LM 5.00 to 0.00 (RM 74.42 to RM 79.20) Alternative 2 & 5 Adjacent Levee with Cutoff W
Index Point LM 1.33 (RM 78.0)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
30.5	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
36.5	0.00000	1.00000	0.00000	1.00000	0.01000	0.99000	0.01000	0.990000
39.5	0.00000	1.00000	0.00000	1.00000	0.01200	0.98800	0.01200	0.988000
41.5	0.03797	0.96203	0.00000	1.00000	0.01700	0.98300	0.05432	0.945679
44.5	0.09642	0.90358	0.00094	0.99906	0.03000	0.97000	0.12434	0.875657

Combined Geotechnical Risk and Uncertainity - LM 1.33
Alternative 2 & 5 Adjacent Levee with Cutoff Wall



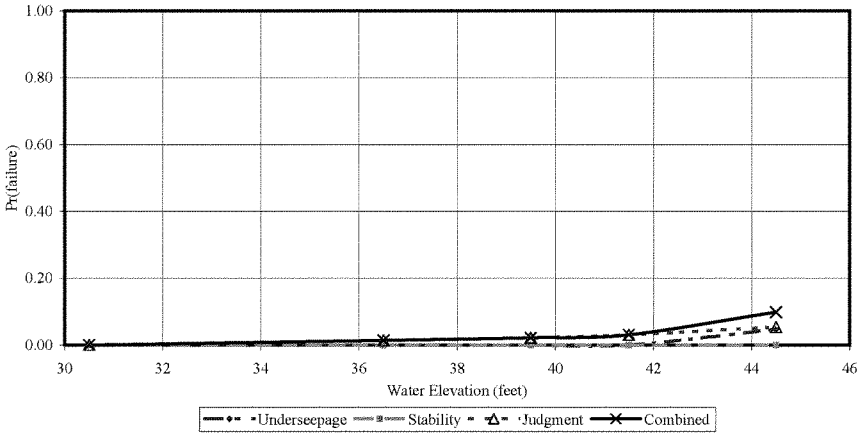
Levee Waterside Toe Elev. 30.5 feet
Levee Crest Elev. 44.5 feet
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 1 Reach C (NAT C)
Sacramento River East Levee, LM 5.00 to 0.00 (RM 74.42 to RM 79.20) Alternative 4 Cutoff Wall In Place
Index Point LM 1.33 (RM 78.0)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
30.5	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
36.5	0.00000	1.00000	0.00000	1.00000	0.01401	0.98599	0.01401	0.985995
39.5	0.00000	1.00000	0.00000	1.00000	0.02200	0.97800	0.02200	0.977998
41.5	0.00000	1.00000	0.00000	1.00000	0.03096	0.96904	0.03096	0.969044
44.5	0.04705	0.95295	0.00000	1.00000	0.05406	0.94594	0.09857	0.901432

Combined Geotechnical Risk and Uncertainity - LM 1.33
Alternative 4 Cutoff Wall In Place



Levee Waterside Toe Elev. 30.5 feet
Levee Crest Elev. 44.5 feet
The elevations are in Datum NAVD 88

BORINGS

Natomas Basin Levee Unit 4 Reach D (NAT D)
Natomas Cross Canal South Levee, LM 4.38 to 16.08 (RM 0.06 to 0.37) Existing Conditions Expert Elicitation
Index Point 0.1 (RM 4.3)

Boring #	Blanket Thickness (ft)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Blanket		Aquifer Material		kh/kv	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Sand Thickness (BF)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation
						Material	Kv (ft/day)	Material	Kh (ft/day)										
Sac. River East Levee Unit 1 LM 0.5 to 3.0																			
NCCB-5	6					CL, ML	0.057	SP	5.7	100					32				
NCCB-6	8					CL	0.0028	SP	5.7	2036					60				
CPT-00-21	16					CL	0.0028	SP	5.7	2036					26				
DH-20	12					CL	0.0028	SP	5.7	2036					28				
2F-01-15	11	10	3	8	29	CL	0.0028	SP	5.7	2036	1606	854	728581	53	30	37	13	160	34
CPT-00-22	10					CL,ML	0.057	SP	5.7	100					29				
2F-01-16	9					CL	0.0028	SP	5.7	2036					30				
CPT-00-23	8					CL	0.0028	SP	5.7	2036					51				
CT-1987-B2	10					CL	0.0028	SP	5.7	2036					50				

Permeabilities:

	Kh cm/sec	Kh ft/day	Kv cm/sec	Kv ft/day	Kv/Kh
Clays(CL)	4.00E-06	0.0112	1.00E-06	0.0028	0.25
Silt (ML)	2.00E-04	0.228	5.00E-05	0.057	0.25
Poorly Graded Sand (SP)	2.00E-03	5.7	2.00E-04	0.57	0.1
Sand, silty sand (SP, SM)	2.00E-04	0.57	2.00E-05	0.057	0.1

UNDERSEEPAGE ANALYSIS **Reliability**

Natomas Basin Levee Unit = Reach D (NAT D)
Natomas Cross Canal South Levee, LM 4.38 to 16.08 (RM 0.06 to 0.37) Existing Conditions Expert Elicitation
Index Point 0.1 (RM 4.3)

Crest width (feet)		20.00	H	= max head or levee height	L2	= levee base width
Horizontal to vertical slope ratio		3.00	Hwt	= head above tailwater at berm exit	Le	= landside effective length
			Hwt	= head above tailwater at 1/2 berm	Lt	= total effective length
K-r	= riverside permeability		Hfo	= head above tailwater at levee toe (w/ berm)	t'	= underseepage berm thickness at toe
K-L	= landside permeability		i-e	= critical seepage gradient	Sc	= calculated slope of underseepage berm
Dbr	= riverside blanket thickness		Wt	= berm width	tu	= used thickness of underseepage berm
DbL	= landside blanket thickness		i-o	= seepage gradient		
Df	= thickness of pervious foundation		Cr	= riverside effective length coefficient		
Lr	= length of riverside blanket		Cl	= landside effective length coefficient		
Ll	= length of landside blanket		Ll	= riverside effective length		

Station	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-e	Lr	Wt	Factor of Safety	L't	Hwt	H'wt	i-o	Cr	Cl	L1	L2	Le	Lt	H'o	t'
1.30	1606	1606	10.0	10.0	10.0	37.3	18.0	0.800	100	0	0.57	986	14.1	14.1	1.41	774	774	99	114	774	988	NA	NA

Head = 18.00
X2 = 140

Mean

K/Kb	z	d	X3	s	bo	I	Variance Component	Percent of Variance
1606	10	37.3	774	239	13.7	1.4736832		
2459	10	37.3	958	240	14.4	1.4368482	0.0099145	6.4419
752	10	37.3	530	239	12.4	1.2497387		
1606	13	37.3	878	240	14.1	1.068698	0.1406365	91.378
1606	7	37.3	654	239	13.2	1.8487287		
1606	10	50.0	896	240	14.2	1.4262648	0.0033549	2.1798
1606	10	24.7	629	239	13.0	1.5049626		
						Total	0.1539059	100

E[I] = 1.3748 E[ln I] = 0.27917
Var[I]= 0.15391
sigma[I]= 0.39231 sigma [ln I] = 0.279799
V(I) = 0.2854

I crit = 0.800 ln(I crit) = -0.22314

P(z) = 0.03630
Pr(F) = 96.36987

Head = 16.00
X2 = 140

Mean

K/Kb	z	d	X3	s	bo	I	Variance Component	Percent of Variance
1606	10	37	774	239	12.2	1.2220473		
2459	10	37	958	240	12.8	1.2798551	0.0078337	6.4419
752	10	37	530	239	11.0	1.1028788		
1606	13	37	878	240	12.6	0.9766204	0.1111262	91.378
1606	7	37	654	239	11.7	1.6433144		
1606	10	50	896	240	12.6	1.2624693	0.0026507	2.1798
1606	10	25	629	239	11.6	1.3594304		
						Total	0.1216046	100

E[I] = 1.2220 E[ln I] = 0.16139
Var[I]= 0.12160
sigma[I]= 0.34872 sigma [ln I] = 0.279799
V(I) = 0.2854

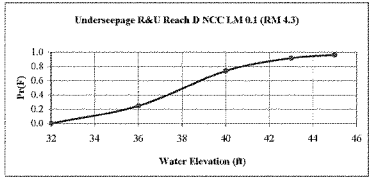
I crit = 0.800 ln(I crit) = -0.22314

P(z) = 0.08407
Pr(F) = 91.53338

Table 1: Random Variables

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	10	3	29
Perm Ratio	1606	854	53
Fdn Sand thickness	37	13	34

Head	Elevation	Pof Seepage
5	32	0.00289
9	36	0.21760
13	40	0.73038
16	43	0.91533
18	45	0.96370



Head =
X2 =

		Kf/Kb	z	d	X3	s	hs	I	Variance Component	Percent of Variance
Mean		1606	10	37	574	239	9.9	0.9929134		
		2459	10	37	958	240	10.4	1.0309148	0.0031715	6.4419
		752	10	37	530	239	9.9	0.896089		
		1606	13	37	878	240	10.2	0.7935041	0.0733567	91.378
		1606	7	37	654	239	9.5	1.1851958		
		1606	10	50	896	240	10.3	1.0257035	0.0017499	2.1798
		1606	10	25	629	239	9.4	0.9420306		
								Total	0.0802781	100

E[I] =	0.9929	E[ln I] =	-0.04625	
Var[I]=	0.08028			
sigma[I]=	0.28333	sigma [ln I] =	0.279790	
V(I) =	0.2854			
				P(z) = 0.26362
I crit =	0.800	ln(I crit) =	-0.22314	Pn(f) = 73.63804

Head =
X2 =

		Kf/Kb	z	d	X3	s	hs	I	Variance Component	Percent of Variance
Mean		1606	10	37	574	239	6.9	0.6674016		
		2459	10	37	958	240	7.2	0.719941	0.0024786	6.4419
		752	10	37	530	239	6.2	0.6203693		
		1606	13	37	878	240	7.1	0.5493481	0.0351591	91.378
		1606	7	37	654	239	6.6	0.8243613		
		1606	10	50	896	240	7.1	0.7101024	0.0008387	2.1798
		1606	10	25	629	239	6.5	0.6521813		
								Total	0.0384765	100

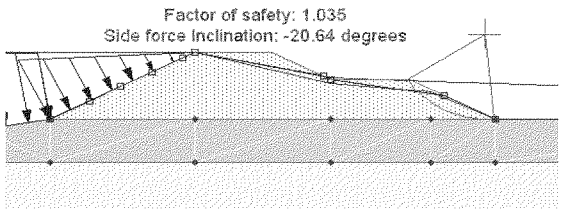
E[I] =	0.6874	E[ln I] =	-0.41398	
Var[I]=	0.03848			
sigma[I]=	0.19615	sigma [ln I] =	0.279790	
V(I) =	0.2854			
				P(z) = 0.75249
I crit =	0.800	ln(I crit) =	-0.22314	Pn(f) = 24.75958

Head =
X2 =

		Kf/Kb	z	d	X3	s	hs	I	Variance Component	Percent of Variance
Mean		1606	10	37	574	239	5.8	0.5818898		
		2459	10	37	958	240	6.0	0.5999672	0.0007650	6.4419
		752	10	37	530	239	5.4	0.5466496		
		1606	13	37	878	240	5.9	0.5051939	0.0108516	91.378
		1606	7	37	654	239	5.7	0.5133357		
		1606	10	50	896	240	5.9	0.5945013	0.0002889	2.1798
		1606	10	25	629	239	5.6	0.5623229		
								Total	0.0118755	100

E[I] =	0.5819	E[ln I] =	-1.00176	
Var[I]=	0.01188			
sigma[I]=	0.10897	sigma [ln I] =	0.279790	
V(I) =	0.2854			
				P(z) = 0.99731
I crit =	0.800	ln(I crit) =	-0.22314	Pn(f) = 0.26940

STABILITY ANALYSIS
Natomas Basin Levee Unit 4 Reach D (NAT D)
Natomas Cross Canal South Levee, LM 4.38 to 16.08 (RM 0.06 to 0.37) Existing Conditions Expert Elicitation
Index Point 0.1 (RM 4.3)



Water	45.00
X2 =	135

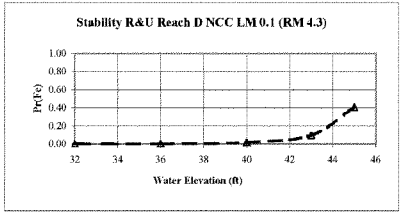
	Reliability Analysis of Critical Slide							
	Run	Sand Φ	Clay Cohesion	Clay Φ	Levee γ	Clay γ	FS	Variance Component	Percent of Variance
Mean	1	32	50	28	120	115	1.035		
	2	36	50	26	120	115	1.159	0.0144000	97.7995
	3	28	50	28	120	115	0.919		
	4	32	30	28	120	115	1.035	0.0000000	0.0000
	5	32	70	28	120	115	1.035		
	6	32	50	31	120	115	1.035	0.0000000	0.0000
	7	32	50	25	120	115	1.035		
	8	32	50	28	125	115	1.052	0.0003240	2.2005
	9	32	50	28	115	115	1.016		
	10	32	50	28	120	120	1.035	0.0000000	0.0000
	11	32	50	28	120	110	1.035		
							Total	0.0147240	100

E[FS] =	1.0350	E[ln FS] =	0.02758
Var[FS]=	0.01472		
sigma[FS]=	0.12134	sigma [ln FS] =	0.116839
V(FS) =	0.1172		
FS req'd =	1.000	ln(FS req'd) =	0.00000

Beta =	0.236014
F(z) =	0.406711
Pr(f) =	40.671080

Table 1 : Random Variables for East Bottoms

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee Fill	32	4	12.00
Foundation Clay c	50	20	40.00
Clay Φ	28	3	12.00
Levee γ	120	5	4.00
Clay γ	115	5	4.00

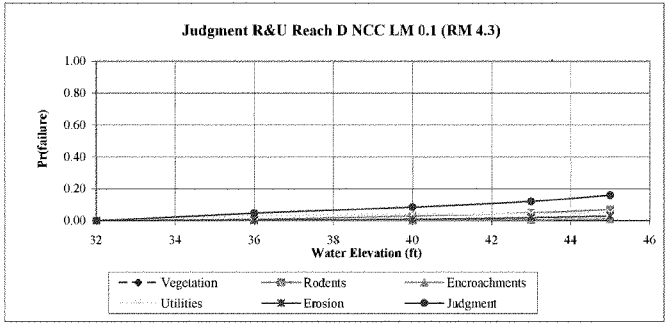


Elevation	Prf Stability
32	0.00000
36	0.00000
40	0.01682
43	0.09554
45	0.40671

Judgment Risk

Natomas Basin Levee Unit 4 Reach D (NAT D)
Natomas Cross Canal South Levee, LM 4.38 to 16.08 (RM 0.06 to 0.37) Existing Conditions Expert Elicitation
Index Point 0.1 (RM 4.3)

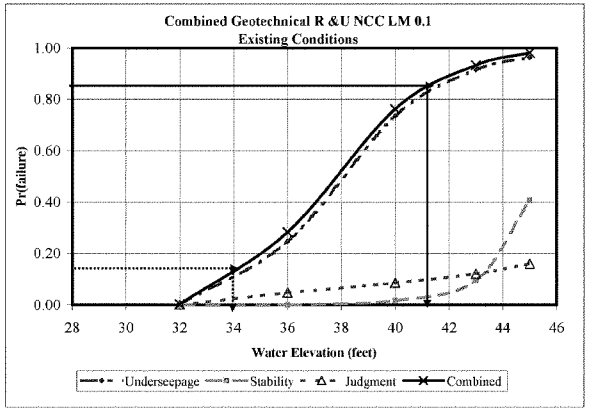
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Vegetation		Rodents		Encroachments		Utilities		Erosion		Judgment	
32	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.0000	1.00000	0.00000	1.00000	0.00000	1.000000
36	0.00200	0.99800	0.01000	0.99000	0.00100	0.99900	0.0300	0.97000	0.00500	0.99500	0.04737	0.952634
40	0.00500	0.99500	0.03000	0.97000	0.00300	0.99700	0.0400	0.96000	0.01000	0.99000	0.08547	0.914527
43	0.00700	0.99300	0.05000	0.95000	0.00500	0.99500	0.0450	0.95500	0.02000	0.98000	0.12153	0.878467
45	0.01000	0.99000	0.07000	0.93000	0.01000	0.99000	0.0500	0.95000	0.03000	0.97000	0.16006	0.839941



Combined Risk

Natomas Basin Levee Unit 4 Reach D (NAT D)
Natomas Cross Canal South Levee, LM 4.38 to 16.08 (RM 0.06 to 0.37) Existing Conditions Expert Elicitation
Index Point 0.1 (RM 4.3)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
32	0.00269	0.99731	0.00000	1.00000	0.00000	1.00000	0.00269	0.997306
36	0.24760	0.75240	0.00000	1.00000	0.04737	0.95263	0.28324	0.716762
40	0.73638	0.26362	0.01682	0.98318	0.08547	0.91453	0.76297	0.237032
43	0.91533	0.08467	0.09554	0.90446	0.12153	0.87847	0.93273	0.067271
45	0.96370	0.03630	0.40671	0.59329	0.16006	0.83994	0.98191	0.018090



Levee Landside Toe Elev.	29.0 feet
Levee Crest Elev.	45.0 feet
15% Probability of Failure	34.0 feet
85% Probability of failure	41.0 feet

The elevations are in Datum NAVD 88

The levee landside toe

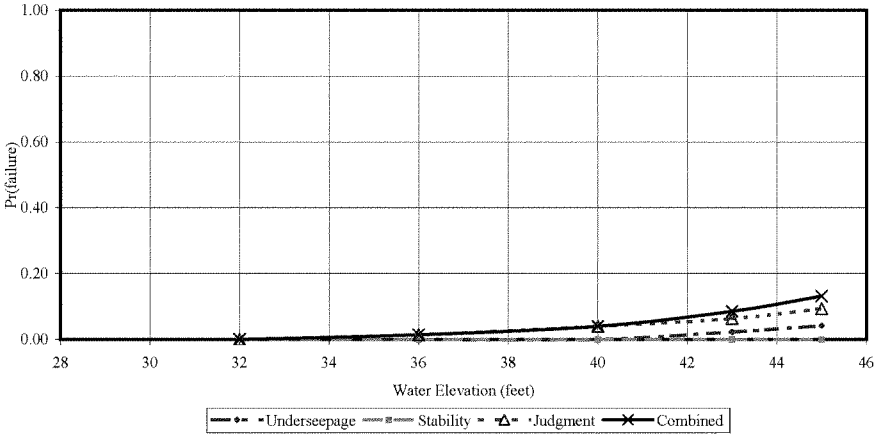
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Combined Risk

Natomas Basin Levee Unit 4 Reach D (NAT D)
Natomas Cross Canal South Levee, LM 4.38 to 16.08 (RM 0.06 to 0.37) Alternative 1 Cutoff Wall In Place
Index Point 0.1 (RM 4.3)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
32	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
36	0.00000	1.00000	0.00000	1.00000	0.01401	0.98599	0.01401	0.985995
40	0.00000	1.00000	0.00000	1.00000	0.03982	0.96018	0.03982	0.960180
43	0.02301	0.97699	0.00000	1.00000	0.06349	0.93651	0.08504	0.914961
45	0.04199	0.95801	0.00000	1.00000	0.09306	0.90694	0.13115	0.868849

Combined Geotechnical Risk and Uncertainty LM 0.1
Alternative 1 Cutoff Wall In Place



Levee Landside Toe Elev. 29.0 feet
Levee Crest Elev. 45.0 feet
The elevations are in Datum NAVD 88

Borings
Natomas Basin Levee Unit 3 Reaches E & F (NAT E & F)
PGCC LM 16.08 to 12.55 (RM 0.37 to 3.45), NEMDC LM 12.55 to 7.89 (RM 3.45 to 10.38) Existing Conditions Expert Elicitation
Index Point LM 6.43 NEMDC RM 9.6)

Boring #	Blanket Thickness (ft)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Blanket Material	Blanket Kv (ft/day)	Aquifer Material	Aquifer Kh (ft/day)	kh/kv	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Sand Thickness (BF)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation
Natomas East Main Drainage Canal West Levee Unit 3 LM 7.8 to 11.9																			
WK06_D27	9					CL	0.0028	SC	5.7	2036					5				
WK06_D24	5.5					CL	0.0028	SC	5.7	2036					5				
WK06_D21	5	7	2	5	32	CL	0.0028	SC	5.7	2036	3629	3562	12685969	98	6	7	3	11	47
WK06_D14	10					CL	0.0028	SC	5.7	2036					12				
WR1000_008B	6					CL	0.0028	SP	28	10000					9				

	Kh Permeabilities: cm/sec		Kv cm/sec	ft/day	Kv/Kh
Clays(CL)	1.00E-05				
Clay with Silt (CL,ML)	2.00E-04	ft/day			
Sand, silty sand (SP, SM)	2.00E-03	0.028	1.00E-06	0.0028	1
Gravel, Sandy Gravel (GP)	1.00E-02	0.57	5.00E-05	0.057	0.1
		5.7	2.00E-04	0.57	0.1
		28	1.00E-01	280	0.1

UNDERSEEPAGE ANALYSIS **Reliability**

Natomas Basin Levee Unit 3 Reaches E & F (NAT E & F)
PGCC LM 16.08 to 12.55 (RM 0.37 to 3.45), NEMDC LM 12.55 to 7.89 (RM 3.45 to 10.38) Existing Conditions Expert Elicitation
Index Point LM 6.43 NEMDC RM 9.0)
Crest width (feet) 25.00
Horizontal to vertical slope ratio 2.50

K-r = riverside permeability
K-L = landside permeability
Dbr = riverside blanket thickness
DbL = landside blanket thickness
Df = thickness of pervious foundation
Lr = length of riverside blanket
Ll = length of landside blanket

H = max head or levee height
Hwt = head above tailwater at berm end
Hwt = head above tailwater at 1/2 berm
Ho = head above tailwater at levee toe
i-c = critical seepage gradient
Wt = berm width
i-o = seepage gradient
Cr = riverside effective length coefficient
Cl = landside effective length coefficient
L1 = riverside effective length

L2 = levee base width
Le = landside effective length
Lt = total effective length
t = underseepage berm thickness at toe
Sc = calculated slope of underseepage berm
tu = used thickness of underseepage berm

Levee Mile	K-r	K-L	DbL	Dbe	Dbr	Df	H	i-c	Lr	Wt	Factor of Safety	L'l	Ho	H'wt	i-o	Cr	Cl	L1	L2	Le	Lt	Hwt	t'
6.43	3629	3629	7.1	7.1	7.1	7.1	17.0	0.800	60	0	0.48	612	11.9	11.9	1.67	428	428	60	125	428	612	NA	NA

Head = 17.00
X2 = 140

	K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	3629	7	7.1	428	200	11.6	1.6324648		
	7190	7	7.1	602	200	12.8	1.7977476	0.3757303	60.8346
	67	7	7.1	58	185	4.1	0.5718108		
	3629	9	7.1	491	200	12.1	1.2926661	0.2242778	36.313
	3629	5	7.1	354	199	10.9	2.2398257		
	3629	7	10.4	518	200	12.3	1.7278273	0.0176184	2.8526
	3629	7	3.8	313	199	10.4	1.462359		
							Total	0.6176264	100

E[I] = 1.6325 E[ln I] = 0.38587
Var[I]= 0.61763
sigma[I]= 0.78589 sigma [ln I] = 0.456557
V(I) = 0.4814

I crit = 0.800 ln(I crit) = -0.22314

P(z) =	0.09111
Pr(f) =	90.88859

Head = 14.00
X2 = 140

	K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	3629	7	7	428	200	9.5	1.3443828		
	7190	7	7	602	200	10.5	1.480498	0.2548209	60.8346
	67	7	7	58	185	3.3	0.470903		
	3629	9	7	491	200	10.0	1.0645486	0.1521053	36.313
	3629	5	7	354	199	9.0	1.8445623		
	3629	7	10	518	200	10.1	1.4229166	0.0119488	2.8526
	3629	7	4	313	199	8.6	1.2042956		
							Total	0.4188747	100

E[I] = 1.3444 E[ln I] = 0.19171
Var[I]= 0.41887
sigma[I]= 0.64721 sigma [ln I] = 0.456557
V(I) = 0.4814

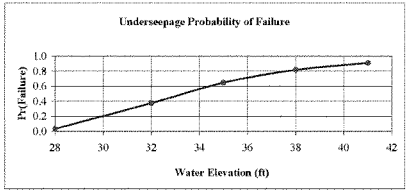
I crit = 0.800 ln(I crit) = -0.22314

P(z) =	0.18176
Pr(f) =	81.82363

Table 1 : Random Variables

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	7	2	32
Perm Ratio	3629	3562	98
Fdn Sand thickness	7	3	47

Head	Elevation	Prf Seepage
4	28	0.03323
8	32	0.37560
11	35	0.64819
14	38	0.81824
17	41	0.90889



Head = 11.90
X2 = 140

	Kf/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	3629	7	7	428	200	7.5	1.0563008		
	7190	7	7	602	200	8.3	1.1632485	0.1573127	60.8346
	67	7	7	58	185	2.6	0.3699952		
	3629	9	7	491	200	7.8	0.836431	0.0939018	36.313
	3629	5	7	354	199	7.0	1.449299		
	3629	7	10	518	200	7.9	1.1180659	0.0073765	2.8526
	3629	7	4	313	199	6.7	0.9462323		
							Total	0.2585910	100

E[I] = 1.0563 E[ln I] = -0.04945
Var[I]= 0.25859
sigma[I]= 0.50852 sigma [ln I] = 0.456557
V(I) = 0.4814

I crit = 0.800 ln(I crit) = -0.22314

F(z) = 0.35183
Pr(f) = 64.81924

Head = 8.00
X2 = 140

	Kf/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	3629	7	7	428	200	5.5	0.7682187		
	7190	7	7	602	200	6.0	0.8499989	0.0832067	60.8346
	67	7	7	58	185	1.9	0.2690874		
	3629	9	7	491	200	5.7	0.6083135	0.0496671	36.313
	3629	5	7	354	199	5.1	1.0540356		
	3629	7	10	518	200	5.8	0.8130952	0.0039016	2.8526
	3629	7	4	313	199	4.9	0.6881689		
							Total	0.1367754	100

E[I] = 0.7682 E[ln I] = -0.36790
Var[I]= 0.13678
sigma[I]= 0.36983 sigma [ln I] = 0.456557
V(I) = 0.4814

I crit = 0.800 ln(I crit) = -0.22314

F(z) = 0.62440
Pr(f) = 37.35963

Head = 4.00
X2 = 140

	Kf/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	3629	7	7	428	200	2.7	0.3841094		
	7190	7	7	602	200	3.0	0.4229994	0.0208017	60.8346
	67	7	7	58	185	1.0	0.1345437		
	3629	9	7	491	200	2.8	0.3041567	0.0124168	36.313
	3629	5	7	354	199	2.6	0.5270178		
	3629	7	10	518	200	2.9	0.4065476	0.0009754	2.8526
	3629	7	4	313	199	2.4	0.3440845		
							Total	0.0341939	100

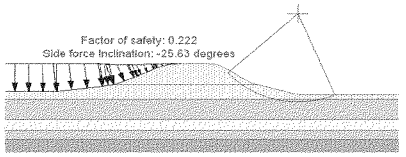
E[I] = 0.3841 E[ln I] = -1.06105
Var[I]= 0.03419
sigma[I]= 0.18492 sigma [ln I] = 0.456557
V(I) = 0.4814

I crit = 0.800 ln(I crit) = -0.22314

F(z) = 0.90677
Pr(f) = 3.32326

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STABILITY ANALYSIS
Natomas Basin Levee Unit 3 Reaches E & F (NAT E & F)
PGCC LM 16.08 to 12.55 (RM 0.37 to 3.45), NEMDC LM 12.55 to 7.89 (RM 3.45 to 10.38) Existing Conditions Expert I
Index Point LM 6.43 NEMDC RM 9.0)



Water Elevation: 41.00

Reliability Analysis of Critical Slide

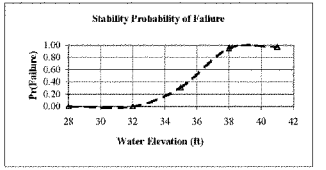
Run	Silty Sand Φ	Clay Cohesion	Clay Φ	Silty Sand γ	Clay γ	FS	Variance Component	Percent of Variance
Mean 1	33	50	28	130	110	0.222		
2	37	50	26	130	110	0.248	0.0529000	40.3062
3	29	50	28	130	110	0.708		
4	33	30	28	130	110	1.027	0.0163840	12.4835
5	33	70	28	130	110	0.771		
6	33	50	31	130	110	0.566	0.0370563	28.2344
7	33	50	25	130	110	0.181		
8	33	50	28	135	110	0.199	0.0002560	0.1951
9	33	50	28	125	110	0.231		
10	33	50	28	130	114	0.553	0.0246490	18.7809
11	33	50	28	130	106	0.239		
						Total	0.1312453	100

E[FS] =	0.2220	E[ln FS] =	-2.15422
Var[FS]=	0.13125		
sigma[FS]=	0.36228	sigma [ln FS] =	1.139427
V(FS) =	1.6319		
FS req'd =	1.000	ln(FS req'd) =	0.00000

Beta =	-1.890621
P(Z) =	0.970663
Pr(f) =	97.066255

Table 1 : Random Variables for East Bottoms

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Silty Sand Φ	33	4	12.00
Clay Cohesion	50	20	40.00
Clay Φ	28	3	12.00
Silty Sand γ	130	5	4.00
Clay γ	110	4	4.00



Elevation	Prf Stability
28	0.00000
32	0.00000
35	0.31046
38	0.94758
41	0.97066

396

Water Elevation: 38.00

Reliability Analysis of Critical Slide

	Run	Silty Sand Φ	Clay Cohesion	Clay Φ	Silty Sand γ	Clay γ	FS	Variance Component	Percent of Variance
Mean	1	33	50	28	130	110	0.296		
	2	37	50	26	130	110	0.253	0.0015210	1.1589
	3	29	50	28	130	110	0.175		
	4	33	30	28	130	110	0.233	0.1072563	81.7220
	5	33	70	28	130	110	0.888		
	6	33	50	31	130	110	0.760	0.0032490	2.4755
	7	33	50	25	130	110	0.646		
	8	33	50	28	135	110	0.187	0.1335903	101.7867
	9	33	50	28	125	110	0.918		
	10	33	50	28	130	114	0.851	0.0190440	14.5102
	11	33	50	28	130	106	0.575		
							Total	0.2646605	202

E[FS] =	0.2960	E[ln FS] =	-1.91312
Var[FS] =	0.26466		
sigma[FS] =	0.51445	sigma [ln FS] =	1.179599
V(FS) =	1.7380		
FS req'd =	1.000	ln(FS req'd) =	0.00000

Beta =	-1.621842
F(z) =	0.947581
Pr(f) =	94.758138

Water Elevation: 35.00

Reliability Analysis of Critical Slide

	Run	Sand Φ	Clay Cohesion	Clay Φ	Sand γ	Clay γ	FS	Variance Component	Percent of Variance
Mean	1	33	50	28	130	110	1.259		
	2	37	50	26	130	110	1.274	0.0006250	0.4762
	3	29	50	28	130	110	1.224		
	4	33	30	28	130	110	0.490	0.1887903	143.8454
	5	33	70	28	130	110	1.359		
	6	33	50	31	130	110	1.361	0.0104040	7.9271
	7	33	50	25	130	110	1.157		
	8	33	50	28	135	110	1.266	0.0000490	0.0373
	9	33	50	28	125	110	1.252		
	10	33	50	28	130	114	1.285	0.0007562	0.5762
	11	33	50	28	130	106	1.230		
							Total	0.2606245	153

E[FS] =	1.2590	E[ln FS] =	0.17073
Var[FS] =	0.20062		
sigma[FS] =	0.44791	sigma [ln FS] =	0.345222
V(FS) =	0.3558		
FS req'd =	1.000	ln(FS req'd) =	0.00000

Beta =	0.494548
F(z) =	0.310460
Pr(f) =	31.045962

697

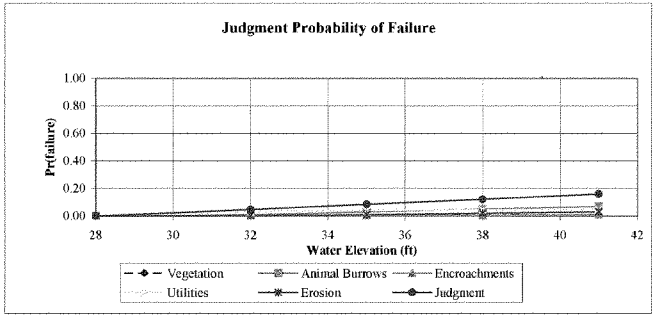
Judgment Risk

Natomas Basin Levee Unit 3 Reaches E & F (NAT E & F)

PGCC LM 16.08 to 12.55 (RM 0.37 to 3.45), NEMDC LM 12.55 to 7.89 (RM 3.45 to 10.38) Existing Conditions Expert Elicitation

Index Point LM 6.43 NEMDC RM 9.0)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
28	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.0000	1.00000	0.00000	1.00000	0.00000	1.000000
32	0.00200	0.99800	0.01000	0.99000	0.00100	0.99900	0.0300	0.97000	0.00500	0.99500	0.04737	0.952634
35	0.00500	0.99500	0.03000	0.97000	0.00300	0.99700	0.0400	0.96000	0.01000	0.99000	0.08547	0.914527
38	0.00700	0.99300	0.05000	0.95000	0.00500	0.99500	0.0450	0.95500	0.02000	0.98000	0.12153	0.878467
41	0.01000	0.99000	0.07000	0.93000	0.01000	0.99000	0.0500	0.95000	0.03000	0.97000	0.16006	0.839941



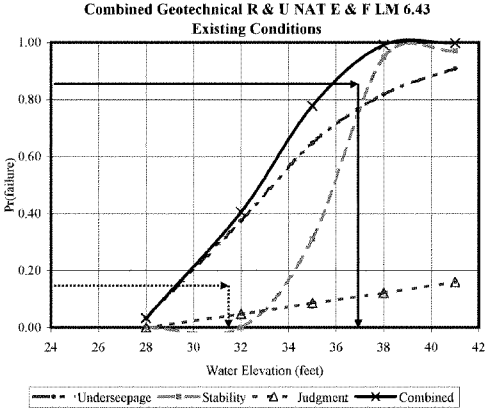
Combined Risk

Natomas Basin Levee Unit 3 Reaches E & F (NAT E & F)

PGCC LM 16.08 to 12.55 (RM 0.37 to 3.45), NEMDC LM 12.55 to 7.89 (RM 3.45 to 10.38) Existing Conditions Expert Elicitation

Index Point LM 6.43 NEMDC (RM 9.0)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
28	0.03323	0.96677	0.00000	1.00000	0.00000	1.00000	0.03323	0.966767
32	0.37560	0.62440	0.00000	1.00000	0.04737	0.95263	0.40517	0.594828
35	0.64819	0.35181	0.31046	0.68954	0.08547	0.91453	0.77815	0.221851
38	0.81824	0.18176	0.94758	0.05242	0.12153	0.87847	0.99163	0.008370
41	0.90889	0.09111	0.97066	0.02934	0.16006	0.83994	0.99775	0.002245



Levee Landside Toe Elev.	24 feet
Levee Crest Elev.	41 feet
15% Probability of Failure	29.5 feet
85% Probability of failure	36.0feet

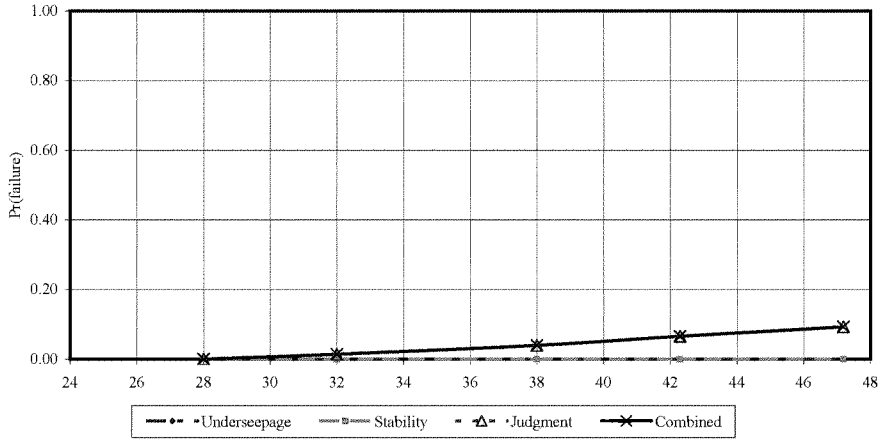
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 3 Reaches E (NAT E)
PGCC LM 16.08 to 12.55 (RM 0.37 to 3.45) Alternative 1 Cutoff Wall In Place
Index Point LM 6.43 NEMDC (RM 9.0)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
28	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
32	0.00000	1.00000	0.00000	1.00000	0.01412	0.98588	0.01412	0.985877
38	0.00000	1.00000	0.00000	1.00000	0.03948	0.96052	0.03948	0.960522
42.29	0.00000	1.00000	0.00000	1.00000	0.06531	0.93469	0.06531	0.934687
47.19	0.00000	1.00000	0.00000	1.00000	0.09306	0.90694	0.09306	0.906936

NAT E: Combined Geotechnical Risk & Uncertainty
Alternative 1 Cutoff Wall In Place



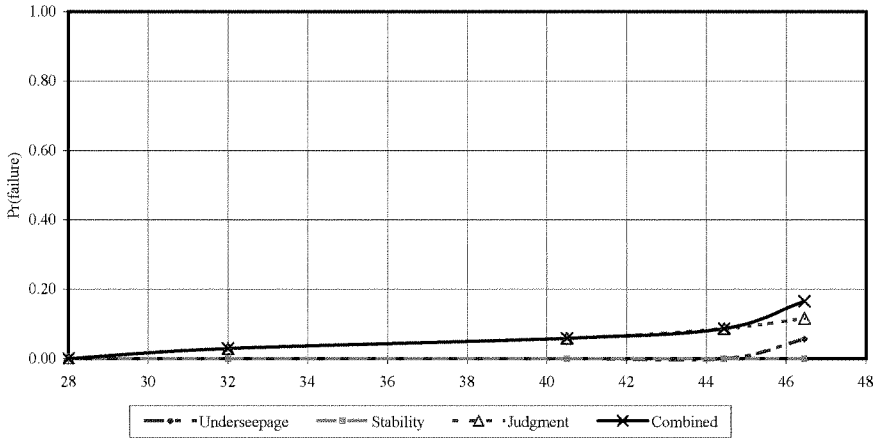
Levee Landside Toe Elev. 24 feet
Levee Crest Elev. 46.20 feet
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 3 Reaches F (NAT F)
NEMDC LM 12.55 to 7.89 (RM 3.45 to 10.38) Alternative 1 Drained Stability Berm
Index Point LM 6.43 NEMDC (RM 9.0)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
28	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
32	0.00000	1.00000	0.00000	1.00000	0.02891	0.97109	0.02891	0.971089
40.5	0.00000	1.00000	0.00000	1.00000	0.05869	0.94131	0.05869	0.941312
44.44	0.00000	1.00000	0.00000	1.00000	0.08634	0.91366	0.08634	0.913657
46.46	0.05613	0.94387	0.00000	1.00000	0.11574	0.88426	0.16538	0.834625

NAT F: Combined Geotechnical Risk & Uncertainty
Alternative 1 Drained Stability Berm



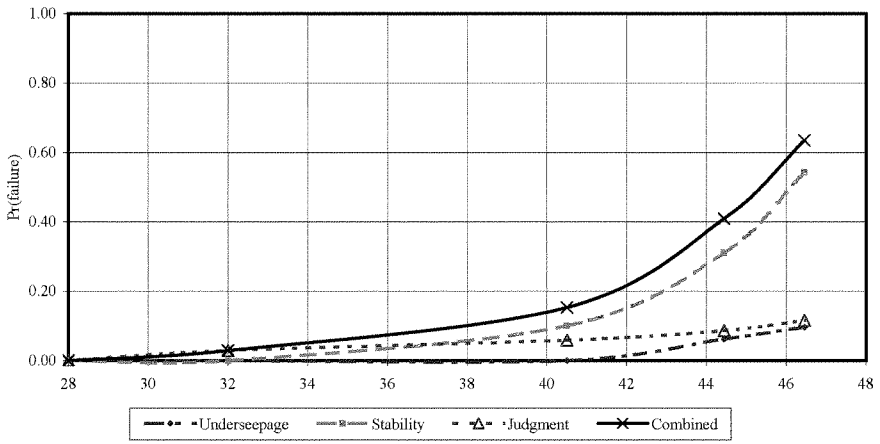
Levee Landside Toe Elev. 24 feet
Levee Crest Elev. 41 feet
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 3 Reaches F (NAT F)
NEMDC LM 12.55 to 7.89 (RM 3.45 to 10.38) Alternative 2 Flattened Levee Slope
Index Point LM 6.43 NEMDC (RM 9.0)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
28	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
32	0.00000	1.00000	0.00000	1.00000	0.02891	0.97109	0.02891	0.971089
40.5	0.00000	1.00000	0.10063	0.89937	0.05869	0.94131	0.15341	0.846589
44.44	0.06206	0.93794	0.31052	0.68948	0.08634	0.91366	0.40915	0.590851
46.46	0.09646	0.90354	0.54279	0.45721	0.11574	0.88426	0.63471	0.365295

NAT F: Combined Geotechnical Risk & Uncertainty
Alternative 2 Flattened Levee Slope



Levee Landside Toe Elev. 24 feet
Levee Crest Elev. 41 feet
The elevations are in Datum NAVD 88

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Borings
Natomas Basin Levee Unit 3 Reach G2 &H (NAT G2 & H)
NEMDC LM 7.89 to 4.25 (RM 10.38 to 6.81) and NEMDC LM 4.25 to 0.0 (RM 6.81 to 2.54), Existing Conditions Expert Elicitation
Index Point LM 4.85 (RM 7.5)

Boring #	Blanket Thickness (ft)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Blanket Material	Blanket Kv (ft/day)	Aquifer Material	Aquifer Material Kh (ft/day)	kh/kv	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Sand Thickness (BF)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation
Natomas East Main Drainage Canal West Levee Unit 3 LM 4.5 to 7.8																			
WR1000_055B	11	12	6	37	52	CL, ML	0.057	SM	5.7	100	1552	968	936747	62	40	50	8	67	16
WK06_D18	20					CL	0.0028	SC	5.7	2036					50				
WK06_D27	10					CL	0.0028	SC	5.7	2036					60				
WK06_D24	5.5					CL	0.0028	SC	5.7	2036					50				

Soil Type	Permeabilities: Kh		Kv		
	cm/sec	ft/day	cm/sec	ft/day	Kv/Kh
Clays(CL)	1.00E-05	0.028	1.00E-06	0.0028	1
Clay with Silt (CL,ML)	2.00E-04	0.57	5.00E-05	0.057	0.1
Sand, silty sand (SP, SM)	2.00E-03	5.7	2.00E-04	0.57	0.1
Gravel, Sandy Gravel (GP	1.00E-02	28	1.00E-01	280	0.1

UNDERSEEPAGE ANALYSIS **Reliability**

Natomas Basin Levee Unit 3 Reach G2 &H (NAT G2 & H)
NEMDC LM 7.89 to 4.25 (RM 10.38 to 6.81) and NEMDC LM 4.25 to 0.0 (RM 6.81 to 2.54), Existing Conditions Expert Elicitation
Index Point LM 4.85 (RM 7.5)

Crest width (feet)		19.00	H	= max head or levee height	
Horizontal to vertical slope ratio		3.50	Hwt	= head above tailwater at berm end	
			HWt	= head above tailwater at 1/2 berm	
K-r	= riverside permeability		Ho	= head above tailwater at levee toe	
K-L	= landside permeability		i-c	= critical seepage gradient	
Dbr	= riverside blanket thickness		Wt	= berm width	
DbL	= landside blanket thickness		i-o	= seepage gradient	
Df	= thickness of pervious foundation		Cr	= riverside effective length coefficient	
Lr	= length of riverside blanket		Cl	= landside effective length coefficient	
Ll	= length of landside blanket		L1	= riverside effective length	

L2	= levee base width				
Le	= landside effective length				
Lt	= total effective length				
t'	= underseepage berm thickness at toe				
Sc	= calculated slope of underseepage berm				
tu	= used thickness of underseepage berm				

Levee Mile	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Factor of Safety	L't	Ho	H'wt	i-o	Cr	Cl	L1	L2	Le	Lt	Hwt	t'
4.85	1552	1552	11.6	11.6	11.6	50.0	18.0	0.800	75	0	0.63	1160	14.7	14.7	1.27	950	950	75	135	950	1160	NA	NA

Head = 17.50
X2 = 135

Mean

K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
1552	12	50.0	950	210	14.3	1.2329518		
2520	12	50.0	1210	210	14.9	1.2828655	0.0077239	1.2677
584	12	50.0	583	210	12.9	1.1070944		
1552	18	50.0	1172	210	14.8	0.8385494	0.6012179	98.677
1552	6	50.0	656	210	13.3	2.3893142		
1552	12	58.2	1024	210	14.5	1.2493994	0.0003399	0.0558
1552	12	41.8	869	210	14.1	1.2125272		
						Total	0.6092816	100

E[I] = 1.2330 E[ln I] = 0.04089
Var[I]= 0.60928
sigma[I]= 0.78056 sigma [ln I] = 0.580553
V(I) = 0.6331

I crit = 0.800 ln(I crit) = -0.22314

F(z) =	0.32463
Pr(f) =	67.53721

Head = 15.00
X2 = 135

Mean

K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
1552	12	50	950	210	12.3	1.0568158		
2520	12	50	1210	210	12.8	1.0993599	0.0020821	0.4689
968	12	50	750	210	11.7	1.0083391		
1552	18	50	1172	210	12.7	0.7187566	0.4417111	99.475
1552	6	50	656	210	11.4	2.0479836		
1552	12	58	1024	210	12.4	1.0709138	0.0002497	0.0562
1552	12	42	869	210	12.1	1.0393009		
						Total	0.4440429	100

E[I] = 1.0568 E[ln I] = -0.11211
Var[I]= 0.44404
sigma[I]= 0.66637 sigma [ln I] = 0.578570
V(I) = 0.6305

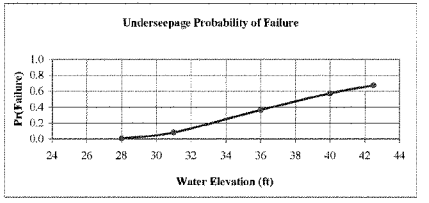
I crit = 0.800 ln(I crit) = -0.22314

F(z) =	0.42391
Pr(f) =	57.60929

Table 1 : Random Variables

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	12	6	52
Perm Ratio	1552	968	62
Fdn Sand thickness	50	8	16

Head	Elevation	Prf Seepage
5	28	0.00490
6	31	0.08241
11	36	0.36506
15	40	0.57609
17.5	42.5	0.67537



604

Head = 11.00
X2 = 135

	K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1552	12	50	950	210	9.0	0.7749983		
	2520	12	50	1210	210	9.4	0.8003726	0.0030517	1.2677
	584	12	50	583	210	8.1	0.6958879		
	1552	18	50	1172	210	9.3	0.7270882	0.2375424	98.677
	1552	6	50	656	210	8.3	1.5018547		
	1552	12	58	1024	210	9.1	0.7853568	0.0001343	0.0558
	1552	12	42	869	210	8.9	0.7621599		
							Total	0.2407284	100

E[I] = 0.7759 E[ln I] = -0.42342
Var[I] = 0.24073
sigma[I] = 0.49064 sigma [ln I] = 0.580553
V(I) = 0.6331

I crit = 0.800 ln(I crit) = -0.22314

F(z) = 0.63494
Pr(I) = 36.50594

Head = 6.00
X2 = 135

	K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1552	12	50	950	210	4.9	0.4227263		
	2520	12	50	1210	210	5.1	0.4398396	0.0009079	1.2677
	584	12	50	583	210	4.4	0.3795752		
	1552	18	50	1172	210	5.1	0.3965027	0.0706738	98.677
	1552	6	50	656	210	4.5	0.8191935		
	1552	12	58	1024	210	5.0	0.4283655	0.0000400	0.0558
	1552	12	42	869	210	4.8	0.4157236		
							Total	0.0716217	100

E[I] = 0.4227 E[ln I] = -1.02955
Var[I] = 0.07162
sigma[I] = 0.26762 sigma [ln I] = 0.580553
V(I) = 0.6331

I crit = 0.800 ln(I crit) = -0.22314

F(z) = 0.91759
Pr(I) = 8.24114

Head = 3.00
X2 = 135

	K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1552	12	50	950	210	2.5	0.2113632		
	2520	12	50	1210	210	2.6	0.2199598	0.0002270	1.2677
	584	12	50	583	210	2.2	0.1897876		
	1552	18	50	1172	210	2.5	0.1437513	0.0176684	98.677
	1552	6	50	656	210	2.3	0.4095967		
	1552	12	58	1024	210	2.5	0.2141828	0.0000100	0.0558
	1552	12	42	869	210	2.4	0.2078618		
							Total	0.0179054	100

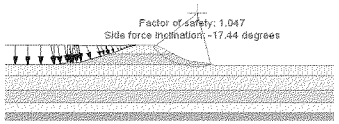
E[I] = 0.2114 E[ln I] = -1.72270
Var[I] = 0.01791
sigma[I] = 0.13381 sigma [ln I] = 0.580553
V(I) = 0.6331

I crit = 0.800 ln(I crit) = -0.22314

F(z) = 0.99510
Pr(I) = 0.48976

STABILITY ANALYSIS

Natomas Basin Levee Unit 3 Reach G2 &H1 (NAT -G2 & H)
NEMDC LM 7.89 to 4.25 (RM 10.38 to 6.81) and NEMDC LM 4.25 to 0.0 (RM 6.81 to 2.54), Existing Conditions Expert Elicitation
Index Point LM 4.85 (RM 7.5)



Water Elevation: 43.00

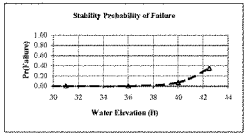
Reliability Analysis of Critical Slide								
Run	Clayey Sand Φ	Lean Clay Cohesion	Lean Clay Φ	Clayey Sand γ	Lean Clay γ	FS	Variance Component	Percent of Variance
Mean	30	50	28	130	110	1.047		
2	34	50	28	130	110	1.128	0.0067240	55.4751
3	26	50	28	130	110	0.964		
4	30	30	28	130	110	0.999	0.0019803	16.3377
5	30	70	28	130	110	1.088		
6	30	50	31	130	110	1.164	0.0030803	25.4130
7	30	50	25	130	110	0.933		
8	30	50	28	135	110	1.050	0.0000123	0.1011
9	30	50	28	125	110	1.043		
10	30	50	28	130	114	1.065	0.0003240	2.6731
11	30	50	28	130	106	1.029		
						Total	0.0121208	100

E[FS] =	1.0479	E[ln FS] =	0.0404
Var[FS]=	0.01212		
sigma[FS]=	0.11009	sigma [ln FS] =	0.103863
V(FS) =	0.1052		
FS req'd =	1.000	ln(FS req'd) =	0.00000

Beta =	0.383557
Fi(z) =	0.349912
Pr(f) =	34.991221

Table 1: Random Variables for East Bottoms

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Clayey Sand Φ	30	4	12.00
Lean Clay Cohesion	50	20	40.00
Lean Clay Φ	28	3	12.50
Clayey Sand γ	130	5	4.00
Lean Clay γ	110	4	4.00



Elevation	Prf Stability
28	0.00000
33	0.00000
36	0.00000
40	0.07106
42.5	0.34991

Water Elevation: 40.00

Reliability Analysis of Critical Slide								
Run	Silty Sand Φ	Clay Cohesion	Clay Φ	Silty Sand γ	Clay γ	FS	Variance Component	Percent of Variance
Mean	30	50	28	130	110	1.171		
2	34	50	28	130	110	1.282	0.0089303	73.6774
3	26	50	28	130	110	1.073		
4	30	30	28	130	110	1.126	0.0017640	14.5536
5	30	70	28	130	110	1.219		
6	30	50	31	130	110	1.233	0.0039063	32.2278
7	30	50	25	130	110	1.108		
8	30	50	28	135	110	1.174	0.0000169	0.1320
9	30	50	28	125	110	1.166		
10	30	50	28	130	114	1.187	0.0002560	2.1121
11	30	50	28	130	106	1.155		
						Total	0.0148725	123

E[FS] =	1.1710	E[ln FS] =	0.15246
Var[FS]=	0.01487		
sigma[FS]=	0.12195	sigma [ln FS] =	0.103863
V(FS) =	0.1041		
FS req'd =	1.000	ln(FS req'd) =	0.00000

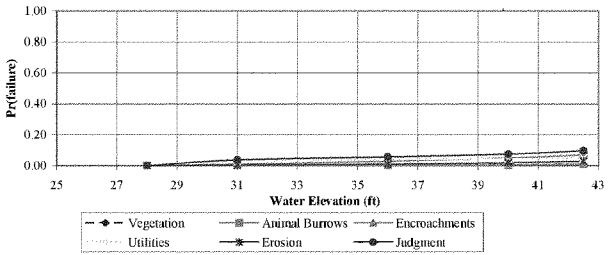
Beta =	1.467930
Fi(z) =	0.071062
Pr(f) =	7.106164

Judgment Risk

Natomas Basin Levee Unit 3 Reach G2 &H (NAT G2 & H)
NEMDC LM 7.89 to 4.25 (RM 10.38 to 6.81) and NEMDC LM 4.25 to 0.0 (RM 6.81 to 2.54), Existing Conditions Expert Elicitation
Index Point LM 4.85 (RM 7.5)

	Pr(f)	R			Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
28	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.0000	1.00000	0.00000	1.00000	0.00000	1.000000
31	0.00200	0.99800	0.01000	0.99000	0.00100	0.99900	0.0300	0.97000	0.00500	0.99500	0.03774	0.962256
36	0.00500	0.99500	0.03000	0.97000	0.00300	0.99700	0.0400	0.96000	0.01000	0.99000	0.05719	0.942811
40	0.00700	0.99300	0.05000	0.95000	0.00500	0.99500	0.0450	0.95500	0.02000	0.98000	0.07530	0.924702
42.5	0.01000	0.99000	0.07000	0.93000	0.01000	0.99000	0.0500	0.95000	0.03000	0.97000	0.09684	0.903162

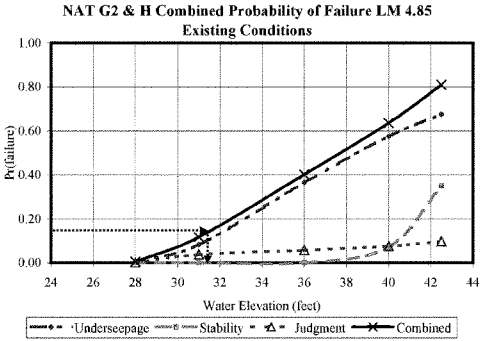
NAT G Existing Conditions - Judgment Probability of Failure



Combined Risk

Natomas Basin Levee Unit 3 Reach G2 &H (NAT G2 & H)
NEMDC LM 7.89 to 4.25 (RM 10.38 to 6.81) and NEMDC LM 4.25 to 0.0 (RM 6.81 to 2.54), Existing Conditions Expert Elicitation
Index Point LM 4.85 (RM 7.5)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
28	0.00490	0.99510	0.00000	1.00000	0.00000	1.00000	0.00490	0.995102
31	0.08241	0.91759	0.00000	1.00000	0.03774	0.96226	0.11704	0.882956
36	0.36506	0.63494	0.00000	1.00000	0.05719	0.94281	0.40137	0.598629
40	0.57609	0.42391	0.07106	0.92894	0.07530	0.92470	0.63587	0.364132
42.5	0.67537	0.32463	0.34991	0.65009	0.09684	0.90316	0.80940	0.190600



Levee landside Toe Elev.	25 feet
Levee Crest Elev.	43 feet
15% Probability of Failure	31.5 feet
85% Probability of failure	above levee crest

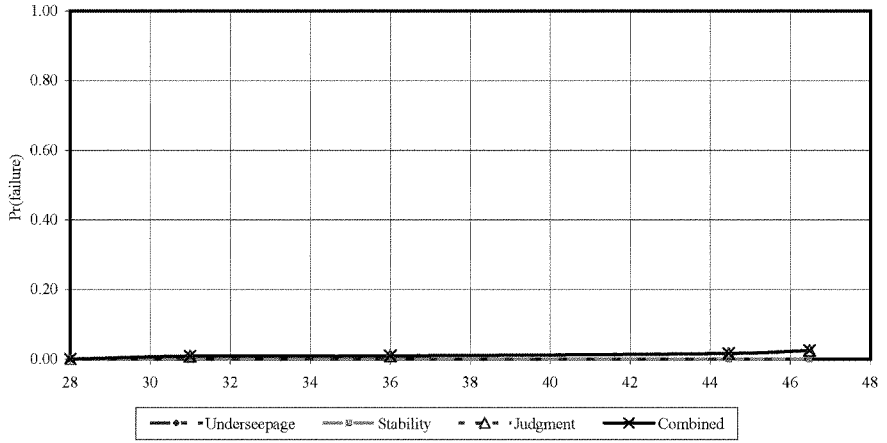
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 3 Reach G (NAT G)
NEMDC LM 7.89 to 4.25 (RM 10.38 to 6.81), Alternative 1 Cutoff Wall In Place
Index Point LM 4.85 (RM 7.5)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
28	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
31	0.00000	1.00000	0.00000	1.00000	0.00865	0.99135	0.00865	0.991352
36	0.00000	1.00000	0.00000	1.00000	0.00952	0.99048	0.00952	0.990477
44.46	0.00000	1.00000	0.00000	1.00000	0.01612	0.98388	0.01612	0.983881
46.48	0.00000	1.00000	0.00000	1.00000	0.02480	0.97520	0.02480	0.975200

NAT G: Combined Probability of Failure
Alternative 1 Cutoff Wall In Place



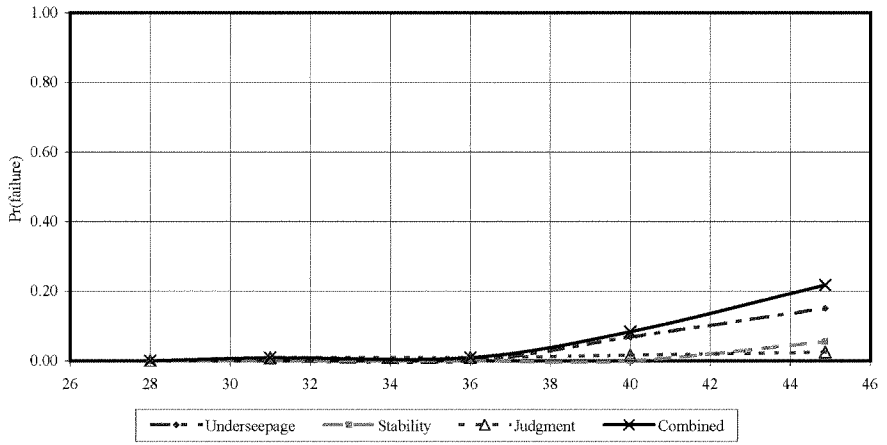
Levee landside Toe Elev. 25 feet
Levee Crest Elev. 43 feet
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 3 Reach H (NAT H)
NEMDC LM 4.25 to 0.0 (RM 6.81 to 2.54), Alternative 1 Cutoff Wall In Place
Index Point LM 4.85 (RM 7.5)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
28	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
31	0.00000	1.00000	0.00000	1.00000	0.00865	0.99135	0.00865	0.991352
36	0.00000	1.00000	0.00000	1.00000	0.00952	0.99048	0.00952	0.990477
40	0.06832	0.93168	0.00000	1.00000	0.01612	0.98388	0.08333	0.916667
44.87	0.15097	0.84903	0.05481	0.94519	0.02480	0.97520	0.21741	0.782592

NAT H: Combined Probability of Failure
Alternative 1 Cutoff Wall In Place



Levee landside Toe Elev. 25 feet
Levee Crest Elev. 43 feet
The elevations are in Datum NAVD 88

Borings

Natomas Basin Levee Unit 2 Reach I (NAT I)
American River North Levee, LM 0.0 to 2.33 (RM 0.0 to 1.7) Existing Conditions Expert Elicitation
Index Point LM. 1.28 (RM 0.9)

Boring #	Blanket Thickness (ft)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Blanket Material	Blanket Kv (ft/day)	Aquifer Material	Aquifer Material Kh (ft/day)	kh/kv	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation	Sand Thickness (BF)	Mean	Standard Deviation	Variation Excel Function	Coefficient of Variation
Sac. River East Levee Unit 2 LM 0.3 to 2.1																			
ARB-6	27					CL	0.0028	SM	5.7	2036					4				
ARB-7	33					CL	0.0028	SP	5.7	2036					11				
ARB-8	37.5	29	7	54	25	CL, ML	0.057	SM/SP	5.7	100	1261	1060	1124097	84	17	9	6	34	66
ARB-11	18					CL, ML	0.057	SM	5.7	100					3				
ARB-12	30.5					CL	0.0028	SP	5.7	2036					11				

	Permeabilities:				
	kh		Kv		
		ft/day	cm/sec	ft/day	Kv/Kh
Clays(CL)	4.00E-06	0.0112	1.00E-06	0.0028	0.25
Clay with Silt (CL,ML)	2.00E-04	0.228	5.00E-05	0.057	0.25
Sand, silty sand (SP, SM)	2.00E-03	5.7	2.00E-04	0.57	0.1

611

UNDERSEEPAGE ANALYSIS
Natomas Basin Levee Unit 2 Reach I (NAT I)
American River North Levee, LM 0.0 to 2.3 3 (RM 0.0 to 1.7) Existing Conditions Expert Elicitation
Index Point: LM 1.28 (RM 0.9)

Crest width (feet) 50.00
Horizontal to vertical slope ratio 4.00

		Hf	= max head or levee height	L2	= levee base width
		Hwt	= head above tailwater at berm end	Le	= landside effective length
		HFwt	= head above tailwater at 1/2 berm	Lt	= total effective length
K-r	= riverside permeability	Ho	= head above tailwater at levee toe	t'	= underseepage berm thickness at toe
K-L	= landside permeability	i-e	= critical seepage gradient	Sc	= calculated slope of underseepage berm
Dbr	= riverside blanket thickness	Wt	= berm width	tu	= used thickness of underseepage berm
DbL	= landside blanket thickness	i-o	= seepage gradient		
Df	= thickness of pervious foundation	Cr	= riverside effective length coefficient		
Lr	= length of riverside blanket	Cl	= landside effective length coefficient		
Ll	= length of landside blanket	L1	= riverside effective length		

Levee Mile	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-e	Lr	Wt	Factor of Safety	L't	Ho	Hfwt	i-o	Cr	Cl	L1	L2	Le	Lt	Hwt	t'
1.28	1261	1261	29.2	29.2	29.2	8.9	20.5	0.800	150	0	1.75	879	13.3	13.3	0.46	573	573	147	160	573	879	NA	NA

Head = 20.50

	K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1261	29	8.9	573	147	16.3	0.5588943		
	2522	29	8.9	777	148	17.2	0.5805929	0.0051868	20.5452
	201	29	8.9	229	132	13.0	0.4455543		
	1261	37	8.9	640	147	16.7	0.4561578	0.0180279	71.410
	1261	22	8.9	495	146	15.8	0.7246935		
	1261	29	14.7	737	148	17.1	0.5846719	0.0020310	8.0451
	1261	29	3.1	335	141	14.4	0.4945377		
							Total	0.0252457	100

E[I] =	0.5589	E[ln I] =	-0.62066
Var[I]=	0.02525		
sigma[I]=	0.15889	sigma [ln I] =	0.278786
V(I) =	0.2843		
I crit =	0.800	ln(I crit) =	-0.22314

F(z) =	0.92305
Pr(f) =	7.69530

Head = 17.50

	K/Kb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1261	29	9	573	147	13.9	0.4771049		
	2522	29	9	777	148	14.7	0.503311	0.0037798	20.5452
	201	29	9	229	132	11.1	0.3805512		
	1261	37	9	640	147	14.2	0.389403	0.0131375	71.410
	1261	22	9	495	146	13.5	0.6186408		
	1261	29	15	737	148	14.6	0.4991101	0.0014801	8.0451
	1261	29	3	335	141	12.3	0.4221663		
							Total	0.0183974	100

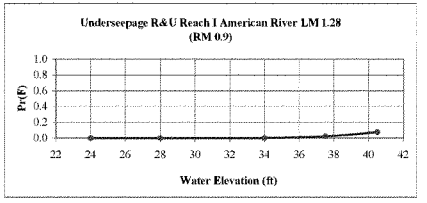
E[I] =	0.4771	E[ln I] =	-0.77888
Var[I]=	0.01840		
sigma[I]=	0.13564	sigma [ln I] =	0.278786
V(I) =	0.2843		
I crit =	0.800	ln(I crit) =	-0.22314

F(z) =	0.97689
Pr(f) =	2.31079

Table 1 : Random Variables

Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Blanket z	29	7	25
Perm Ratio	1261	1060	84
Fdn Sand thickness	9	6	66

Head	Elevation	Prf Seepage
4	24	0.00000
8	28	0.00000
14	34	0.00260
17.5	37.5	0.02311
20.5	40.5	0.07095



612

Head = 14.00

	KfKb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1261	29	9	573	147	11.1	0.3816839		
	2322	29	9	777	148	11.8	0.4020488	0.0024191	20.5452
	201	29	9	229	132	8.9	0.304281		
	1261	37	9	640	147	11.4	0.3115224	0.0084080	71.410
	1261	22	9	495	146	10.8	0.4949126		
	1261	29	15	737	148	11.7	0.3992881	0.0009473	8.0451
	1261	29	3	335	141	9.9	0.3377331		
							Total	0.0117743	100

E[I] =	0.3817	E[ln I] =	-1.00202
Var[I] =	0.01177		
sigma[I] =	0.10851	sigma [ln I] =	0.278786
V(I) =	0.2843		
I crit =	0.800	ln(I crit) =	-0.22314

F(z) =	0.99740
Pr(I) =	0.26044

Head = 8.00

	KfKb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1261	29	9	573	147	6.4	0.2181051		
	2322	29	9	777	148	6.7	0.230085	0.0007899	20.5452
	201	29	9	229	132	5.1	0.1738749		
	1261	37	9	640	147	6.5	0.1780128	0.0027455	71.410
	1261	22	9	495	146	6.2	0.2828072		
	1261	29	15	737	148	6.7	0.2281646	0.0003093	8.0451
	1261	29	3	335	141	5.6	0.1929903		
							Total	0.0038447	100

E[I] =	0.2181	E[ln I] =	-1.56164
Var[I] =	0.00384		
sigma[I] =	0.06201	sigma [ln I] =	0.278786
V(I) =	0.2843		
I crit =	0.800	ln(I crit) =	-0.22314

F(z) =	1.00000
Pr(I) =	0.00008

Head = 4.00

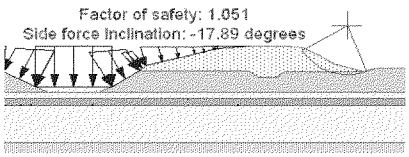
	KfKb	z	d	X3	s	ho	I	Variance Component	Percent of Variance
Mean	1261	29	9	573	147	3.2	0.1050525		
	2322	29	9	777	148	3.4	0.1150425	0.0001975	20.5452
	201	29	9	229	132	2.5	0.0869374		
	1261	37	9	640	147	3.3	0.0890064	0.0006864	71.410
	1261	22	9	495	146	3.1	0.1414036		
	1261	29	15	737	148	3.3	0.1140823	0.0000773	8.0451
	1261	29	3	335	141	2.8	0.0964952		
							Total	0.0009612	100

E[I] =	0.1091	E[ln I] =	-2.25479
Var[I] =	0.00096		
sigma[I] =	0.03100	sigma [ln I] =	0.278786
V(I) =	0.2843		
I crit =	0.800	ln(I crit) =	-0.22314

F(z) =	1.00000
Pr(I) =	0.00000

STABILITY ANALYSIS

Natomas Basin Levee Unit 2 Reach I (NAT I)
American River North Levee, LM 0.0 to 2.33 (RM 0.0 to 1.7) Existing Conditions Expert Elicitation
Index Point LM. 1.28 (RM 0.9)



Water Elevation: 40.50

Reliability Analysis of Critical Slide

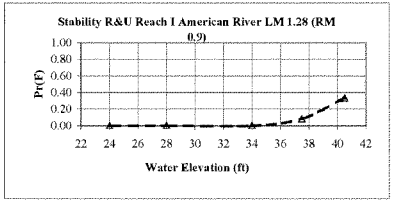
Run	Foundation Silt Φ	Levee Silt Cohesion	Levee Silt Φ	Foundation Silt Cohesion	Levee Silt γ	FS	Variance Component	Percent of Variance
Mean 1	29	50	27	50	125	1.051		
2	32	50	27	50	125	1.107	0.0031923	26.9963
3	26	50	27	50	125	0.994		
4	29	30	27	50	125	1.002	0.0017640	14.9179
5	29	70	27	50	125	1.086		
6	29	50	30	50	125	1.119	0.0036603	30.9541
7	29	50	24	50	125	0.998		
8	29	50	27	70	125	1.107	0.0031360	26.5206
9	29	50	27	30	125	0.995		
10	29	50	27	50	130	1.060	0.0000723	0.6110
11	29	50	27	50	120	1.043		
						Total	0.0118248	100

E[FS] =	1.0510	E[ln FS] =	0.04442
Var[FS]=	0.01182		
sigma[FS]=	0.10874	sigma [ln FS] =	0.103190
V(FS) =	0.1035		
FS req'd =	1.000	ln(FS req'd) =	0.00000

Beta =	0.430431
F(z) =	0.333434
Pr(f) =	33.343397

Table 1 : Random Variables for East Bottoms

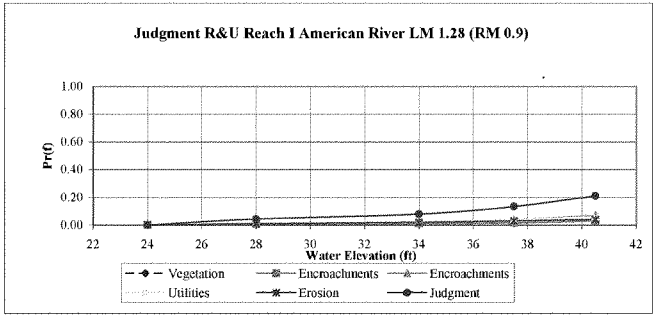
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Foundation Silt Φ	29	3	12.00
Levee Silt Cohesion	50	20	40.00
Levee Silt Φ	27	3	12.00
Foundation Silt Cohesion	50	20	40.00
Levee Silt γ	125	5	4.00



Elevation	Prf Stability
24	0.00000
28	0.00000
34	0.00000
37.5	0.08261
40.5	0.33343

Judgment Risk
Natomas Basin Levee Unit 2 Reach I (NAT I)
American River North Levee, LM 0.0 to 2.33 (RM 0.0 to 1.7) Existing Conditions Expert Elicitation
Index Point LM. 1.28 (RM 0.9)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Vegetation		Encroachments		Encroachments		Utilities		Erosion		Judgment	
24	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.0000	1.00000	0.00000	1.00000	0.00000	1.000000
28	0.00500	0.99500	0.01000	0.99000	0.01000	0.99000	0.0100	0.99000	0.01000	0.99000	0.04421	0.955793
34	0.01000	0.99000	0.01200	0.98800	0.02000	0.98000	0.0200	0.98000	0.02000	0.98000	0.07940	0.920599
37.5	0.01500	0.98500	0.01700	0.98300	0.04000	0.96000	0.0400	0.96000	0.03000	0.97000	0.13443	0.865573
40.5	0.03000	0.97000	0.03000	0.97000	0.07000	0.93000	0.0600	0.94000	0.04000	0.96000	0.21037	0.789633



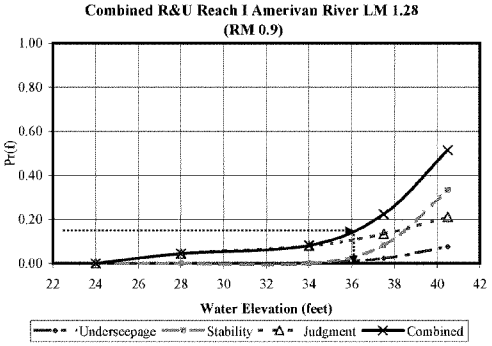
Combined Risk

Natomas Basin Levee Unit 2 Reach I (NAT I)

American River North Levee, LM 0.0 to 2.33 (RM 0.0 to 1.7) Existing Conditions Expert Elicitation

Index Point LM. 1.28 (RM 0.9)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
24	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
28	0.00000	1.00000	0.00000	1.00000	0.04421	0.95579	0.04421	0.955792
34	0.00260	0.99740	0.00000	1.00000	0.07940	0.92060	0.08180	0.918201
37.5	0.02311	0.97689	0.08261	0.91739	0.13443	0.86557	0.22428	0.775716
40.5	0.07695	0.92305	0.33343	0.66657	0.21037	0.78963	0.51416	0.485839



Levee Landside Toe Elev.	20 feet
Levee Crest Elev.	40.5 feet
15% Probability of Failure	36 feet
85% Probability of failure	above levee crest

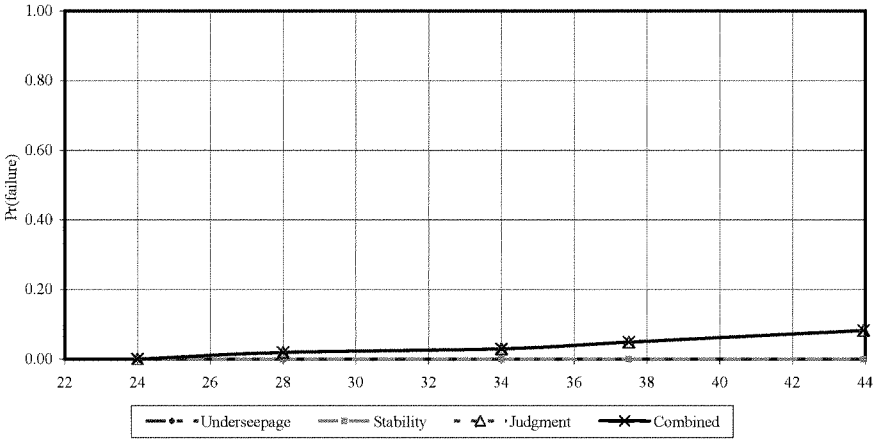
The elevations are in Datum NAVD 88

Combined Risk

Natomas Basin Levee Unit 2 Reach I (NAT I)
American River North Levee, LM 0.0 to 2.33 (RM 0.0 to 1.83) Alternative 1 Cutoff Wall In Place
Index Point LM. 1.28 (RM 0.9)

	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
Elevation	Underseepage		Stability		Judgment		Combined	
24	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.000000
28	0.00000	1.00000	0.00000	1.00000	0.01908	0.98092	0.01908	0.980917
34	0.00000	1.00000	0.00000	1.00000	0.02969	0.97031	0.02969	0.970310
37.5	0.00000	1.00000	0.00000	1.00000	0.04867	0.95133	0.04867	0.951334
43.95	0.00000	1.00000	0.00000	1.00000	0.08258	0.91742	0.08258	0.917423

NAT I: Combined Geotechnical Risk & Uncertainty
Alternative 1 Cutoff Wall In Place



Levee Landside Toe Elev. 20 feet
Levee Crest Elev. 40.5 feet
The elevations are in Datum NAVD 88

AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

NATOMAS POST AUTHORIZATION CHANGE REPORT

ENCLOSURE F5

USACE EXPERT-OPINION ELICITATION

American River Common Features GRR Geotechnical Expert Elicitation

DAY 1

Project:	American River Common Features GRR
Date:	Wednesday, June 17th, 2009 8:00 am to 5:00 pm USACE - Sacramento District, Room 1424
Facilitator:	Michael Ramsbotham (MDR), USACE
Meeting Called By:	Mary Perlea (MPP), USACE, Project Geotechnical Engineer

ATTENDEES

See Attendance Record (to be attached at end of finalized meeting minutes)

MEETING MINUTES

Call to order at 8:15 am

The meeting was called to order at approximately 8:15 am by the Facilitator, Michael Ramsbotham (MDR).

Introductions and Sign-In

A few minutes was spent on introductions and attendees signing the attendance list.

Identify EOE Team / Affiliation and Observers / Participants

The following attendees were recognized as Panel Members, meaning they would be voting on various items during this 2-day meeting:

- Paul Devereux, RD1000
- Les Harder, HDR, Inc.
- Mike Inamine (Mike I.), DWR
- Ed Ketchum, US Army Corps of Engineers
- Steve Mahnke, DWR
- Henri Mulder, US Army Corps of Engineers
- Mike Nolan (Mike N.), Consultant to City of Sacramento Utilities Department
- Tom Smith, Ayres Associates
- Mohsen Tovana, US Army Corps of Engineers

The following observers participated at the meeting

- Peter Ghelfi, SAFCA
- Jesse Hogan, US Army Corps of Engineers
- Dan Tibbitts, US Army Corps of Engineers
- Kevin Knuuti, US Army Corps of Engineers
- Jeff Taylor, US Army Corps of Engineers
- Joe Sciadrone, US Army Corps of Engineers

Introductory Comments by Attendees

Mary Perlea opened the meeting by requesting introductory comments from the audience.

Kevin Knutti thanked everyone for their time in being there. He stated he realized everyone's schedules are busy and really appreciates them making time for this meeting. Dan Tibbitts concurred with Kevin's comments and advised he hopes this meeting will bring about resolution on various tasks in which there is currently little-to none criteria in setting up judgment of the levee performance curves.

Pete Ghelfi commented that he is attending the meeting as an observer and will try to play that role. He feels it is important to be able to see within the black box a little bit and welcomes the opportunity to work together.

Kevin added that the Corps' Sacramento District is taking the lead for the Corps on a couple of items. It is recognized that this is one area where the Corps' policy has problems. While this issue is recognized by some, it

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will allow further discussion with others within the Corps to begin refining the Corps' policy.

Ed Ketchum concurred with Kevin's comment. He included the statement that this is very important work and the values that come out of this meeting will affect the national economic plan. This has a huge influence on Benefit/ Cost ratio and everything else.

This part of the meeting concluded with Steve Mahnke noting that there is a partnering of many of the attendees, so it is very important to see this issue from the Corps' perspective.

Introductory Comments by Facilitator
MDR led the group in an informal discussion regarding the different meeting elements. Those discussion points included:

The Purpose/Expected Outcome of the 2-Day meeting:

- The purpose is to assist the Corps in development of the geotechnical judgment curves for the American River Common Features GRR (ARCF-GRR) project
- MDR added the judgment curves impact Economics and inquired as to the expected outcome. It was noted that Melanie Garland will provide meeting minutes of the 2-day discussion and Mary will provide a report that captures the summary, conclusions and recommendations. In addition, Mary will include revised judgment and fragility curves for the ARCF-GRR. The outcome of these discussions may lead to policy change, new Corps' guidance and/or a revised ETL.

Rules of Engagement

- Directions to accommodations was provided
- If a break is needed, the group was encouraged to suggest it
- MDR stated the discussions should be informal as he wanted everyone to be engaged and provide frank input freely
- MDR added that he hoped to see general information to final analysis and specific circumstances with the American River
- Side bar conversations were to be minimal
- Avoidance of "group" think and independent voice of opinions was supported

Review of Agenda / Scope
A brief review of the agenda and scope of discussion was held
Questions and Answers

- MDR led the attendees in an overall questions and answers period to familiarize themselves more on the general topic at hand. This was done to gain a better understanding of the role they were asked to play. The following discussion took place:

  Seepage and stability was brought up. Mary clarified they are only discussing judgment curves here as the seepage and stability components were straightforward. Mary added that the intent was to discuss poor performance first and then see if we can come to conclusion on chances of failure. Ed feels the seepage and stability will need to be discussed as well. Mary responded that they will not be left out; however, they will not be judged in this forum. She iterated that the final will include all of them, but the geotechnical analysis is already known and is not based on subjective discussion. Mary's scope is to decide on judgment curves first.

  Les Harder commented that he assumed "failure" would be clarified. Mary responded by saying that "failure" equals poor performance or breach. MDR added that this may continue to be refined during the meeting. If we are coming up with judgment curves on vegetation, encroachment, etc., it will depend on how robust the levees are. They may have a different set of curves for the levee based on this and seepage/stability. Mary stated information will be provided. Judgment (erosion, penetration, vegetation, encroachment) is what Mary needed the full panel for. The others have already been decided. Then, there is likelihood of failure being discussed.

  In the geotechnical analysis that includes stability, seepage and judgment, Mike Nolan inquired if judgment is weighted the same as seepage and stability, or if its weighting can be

reduced in the risk-based / FDA model. MDR responded that the hope is to get into this more in depth as they look into poor performance after taking a look from the judgment perspective. It was noted that FDA uses the total combined curve. Ed stated weighting will likely be based on folks' past experience. Pete added that in this forum, the group was hoping to make a judgment on judgment.

Mary discussed some of the work that had already been done by URS in regards to Erosion Analysis. She conveyed that she did not believe the Corps provided URS with the information needed for the evaluation, so erosion analysis will likely need to be revised. URS identified the highly erodible area which was considered by Mary on the initial judgment curves.

Ed asked if recommendations could be made to Headquarters (HQ) based on this meeting. Mary answered by stating this is the first time this has been done. The conclusion will be included in the CF GRR study that will be provided to the Headquarters, but the scope is not to provide recommendation to the Headquarter policies.

Paul Devereaux questioned whether the current procedure was over predicting or under predicting failure? Mary advised she provided all preliminary curves already. The curves will be revised based on the panel recommendation.

Henri Mulder asked about the current guidance ETL. Dan responded by advising him yes, the current guidance ETL 1110-2-556 was being used, however, it is only one paragraph regarding the judgment fragility curves and not much guidance provided. It is expected the guidance ETL will be revised, but in the meantime, that was part of the purpose for the 2-day meeting.

- At this point, MDR noted the discussion had gotten off track and reminded the group, that while flood fighting had been a huge discussion, the purpose was to resolve the judgment curve issue. This effort that includes erosion, vegetation, penetration and encroachment was a difference that he had seen in previous efforts. As far as he could tell, it had never been done consistently. In his opinion, whoever analyzes the "without project" conditions needs to be the same person to analyze it for "with project".

  Mike Inamine questioned why the group wasn't just looking at failure and what in the FDA model came close to this. Ed responded it has a national impact so the benefits from this project will be for others as well. Mary added that poor performance is indicative of a weaker levee for future events and may lead to levee failure. While it may not be a "failure", it has the propensity for failure and damages. Mike I. countered that they are looking at a fuzzy area that would result in a breach or such poor performance that it would result to what?

  Les added to combine them equally as the curves should be scaled the same. Mike I. commented that looking at poor performance as definition while Mike N. advised performance to him is no inundation if that is what is being used for economic analysis in the Corps' FDA model.

  Mary asserted that for now we are looking at existing conditions of the levee as performance, however, Henri and Mike N. both felt the group should be looking at both.

  Pete suggested displaying a probability curve with seepage and stability to reflect how judgment affects it by applying those components. In regards to economic analysis, he queried as to whether or not it needed to be limited. Les agreed, however, added that they should be applied under the same criteria or at least comparable in terms to what "failure" means.

  MDR responded by explaining that is partly the way it has been done based on the current guidance and trying to be consistent nationwide. He conveyed that what is happening in the

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	economic study is determining what the benefits are versus the cost. He further went on to express that he felt it was a mistake to take economic criteria and applying it to performance. He added that, in his mind, to get to the true level of protection, a different approach should be taken.

Background Presentation / Project Overview - MPP

Mary provided the team with a presentation of the ARCF-GRR with a description of the three primary areas: Natomas Basin, American River North Basin, and American River South Basin. These three primary areas were analyzed by URS who determined the critical reaches considering seepage, stability, and erosion based on 100-year high water elevation. The map Mary showed the group had seepage, stability, erosion and height deficiency plotted in reaches in the three different primary areas and reflected the areas that ARCF-GRR encompasses. Mary added that based on another URS analysis, for a 200-year event (not displayed), erosion was everywhere.

Mary reported that eventually, the ARCF-GRR team may breakout the Natomas Basin from the other basins due to priority.

It was noted that the damages shown on the map are determined based on a deterministic analysis considering a minimum factor of safety 1.4 for stability and 1.6 (gradient higher than 0.5) for under seepage for the 100-year flood event. The deterministic analysis was conducted determining the weakest cross sections within a reach considering the worst geotechnical parameters. Geotechnical R&U analysis made for the index points (as selected by the deterministic analysis as the critical points on a reach) uses the average values (or the most credible values) applying a coefficient of variation based on statistical analysis. The R&U determine the risk of failure due to stability and under seepage applying the coefficients of variation around the mean values considering the factor of safety of 1.

Mary walked the group through a specific sample to illustrate the engineering R&U fragility curves determined by seepage and stability R&U analysis versus the judgmental portion of the R&Y combined fragility curves.
Ed inquired if a variation across the levee for vegetation and encroachment were being looked at the same as is done for under seepage and stability. Mary responded no, that for the judgment curve, items are looked at within the reach where for the stability and under seepage it was considered the critical cross section representing a reach, with average parameters and their coefficient of variation. Ed countered by asking if they should look at the average condition along the reach. Mary answered by advising they have some index points where seepage and stability are not an issue, however, vegetation and encroachment are. Ed replied by asking if the integral of the area underneath is what is taken into consideration. Mary confirmed. She added that she will describe the specifics of each reach when they get to each reach section.

Most Likely Failure Modes Identification - Team

This part of the meeting consisted of the team being polled in relation to identifying what causes a levee to go into failure mode, that is, what causes levees to fail or breach. Nineteen different causes were identified as listed at the end of this section.

After the various factors where identified, the panel was asked to vote which ones are most likely to cause a levee to fail. The number listed to the side reflects the number of votes it received during this particular exercise in relation to their view of its significance to causing a failure mode.

- Under seepage - piping / stability - 9
- Overtopping - 4
- Stability - 6
- Erosion - waterside, scour - 7
- Through - seepage (internal erosion) - 4
- Closure structures - 0
- Penetrations through foundation - 1
- Seepage through animal holes - 6
- Uprooted trees - 0
- Human intervention - 0
- Seismic - overtopping - 0
- Seismic - seepage - 0
- Seismic - stability - 0
- Through - seepage (stability) - 4

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- Penetrations through levee -5
- Encroachment (pools) - 0
- Wave/Wind erosion leads to overtopping - 0
- Wave erosion - 0
- Ditches (seepage / encroachment) - 0

After this vote, much discussion was held as to how the different failure modes interact and impact one another.

Mohsen inquired about the levee failure in RD 784 in '97. Ed advised the erosion moved back faster than they could do the flood fighting and it became larger at the crescent as it worked its way back to the levee. Mohsen stated his point is that some of these breaches have occurred on some good levees in relation to the inspection point. Ed advised he said that he's seen where erosion has affected the seepage, which has impacted the stability.

Identification of Significant Failure Modes - Panel Votes

The panel was asked to consider the top seven significant failure modes identified from the previous exercise and vote in regards to how they see the likelihood of a failure mode caused by one of these factors. The results (with the number of votes received) are provided below:

- Under seepage - 10
- Through seepage - 8
- Erosion = Analysis* - 7 / *Research analytical methods - use existing tools to form judgment.
- Overtopping - 4
- Penetrations - 6
- Stability - 6
- Rodents - 6

It was determined that when considering "Other Failure Modes" (sense on how these relate to those identified as most important), judgment is very important, but should not be more about 20%.

Relative Ranking and Contribution of Significant Failure Modes (weighting factor 0 - 100%) - no flood fighting - Team

The panel was then asked to conduct a relative ranking of the significant failure modes with no flood fighting involved. The results were as follows:

- Erosion
- Penetrations
- Rodents
- Others

After another vote, it was determined that the Top 3 may contribute 10-25% to a levee breach or failure.

Discussion of Importance of Judgment Curve - Team

A lengthy discussion was held with the team as far as the importance of the judgment curve and the various components that should be included.

It was noted that certain components are currently being considered in the evaluations and analytical models. These include erosion, penetration, vegetation (includes rodents, beavers, squirrels, etc.), and encroachment. The team felt there were other components that should be considered as well. These include as-builts/knowledge of construction/maintenance, the separation of rodents from vegetation, swimming pool encroachments, penetrations through the levee, and penetrations through levee foundation.

After much discussion, the team came to the consensus that the following components are what need to be considered:

- Encroachments
- Erosion
- Penetrations
  - Through levee
  - Through foundation
- Rodents

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- Beaver
- Squirrel
- Vegetation
  - Trees
  - Brush
- Maintenance - Overall

It was noted that failure considers the overall reliability of the levee.

Dan advised they are trying to define a methodology of performance curves to apply to both "with" and "without project" conditions. Mike N. responded by asking if this shouldn't be done in parallel to Economics. Dan explained there is a difference between the two based on the performance of the levee. Mary added to this by explaining the goal in their economic analyses is to determine damages based on levee failure. MDR then conveyed to the team that where Mary needs the most support is in determining how to do this.

Mike I. stated that collectively there is not a way to quantify how they feel about a specific section. Les asked Mike I. If there was a way to tell how the seepage and stability curves are being used. Mike I. responded by stating there was, as another category of judgment. He went on to say that on its own, erosion may not be an issue, however, when the section is looked at collectively, it causes "heartburn". Further, individually they may not add up to such a bad score, however, collectively it poses an issue.

Pete contributed to the discussion by inquiring as to how much should judgment affect the curve. Tom Smith added that how comfortable one is with the data they have is an important component. Dan stated in his mind it is more reach-specific.

Les expressed concern about using the term "judgment". He wanted to look at analytical components and temper them. MDR agreed we need to revise the agenda to include "relative importance of judgment". Judgment can be based on non-analytical info as well as analytical inputs. Non-analytical should look at best estimates; while analytical is the best estimate with Co-efficient Of Variations (COV). Henri and Paul both commented that the analytical stuff is what points to failure on the weaker levees. Judgment is still important.

It was noted that consideration of agreement in failure modes & influence, importance of the economic model versus level of protection & public safety can have a difference on the basis of risk and communication. It is important to define the level of performance versus economics.

Discussion of Need for Specific Performance Curve for Unique Flaw / Failure Mode - Team
MDR led the group in a discussion of specific performance curves needed for unique flaws or failure modes. In this discussion failure modes or flaws not covered in typical analysis were looked at. MDR advised it is important to recognize these specific potential failures as they may need to be included in a special curve for special instances, current or future.

Pumping stations/plants, drainage ditches, and farmer water supply wells were some items that were mentioned as having an impact on levee performance. Henri noted that some items could be categorized under "maintenance". Mary commented that while she agrees it can be a failure mode, the problem with maintenance is that it cannot be added in remediation (the sponsors are responsible for the maintenance) or included in the remediation action for the feasibility study.

A question was posed as to whether or not the failure modes should be analyzed or just included in the judgment. It was suggested that special / unique failure modes should be considered for inclusion as a special curve if analytical methods are available. Les commented that his sense was that this should be captured under the various categories under judgment. Mike N. cautioned the team not to double-up and compounding the "unknowns".

Change in Agenda
At this point of the meeting, a decision was made to change the agenda by fast forwarding to looking at the various sites individually versus the development of generalized performance curves for each component.

Site-Specific Performance Curves for Various Situations / Flaws - MDR / MPP
The purpose of this section was to provide Mary with feedback on specifics. For the first site, Mary presented a

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specific scenario for components of the judgment curve. The team discussed and provided input to the judgment curve.

SITE 1 - Natomas Basin, Sacramento River close to American River at location of Pump Station #1 on the Sacramento River

- **GENERAL CONDITIONS:**
  - Sandy foundation and seepage issues. Seepage analysis shows a very high risk due to under seepage (high hydraulic gradients). Based on URS erosion analysis, this area is flagged as high risk when the water is at the highest elevation, but Mary isn't sure the analyses assessed the existing conditions such as vegetation, riverbank protection and encroachments on the waterside including apartment houses constructed on fill placed on the river berm to the crest of the levee. Mary also sees penetration issues here from pipes from the RD 1000 pump station, pressurized pipes and other. Ed advised the Corps found old wood, concrete, etc. when the Corps studied the area for improvement. Paul noted there are a lot of structures within the entire reach such as restaurants, businesses, etc. On some areas of the reach the levee is oversized, with the crest as much as 60 feet wide. The existing conditions include the following:
  - A deep soil/cement/bentonite wall to be constructed under WRDA'99 authorization
  - No gap
  - An existing shallow slurry wall (30' to 40')
  - Generally the levee crest is 40 feet wide except the area where it is further overbuilt
  - The levee is constructed of sand (typical dredge fill) with containment berm
  - The side slope is as everywhere else 1V:3H on the waterside and 1V:2H on the landside
  - Tom added that this is a unique piece of the river and high water elevations should have lower velocities due to Sacramento Bypass on the upper end which diverts the water in the Yolo Bypass

Scenario #1 - VEGETATION

- **CONDITIONS (and discussion on conditions):**
  - In specific to vegetation, the trees go up to the top of the levee on both sides (water and land). Rodents are an issue, too.
  - Trees - 10 years old in levee
  - Possible roots
  - Henri feels the numbers on Mary's proposed curves are way too high on vegetation
  - Les drove a clarification discussion regarding openness to changing the categories. It was decided the Corps is willing to do this, however, Mary advised she cannot drop vegetation based on Corps policy
  - Clarifying point: vegetation goes to extent of the levee. It is everywhere and oversized
  - Mohsen asked how the tree roots behave near slurry walls. Do they penetrate the wall or what? Ed advised composition of the wall influences the behavior of the roots and their strength.
  - Tom advised the wind affects the trees on levees more than anything else, so he is challenging the current curve result. He thinks the failure mode for trees on levees is windfall.
  - MDR advised we are now looking at redefining failure in this case as poor performance. The meeting's objective is to redefine the judgmental curves based on people opinion with experience on the Sacramento River system.
  - Trees are in 40' crown width section in vicinity of the pump station and at the top of the levee. Are they so bad that they would require human intervention such as flood fighting or levee repairs later? The scenario would be something that might affect the performance of the levee with tree gone needing immediate action such as flood fight:
    - For 60' crown width reach on the overbuilt levee (vote taken after earlier misunderstanding on issue / scope):
      - After removing the high and low factors, the average was 5.14%
    - For 40' reach considering the water at top of levee:
      - After removing the high and low factors, the average was 5.14%
    - For 40' reach considering the water at half of levee height :
      - After removing the high and low factors, the average was 9.14%

- Results must be consistent with other analytical approaches
- Mary wants to know how much does water velocity change impact the removal of the trees from the levee slope and cause holes in the slope. The Sacramento Bypass Weir is open at elevation 27 feet and at some point the velocity goes to 0 and then upstream it goes to 2 feet per second back towards the Weir (per Tom Smith). Tom advised this is such a small percent as associated with vegetation. The problem with trees is wind and erosion. Ed recommended 2% from 28 all the way across to top of levee.

Scenario #2 - ENCROACHMENTS

- **CONDITIONS (and discussion on conditions):**
  - Homes on waterside (difficult to inspect) - multi-million $ homes
  - All of the housing on the water side brings water & utilities together, which makes it difficult to inspect.
  - Restaurants
  - Apartments
  - On the land side, this is an Urban area. The city has a pump station there and there are some ranchettes further up.
  - Most of the encroachments are on the waterside and at the top of levee & berm.
  - Lack of inspection due to fences and hedges
  - Visibility is poor and access is difficult as people will not permit inspections
  - Paul advised there has been work in regards to the inspection - not resolved, but in progress
  - Interventions can be done
    - Inspections
    - Maintenance
  - Mary is most concerned with encroachment (particularly swimming pool and landscaping) causing seepage issues
  - Les noted that they need to be looking at this as a serious condition - safety factor of 1. Problem of Encroachments commensurate with limiting P(S) = 1
  - Ed noted both the seepage and stability analytical methods cannot include the encroachments, however, encroachments can impact seepage and stability
  - Mohsen stated he was more concerned about the leach fields that were put in this area some years ago. He doesn't believe there was anything to regulate their placement.
  - The question was posed if encroachments contribute to the development of a problem in regards to the safety of the levee. It was determined it was higher than trees, but lower than utilities.
    - For 40' crown width reach considering the water at top of levee:
      - After removing the high and low factors, the average was 6.57%
      - Influence factors
        - Operational issues
        - Impact on seepage & stability
        - Water at top of levee
  - MDR brought up the issue of whether or not encroachments should be kept in our evaluation. In some areas, they are significant and others are not. Henri stated he didn't think it is significant enough. He felt in cases where we aren't able to drive or walk on the levees, they should be considered. Paul agreed with Henri on the American River, but on Sacramento River he felt it should be considered. Mary advised she has to include them for consistency, however, she can put the impact as 0 wherein that's the case.
  - Pete & Les suggested we continue this process and see where we are on it after we've looked at few more areas and then revisit it.

Scenario #3 - PENETRATIONS

- **CONDITIONS (and discussion on conditions)**
  - Shallow slurry cut-off wall
  - Utility lines through the levee
  - Pump 1A and Pump 1B are constructed differently and Corps is evaluating this matter per Joe S and is being evaluated under WRDA 96-99. There could be some potential seepage under the boxed culvert. This should be analyzed as a seepage model.
  - Structure was built in 1915. Inspection of the inside is being done and the Corps is awaiting the results.

- The discharge lines from the pump station have flap gates and hand cranks that are 1914 vintage. There is seepage at joints into conduit.
- This is the only issue in this area that is not characterized.
- Mary stated she needs to know if seepage in an issue in regards to the culvert. The response was that seepage is an issue with the culvert and it is being looked at. However, the authorized repair is only for the cut-off wall, does not include discharge line replacement or repair so seepage along the conduit and structural failure of the culvert remain issues. For the existing condition, Mary has no idea as to what is there. Repair of the conduit would be considered in the CF GRR alternatives.
- A question was posed a far as what the chance is the culvert would damage the levees. MDR noted that if this culvert is this big of a problem, then they need to get engineering involved. This culvert is critical for the entire reach.
- Paul advised this has been an ongoing issue with SAFCA for some time.
- Ed commented that if we pulled the culvert out, then we need to look at the utilities along the rest of the reach. His concern that this one spot will mask things for the entire reach.
- MDR made a decision that at this point we are going to discuss utility penetrations along the reach eliminating the discharge lines from the pumping plant, accepting that these need further civil investigation and special design.
- Paul advised there are some other utilities along the waterside as well as some utility crossings. It is a mixed bag. There is also a big sewer force main and some irrigation lines. These are the ones that Paul is aware of.
- Steve Mahnke mentioned there was a sewer line along I-80 that caved at the installation by directional drilling and this is a concern. The levee settled a couple of inches and a big subsidence was observed under an abandoned house. Ed stated he thought that was going to be put into a judgment. He added that he was not planning to pull that out. Ed asked Steve if the collapse was mitigated. Steve responded that he did not think so. Paul advised pressure grouting was added and impact of seepage was looked at. Mary was involved in the repair of the site that included compaction grouting and backfilling the subsidence. The levee is monitored monthly for any further movements and the reports provided to Mary for information. So far, the repair of the area shows to be satisfactory so there is no more concern regarding this line.
- Paul advised there are some pressurized gas lines as well. These are transmission gas lines and fuel lines that go under the levee.
- It was noted there are lots of utilities; some of which go high, some go low, some are in good shape and others are not.
- A vote was called in regards to Utilities' impact on the levee for the reach from the Sacramento Bypass to the American River:
    - For 40' reach at top of levee (with the water at the upper 3 feet):
        - After removing the high and low factors, the average was 10.29%
        - Influence factors
            - Uncertainty biggest failure
            - Slurry wall cut off shallow, the pipes were not relocated during cut-off wall construction
            - Sewer problem
            - Rectified/Fixed
            - Concerns on directional drilling
            - Sewer line controlled closer
    - Another vote was called for the same conditions with the sewer line being considered:
        - Considering the high and low factors, the average was 19.44%
        - After removing the high and low factors, the average was 16%
    - A third vote was called for the same conditions without sewer line, but considering penetrations in general for this reach:
        - Considering the high and low factors, the average was 6.11%
        - After removing the high and low factors, the average was 5.43%
- Les noted that we need to remember what was said earlier today and not to look at worse conditions. The group is supposed to look at standard deviations. Mary's point was that it

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must be included in this case because it's the worse condition and the best is zero. In order to get average, she must consider it.
- Pete commented that it sounds like it's the same type of thing as the culvert.

SUGGESTIONS FOR DAY 2

The meeting shifted to a discussion led by MDR as to what could make the discussions better on Day 2.

- Ed suggested Mary go back and provide the details on the scenarios she wants answers to.
- A question was raised if other panels are going to be held on GRR. Ed said perhaps and MDR recommended they make the panels smaller if they do.
- Mike I said he saw the discussions as useful. He thinks we need to go back to our original premise that all of these together only contribute 20% to the judgment. It was agreed that the reach the team just reviewed is different. After this one, is 20% appropriate for judgment?
- Mike N. asked as far as the overall scope was the objective still to get all areas done as originally laid out in the agenda. Dan advised that all areas are needed in order for them to breakout Natomas.
- Tom added that each reach is different and expressed he didn't think the team was going to race through them.
- Les suggested that, for tomorrow, to pick the ones that have the best range of things, i.e., typical versus extreme. Mary advised she doesn't have any "typical".
- A need to prioritize work was expressed
- A recommendation was given to pick a range of sites to get broad feedback.

Day 1 Concluded at 5:15 pm

DAY 2

Project:	American River Common Features GRR
Date:	Thursday, June 18th, 2009 8:00 am to 4:30 pm USACE - Sacramento District, Room 1424
Facilitator:	Michael Ramsbotham (MDR), USACE
Meeting Called By:	Mary Perlea (MPP), USACE, Project Geotechnical Engineer

ATTENDEES

See Attendance Record (to be attached at end of finalized meeting minutes)

MEETING MINUTES

Sign-In

Day 2 of the meeting commenced at 8:00 am with team members signing in.

Introductory Comments - MDR

MDR led the group with introductory comments. Mary iterated where the meeting ended yesterday in regards to Utilities and the sewer line. She expressed a desire to revisit it this morning in regards to its impact on the levee safety due to the age of the pipe. This is unknown to her at this point.

MDR conveyed his belief that the conclusion drawn was that it should be analyzed separately, giving it a full engineering evaluation and not "lump summed" in this evaluation. He advised we are not going to review it under this judgment curve, but on its own curve supported by additional analysis. He iterated that it should not be "eliminated" but handled separately by a civil engineer, possibly as its own reach.

Ed stated he understood WRDA 96-99 was going to take care of the under seepage portion. The pipe itself was

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where we were going to do a separate evaluation. Henri said if WRDA 96 covers it, it's probably not going to be the weak link anymore; in addition, it's being maintained. Steve added that with it being made of concrete, it should have long life. Mike I stated he thought it could be a weak link. Ed expressed concern about the pipe joints. Additional concern was expressed regarding who has authority. Ed advised they need to go back and discuss with the PM organization and see where it stands with the WRDA 96. Dan stated they have already made the argument and can argue that repair/replacement of pipe may be accomplished under WRDA 96-99, if needed.

MDR reminded the group the purpose of the meeting is to get through as many of these scenarios as possible in order to give Mary guidance in completing the curves.

RESUMPTION OF SITE 1 DISCUSSIONS FROM DAY 1

Scenario #4 - ANIMAL BURROWS (RODENTS)

- **CONDITIONS (and discussion on conditions)**
  - Animal burrows (low density)
    - 4' to ? in depth
  - There is no history of beaver dens / damage
    - Beaver - low
    - Squirrel - located more near the toe, but can be anywhere on the slope
  - Rodent abatement program is reactive
  - Levee is average of 40' wide
  - There is lots of housing and development (on both sides)
  - Cut off wall = 35'
  - A vote was called for these conditions:
    - Considering the high and low factors, the average was 2.78%
    - After removing the high and low factors, the average was 2.71%
    - Conclusion: Animal burrows not a significant issue at this site

Scenario #5 - EROSION

- **CONDITIONS (and discussion on conditions)**
  - No Sacramento Bank Erosion Site documented per Tom Smith
  - Houses & Encroachments add some problem
  - Per Tom Smith, no history of erosion; the Sacramento Bypass Weir is at elevation 27 ft, no issue; velocity changes upstream
  - Sand covers the site. It is a very sandy site and there is a unique hydraulic condition that keeps that site scoured out. It has been fixed, so Tom stated he doesn't see a threat of erosion to the reach
  - Erosion from the river at high flow is not a problem; however, it could be with one of those intermediate flows with the water below the elevation 27 feet (below the Sacramento Bypass Weir)
  - Wind wave erosion may be an issue as much as stream velocity?
  - Tom advised they have documented no erosion in this part of the river due to wind wave - short term duration.
  - A vote was called for these conditions:
    - Considering the high and low factors, the average was 4.11%
    - After removing the high and low factors, the average was 3.86%
    - Conclusion: Erosion not an issue overall at this site

SUMMARY OF COMPONENTS ON THIS REACH (PREDICTING ALL WOULD EQUAL 10-25%)

- (General) Utilities (without sewer) 6%
- Vegetation 2-3%
- Erosion 4%
- Encroachment 7%
- Rodents 3%
- TOTAL 22-23% ... not in the formulary method
- FORMULARY METHOD / JUDGMENT = 80.6% ... 19.5% PROBABILITY OF FAILURE

The group decided to take a different rating approach on the subsequent sites. It was decided to discuss all conditions at the individual sites and then vote on all judgment components at the same time. If further discussion is needed, additional votes could be taken. The numbers next to each of the components reflect the average after excluding the highest and lowest factor.

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SITE 2 - NATOMAS CROSS CANAL - DOWNSTREAM OF HIGHWAY 99 / VESTAL DRAIN (24' TO 43.5' landside of the levee toe)

- GENERAL CONDITIONS:
  - Vestal Drain Canal is near the levee
  - Historical seepage problems / remediated
  - Waterside stability at one location
  - Other slips on water side
  - Several phases of remediation
  - Grass only on the levee they regularly burn
  - Embankment constructed of fat clay
  - Cracks - 3' deep
  - There is a landside berm and chimney drain
  - Crest at 43' high / 20' wide
  - A vote was called with these conditions at the top of levee elevation of 43.5'. The results and additional discussion points follow:
    - Utilities - 5%
      - Few, but old
      - 2 Pump Stations
      - Water intake
      - Pipes are 3' wide and are penetrating the levees a little over mid-height
      - Pressurized coated steel pipes that are coated below the 200-year water level
    - Vegetation - 1%
      - Agricultural area on the landside
      - A few trees on water side
    - Erosion - 2.7%
      - Erosion from wind wave pretty low, not an issue
      - Flow velocity is low
      - Erosion at outfall structures mostly
    - Encroachments - 1%
      - Highway 99
    - Rodents - 6.5%
      - Yes, east end - beaver and beaver dams in the berm; no ground squirrel
    - Total 16%
      - The group was satisfied with these numbers

SITE 3 - AMERICAN RIVER SOUTH - CLOSE TO CAPITAL CITY FREEWAY BRIDGE

- GENERAL CONDITIONS:
  - Deep slurry cut-off wall except the window at the bridge that will be closed as WRDA 99
  - SAFCA is placing additional rock onto the levee, but doesn't go up to the crest
  - River Park flood fight in'55 for erosion
  - Cap City Freeway flood fight in '86 for erosion
  - H Street Bridge
  - All part of historical Erosion - Vegetation covers portion of the levee; Stone protection placed on 5 sites
  - Tom provided Dan's team last week with a report about the erosion and the existing hard layers in lower American River. This has a lot of the detail that will be included in the CGF GRR alternatives.
  - Downstream of Watt North bank and head cut to sewer line there is potential for channel erosion
  - In regards to velocity on levee, 1 - 2 fps for a discharge of 145,000 to 160,000 cfs. The discharge when the water is at the top of the levee is 192,000 cfs.
  - Significantly Encroached with houses, swimming pools and other
  - Trees on Levee / Some toppling with wind events
  - Considering entire Reach A from Mayhew to end of River Park, a vote was called with these conditions considering the water at the top of levee elevation of 60'. The results and

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additional discussion points follow:

- Utilities - 3.86%
  - Many gravity lines penetrations
  - Some windows in the slurry cut-off wall remain but supposed to be closed
- Vegetation - 3.00%
  - Vegetation reaches top of levee on both land and water side of levee
- Erosion - 31.43%
  - Some historical erosion issues
- Encroachment - 3.57%
  - Lots of houses with swimming pools
  - Homes close to the levee
- Rodents - 2.43%
  - Rodent issues (not bad - rodent abatement and grouting programs are active)
- Total is 44% / Overall average was 31%
  - Conclusion: >

- A second vote was taken under the same conditions for erosion only considering the water at the top of the levee. The results were:
  - Average of 60%
- A third vote was taken under the same conditions for erosion only at 145 cfs at 6 feet below the top of the levee. The results were:
  - Average of 36%
- Mary inquired if we could consider the same threat on the North side. The response was yes, the same mechanism should be considered. Paul noted the North side is not encroached, so the encroachment may be less on the North side.
- With the significant erosion risk, the group noted that this failure method should be pulled out of the judgment curves on this reach and treated with an analytical approach similar to the seepage and stability.

SITE 4 - SACRAMENTO RIVER SOUTH - FROM AMERICAN RIVER DOWN TO LITTLE POCKET

- **GENERAL CONDITIONS:**
  - Levee is 14'high
  - There is a small floodwall, about 4 feet on the landside that works mainly as a retaining wall for the fill placed on the landside. The floodwall is high on the waterside. Railroad lines are on the landside fill. The City will construct the Riverside Promenade along this reach.
  - Numerous encroachments
  - Lot of seepage, mostly clear water, particularly at I-5.
  - 'Boat' I-5 Section is problematic
  - Pioneer Reservoir - relief wells and seepage berm
  - Erosion - "Concrete" rumble placed on the waterside slope that is less efficient for erosion but attracts rodents
  - Mary doesn't know if penetrations are controlled, but there are many of them
  - Closure sections are upstream of Old Sac
  - Just downstream of confluence with American River - some erosion
  - Sutter Road presents a weak link
    - *highest-tallest levee section*
    - *erosion issue*
    - *small slips at entrance*
  - Sac Bank sites are not finished
  - Erosion site at downstream end of reach jus above Little Pocket = at RM 55.2
  - I-5 higher than levee
  - Section very steep
  - Nothing "typical" about this reach.
  - Beavers are active
  - Stan Solida Cave in void at Sac RM 56.7L
  - Erosion site at Captain's Table is being considered as part of this
  - There are some relief wells
  - A vote was called with these conditions considering the water at the top of levee elevation.

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The results and additional discussion points follow:

- Utilities - 5.43%
- Vegetation - 4.71%
- Erosion - 15.71%
- Encroachment - 5.71%
- Rodents - 7.86%

- 2nd vote taken after discussion had the following results:
  - Utilities - 7.14%
  - Vegetation - 3.14%
  - Erosion - 13.57%
  - Encroachment - 6.00%
  - Rodents - 6.43%
  - Medians were as follows:
    - Utilities - 7
    - Vegetation - 3
    - Erosion - 15
    - Encroachment - 5
    - Rodents - 5
  - On lower Sacramento River, it's not just erosion from wind wave, but velocity is involved as well.

SHAPE OF THE CURVES DISCUSSION:
The group diverted from ranking the components for specific sites to holding a brief discussion regarding the shape of the curves. Highlights of the discussion included:

- The shape of the curve may vary
- 0 P(f) not necessarily at toe of levee
- 0 P(f) could be somewhere above the toe
- Specific characteristics of levee will impact shape / inflection points
- Generally concave up to design walls surface of defect
- Risk may not start at elevation of landside levee toe.
- Judgment curves are to deal with miscellaneous conditions not analyzed in seepage and/or stability analyses.

SITE 5 - SACRAMENTO RIVER - LITTLE POCKET (RM 54 to 56)

- **GENERAL CONDITIONS:**
  - Top of Levee is 41' with 20' wide
  - Steep waterside slopes
  - Deep Cutoff wall
  - We do not own right-of-way / access is limited / no immediate access/fences and gates all along the levee slopes and crown
  - A lot of room on the waterside for rodents - hard to mitigate, but not an apparent problem
  - A lot of vegetation / trees & plants
  - Seepage a problem before cutoff wall
  - Lots of penetrations
  - Bend in the river - large berm / erosion not an issue
  - A lot of encroachments
    - *Swimming Pools - some go to the toe of the levees*
    - *Tennis Court - cracked up due to under seepage or perhaps just normal wear?*
    - *Sprinklers all over the place*
  - A vote was called with these conditions at the top of levee elevation. The results and additional discussion points follow:
    - Utilities - 4.43%
    - Vegetation - 2.71%
    - Erosion - 8.43%
    - Encroachment - 6.43%
    - Rodents - 3.43%

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- Medians:
  - Utilities - 5
  - Vegetation - 2
  - Erosion - 8
  - Encroachment - 6
  - Rodents - 3

- After further discussion it was determined that a second vote was not needed.
- A special note:
  - *It will be important for Mary to go back and compare the feedback on various sites for the same issue. It should also be noted that information is based on conditions today and are subject to change.*

SITE 6 - ARCADE CREEK

- GENERAL CONDITIONS:
  - There is a pump station
  - Levee height deficiency - Water is at top of levee
  - Levee embankments aren't as bad as the others
  - Levee constructed of clay material and it is less erosive
  - No trees on these levees
  - Levees were raised in the 1990s
  - T-wall exists
  - Arcade Creek is a narrow, deep and fast-acting canal
  - Some of the tallest floodwalls - up to 20'
  - Beavers are an issue
    - Have had collapses due to them upstream of Norwood bridge on the north side
    - Not many squirrel
  - Deep drainage canal on North side where it meets NEMDC. The city has an 8 foot deep concrete line channel
  - No slurry walls
  - Some older utilities cross the levees
  - Several pump stations that came in with the Folsom Dam Project and are likely around 60-years old
  - Protected agricultural area at one time, now highly developed
  - Access is good
  - Few encroachments
  - Water has high velocity, but not aware of erosion issues
  - A vote was called with these conditions at the top of levee elevation. The results and additional discussion points follow:
    - Utilities - 3.86%
    - Vegetation - 1%
    - Erosion - 2.71%
    - Encroachment - 2.86%
    - Rodents - 5.43%
    - Medians:
      - Utilities - 5
      - Vegetation - 1
      - Erosion - 3
      - Encroachment - 3
      - Rodents - 5
  - A second vote with the same conditions was called for utilities and rodents only after further discussion. The results and additional discussion points follow:
    - Utilities - 6.86%
    - Vegetation -
    - Erosion -
    - Encroachment -
    - Rodents - 8.29%
    - Medians:

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- Utilities - 7
- Vegetation -
- Erosion -
- Encroachment -
- Rodents - 8

SITE 7 - SACRAMENTO RIVER BIG POCKET

- GENERAL CONDITIONS:
  - This is a narrow levee, only about 20' wide
  - It is asphalt paved
  - Sump132 is an active seepage site. Relief wells have been put in to fix and bring the new intake into compliance
  - Slurry wall stops at Cliff's Marina, where railroad track leaves the levee
  - Known utilities were cut and relocated
  - Old irrigation line was plugged last summer
  - Encroachments are dramatic (same as in Little Pocket, but may have some going into the levee)
    - *Cliff's Marina*
    - *Railroad prohibits inspection of the levee*
    - *Swimming Pools*
    - *Houses and fences*
  - Public highway at toe
  - Trees go to the crest of the levee and cover most of the levee center line
    - *6 ft tree in diameter on the levee*
  - Erosion issues? Yes, numerous erosion sites at this part of the levee; on West Sac after Mason's Bend, there is a scour / straightens up downstream at Garcia Bend There have been a lot of repair work in this area (6-8 sites repaired) after 2006 flooding. Critical site repair has been completed. Repairs may not include key in trench
  - No berm. It is right at the toe of the levee
  - Made of silty sand and sand; there is also some sort of organic crust, not clay
  - Soil / Cement / Bentonite slurry wall
  - Active Erosion Reach
  - Minimal rodent activity
  - Wind wave - minimal erosion
  - Boat wake / wave issue at lower water, but this is a summer elevation issue
  - A vote was called with these conditions at the top of levee elevation. The results and additional discussion points follow:
    - Utilities - 3.86%
    - Vegetation - 3.29%
    - Erosion - 13.14%
    - Encroachment - 7.43%
    - Rodents - 3.29%
    - Medians:
      - Utilities - 3
      - Vegetation - 2
      - Erosion - 15
      - Encroachment - 7
      - Rodents - 3
    - Conclusion: The group feels this erosion is just as bad as Little Pocket (although Little Pocket higher).
  - A second vote with the same conditions was called for erosion only after further discussion. The results and additional discussion points follow:
    - Utilities -
    - Vegetation -
    - Erosion - 16.29%
    - Encroachment -
    - Rodents -

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- Medians:
  - Utilities -
  - Vegetation -
  - Erosion - 16
  - Encroachment -
  - Rodents -
  - Encroachment -
  - Rodents -

Site 7 concluded the rankings portion of the meeting for specific sites.

QUESTION FROM DAN:
MDR advised the team he had a question from the Project Manager, Dan Tibbitts, to pose to the panel:
"On the components below, are there any other problem reaches that we did not cover, i.e., "reaches of concern"?

Les stated he feels the 5-6 sites that we've rated should cover the other 21 sites. Mike I agreed.

After further discussion, the following areas were identified to be of concern for the component described:

UTILITIES:
- Natomas: Pump Station 1 & 2
- Pleasant Grove Creek Canal
- Del Paso Blvd Flood Gate

VEGETATION:
- North of I-5 along Sacramento River

EROSION:
- Wind wave - Sacramento River just below Cross Canal

ENCROACHMENTS:
- None

RODENTS:
- None

QUESTION FROM MARY: SPD1 SAYS SENSITIVITY ANALYSIS NEEDS TO BE DONE IF THE LEVEE FAILS OR JUST POOR PERFORMANCE? PROBABILITY OF POOR PERFORMANCE VERSUS PROBABILITY OF BREACH?
The group proceeded to have a lively discussion on these questions. Highlights / comments of the discussion included:

- As water goes up, human intervention will be less successful. You would be pulling your crews off at that point due to danger level.
- Ability to mitigate the risk with human intervention increases as water surface goes down.
- Can you easily translate P(f) to P(breach)?
- Do we have any chances to prevent failure?
- What is the affect of flood fighting?
- What are the chances of going from poor performance to failure?
- Intervention is either successful or not; if successful, no breach; if not successful, can have breach or no breach (depends if the correct problem has been detected).
- No intervention?
- Success is defined as stopping the progression of the levee failure / breach.
- Don't want to count flood fighting first
- Henri commented it is almost like you need another curve
- Economics group is wanting these sensitivity analysis
- This can be looked at as a "correction factor", however, one is the real curve
- Paul noted that the curves will be different depending where you are in the country.
- Toe of levee does not appear to be an issue
- 33% of the levee height eventually to be considered as less likely the poor performance to lead to failure
- Mike I suggested Mary refers back to historical data and that this discussion is purely conjecture. He doesn't feel it can be done in this forum without empirical data.
- MDR iterated to Mary that she has to look at each curve and evaluate them on this topic individually. She would need another Expert Elicitation to cover this topic

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- This topic of discussion ended without resolution

LESSONS LEARNED / RECOMMENDATIONS TO CORPS - Discussion started at 4:20 pm

MDR led the team in a discussion on the lessons learned, to include recommendations to the Corps, as a result of this 2-day meeting and the feedback they have provided. Highlights / comments include:

- Vegetation does not contribute significantly to P (poor performance)
- Local sponsors with knowledge & experience in maintaining the levee is extremely valuable to the discussion as well as the history of such information
- Need biased and unbiased opinions
- Confidence in prediction were on the reaches where folks had experience and knowledge
- Need better "read ahead" performance history
- Les asked MDR what he thought about having nine panelists. Les commented that he thought it worked out well in regards to consensus. MDR responded that in order to get to what we needed to talk about, it was good to have a broad group; but to try to accomplish 27 sites, it was too many people. Smaller groups normally result in faster answers; however, larger groups likely produce better answers. For this, he felt it went well. Having a panel of nine was valuable in this case.
- Ed expressed he felt the generalized discussion first was good and then going to site specific worked well. Start up with general discussion was helpful for him.
- Les added having clear set of definition and purpose/goal would have been helpful. Further, he said he thought we got there, it just took a while.
- Mike I felt the way we got through things this afternoon went very well.
- Paul suggested that a more expedient voting method would have been helpful and helped things to move forward.
- Mike N noted that judgment curves are important and can significantly affect performance / economic results. He would like to see a cap on how judgment affects the overall decision. Inclusion of judgment curves make "flaws" / failures more frequent and likely increases average annual damages: as components increase, P(f) increases. He expressed a summary of data developed simultaneously as debate proceeds would be good.
- Need separate evaluation for critical site P(f) high and not included in judgment.
- Mike N. inquired about how rodents are being looked at. From discussion, it seems that beavers are of much more concern than squirrels.
- There was an determined need to separate out:
  - Pump Plant 1?
  - Sewer Line?
- What happens now as far as information collected these past two days?
  - Melanie will compose a draft of the meeting minutes to be distributed to the Expert Elicitation attendees
  - Attendees will be asked to provide comments by tracking changes within a specified time
  - Melanie will finalize minutes
  - Mary will then compile report to include summary, statistical information as well as the revised curves. The report will require the signatures of everyone.
  - Once produced, she will provide a copy to all
- Henri noted that while the curves developed by the panel are much lower than Mary's, it doesn't mean the existing conditions considering encroachment, penetration and vegetation are desirable. He advised there is a need to keep probability approach separate from deterministic.
- Dan advised the team they have an array of alternatives that will comply with environmental or with SAFCA's (for which they will likely need a variance).

Wrap-Up Comments - Team

MDR solicited wrap-up comments from the team.

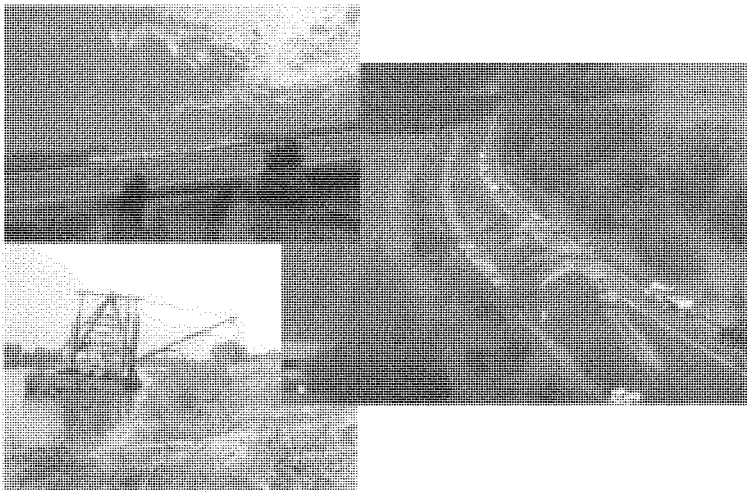
Ed told the team of a vegetation issue he experienced in Lompoc with cottonwood after a large storm. It took out the bridge and flooded the area. It was a big hindrance.

Day 2 Concluded at 5:10 pm

Post-Authorization Change Report
And Interim General Reevaluation Report

American River Watershed

Common Features Project
Natomas Basin
Sacramento and Sutter Counties, California



SAFCA
Sacramento
Area Flood
Control
Agency

US Army Corps
of Engineers ®
Sacramento District
August 2010

Appendix F - Geotechnical
(Part 2)

AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

NATOMAS POST AUTHORIZATION CHANGE REPORT

ENCLOSURE F6

URS SEISMIC ANALYSIS

6.1 GENERAL

This section presents the step-by-step approach to and results of the seismic analyses completed to assess the seismic vulnerability of the ARCF levees. The overall methodology for the seismic evaluations was developed by the Seismic Evaluation and Methodology Group as part of the Urban DWR Levee Evaluations Program. The methodology is described in detail in the document titled *Levee Seismic Vulnerability Assessment Methodology Technical Memorandum* (URS 2008c), dated September 26, 2007. In essence, the seismic vulnerability assessment is conducted using six pieces of information:

1. Seismic hazard maps
2. Cyclic stress ratio charts
3. Maximum acceleration (K_{max}) charts
4. Yield acceleration (K_y) estimation
5. Displacement charts
6. Vulnerability classification table

This section presents the step-by-step approach, showing how these six pieces of information were used to assess the seismic vulnerability of the ARCF levees. The approach was organized into three sets of analyses:

- Liquefaction Triggering Analyses, to assess the potential for liquefaction using the seismic hazard maps and the cyclic stress ratio charts
- Seismic Slope Stability Analyses, to estimate the K_y/K_{max} ratio using the K_{max} charts and results from the section-specific pseudo-static slope stability analyses
- Deformation Analyses and Vulnerability Assessment, to estimate post-seismic deformations using a Newmark-type approach and to assess the seismic vulnerability using the vulnerability classification table

6.1.1 Objective

In general, the goal of the seismic analyses is to estimate the seismic vulnerability of the American River Common Features levees. More specifically, the primary objectives of these analyses are:

1. Evaluate the liquefaction potential of the American River Common Features levees and of the underlying foundation materials.
2. Estimate the likely post-seismic deformations for the levees.
3. Estimate the seismic vulnerability of the levees using a four-tiered classification system.

Ultimately, for relative ranking, the levees are classified using a four-tiered classification system. The vulnerability classes, from least vulnerable to most vulnerable, include: (1) Probably uncompromised; (2) Possibly compromised; (3) Likely compromised; and (4) Compromised.

6.2 SEISMIC LOADING CONDITIONS

The seismic vulnerability analyses presented in this section were completed for one seismic loading condition, the 200-yr return period event. The peak ground acceleration (PGA) values associated with this return period event was estimated from the results of the Probabilistic Seismic Hazard Assessment performed for the Delta Risk Management Study Phase 1 Project (URS 2007c) as presented in URS (2008).

The expected earthquake magnitude (M_w) associated with this return period event is $M_w = 7.0$.

The purpose of the deformation and vulnerability evaluations is to evaluate the post-seismic vertical displacements at the levee crest and estimate the seismic vulnerability of the levees using a four-tiered classification system. The vulnerability classification system adopted in the American River Common Features project includes the following four tiers/classes:

- Probably uncompromised
- Possibly compromised
- Likely compromised
- Compromised

Depending on the calculated post-seismic displacements, each study-section was classified into one of the above four classes. The vulnerability criteria is explained in Section 6.6.

6.3 WATER LEVELS

Two water levels were considered in the seismic analyses: a typical winter water level and a typical summer water level. For the study sections along the major rivers (Sacramento and American), the typical winter water level was taken to be an estimated average water level for the month of February and the typical summer water level was taken to be the average water level for the month of September. For the study sections along the Natomas Cross-Canal and NEMDC, only one water elevation was analyzed, and this corresponds to the landside toe elevation.

6.4 LIQUEFACTION-TRIGGERING ANALYSES

The purpose of the liquefaction-triggering analyses is to evaluate whether any of the levee and/or the underlying foundation materials would potentially liquefy during the considered earthquake event. The results from the liquefaction-triggering analyses were used to estimate the post-seismic strengths of the materials for use in the seismic stability and yield acceleration calculations. The step-by-step procedure adopted for the liquefaction-triggering analyses was as follows:

1. Assess susceptibility to liquefaction using the plasticity criteria:

   Soil type, liquid limit, plasticity index, water content, and fines content were used to evaluate the susceptibility to liquefaction using the procedure recommended by Cetin et al. (2004). If the material was considered to be susceptible to liquefaction, the remaining steps were completed to further evaluate the liquefaction potential of the material, considering the earthquake loading. In contrast, if the plasticity of the material was high

enough to preclude liquefaction, the material was classified as non-liquefiable, irrespective of the earthquake loading.

2. Estimate the PGA:

   As discussed above, the PGA values for the 200-year event were estimated from the seismic hazard maps presented in the Probabilistic Seismic Hazard Assessment study performed for the Delta Risk Management Study Phase 1 Project (URS 2008c). A chart from this report is shown in Figure 6-1.

3. Evaluate the cyclic resistance ratio (CRR) using the SPT data:

   - Using the cross-section specific SPT blows per foot data, CRR values were calculated in accordance with the procedure recommended by Cetin et al. (2004).
   - The cone penetration test (CPT)-based correlations of Moss et al. (2006) are compatible with the standard penetration test (SPT)-based methods from Seed et al. (2003) and Cetin et al. (2004). The Moss et al. (2006) procedure was therefore used when evaluating liquefaction from CPT data.
   - An earthquake magnitude of $M_w = 7.0$ was used for the analyses.

4. Evaluate the cyclic stress ratio (CSR):

   The PGA values estimated in Step 2 were used to estimate the CSR values with depth using the charts shown on Figure 6-1. These charts were developed as part of the overall levee seismic vulnerability assessment approach discussed earlier. The charts are developed for three general locations along the levee cross section–waterside free field, center of crest, and landside free field. The chart that best represents the location of the SPT hole or CPT sounding being evaluated was used to estimate the CSR values for that particular location.

5. Assess FS against liquefaction (CRR/CSR):

   - For each SPT sample and CPT data point, the FS against liquefaction was calculated. FS against liquefaction was not calculated for the locations that were above the water table, or for materials that were classified as non-liquefiable based on the plasticity criteria (Step 1).
   - If the FS against liquefaction, in a particular layer, was calculated to be less than 1.0, that portion of the soil layer was classified as liquefiable.
   - If all FS values in a particular layer were calculated to be higher than 1.2, that soil layer was classified as non-liquefiable.
   - If the FS was calculated to be between 1.0 and 1.2, judgment was used to classify the material as liquefiable or non-liquefiable (due to the marginal FS conditions).

6. Estimate the post-seismic shear strength for the various materials:

   - Soil layers classified as non-liquefiable were assigned static shear strengths in the post-seismic and yield acceleration analyses.
   - Soil layers classified as liquefiable were assigned post-liquefaction undrained residual shear strength using the correlation proposed by Seed and Harder (1990), as shown on

Figure 6-1 and Appendix C. For estimating the residual shear strength from the Seed and Harder plot, the lower 1/3 curve of the upper and lower bands was used. By using the lower 1/3 of the Seed and Harder (1990) relationship, zero post-liquefaction strength was selected for $(N_1)_{60\text{-}cs} < 6$. This zero-strength was used in such cases for post-liquefaction analyses.

- When liquefaction analyses were performed from CPT data, the post-liquefaction strengths were still estimated by using the Seed and Harder (1990) relationship. For the assessment of the seismic vulnerability, the following relationship was used for calculating the "equivalent" $(N_1)_{60\text{-}cs}$ from the $q_{c,1,mod}$ value (URS, 2008 Guidance Document):

$$q_{c,1,mod}\ (tsf)/4.2 \sim (N_1)_{60\text{-}cs}$$

- For low plasticity silts and clays (ML, CL) that are not included in the Seed and Harder plot, a post-liquefaction undrained residual shear strength ratio (s_u/p') of 0.20 was assumed (URS, 2008 Guidance Document).

The entire liquefaction-triggering analysis procedure was programmed into a spreadsheet. Spreadsheet printouts showing the input values and the calculated results, individually for each SPT and CPT, are presented in Appendix C. The post-liquefied strength values selected for analyses in each layer are presented in Appendix C.

6.5 SEISMIC SLOPE STABILITY ANALYSES

The purposes of the seismic slope stability analyses are to: (1) evaluate the minimum FS for the post-earthquake condition, and (2) estimate the yield acceleration values for potential failure surfaces. The yield acceleration values were used as an input in the deformation analyses.

6.5.1 Seismic Shear Strengths

Seismic loading is considered to be a rapid-loading condition. The seismic shear strength evaluations were developed using standard soil mechanics references, including Terzaghi, Peck, and Mesri (1996), Holtz and Kovacs (1981), the USACE Slope Stability manual (EM-1110-2-1902), and Duncan and Wright (2005). The following paragraphs present a brief synopsis of the strength selection process used for the various materials.

6.5.1.1 Dense Coarse-Grained Materials (Dense/Compacted Sands and Gravels)

These materials, because of their high density, are not expected to liquefy. When sheared, these materials are expected to dilate and potentially generate negative pore pressures (when saturated). When negative pore pressures are generated, the undrained shear strength of these materials could conceivably be higher than their drained strength, especially for rapid-loading conditions. Because these materials are also highly permeable, it was considered prudent not to rely on the negative pore pressures and to use the lower of the drained and undrained strength for these materials.

The shear strengths of these materials were generally represented by a friction angle and the pre-seismic pore pressures. Typical material types included dense natural coarse-grained sediments and compacted fills composed of relatively clean gravels and sands.

6.5.1.2 Loose Coarse-Grained and/or Silty/Clayey Materials

These materials are expected to contract and generate positive pore pressures during shear. During the rapid seismic loading, the rate of pore pressure generation typically exceeds the rate of pore pressure dissipation, resulting in an incremental increase in pore pressures in these materials. Pore pressure increase leads to shear strength degradation, which may ultimately lead to liquefaction. Depending on the results of the liquefaction-triggering analyses, if these materials were classified as liquefiable, they were assigned residual shear strengths.

As stated earlier, residual shear strengths were estimated using the correlation proposed by Seed and Harder (1990). For estimating the residual shear strengths from the Seed and Harder plot, the lower 1/3 curve of the upper and lower bands was used. For these liquefiable materials, the residual shear strengths were used both in the post-earthquake analyses and in the yield acceleration analyses. The residual undrained strength was compared to the drained strength, to confirm that the lower of the two is used in the analyses.

6.5.1.3 Fine-Grained Materials Not Expected to Liquefy

Whether they are dilatant or contractive, following the criteria of Seed et al (2003), higher plasticity fine grained materials are not expected to liquefy. However, because of their low permeability, these materials are likely to develop some pore pressures during seismic shearing. The rapid rate of seismic loading could increase their shear strength while the increase in pore pressures could degrade their shear strength. The combined effect of this increase and decrease in strength is uncertain and depends on the nature of the earthquake and the soil characteristics. For this study, no increase or decrease in shear strength was considered for these materials. Accordingly, the static shear strength friction angle was used for these materials. Because of the rapid loading that an earthquake can cause, these materials are generally modeled with undrained strength. The USACE does not have a recommended procedure for analyzing levee stability during earthquakes. Therefore, in accordance with the static slope stability procedure recommended by USACE, any material which is not expected to liquefy was modeled with the static strength recommended by the USACE manuals (drained friction angle).

6.5.2 Seismic Stability Computations

As with the static slope stability analyses, post-seismic slope stability and yield acceleration analyses were completed using the computer program UTEXAS4. Both waterside and landside slopes were evaluated using the circular and wedge-shaped failure modes using the search routines available within UTEXAS4. For the yield acceleration analyses, the inertial force was applied only in the horizontal direction. The step-by-step approach adopted for the stability computations was as follows:

1. Estimate K_{max} values for the potential shear surfaces:
    - K_{max} is defined as follows: The seismic loading for a potential sliding mass can be represented by the horizontal equivalent acceleration (HEA), which accounts for the cumulative effect of the non-uniform horizontal acceleration distribution in the overlying deformable material (Seed and Martin 1966). Based on this concept, k_{max} represents the maximum seismic coefficient on the sliding mass: K_{max} = max(HEA)/g

- Using the K_{max} vs. PGA chart shown in Figure 6-1, K_{max} values were estimated for the shallow and deep shear surfaces for the 200-yr event. The "medium" curves were selected for all analyzed levees in the American River Common Features project.

2. Prepare the UTEXAS4 data files:
   - The UTEXAS4 data files completed for the static analyses were copied and modified for the seismic analyses. Modifications included changing the material properties for the liquefiable materials, and changing the piezometric line information. When necessary, sub-layers were created within a layer to show potentially liquefiable sub-layers within a thicker layer.
   - The seismic shear strengths were input in accordance with the discussion presented in Section 6.5.1.
   - The seismic water levels were input in accordance with the discussion presented in Section 6.3. Piezometric surfaces, developed based on judgment, were used to calculate the pore water pressures. No SEEP/W analyses were performed for the seismic water level conditions. In most cases, the water surface elevations (WSEs) were below the landside toe and, therefore, a horizontal piezometric line was assumed.
3. Perform post-earthquake analyses:
   - Using the seismic shear strengths, discussed earlier in Section 6.5.1, post-earthquake analyses were completed using UTEXAS4.
   - No horizontal seismic coefficient was used in the post-earthquake analyses.
   - If the post-earthquake FS, for any potential shear surface, was computed to be equal to or less than 1.0, the study-section was classified as unstable and no further yield acceleration analyses were completed for that study-section.
4. Perform pseudo-static stability analyses with a single seismic coefficient:
   - For each study-section, pseudo-static slope stability analyses were completed using a horizontal seismic coefficient, k, equal to one half of K_{max} ($k = 0.5 \cdot K_{max}$). All waterside and landside shear surfaces were checked with the search routines.
   - If the minimum FS, for all shear surfaces, for this acceleration level was computed to be is greater than 1.0, (which means that the K_y/K_{max} will be larger than 0.5) minimal or no seismic displacements were anticipated for the study-section. Under this condition, the study-section was classified as "probably uncompromised," and further refinement for the vulnerability evaluation was considered unnecessary.
5. Estimate the yield acceleration (K_y) values:
   - Whenever a section had a post-earthquake FS greater than 1.0 and the pseudo-static FS (with $k = 0.5\ K_{max}$) less than 1.0, non-negligible deformations are expected for the evaluated conditions. No further analyses were done for most of the sections that fell into this group and they were identified as "likely compromised" because of the possibility of large deformations. For some of the sections the yield acceleration was calculated.

- Yield acceleration (K_y) is defined as the maximum horizontal acceleration resulting in a "Just-Stable" condition equivalent to an FS of 1.0.
- For each qualifying study-section, pseudo-static slope stability analyses were completed for a range of horizontal seismic coefficients (e.g., K = 0.02g, 0.04g, 0.06g, etc.) to estimate the yield acceleration values. All waterside and landside shear surfaces were checked with the search routines.
- The yield acceleration value for each potential shear surface was estimated by plotting the seismic coefficient (k) values versus the computed FS values and selecting the k value that corresponds to an FS value of 1.0.

6. Estimate the minimum K_y/K_{max} ratio value:
   - Using the K_{max} value estimated in Step 1 and the K_y value estimated in Step 5, the K_y/K_{max} ratio was estimated for each potential shear surface.
   - The minimum K_y/K_{max} ratio value was selected for each study-section for use in the subsequent deformation and vulnerability assessment evaluations.
   - Results from the seismic slope stability analyses are summarized on Table 6-2.

6.6 DEFORMATION ANALYSES AND VULNERABILITY ASSESSMENT

As previously stated, the purpose of the deformation and vulnerability evaluations is to evaluate the post-seismic vertical displacements at the levee crest and estimate the seismic vulnerability of the levees using a four-tiered classification system. The vulnerability classification system adopted in the American River Common Features project includes the following four tiers/classes:

- Probably uncompromised
- Possibly compromised
- Likely compromised
- Compromised

Depending on the calculated post-seismic displacements, each study-section was classified into one of the above four classes. The step-by-step approach adopted for the deformation and vulnerability evaluations is outlined in the following paragraphs. Further details about this approach, including the background and rationale behind the charts and figures used in this approach, are presented in the *Levee Seismic Vulnerability Assessment Methodology Technical Memorandum* (URS 2008c) document.

1. Estimate the Newmark type displacements:
   - Using the minimum K_y/K_{max} ratio, estimated for each study-section, Newmark-type displacements were calculated from the charts shown in Figure 6-1. Displacements were estimated for an earthquake magnitude of M_w = 7.0, which represent the 200-yr event.
2. Estimate Weighted Freeboard Loss:

- A 0.7 ft of vertical displacement for every 1.0 ft of Newmark displacement was used to estimate the freeboard loss (vertical displacements) from the Newmark-type displacement values (assuming a 1:1 failure surface means that a 1ft displacement along the failure surface results in approximately 0.7ft freeboard loss).

3. Estimate Vulnerability Class:
   - Depending on the calculated freeboard loss value, each study-section was classified into one of the four vulnerability classes shown on Table 6-1.
   - Results from the seismic vulnerability analyses are summarized on Table 6-2.

Table 6-1 Seismic Vulnerability Classes

Amount of Deformation	Significant Damage to Internal Structures (e.g., Cutoff Walls)	Remaining Freeboard for Post Seismic Evaluation (2-Year Flood Water Surface Elevation)	Post Seismic Flood Protection Ability
< 1 foot	No	> 1 foot	Probably Uncompromised
1 foot to 3 feet	Possibly	> 1 foot	Possibly Compromised
3 feet to 10 feet	Likely if existing	None	Likely Compromised
Unlimited (flow slide condition)	Yes	None	Compromised

6.7 VULNERABILITY EVALUATION RESULTS

Plate 9 summarizes the seismic vulnerability evaluations that this study considers best represents the expected response of the levee to the 200-yr return period event. Results from the seismic vulnerability analyses were summarized on Table 6-2 and the following paragraphs summarize the results evaluation.

In summary, the deformation analyses indicate that 17 of the 23 analyzed sections present a risk for "flow" failure for the 200-yr event, 5 of the analyzed sections are expected to show negligible deformations, and 1 is expected to show non-negligible deformations. The large amount of flow failures in the analyzed sections are in part due to the selection of "problem" areas as analyses sections. This may appear somewhat conservative, but failure of any one section can cause the complete flooding of the basin, and the weakest link is the target of the analyses.

The following sub-sections describe the results of the seismic vulnerability analyses as applied to the evaluated sections.

6.7.1 Natomas Cross Canal–LM 4.27, Unit 4 (Figure 6-1)

The analysis results show that for the 200-yr seismic load (PGA: 0.12, Mw: 7.0), the lower 5 to 7 ft of the silt embankment have liquefaction potential. The upper 10 ft of the underlying clay

blanket also show potential for liquefaction, with corrected blow counts of less than 10 blows per foot.

A deeper sand layer also exhibits liquefaction potential under the analyzed seismic load, but it is found beneath elevation 0 ft.

For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area, in a shallow waterside failure surface. For the analyzed event, the ability of this section to provide flood protection can be compromised. Furthermore, the NCC alignment located at the waterside toe can act as a "free face" for exacerbating waterside movements.

6.7.2 Natomas Cross Canal–LM 3.33, Unit 4 (Figure 6-2)

The analysis results show that for the 200-yr seismic load (PGA: 0.12, Mw: 7.0), two zones of potential liquefaction are present within silty sand and silt deposits. The upper zone was found beneath the levee embankment, between elevations 22 and 25 ft, and does not appear to be continuous landward. The deeper liquefiable zone is located between elevations +5.0 and -7.0 ft, in silty sand to silt deposits.

Low blow counts were measured in the above mentioned sand and silty sand layers. This leads to an expected widespread liquefaction. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area, in a shallow landside failure surface. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.3 American River North–LM 1.28, Unit 2 (Figure 6-3)

The analysis results show that for the 200-yr seismic load (PGA: 0.13, M_w: 7.0), the lower majority of the silt blanket has liquefaction potential. Two crest explorations were available for this section. Because this layer is assumed to be continuous on both landside and waterside areas, widespread liquefaction can be expected at this site. Furthermore, the canal located at the waterside toe can act as a "free face" for exacerbating waterside movements.

For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area, in a shallow landside failure surface. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.4 American River North–LM 2.75, Unit 3 (Figure 6-4)

The section stratigraphy consists of clay with interbedded silt and silty sand. The levee has approximately 3:1 slopes on both the landside and waterside.

Low to very low blow counts were measured in the silt and clay layers (thick layers with blow counts below N = 10) from 8 to 32 ft below ground surface (bgs). Liquefaction potential was substantially reduced by the depth of the winter and summer mean WSEs. The summer mean WSE is below the liquefiable layers and the winter mean WSE is above only one SPT blow count. A residual strength envelope was created for the portion of the liquefiable layer that is below the winter mean WSE and the strength envelope was not altered for residual strength at the summer mean WSE.

For the analyzed conditions with a 200-yr return period event, flow failure is not expected and negligible deformations are expected in the area. For the analyzed event, the ability of this section to provide flood protection will likely not be compromised.

6.7.5 American River North–LM 1.32, Unit 9 (Figure 6-5)

The levee consists of silt with approximately 3.5:1 slopes on both the landside and waterside. Below the silt levee is a silty sand layer underlain by sand and gravel. The summer and winter mean WSEs are both below the landside and waterside toe elevations.

Medium blow counts were measured in the silt, sand, and silty sand layers in the levee and levee foundation, with blow counts increasing at a depth of 40 ft bgs in the gravel layer. This leads to no liquefiable layers with only one location requiring judgment. Due to high blow counts in the possible liquefiable layer, the strength envelope was not adjusted for residual strength. For the analyzed conditions with a 200-yr return period event, flow failure and non-negligible deformations were not expected in the area. For the analyzed event, the ability of this section to provide flood protection will not be compromised.

6.7.6 American River South–LM 1.51, Unit 4 (Figure 6-6)

From SPT-based liquefaction analysis with a landside toe boring WSCBAR_001B, liquefiable layers are observed as follows: silty sand (SM) at 25-ft depth, sandy silt (ML) at 30-ft depth and well-graded sand with silt (SW-SM) at 40-ft depth. This leads to an expected widespread liquefaction between elevations 16 ft and -13 ft. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur at waterside, and the ability of this section to provide flood protection can be compromised.

6.7.7 American River South–LM 3.89, Unit 4 (Figure 6-7)

From SPT-based liquefaction analysis with both crest and landside borings 2F-96-29 and 2F-00-9W, respectively, liquefiable layers are observed as follows: sandy silt (ML), silty sand (SM), and poorly graded sand with silt (SP-SM). This leads to an expected widespread liquefaction between elevations (NAVD88) +18 ft and -5.0 ft. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur at waterside in the area. For the analyzed conditions with a 200-yr return period event, the ability of this section to provide flood protection can be compromised.

6.7.8 American River South–LM 10.81, Unit 4 (Figure 6-8)

From SPT-based liquefaction analysis with crest boring 2F-99-20, no liquefiable layers are observed. Pseudostatic seismic slope stability analyses were performed for the winter and summer water levels, at the landside and waterside, with a horizontal equivalent acceleration equal to half of K_{max}. For the analyzed conditions with a 200-yr return period event, the ability of this section to provide flood protection will be probably uncompromised.

6.7.9 American River South–LM > 10.99, Unit 4 (Figure 6-9)

From SPT-based liquefaction analysis with crest boring B-7 for both winter and summer WSEs, liquefiable layers are observed as follows; well-graded gravel (GW) at 45-ft depth, poorly graded sand (SP) at 50-ft depth and poorly graded sand with silt (SP-SM) at 55-ft depth. This leads to localized liquefaction in a deep soil layer between elevation +18 ft and -2.0 ft. For the analyzed conditions with a 200-yr return period event, the ability of this section to provide flood protection will be probably uncompromised.

6.7.10 NEMDC-E–LM 0.91, Unit 7 (Figure 6-10)

The levee consists of clay underlain by sand interbedded with silt and approximately 3 to 4:1 (H:V) slopes on both the landside and waterside. Below the levee are sandy silt, silty sand, and sand layers. In the absence of winter and summer mean data the levee was analyzed with a WSE equal to the landside toe.

Low to very low blow counts and CPT tip resistance were measured in the sandy clay, silty sand, and sand layers (thick layers with blow counts below N = 10) below the levee. This leads to an expected widespread liquefaction. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.11 NEMDC-E–LM 0.81, Unit 2 (Figure 6-11)

The levee consists of clay with interbedded silt and approximately 3.5 to 3:1 slopes on both the landside and waterside. Below the levee are sandy silt, silty sand, and sand layers. On the landside slope (approximately mid-height on the slope) is a Union Pacific Railroad track that runs parallel to the levee. In the absence of winter and summer mean data the levee was analyzed with a WSE equal to the landside toe.

Low to very low blow counts and CPT tip resistance were measured in the clay, silt, and sand layers (thick layers with blow counts below N = 10) below the levee. This leads to an expected widespread liquefaction. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.12 NEMDC-W–LM 6.43, Unit 3 (Figure 6-12)

The embankment seems to be composed of clayey materials, overlaying a thin clayey blanket approximately 2.5 ft thick. Below the clay blanket is an approximately 11-ft-thick permeable layer. In the absence of winter and summer mean data, the levee was analyzed with a WSE equal to the landside toe.

Very low tip resistance was measured below the levee. The thin weak fine grained layer below the levee may experience seismic softening. For the analyzed conditions with a 200-yr return period event, slumping may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.13 NEMDC-W–LM 4.85, Unit 3 (Figure 6-13)

From the available explorations in this section, the embankment is composed of clay, overlying a clay blanket approximately 40 ft thick. Below the clay blanket is an approximately 10-ft-thick silty sand layer. In the absence of winter and summer mean data, the levee was analyzed with a WSE equal to the landside toe.

Low to very low blow counts and CPT tip resistance were measured in the clay and clayey sand layers (thin layers with blow counts below N = 20) below the levee. This leads to marginal or localized liquefaction or seismic softening. For the analyzed event, the ability of this section to provide flood protection will likely be compromised.

6.7.14 NEMDC-W–LM 3.85, Unit 3 (Figure 6-14)

The embankment is composed of clay, overlying a clayey and silty blanket. Below the embankment is a thick pervious layer approximately 13 ft thick. Under the pervious layer, interbedded silts and sand compose the rest of the profile. In the absence of winter and summer mean data, the levee was analyzed with a WSE equal to the landside toe.

Low to very low tip resistance was measured in the clay and silt layers (thick layers with tip resistance less than 50) below the levee. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection will likely be compromised.

6.7.15 NEMDC-W–LM 0.98, Unit 3 (Figure 6-15)

The embankment is composed of clay and has slopes of approximately 2.6H:1V on both waterside and landside. Below the embankment is a thin clay blanket underlain by an approximately 8 ft thick sand layer. In the absence of winter and summer mean data, the levee was analyzed with a WSE equal to the landside toe.

Medium to high blow counts were measured in the sand and silty sand layers (thick layers with blow counts above N = 20). Blow counts indicate that this exploration is not liquefiable, but the paired CPT has low to very low tip resistance in thick layers, with possible seismic softening. For the analyzed conditions with a 200-yr return period event..slumping may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.16 Sacramento River East Levee (RD 1000)–LM 7.05, Unit 1 (Figure 6-16)

A stability berm roughly 10 ft wide is present in this section. The berm extends to about two thirds of the height of the levee. A chimney drain consisting of drain rock between geotextile layers was constructed on the inclined base of the stability berm to a few feet below the top of the berm, and was continued as a horizontal drainage layer along the base of the berm.

Low to very low blow counts were measured in the sand and silty sand layers (thick layers with blow counts below N = 10). This leads to an expected widespread liquefaction. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.17 Sacramento River East Levee (RD 1000)–LM 10.40, Unit 1 (Figure 6-17)

A stability berm roughly 10 ft wide is present in this section. The berm extends to about half of the levee height. A chimney drain consisting of drain rock between geotextile layers was constructed on the inclined base of the stability berm to a few feet below the top of the berm, and was continued as a horizontal drainage layer along the base of the berm.

Low to very low blow counts were measured in the relatively shallow sand and silty sand layers (N < 10). Deeper thick sands also show relatively low blow counts. This layer is expected to generate enough pore pressure to make it lose significant strength. These conditions are expected to lead to widespread liquefaction. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.18 Sacramento River East Levee (RD 1000)–LM 13.19, Unit 1 (Figure 6-18)

The section presents a slurry cutoff wall approximately 25 ft deep. A Kleinfelder (2006a) boring at the crest of the levee shows a clayey material in the levee. Previous studies have modeled this levee as a sandy levee. A sandy levee is in agreement with adjacent borings and the history of the levee system for the area. It is possible that this boring went through the slurry wall.

Marginal or localized liquefaction is expected at this site, located in a deep layer on the landside of the levee. For the analyzed event, the ability of this section to provide flood protection will probably not be compromised.

6.7.19 Sacramento River East Levee (RD 1000)–LM 14.51, Unit 1 (Figure 6-19)

The section presents a slurry cutoff wall approximately 30 ft deep. One Kleinfelder (2006a) boring at the crest of the levee shows a sandy levee. This is in agreement with adjacent borings and the history of the levee system for the area. The section presents a slurry wall and a relatively shallow landside ditch.

Interbedded layers of low to very low blow counts (from N = 4 to N = 22) were measured in the upper portion of the thick clean sandy layer that underlies the levee. Deeper thick sands also show relatively low blow counts. This layer is expected to generate enough pore pressure to make it lose significant strength. These conditions are expected to lead to widespread liquefaction. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.20 Sacramento River East Levee (COS)–LM 1.49, Unit 1 (Figure 6-20)

From the available explorations near this section, the embankment seems to be composed of silty sand and silt, overlying a silt blanket about 10 to 15 ft thick. The blanket overlays a silty sand layer over a thick sand and gravel aquifer. No improvements are present in this section. There is a relatively large berm related to the Pioneer Reservoir site about 50 ft landward of the landside toe.

Liquefaction analysis on a crest CPT advanced as part of the DWR Urban Levee Geotechnical Evaluations at this section predicts widespread liquefaction of the foundation silts and the sand aquifer, due to low cone resistance. Liquefaction at a crest and toe boring drilled by Kleinfelder in 1977 indicated only localized liquefaction within the silts and sand. Analyses for the remainder of the Sacramento River East Levee south of American River indicate thick, widespread liquefaction in the foundation and deep soils, consistent with what the CPT liquefaction analysis at 1099+92 predicts. Accordingly, liquefiable layers for the deformation analysis were assigned based on the CPT sounding, and were assumed to continue to the landside and waterside. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.21 Sacramento River East Levee (MA 09)–LM 2.83, Unit 1 (Figure 6-21)

From the available explorations near this section, the embankment seems to be composed of silty sand and clean sand, overlying a silt blanket about 8 to 10 ft thick. The blanket overlays silty

sand and sandy silt layers over sand and gravel. A slurry cutoff wall is present at this section, which extends through the levee 2 to 3 ft into the foundation silts.

Low to very low blow counts were measured in the relatively shallow silty sand and sandy silt layers. Deeper sands and silts also show relatively low blow counts. These layers are expected to generate enough pore pressure to make it lose significant strength. These conditions lead to an expected widespread liquefaction. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.22 Sacramento River East Levee (MA 09)–LM 3.38, Unit 1 (Figure 6-22)

From the available explorations near this section, the embankment seems to be composed of silty sand, overlying a thick silt blanket. The blanket overlays sand and sandy silt. A lens of clean sand connected to the river cuts through the silt blanket about 15 ft below the toe and extends beyond the landside levee toe. A slurry cutoff wall is present at this section, which extends through the levee 2 to 3 ft into the foundation silts.

Low to very low blow counts were measured in the relatively shallow silty sand and sandy silt layers. Deeper sands and silts also show relatively low blow counts. These layers are expected to generate enough pore pressure to make it lose significant strength. These conditions are expected to lead to widespread liquefaction. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

6.7.23 Sacramento River East Levee (MA 09)–LM 7.17, Unit 1 (Figure 6-23)

From the available explorations near this section, the embankment seems to be composed of silt, overlying a clay blanket about 8 ft thick at the toe which thins as it moves away from the toe. The blanket overlays a thick silt layer, which overlays a thick sand and gravel aquifer. A slurry cutoff wall is present at this section, which extends through the levee 2–3 ft into the foundation clay.

The silt layer below the thin clay blanket shows low to very low blow counts. Deeper thick sands also show relatively low blow counts. These layers are expected to generate enough pore pressure to make it lose significant strength. These conditions lead to an expected widespread liquefaction. For the analyzed conditions with a 200-yr return period event, "flow failure" may occur in the area. For the analyzed event, the ability of this section to provide flood protection can be compromised.

Table 6-2 Summary of Seismic Vulnerability Assessment Results

Study-Section ID	Liquefaction?	Post-earthquake Minimum FS (K = 0)	Minimum FS with $K = \frac{1}{2} \cdot K_{max}$	Post Seismic Flood Protection Ability	Comments	Figure number
NCC – LM 4.27 (U4) RD 1000 (DWR Sta. 1120+00	Yes– Widespread	< 1.0	< 1.0	**Compromised**	Flow Failure	6-2
NCC – LM 3.33 (U4) RD 1000 (DWR Sta. 1067+00	Yes– Widespread	< 1.0	< 1.0	**Compromised**	Flow Failure	6-3
ARN–LM 1.28 (U2) RD 1000 (DWR Sta. 2154+00	Yes – Widespread	< 1.0	< 1.0	**Compromised**	Flow Failure	6-4
ARN - LM 2.75 U3 (DWR Sta. 3038+25)	Yes	1.63	1.22	**Probably Uncompromised**	Negligible deformations are expected	6-5
ARN - LM 1.32 U9 (DWR Sta. 3306+35)	No	1.99	1.61	**Probably Uncompromised**	Negligible deformations are expected	6-6
ARS - LM 1.51 U4 (DWR Sta. 1078+00)	Yes Widespread	0.99	-	**Compromised**	Flow Failure	6-7
ARS - LM 3.89 U4 (DWR Sta. 1206+75)	Yes Widespread	0.66	-	**Compromised**	Flow Failure	6-8

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Table 6-2 Summary of Seismic Vulnerability Assessment Results

Study-Section ID	Liquefaction?	Post-earthqnake Minimnm FS (K = 0)	Minimum FS with $K = \frac{1}{2} \cdot K_{max}$	Post Seismic Flood Protection Ability	Comments	Figure number
ARS - LM 10.81 U4 (DWR Sta. 1565+00)	No	2.78	2.32	**Probably Uncompromised**	-	6-9
ARS - LM > 10.99 U4 (DWR Sta. 1611+00)	Yes Widespread	1.68	1.15	**Probably Uncompromised**	-	6-10
NEMDC E - LM 0.91 U7 (DWR Sta. 5048+49)	Yes– Widespread	< 1.0	< 1.0	**Compromised**	Fine grained soil strength loss, may lead to slumping.	6-11
NEMDC E - LM 0.81 U2 (DWR Sta. 3029+56)	Yes– Widespread	1.02	-	**Compromised**	Fine grained soil strength loss, may lead to slumping.	6-12
NEMDC W - LM 6.43 (U3) RD 1000 (DWR Sta. 334+74)	Yes – Localized	< 1.0	Not Analyzed	**Compromised**	Fine grained soil strength loss, may lead to slumping.	6-16
NEMDC W - LM 4.85 (U3) RD 1000 (DWR Sta. 252+47)	Yes – Localized	1.18	< 1.0	**Likely Compromised**	Non-negligible deformations are expected	6-15
NEMDC W - LM 3.85 (U3) RD 1000 (DWR Sta. 200+26)	Yes– Widespread	< 1.0	Not Analyzed	**Compromised**	Fine grained soil strength loss, may lead to slnmping.	6-14

Table 6-2 Summary of Seismic Vulnerability Assessment Results

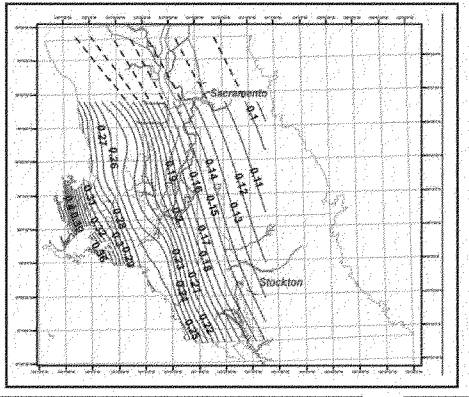
Study-Section ID	Liquefaction?	Post-earthquake Minimum FS (K = 0)	Minimum FS with $K = \frac{1}{2} \cdot K_{max}$	Post Seismic Flood Protection Ability	Comments	Figure number
NEMDC W - LM 0.98 (U3) RD 1000 (DWR Sta. 51+27)	Yes– Widespread	< 1.0	Not Analyzed	**Compromised**	Flow Failure	6-13
SRN - LM 7.05 (U1) RD 1000 (DWR Sta. 1489+00)	Yes– Widespread	< 1.0	< 1.0	**Compromised**	Flow Failure	6-17
SRN - LM 10.4 (U1) RD 1000 (DWR Sta. 1662+00)	Yes– Widespread	< 1.0	< 1.0	**Compromised**	Flow Failure	6-18
SRN - LM 13.19 (U1) RD 1000 (DWR Sta. 1807+00)	Yes – Localized	1.6	1.3	**Probably Uncompromised**	Negligible deformations are expected	6-19
SRN - LM 14.51 (U1) RD 1000 (DWR Sta. 1875+00)	Yes– Widespread	< 1.0	< 1.0	**Compromised**	Flow Failure	6-20
SRS - LM 1.49 (U1-COS) (DWR Sta. 1099+92)	Yes– Widespread	< 1.0	< 1.0	**Compromised**	Flow Failure	6-21
SRS - LM 2.83 (U1-MA 09) (DWR Sta. 1363+00)	Yes– Widespread	< 1.0	< 1.0	**Compromised**	Flow Failure	6-22

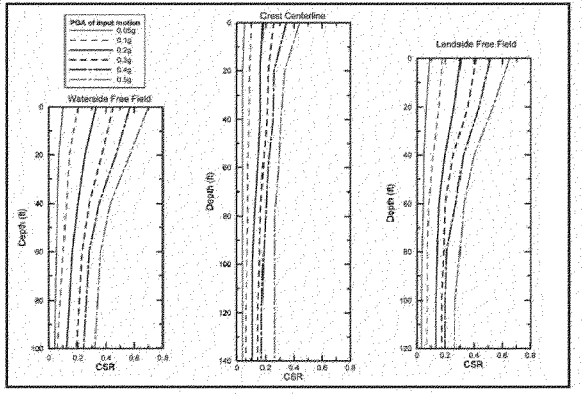
Table 6-2 Summary of Seismic Vulnerability Assessment Results

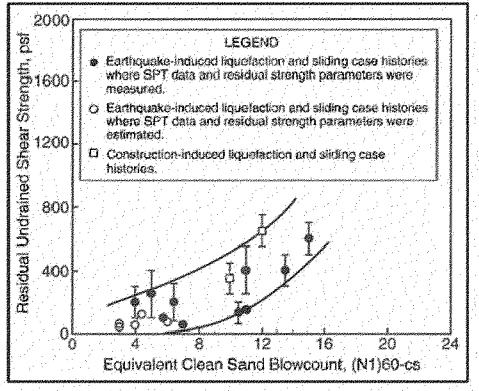
Study-Section ID	Liquefaction?	Post-earthquake Minimum FS (K = 0)	Minimum FS with $K = \frac{1}{2} \cdot K_{max}$	Post Seismic Flood Protection Ability	Comments	Figure number
SRS - LM 3.38 (U1-MA 09) (DWR Sta. 1392+00)	Yes– Widespread	< 1.0	< 1.0	Compromised	Flow Failure	6-23
SRS–LM 7.17 (U1-MA 09) (DWR Sta. 1618+00)	Yes– Widespread	< 1.0	< 1.0	Compromised	Flow Failure	6-24

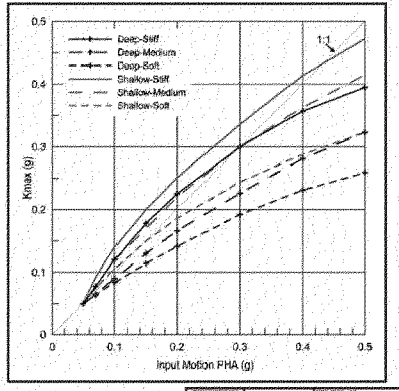
ARN American River north
ARS American River south
COS City of Sacramento
DWR Department of Water Resources
FS factor of safety
LM levee mile
NCC Natomas Cross Canal
NEMDC Natomas East Main Drainage Canal
RD Reclamation District
SRN Sacramento River North
SRS Sacramento River South
Sta. station

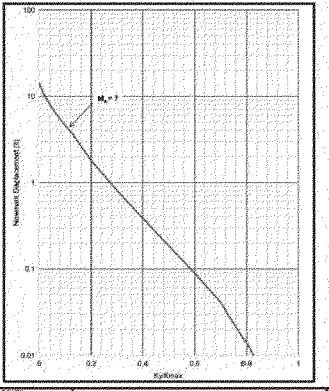
656





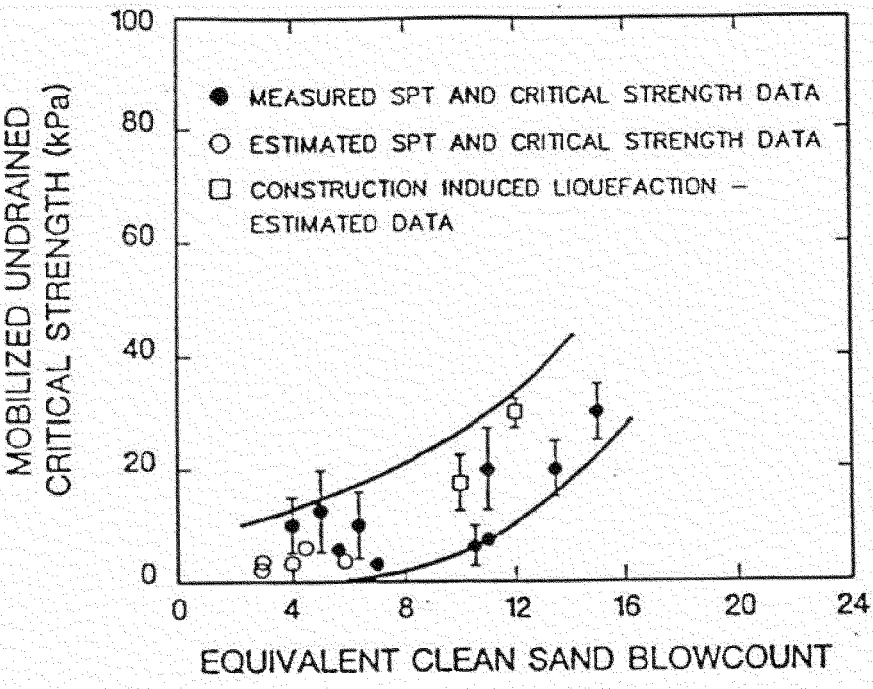






URS / US Army Corps of Engineers	PROJECT NO. 25815793	DRAWN SOB	Charts for Seismic Analyses	DATE 3/2/2009
	CONTRACT NO. W912DR-08-D-0001	ANALYZED SOB		FIGURE 6-1
	DELIVERY ORDER 0004	REVIEWED JFP		

Appendix C
Liquefaction Calculations



Recommended Relationship Between $S_{u,r}$ and $N_{1,60,CS}$ (Seed and Harder, 1990)

Figure 6-8

NATOMAS CROSS CANAL

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1312-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analyses*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on NCAL and SCAL sampler correction)*

PROJECT NAME:	ARCF (PRE - 2007)
LEVEE SEGMENT:	NATOMAS CROSS CANAL
PROJECT NUMBER:	26141/60155000
Reach ID:	NCC SCA1A-L4/5R
Station:	LM 3.01 LA (2005 SRA 1967+88)
Boring ID:	NCCL04-17
Boring Location (Exact waterfront/levee/etc. and distance from/west/north/south/levee toe)	Landside toe

Analyst By: Cesar Cerna-Plua
Check By:
Date:
Date:

Input Field (By Analyst)
Results of Analyses
Calculated Values

Ground Elevation (E_g) = 27.0
Groundwater Elev. During Drilling (E_w) = 14.0
Analyzed Groundwater Elevation (E_{gw}) = 17.0
Note: Field boring log data
Note: Typical water assumed as WS toe

Groundwater Depth Below GS During Drilling (d_w) = 13.0
Analyzed Groundwater Depth Below GS (d_{gw}) = 10.0

Hammer Type = Automatic
Energy Ratio = 1.30

Earthquake Information
Return Period (years) = 500
M$_w$ = 7.6
PGA (g) = 0.12
Location = Levee Site: Crest, Landside, or Waterside

| | | |

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2008)*
2. URS Corporation 2009. *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.B.S. Queens Mary, Long Beach, Ca.
4. Southern California Earthquake Center, *University of Southern California, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on NCAL and SCAL sampler corrections)*

PROJECT NAME:	ASCE (SRK) - 2008
LEVEE SEGMENT:	NATOMAS CROSS CANAL
PROJECT NUMBER:	26119619.4500
Reach ID:	NCC SOUTH LEVEE
Station:	LM 3.3 SJ LM (DWR STA 1057+00)
Boring ID:	NCCSB-15
Boring Location (Cen=Crest, ush=Upstream, dsh=Downstream, bse=Base, ush-toe=Upstream toe, dsh-toe=Downstream toe)	Crest

Analysis By: Diego Cobos-Roa
Check By:

Date:
Date:

Data Input (by Analyst)
Results of Analysis
Calculated Values

Ground Elevation (ft.)= +34.0
Groundwater Elev. During Drilling (ft.) = +24.0
Analyzed Groundwater Elevation (ft.)= +27.0

Note: From boring log data
Note: Typical value assumed as MEDian

Groundwater Depth Below GS During Drilling (ft.) = 10.0
Analyzed Groundwater Depth Below GS (ft.) = 7.0

Hammer Type = Automatic
Energy Ratio = 70

Earthquake Information:
Return Period (years) = 1000
ML = 6.5

PGA (g) = 0.27
Location = Crest

Silver Creek, Landslide, or Waterside

Sample ID	Depth to Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1, for SCAL, NCAL)	N_1 for Sampler Correction Only (for SW Sampler)	Sampler Corrections, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick-Up (+)/Recession (-) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, α_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS_L = 1.0 (Yes/No) Column AS	Below Analyzed Groundwater Level (Yes/No) Column AT	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AV	Final Assessment (Yes/No) Based on Columns AS, AT, and AV	Factor of Safety, FS	Comment (Liquefiable for FS,=1 and Judgment Required for 1.0 <FS, < 1.2)
NCCSB-15-3	3.5	3	SM	110	325	325	325	1.8	1.2	H	8	1.15	SCAL	11	1.13	0.93	0	0.5	0.75	5	7		12	1.1	8	0.119	0.119	0.150	1.00	Yes	No	SM				Yes	No	1.00	-
NCCSB-15-5	5	5	SM	110	550	550	550	1.6	1.2	H	8	1.15	SCAL	19	1.23	0.95	0	1.2	0.75	8	13		12	1.1	14	0.149	0.147	0.014	1.27	No	No	SM				Yes	No	1.27	-
NCCSB-15-7	7.5	7	SM	120	975	975	975	1.4	1.2	H	8	1.15	SCAL	17	1.20	0.95	0	2.0	0.75	8	11		12	1.1	12	0.119	0.115	0.112	1.04	Yes	No	SM				Yes	No	1.04	-
NCCSB-15-9	10	10	ML	120	1275	1275	1275	1.3	1.2	H	8	1.15	SCAL	13	1.14	0.95	0	2.7	0.75	7	9		39	1.8	11	0.100	0.113	0.124	0.89	Yes	No	ML				Yes	No	0.89	-
NCCSB-15-11	12.5	13	ML	120	1575	1575	1575	1.1	1.2	H	8	1.15	SCAL	18	1.21	0.95	0	3.2	0.75	10	12		38	1.3	15	0.129	0.111	0.038	1.16	Yes	No	ML				Yes	No	1.16	-
NCCSB-15-13	15	12	SM	120	1900	1900	1900	1.0	1.2	H	8	1.15	SCAL	14	1.18	0.95	0	4.3	0.90	10	10	12	13	1.1	11	0.090	0.109	0.460	0.63	Yes	No	SM				Yes	No	0.63	-
NCCSB-15-15	17.5	11	SM	120	2225	2225	2225	0.9	1.2	M	4	1.00	SCAL	14	1.18	0.95	0	5.9	0.94	10	9	15	35	1.3	12	0.092	0.107	0.374	0.86	Yes	No	SM				Yes	No	0.86	-
NCCSB-15-17	20	11	SM	120	2550	2550	2425	0.9	1.2	M	4	1.00	SCAL	14	1.17	0.95	0	5.9	0.87	11	9		12	1.1	10	0.090	0.105	0.647	0.76	Yes	Yes	SM				Yes	YES	0.76	Liquefiable
NCCSB-15-19	22.5	12	SM	120	2875	2875	2594	0.8	1.2	M	4	1.00	SCAL	12	1.15	0.95	0	6.9	0.90	10	9	20	21	1.2	10	0.078	0.105	0.717	0.75	Yes	Yes	SM				Yes	YES	0.75	Liquefiable
NCCSB-15-21	25	13	SM	120	3175	3175	2738	0.8	1.2	M	4	1.00	SCAL	48	1.30	0.95	0	7.3	0.92	25	20		35	1.2	33	0.453	0.104	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
NCCSB-15-23	27.5	15	SM	120	3500	3500	2907	0.8	1.2	M	4	1.00	SCAL	29	1.30	0.95	0	8.1	0.94	29	21		12	1.1	23	0.169	0.104	0.500	1.62	No	Yes	SM				Yes	No	1.62	-
NCCSB-15-25	30	16	SM	120	3825	3825	3076	0.7	1.2	M	4	1.00	SCAL	27	1.30	0.95	0	9.0	0.95	27	20	25	12	1.1	21	0.170	0.104	0.001	1.64	No	Yes	SM				Yes	No	1.64	-
NCCSB-15-27	32.5	17	CL	120	4125	4031	3235	0.7	1.2	M	4	1.00	SCAL	29	1.30	0.95	0	9.6	0.96	29	21		35	1.2	26	0.233	0.103	0.000	2.26	No	Yes	ML				Yes	No	2.26	-
NCCSB-15-29	35	18	CL	120	4400	4156	3389	0.7	1.2	M	4	1.00	SCAL	31	1.30	0.95	0	10.4	0.97	32	22		35	1.2	27	0.260	0.103	0.000	2.52	No	Yes	CL				No	No	2.52	-
NCCSB-15-31	37.5	20	CL	120	4675	4269	3458	0.7	1.2	M	4	1.00	SCAL	43	1.30	0.95	0	11.1	0.98	47	32		35	1.2	38	0.580	0.103	0.000	3.00	No	Yes	CL				No	No	3.00	-
NCCSB-15-33	40	22	SM	120	4975	4413	3602	0.7	1.2	M	4	1.00	SCAL	43	1.30	0.95	0	11.9	0.98	48	32	35	35	1.2	37	0.514	0.102	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
NCCSB-15-35	42.5	21	SM	120	5275	4557	3746	0.7	1.2	M	4	1.00	SCAL	32	1.30	0.95	0	12.6	0.99	33	23		35	1.2	27	0.278	0.101	0.970	0.78	Yes	Yes	SM				Yes	YES	0.78	Liquefiable
NCCSB-15-37	45	19	SM	120	5575	4701	3890	0.7	1.2	M	4	1.00	SCAL	19	1.26	0.95	0	13.4	0.99	23	14		35	1.2	16	0.123	0.099	0.535	1.34	No	Yes	ML				Yes	No	1.34	-
NCCSB-15-39	47.5	20	ML	120	5875	4845	4034	0.6	1.2	M	4	1.00	SCAL	20	1.28	0.95	0	14.2	0.99	22	14		35	1.2	15	0.113	0.099	0.000	2.18	No	Yes	ML				Yes	No	2.18	-
NCCSB-15-41	50	24	SM	120	6200	5014	4203	0.6	1.2	M	4	1.00	SCAL	21	1.28	0.95	0	14.8	0.99	26	16	20	35	1.2	20	0.142	0.098	0.000	1.47	No	Yes	SM				Yes	No	1.47	-
NCCSB-15-43	52.5	40	SM	120	6525	5183	4372	0.6	1.2	M	4	1.00	SCAL	19	1.29	0.95	0	15.7	0.99	23	14		12	1.1	15	0.099	0.095	0.139	1.03	Yes	Yes	SM				Yes	YES	1.03	Judgment Required
NCCSB-15-45	55	45	SM	120	6850	5352	4541	0.6	1.3	M	4	1.00	SCAL	27	1.30	0.95	0	16.5	1.00	33	20	25	26	1.2	24	0.182	0.093	0.000	1.95	Yes	Yes	SM				Yes	No	1.95	-
NCCSB-15-47	57.5	50	SP-SM	120	7175	5521	4710	0.6	1.2	M	4	1.00	SCAL	37	1.30	0.95	0	17.2	1.00	47	28	5	9	1.1	30	0.261	0.092	0.000	3.00	No	Yes	SP-SM				Yes	No	3.00	-
NCCSB-15-49	60	57	SP-SM	120	7500	5680	4879	0.6	1.2	M	4	1.00	SCAL	38	1.30	0.95	0	18.0	1.00	53	19	5	5	1.1	20	0.139	0.090	0.002	1.54	No	Yes	SP-SM				Yes	No	1.54	-
NCCSB-15-51	62.5	60	ML	120	8100	5879	5167	0.6	1.2	M	4	1.00	SCAL	28	1.30	0.95	0	19.5	1.00	36	21	20	35	1.2	26	0.205	0.089	0.000	2.29	No	Yes	ML				Yes	No	2.29	-
NCCSB-15-53	65	70	ML	120	8700	6286	5455	0.6	1.2	M	4	1.00	SCAL	21	1.30	0.95	0	21.0	1.00	29	16		35	1.2	20	0.155	0.088	0.002	1.51	No	Yes	ML				Yes	No	1.51	-
NCCSB-15-55	67.5	80	ML	120	9000	6554	5743	0.6	1.2	M	4	1.00	SCAL	16	1.22	0.95	0	22.6	1.00	22	12		35	1.2	16	0.992	0.087	0.122	1.06	Yes	Yes	ML				Yes	YES	1.06	Judgment Required
NCCSB-15-57	70	90	SM	120	9300	6822	6031	0.5	1.2	M	4	1.00	SCAL	22	1.30	0.95	0	24.1	1.00	33	17		12	1.1	18	0.110	0.086	0.017	1.29	No	Yes	SM				Yes	No	1.29	-
NCCSB-15-59	72.5	100	SP-SM	120	10800	7330	6419	0.5	1.2	M	4	1.00	SCAL	34	1.30	0.95	0	25.6	1.00	49	24	5	8	1.0	27	0.224	0.085	0.000	2.47	No	Yes	SP-SM				Yes	No	2.47	-
NCCSB-15-61	75	100	SP-SM	120	11259	7969	6787	0.5	1.2	M	4	1.00	SCAL	31	1.30	0.95	0	27.1	1.00	46	34	5	7	1.0	25	0.176	0.082	0.000	2.14	No	Yes	SP-SM				Yes	No	2.14	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE
1. **Cetin, K.O., et al, 2004.** *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1113-1140. and Discussions and Closures* **(May, 2008)**
2. **URS Corporation 2008.** *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.**
3. **Seed, R.B., et al, 2003,** *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework.* **26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.B. Gomes Navy, Long Beach, Ca .**
4. **Southern California Earthquake Center, University of Southern California,** *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* **(1999), (used only for guidance on NCAL and SCAL sampler correction)**

PROJECT NAME	WRDF ORE - 2009
LEVEE SEGMENT	WATONKA CROSS CANAL
PROJECT NUMBER	29410680.48400
Reach ID	WDC SOUTH LEVEE
Station:	LM 5.2 AR (DWR RTA 1067+00)
Boring ID:	B-BS-6
Boring Location (Levee/Landside/Waterside, and distance from Levee) landside/landside/waterside,ft	Landside toe

Analyzed By:	Diego Cisneros/Rita
Check By:	

Date:	
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 27.4
Groundwater Elev. During Drilling (ft.)= 19.4 Note: Assumed from MCDS-6-31
Analyzed Groundwater Elevation (ft.)= 23.0 Note: Tested water elevation as WSE'ed

Groundwater Depth Below GS During Drilling (d_1) = 12.0
Analyzed Groundwater Depth Below GS (d_1) = 8.0

Hammer Type = Automatic
Energy Ratio = 0.82

Earthquake Information
Return Period (years) = 200
M_w = 7.8

PGA (g) = 0.10
Location = Avenal or Ledger Creek, Lauralee, or Watenside

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (0.85 for SCAL, NCAL)	R_L for Sampler Correction Only (for SW samples)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Extension) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Sustance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	$FS_L < 1.0$ (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AH	First Assessment (Yes/No) Based on Columns AB, AF, and AH	Factor of Safety, FS_L	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS< 1.3)
1	3.5	20	CL	110	275	275	150	1.5	1.2	M	4	1.00	SCAL	48	1.30	0.65	0	0.5	0.75	17	27	68	29	1.2	33	0.930	0.200	0.000	3.50	No	Yes	CL	29	17	15	No	No	3.50	-
2	5.5	31	CL	114	656	606	293	1.5	1.2	M	4	1.00	S	34	1.30	1.00	0	1.4	0.75	18	29		35	1.2	35	0.955	0.198	0.000	3.00	No	Yes	CL				No	No	3.00	-
3	10.5	11	SP	120	1255	1205	531	1.3	1.2	M	4	1.00	SCAL	14	1.14	0.85	0	3.9	0.75	6	8	21	21	1.2	10	0.129	0.196	0.398	0.57	Yes	Yes	SP				Yes	YES	0.57	Liquefiable
4	15.5	35	SP	120	1905	1667	369	1.1	1.2	M	4	1.00	S	19	1.18	1.00	0	4.4	0.81	14	15	7	7	1.1	16	0.159	0.193	0.677	0.96	Yes	Yes	SP				Yes	YES	0.83	Liquefiable
5	20.5	24	CL	115	2405	1925	1207	1.0	1.2	M	4	1.00	SCAL	24	1.30	0.65	0	5.9	0.88	16	16		35	1.2	20	0.254	0.175	0.125	1.16	Yes	Yes	CL				No	No	1.16	-
6	25.5	15	SC	115	3105	2293	1545	0.9	1.2	M	4	1.00	S	11	1.14	1.00	0	7.5	0.93	13	12	31	31	1.3	16	0.130	0.164	0.349	0.79	Yes	Yes	SC				Yes	YES	0.79	Liquefiable
7	30.5	34	CL	120	3659	2661	1783	0.9	1.2	M	4	1.00	SCAL	36	1.30	0.65	0	9.0	0.96	25	20		35	1.2	27	0.299	0.153	0.000	1.95	No	Yes	CL				No	No	1.95	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. **Cetin, K.O., et al, 2004.** *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)
2. **URS Corporation 2008.** *Guidance Document for Geotechnical Analysis , Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.*
3. **Seed, R.B., et al, 2003.** *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework* . 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Queens Navy, Long Beach, Ca .
4. **Southern California Earthquake Center, University of Southern California,** *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* **(1999), (used only for guidance on MCAL and SCAL sampler correction)**

PROJECT NAME:	ARCF GRR - 2008
LEVEE SEGMENT:	NATOMAS CROSS CANAL
PROJECT NUMBER:	29416[10]/60436
Reach ID:	NCS SOUTH LEVEE
Station:	LM 0.2 LT (USER STA 1139+00)
Boring ID:	NCCB-L3
Boring Location (Coord. units/northing/easting and datum) from coord.units/northing/eas	Coord.

Analyzed By: Diego Cobos-Roa
Check By:
Date: 9/30/2008

Input Data (By Analyst)
Results of Analysis
Calculated Values

Ground Elevation (ft.)= +5.0
Groundwater Elev. During Drilling (ft.) = 12.0
Analyzed Groundwater Elevation (ft.)= 15.0

Note: From NCCB-L3.csv
Note: Typical water assumed as NAVD88

Groundwater Depth Below GS During Drilling (ft.) = 23.0
Analyzed Groundwater Depth Below GS (ft.) = 26.0

Hammer Type = Safety
Energy Ratio = 0.8

Earthquake Information:
Return Period (years) = 200
M_w = 6.8

PGA (g) = 0.32
Location = Creep Creep, Lassleite, et Wakenite

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URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analyses*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework* , 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	LRRP (RRI) - 2008
LEVEE SEGMENT:	NATOMAS CROSS CANAL
PROJECT NUMBER:	26184892.04MS
Reach ID:	NCC SAC/SUTTER
Station:	LM 0.27 US (SHIP RTA 1150+00)
Boring ID:	NCCB-6-7
Boring Location (Check position/dimension and distance from/LM/Levee/Waterside toe)	Crest

Analyst By:	Diego Cobos-Roa
Check By:	

Date:	5/20/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 45.0
Groundwater Elev. During Drilling (ft.) = 23.0
Analyzed Groundwater Elevation (ft.)= 24.0

Note: From NCCB-3 (Adj)
Note: Typical value assumed, as WS bel

Groundwater Depth Below GS During Drilling (ft.) = 23.0
Analyzed Groundwater Depth Below GS (ft.) = 20.0

Hammer Type = Automatic
Energy Ratio = 1.00

Earthquake Information
Return Period (years) = 200
M_w = 7.8

PGA (g) = 0.45
Location = Crest (Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft.)	N_{SPT}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (if SE: SCAL, MCAL)	R_L for Sampler Correction Only (for SW sampler)	Sampler Correction for Analysis, C_S	Stick Up (Protrusion) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$H_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	$FS_L < 1.0$ (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AC	First Assessment (Yes/No) Based on Columns AC, AF, and AB	Factor of Safety, FS	Consistent (Liquefiable for FS <1 and Judgment Required for 1.0 <FS, < 1.3)
NCCB3-1	3.5	4	SM	119	325	325	325	1.6	1.2	H	8	1.15	SCAL	32	1.30	0.85	0	0.5	0.75	13	21		12	1.1	23	0.346	0.119	0.000	2.92	No	No	SM				Yes	No	2.92	-
NCCB3-2	5	10	SM	119	556	556	556	1.6	1.2	H	8	1.15	SCAL	16	1.19	0.85	0	1.2	0.75	7	10		12	1.1	12	0.125	0.117	0.993	1.07	Yes	No	SM				Yes	No	1.07	-
NCCB3-3	7.5	5	SM	119	956	956	956	1.5	1.2	H	8	1.15	SCAL	6	1.10	0.85	0	2.0	0.75	3	4	5	23	1.8	6	0.075	0.115	0.660	0.65	Yes	No	SM				Yes	No	0.65	-
NCCB3-4	10	11	SM	119	1275	1275	1275	1.3	1.2	H	8	1.15	SCAL	8	1.10	0.85	0	2.7	0.75	4	5		12	1.2	6	0.084	0.113	0.956	0.89	Yes	No	SM				Yes	No	0.89	-
NCCB3-5	12.5	9	SM	120	1600	1600	1600	1.1	1.2	H	8	1.15	SCAL	8	1.10	0.85	0	3.5	0.75	6	9		12	1.2	6	0.084	0.111	0.952	0.80	Yes	No	SM				Yes	No	0.80	-
NCCB3-6	15	10	SM	120	1925	1925	1925	1.0	1.2	H	8	1.15	SCAL	8	1.10	0.85	0	4.3	0.80	6	8	10	25	1.4	9	0.072	0.109	0.942	0.66	Yes	No	SM				Yes	No	0.66	-
NCCB3-7	17.5	10	ML	118	2225	2225	2225	0.9	1.2	H	8	1.15	SCAL	9	1.12	0.85	0	5.0	0.84	7	7	10	29	1.4	10	0.077	0.107	0.710	0.72	Yes	No	ML				Yes	No	0.72	-
NCCB3-8	20	7	SM	118	2550	2550	2550	0.8	1.2	H	8	1.15	SCAL	6	1.10	0.85	0	5.8	0.87	5	5	7	34	1.6	7	0.091	0.105	0.949	0.58	Yes	Yes	SM				Yes	YES	0.58	Liquefiable
NCCB3-9	22.5	7	SM	118	2875	2875	2719	0.8	1.2	M	4	1.00	SCAL	6	1.10	0.85	0	6.6	0.90	5	4	6	19	1.3	5	0.052	0.105	0.950	0.50	Yes	Yes	SM				Yes	YES	0.50	Liquefiable
NCCB3-10	25.5	7	SM	118	3150	3025	2838	0.8	1.2	M	4	1.00	SCAL	6	1.10	0.85	0	7.5	0.92	6	4	6	19	1.3	5	0.052	0.104	0.949	0.49	Yes	Yes	SM				Yes	YES	0.49	Liquefiable
NCCB3-11	27.5	9	SM	118	3425	3144	2957	0.8	1.2	M	4	1.00	SCAL	7	1.10	0.85	0	8.1	0.94	8	5	8	25	1.5	8	0.061	0.104	0.954	0.59	Yes	Yes	CL				Yes	YES	0.59	Liquefiable
NCCB3-12	30	10	CL	119	3700	3269	3076	0.8	1.2	M	4	1.00	SCAL	9	1.11	0.85	0	9.0	0.95	9	7		25	1.4	9	0.070	0.104	0.945	0.66	Yes	Yes	CL				Yes	YES	0.66	Liquefiable
NCCB3-13	32.5	10	CL	119	3975	3382	3186	0.8	1.2	M	4	1.00	SCAL	29	1.30	0.85	0	9.6	0.96	28	21		35	1.2	24	0.239	0.103	0.609	2.31	No	Yes	CL				No	No	2.31	-
NCCB3-14	35	20	CL	119	4250	3501	3314	0.8	1.2	M	4	1.00	SCAL	16	1.20	0.85	0	10.4	0.97	16	11		25	1.3	14	0.089	0.103	0.226	0.96	Yes	Yes	CL				No	No	0.96	-
NCCB3-15	37.5	20	CL	119	4525	3639	3433	0.7	1.2	M	4	1.00	SCAL	27	1.30	0.85	0	11.1	0.98	27	20		25	1.2	24	0.209	0.103	0.000	2.01	No	Yes	CL				No	No	2.01	-
NCCB3-16	40	30	CL	119	4800	3739	3552	0.7	1.2	M	4	1.00	SCAL	35	1.35	0.85	0	11.9	0.99	36	27		35	1.2	32	0.367	0.102	0.000	3.00	No	Yes	CL				No	No	3.00	-
NCCB3-17	42.5	30	CL	119	5075	3958	3671	0.7	1.2	M	4	1.00	SCAL	12	1.15	0.85	0	12.6	0.99	12	9		35	1.3	12	0.077	0.101	0.653	0.76	Yes	Yes	CL				No	No	0.76	-
NCCB3-18	45	30	CL	119	5375	4002	3915	0.7	1.2	M	4	1.00	SCAL	9	1.10	0.85	0	13.4	0.99	7	5	10	25	1.5	7	0.055	0.099	0.374	0.55	Yes	Yes	ML				Yes	YES	0.55	Liquefiable
NCCB3-19	47.5	17	SM	120	5700	4171	3984	0.7	1.2	M	4	1.00	SCAL	12	1.15	0.85	0	14.2	0.99	10	9	14	35	1.3	12	0.077	0.099	0.579	0.79	Yes	Yes	SM				Yes	YES	0.79	Liquefiable
NCCB3-20	50	35	SC	120	6000	4316	4129	0.7	1.2	M	4	1.00	SCAL	16	1.22	0.85	0	14.9	0.99	16	12		35	1.3	16	0.105	0.098	0.098	1.07	Yes	Yes	ML				Yes	YES	1.07	Judgment Required
NCCB3-21	52.5	35	SM	120	6325	4494	4297	0.7	1.2	M	4	1.00	SCAL	16	1.22	0.85	0	15.7	0.99	16	12	16	35	1.3	16	0.100	0.096	0.119	1.06	Yes	Yes	SM				Yes	YES	1.06	Judgment Required
NCCB3-22	55	35	SM	120	6650	4663	4468	0.7	1.2	M	4	1.00	SCAL	22	1.27	0.85	0	16.5	1.00	23	15		5	1.0	15	0.099	0.093	0.113	1.05	Yes	Yes	SP				Yes	YES	1.05	Judgment Required
NCCB3-23	57.5	40	SM	120	6975	4822	4635	0.6	1.2	M	4	1.00	SCAL	24	1.30	0.85	0	17.2	1.00	31	20		12	1.1	22	0.153	0.092	0.000	1.67	No	Yes	SM				Yes	No	1.67	-
NCCB3-24	60	100	SM	120	7300	4991	4804	0.6	1.2	M	4	1.00	SCAL	36	1.36	0.85	0	18.0	1.00	43	27	40	32	1.2	62	0.343	0.090	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
NCCB3-25	62.5	50	SP-SM	120	7650	5239	5143	0.6	1.2	M	4	1.00	SCAL	19	1.26	0.85	0	19.5	1.00	23	14	21	9	1.1	15	0.094	0.089	0.109	1.66	Yes	Yes	SP-SM				Yes	YES	1.66	Judgment Required
NCCB3-26	65	60	SP-SM	120	8000	5667	5480	0.6	1.2	M	4	1.00	SCAL	24	1.30	0.85	0	21.0	1.00	36	18	27	11	1.1	19	0.124	0.088	0.104	1.41	No	Yes	SP-SM				Yes	No	1.41	-
NCCB3-27	67.5	80	SC	120	9150	5965	5718	0.6	1.2	M	4	1.00	SCAL	29	1.30	0.85	0	22.6	1.00	33	19		35	1.2	23	0.166	0.087	0.000	1.91	No	Yes	CL				No	No	1.91	-
NCCB3-28	70	60	ML	119	9750	6193	6006	0.6	1.2	M	4	1.00	SCAL	36	1.30	0.85	0	24.1	1.00	49	25		35	1.2	28	0.229	0.086	0.000	2.66	No	Yes	ML				Yes	No	2.66	-
NCCB3-29	72.5	60	ML	119	10350	6481	6294	0.6	1.2	M	4	1.00	SCAL	23	1.30	0.85	0	25.6	1.00	31	17		35	1.2	21	0.140	0.084	0.000	1.67	No	Yes	ML				Yes	No	1.67	-
NCCB3-30	75	60	ML	119	10950	6769	6582	0.6	1.2	M	4	1.00	SCAL	22	1.30	0.85	0	27.1	1.00	30	16		35	1.2	21	0.129	0.082	0.001	1.57	No	Yes	ML				Yes	No	1.57	-

AMERICAN RIVER NORTH LEVEE

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCES:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analysis - Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	MFCP CP#1 - 2009
LEVEE SEGMENT:	AMERICAN RIVER NORTH LEVEE
PROJECT NUMBER:	26614785.03400
Reach ID:	ARN R07W2
Station:	LM 1.2 R1.2 (DWR STA 2194+00)
Boring ID:	DWR-10
Boring Location (Levee Landside/Waterside, and distance from Levee Landside/Waterside toe)	Crest

Analyzed By: Diego Cobos-Roa
Checked By:

Date: 9/29/2009
Date:

Data Input by Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 41.0
Groundwater Elev. During Drilling (ft.) = 23.0
Analyzed Groundwater Elevation (ft.)= 19.0

Note: Piezo testing bio
Note: Typical water elevation as it is above MHHW

Groundwater Depth Below GS During Drilling (ft.) = 18.0
Analyzed Groundwater Depth Below GS (ft.) = 22.0

Hammer Type = Pneumatic
Energy Ratio = 78

Earthquake Information:
Return Period (years) = 200
M_w = 6.6

PGA (g) = 0.15
Location = Crest

Levee Crest, Landside or Waterside

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (C for CAL, S for SCAL, SCAL)	N_c for Sampler Correction Only (for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Penetration) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	H_{fs}	N_{1c}	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1(60)cs}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS_c < 1.2 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Lab Test Results for CL, ML Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AH	Final Assessment (Yes/No) Based on Columns AE, AF, and AH	Factor of Safety, FS	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS< 1.2)
S01	4	4	SM	120	960	600	600	1.5	1.2	H	8	1.15	SCAL	22	1.20	0.95	0	1.5	0.75	9	15		12	1.1	16	0.174	0.124	0.003	1.40	No	No	SM				Yes	No	1.40	-
S02	9	7	SM	120	1260	1260	1260	1.3	1.2	H	8	1.15	SCAL	16	1.18	0.95	0	2.7	0.75	8	10	20	25	1.3	13	0.117	0.126	0.186	0.97	Yes	No	SM				Yes	No	0.97	-
S03	14	12	SM	120	1500	1500	1500	1.0	1.2	H	8	1.15	SCAL	14	1.16	0.95	0	4.3	0.90	10	10		12	1.1	11	0.089	0.119	0.053	0.77	Yes	No	SM				Yes	No	0.77	-
S04	19	11	SM	120	2340	2340	2340	0.8	1.2	H	8	1.15	SCAL	15	1.29	0.95	0	5.8	0.87	13	11		12	1.1	13	0.093	0.112	0.491	0.93	Yes	No	SM				Yes	No	0.93	-
S05	24	10	ML	120	2880	2880	2880	0.8	1.2	M	4	1.00	SCAL	10	1.12	0.95	0	6.6	0.80	8	7		15	1.4	10	0.072	0.112	0.850	0.64	Yes	No	ML				Yes	No	0.64	-
S06	29	10	ML	120	3180	3180	3025	0.8	1.3	M	4	1.00	SCAL	9	1.10	0.95	0	7.3	0.92	8	9	30	25	1.6	9	0.066	0.112	0.945	0.59	Yes	Yes	ML	NP	NP		Yes	YES	0.59	Liquefiable
S07	34	10	ML	120	3480	3480	3169	0.8	1.2	M	4	1.00	SCAL	10	1.23	0.95	0	8.1	0.94	10	12		35	1.3	16	0.112	0.111	0.170	1.01	Yes	Yes	ML				Yes	YES	1.01	Judgment Required
S08	39	12	ML	120	3780	3626	3313	0.7	1.2	M	4	1.00	SCAL	13	1.23	0.95	0	9.8	0.95	17	13		25	1.3	16	0.115	0.111	0.143	1.03	Yes	Yes	ML				Yes	YES	1.03	Judgment Required
S09	44	14	SM	120	4080	3769	3457	0.7	1.2	M	4	1.00	SCAL	4	1.16	0.95	0	11.0	0.96	4	3	20	25	1.7	5	0.049	0.111	0.559	0.44	Yes	Yes	ML				Yes	YES	0.44	Liquefiable
S10	49	16	SM	120	4380	4015	3601	0.7	1.2	M	4	1.00	SCAL	5	1.10	0.95	0	12.1	0.97	5	4	20	25	1.9	7	0.053	0.111	0.956	0.49	Yes	Yes	ML				Yes	YES	0.49	Liquefiable
S11	54	18	SM	120	4680	4057	3745	0.7	1.2	M	4	1.00	SCAL	24	1.30	0.95	0	13.1	0.98	26	19		35	1.2	22	0.167	0.110	0.001	1.51	No	No	ML				Yes	No	1.51	-
S12	59	15	ML	120	4980	4201	3889	0.7	1.2	M	4	1.00	SCAL	19	1.25	0.95	0	14.3	0.98	20	14	20	35	1.2	16	0.119	0.110	0.001	1.08	Yes	Yes	ML				Yes	YES	1.08	Judgment Required
S13	64	20	SM	120	5275	4378	4058	0.7	1.2	M	4	1.00	SCAL	29	1.30	0.95	0	15.8	0.99	32	22		12	1.1	23	0.165	0.109	0.000	1.69	No	Yes	SM				Yes	No	1.69	-
S14	69	36	SP	120	5575	4514	4202	0.7	1.3	M	4	1.00	SCAL	36	1.30	0.95	0	17.4	0.99	39	25		35	1.2	24	0.169	0.107	0.000	1.77	No	Yes	ML				Yes	No	1.77	-
S15	74	25	SM	120	5900	4649	4271	0.7	1.2	M	4	1.00	SCAL	28	1.30	0.95	0	18.2	0.99	33	22		12	1.1	23	0.177	0.105	0.000	1.68	No	Yes	SM				Yes	No	1.68	-
S16	79	24	SM	120	6225	4953	4540	0.6	1.3	M	4	1.00	SCAL	24	1.30	0.95	0	19.3	0.99	29	18	20	39	1.2	22	0.156	0.104	0.001	1.52	No	Yes	SM				Yes	No	1.52	-
S17	84	20	SP	120	6575	5180	4818	0.6	1.3	M	4	1.00	SCAL	27	1.30	0.95	0	20.5	1.00	40	28	5	6	1.0	29	0.263	0.101	0.000	2.62	No	Yes	SP				Yes	No	2.62	-
S18	89	30	SM	120	7475	5479	5166	0.6	1.2	M	4	1.00	SCAL	46	1.30	0.95	0	18.0	1.00	57	36		35	1.2	41	0.659	0.097	0.000	3.60	No	Yes	ML				Yes	No	3.60	-
S19	94	36	SM	120	8125	5816	5504	0.5	1.2	M	4	1.00	SCAL	49	1.30	0.95	0	19.5	1.00	53	39		12	1.1	33	0.326	0.095	0.000	3.60	No	Yes	SM				Yes	No	3.60	-
S20	99	33	SM	120	8775	6154	5842	0.5	1.2	M	4	1.00	SCAL	49	1.30	0.95	0	21.0	1.00	53	35		12	1.1	32	0.322	0.094	0.000	3.60	No	Yes	SM				Yes	No	3.60	-
S21	104	50	SP	120	9425	6492	6180	0.5	1.2	M	4	1.00	SCAL	58	1.30	0.95	0	22.5	1.00	78	49		5	1.0	49	0.717	0.092	0.000	3.60	No	Yes	SP				Yes	No	3.60	-
S22	109	85	SP	120	10075	6818	6518	0.5	1.2	M	4	1.00	SCAL	31	1.30	0.95	0	24.1	1.00	44	24	5	5	1.0	24	0.165	0.090	0.000	1.82	No	Yes	SP				Yes	No	1.82	-
					10075	10075	10075	0.4	1.2			1.00		0	1.10	0.00	0	-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				Yes	No	0.20	-
					10075	10075	10075	0.4	1.2			1.00		0	1.10	0.00	0	-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				Yes	No	0.20	-
					10075	10075	10075	0.4	1.2			1.00		0	1.10	0.00	0	-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				Yes	No	0.20	-
					10075	10075	10075	0.4	1.2			1.00		0	1.10	0.00	0	-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				Yes	No	0.20	-
					10075	10075	10075	0.4	1.2			1.00		0	1.10	0.00	0	-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				Yes	No	0.20	-
					10075	10075	10075	0.4	1.2			1.00		0	1.10	0.00	0	-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				Yes	No	0.20	-
					10075	10075	10075	0.4	1.2			1.00		0	1.10	0.00	0	-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				Yes	No	0.20	-
					10075	10075	10075	0.4	1.2			1.00		0	1.10	0.00	0	-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				Yes	No	0.20	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Queens Natty, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*. (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	SRCP ORD - 2008
LEVEE SEGMENT:	AMERICAN RIVER NORTH LEVEE
PROJECT NUMBER:	29414089.00.06
Reach ID:	ARN 36.5100
Station:	AM 1.2761 (E 6,000,974 N 2,194,493)
Boring ID:	ARB-5
Boring Location (Check address/Materials, get distance from Coast/Levee/Confined/Mines/Dump)	Coast

Analyzed By: Diego Cascallana
Check By:

Date: 4/16/2009
Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 41.0
Groundwater Elev. During Drilling (ft.) = +3.5
Analyzed Groundwater Elevation (ft.)= +6.5

Note: Fixed boring log
Note: Typical water assumed as 5 ft above MSL

Groundwater Depth Below GS During Drilling (ft.) = 28.0
Analyzed Groundwater Depth Below GS (ft.) = 23.0

Hammer Type = Automatic
Energy Ratio = 1.30

Earthquake Information:
Return Period (years) = 200
M_L = 6.5

PGA (g) = 0.22
Location = Coast (Select: Coast, Lacustrine, or Interior)

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Visual Description	Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (L for SCAL, MCAL)	N_1 for Sampler Correction Only (for SPT sampler)	Sampler Correction for Analysis, C_S	Stick Up (Positive) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Sustained Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	$FS_L = 1.0$ (Yes/No) Column AS	Below Analyzed Groundwater Level (Yes/No) Column AT	USCS Classification	Lab Test Results for CL, ML: Liquid Limit, LL	Plasticity Index, PI	#200 Content (%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AR	Final Assessment (Yes/No) Based on Columns AS, AT, and AU	Factor of Safety, FS_L	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS < 1.3)
S01	6	10	SM		120	600	450	1.5	1.2	H	9	1.15	SCAL	24	1.20	0.95	0	1.2	0.75	19	16		12	1.1	17	0.169	0.124	0.021	1.52	No	No	SM				No	No	1.52	-
S02	11	17	SM		120	1100	1305	1305	1.2	1.2	H	9	1.15	SCAL	17	1.21	0.95	0	2.7	0.75	8	11		12	1.1	13	0.111	0.120	0.264	0.92	Yes	No	SM				Yes	No	0.92	-
S03	14	13	SM		124	1950	1950	1950	1.0	1.2	H	9	1.15	SCAL	13	1.16	0.95	0	4.3	0.95	9	9		12	1.1	10	0.093	0.116	0.732	0.71	Yes	No	SM				Yes	No	0.71	-
S04	39	14	ML		140	3900	2990	2990	0.9	1.2	H	9	1.15	SCAL	12	1.19	0.93	0	5.8	0.87	11	9	CL	25	1.2	12	0.091	0.112	0.503	0.81	Yes	No	ML				Yes	No	0.81	-
S05	49	16	SM		130	3925	2925	2925	0.9	1.2	M	4	1.00	SCAL	15	1.18	0.93	0	6.6	0.90	12	10		12	1.1	11	0.091	0.112	0.721	0.72	Yes	No	SM				Yes	No	0.72	-
S06	54	15	ML		130	3725	3205	3105	0.9	1.2	M	4	1.00	SCAL	13	1.15	0.95	0	7.3	0.92	11	9		25	1.3	12	0.093	0.112	0.695	0.74	Yes	Yes	ML				Yes	YES	0.74	Liquefiable
S07	59	19	ML		120	3525	3525	3244	0.8	1.2	M	4	1.00	SCAL	12	1.15	0.93	0	8.1	0.94	11	9		35	1.3	12	0.093	0.111	0.764	0.72	Yes	Yes	ML				Yes	YES	0.72	Liquefiable
S08	74	11	ML		110	3850	3725	3413	0.7	1.2	M	4	1.00	SCAL	9	1.10	0.93	0	9.8	0.95	9	6	ML	25	1.4	8	0.062	0.111	0.974	0.56	Yes	Yes	ML				Yes	YES	0.56	Liquefiable
S09	79	25	SM		125	4175	3894	3582	0.7	1.2	M	4	1.00	SCAL	4	1.10	0.95	0	9.9	0.96	4	3	ML	24	5.8	5	0.046	0.111	1.000	0.41	Yes	Yes	SM				Yes	YES	0.41	Liquefiable
S10	84	16	SM		115	4500	4060	3751	0.7	1.2	M	4	1.00	SCAL	7	1.10	0.95	0	10.4	0.97	7	5		12	1.2	6	0.051	0.111	0.998	0.46	Yes	Yes	SM				Yes	YES	0.46	Liquefiable
S11	94	40	SP-SM		130	4825	4232	3920	0.7	1.2	M	4	1.00	SCAL	23	1.30	0.85	0	11.1	0.98	25	17	ML	9	1.1	18	0.127	0.110	0.953	1.15	Yes	Yes	SP-SM				Yes	YES	1.15	Judgment Required
S12	99	49	SP-SM		130	5150	4465	4083	0.7	1.2	M	4	1.00	SCAL	26	1.30	0.85	0	11.9	0.98	29	20	ML	6	1.0	20	0.145	0.110	0.911	1.32	No	Yes	SP-SM				Yes	No	1.32	-
S13	104	22	CL		120	5425	4598	4208	0.7	1.2	M	4	1.00	SCAL	11	1.14	0.85	0	12.8	0.99	13	9	SC	35	1.3	11	0.073	0.109	0.837	0.67	Yes	Yes	CL	37	17	28	Yes	Yes	0.67	-
S14	109	31	CL		125	5700	4635	4327	0.7	1.2	M	4	1.00	SCAL	14	1.16	0.85	0	13.4	0.99	18	16		35	1.3	14	0.096	0.107	0.560	0.86	Yes	Yes	CL				No	No	0.86	-
S15	124	36	SC		125	6225	4899	4436	0.6	1.2	M	4	1.00	SCAL	23	1.30	0.85	0	14.2	0.99	26	17		12	1.1	18	0.122	0.105	0.047	1.16	Yes	Yes	SC				Yes	YES	1.16	Judgment Required
S16	129	42	SM		130	6350	4977	4483	0.6	1.2	M	4	1.00	SCAL	21	1.29	0.85	0	14.9	0.99	25	16	CL	17	1.3	16	0.115	0.104	0.079	1.11	Yes	Yes	SM				Yes	YES	1.11	Judgment Required
S17	134	37	SM		130	6875	5146	4594	0.6	1.2	M	4	1.00	SCAL	28	1.30	0.85	0	15.7	0.99	31	19		12	1.1	21	0.143	0.102	0.004	1.40	No	Yes	SM				Yes	No	1.40	-
S18	139	35	SM		130	7000	5315	5003	0.6	1.2	M	4	1.00	SCAL	34	1.30	0.85	0	16.5	1.00	39	25	CL	20	1.3	31	0.199	0.101	0.005	1.58	No	Yes	SM				Yes	No	1.58	-
S19	154	37	SM		130	7715	5847	5375	0.5	1.2	M	4	1.00	SCAL	42	1.30	0.85	0	18.1	1.00	56	32		12	1.1	56	0.374	0.097	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S20	159	102	SM		130	8300	5961	5478	0.5	1.2	M	4	1.00	SCAL	58	1.30	0.85	0	18.5	1.00	76	44		12	1.1	46	0.940	0.095	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S21	164	69	SM		130	8650	6309	6017	0.5	1.2	M	4	1.00	SCAL	56	1.30	0.85	0	21.0	1.00	76	43		12	1.1	45	0.844	0.094	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S22	174	60	SM		130	9600	6867	6359	0.5	1.2	M	4	1.00	SCAL	55	1.30	0.85	0	22.6	1.00	76	42	SM	28	1.1	48	0.990	0.092	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S23	181	102	SM		135	10200	7055	6543	0.5	1.2	M	4	1.00	SCAL	54	1.30	0.85	0	24.1	1.00	76	41		25	1.2	49	1.016	0.090	0.000	3.00	No	No	ML				No	No	3.00	-
						10200	10200	10200	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				No	No	0.20	-
						10200	10200	10200	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				No	No	0.20	-
						10200	10200	10200	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				No	No	0.20	-
						10200	10200	10200	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				No	No	0.20	-
						10200	10200	10200	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				No	No	0.20	-
						10200	10200	10200	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				No	No	0.20	-
						10200	10200	10200	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				No	No	0.20	-
						10200	10200	10200	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.025	0.128	1.000	0.20	Yes	No	0				No	No	0.20	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.E. Queens Natty, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*. (used only for guidance on NCAL and SCAL sampler corrections)

PROJECT NAME:	American River Common Feature GRR
LEVEE SEGMENT:	American River North Levee
PROJECT NUMBER:	29314/60.45410
Reach ID:	
Station:	BH2H01
Boring ID:	30-01-0023
Boring Location (Coord. Location/Stationing, and distance from Levee centerline/waterside toe)	Levee Crest

Analyst By: Michael Kahrel
Check By:

Date: 05/12/2008
Date:

Cells Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 47.0
Groundwater Elev. During Drilling (ft.) = 17.0
Analyzed Groundwater Elevation (ft.)= 17.0

Note: Ft.Cat. Sporting Lost
Note: Below Mean WSE

Groundwater Depth Below GS During Drilling (ft.) = 30.0
Analyzed Groundwater Depth Below GS (ft.) = 29.3

Hammer Type =
Energy Ratio =

Earthquake Information:
Return Period (years) = 200
M_L = 7.2

PGA (g) = 0.53
Location = Crest *Crest, Landside, or Waterside*

Sample ID	Depth to Bottom of Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SS, SCAL, NCAL)	N_m for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Pos/Neg) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	M_{eq}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, α_{Fines}	$H_{SWK/S}$	Cyclic Stress Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.2 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Lab Test Results for CL, ML: Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Final Liquefaction Assessment: Liquefiable/Likely Based on Soil Type (Yes/No) Column AH	Final Assessment (Yes/No) Based on Columns AE, AF, and AH	Factor of Safety, FS	Comment: Liquefiable for FS <1 and Judgment Required for 1.0 <FS < 1.2
	1.5	13	CL	110	165	165	165	1.9	1.3	H	8	1.15	S	19	1.30	1.00	7	2.3	0.75	14	22	95	35	1.2	27	0.560	0.119	0.000	3.00	No	No	CL				Yes	No	3.00	-
	3.5	36	SP-SM	130	425	425	425	1.6	1.3	H	8	1.15	S	58	1.30	1.00	7	2.9	0.75	41	66	10	10	1.0	69	10.811	0.118	0.000	3.00	No	No	SP-SM				Yes	No	3.00	-
	9.25	17	SM	130	793	662	783	1.5	1.3	H	8	1.15	S	27	1.30	1.00	7	3.7	0.75	29	32	24	24	1.1	36	0.726	0.116	0.000	3.00	No	No	SM	51	4		Yes	No	3.00	-
	8.75	15	SM	130	1109	911	1108	1.5	1.3	H	8	1.15	S	24	1.30	1.00	7	4.5	0.81	19	29	24	24	1.1	33	0.561	0.114	0.000	3.00	No	No	SM				Yes	No	3.00	-
	11.25	12	SM	130	1463	980	1433	1.4	1.3	H	8	1.15	S	17	1.30	1.00	7	5.3	0.85	16	22	24	24	1.1	26	0.291	0.112	0.000	2.60	No	No	SM				Yes	No	2.60	-
	13.75	8	GM	130	1758	1149	1759	1.3	1.3	H	8	1.15	S	11	1.15	1.00	7	6.0	0.88	11	14	24	24	1.2	17	0.141	0.110	0.000	1.29	No	No	SM				Yes	No	1.29	-
	18	13	SP	130	2310	1436	2310	1.2	1.3	H	8	1.15	S	18	1.25	1.00	7	7.3	0.92	19	22	24	24	1.2	29	0.241	0.106	0.000	2.27	No	No	SP				Yes	No	2.27	-
	21.25	6	ML	120	2708	1624	2700	1.1	1.2	H	8	1.15	S	6	1.10	1.00	7	8.2	0.94	7	9	60	35	1.4	11	0.080	0.105	0.336	0.76	Yes	No	ML				Yes	No	0.76	-
	24	5	SM	130	3520	1810	3509	1.1	1.3	H	8	1.15	S	5	1.10	1.00	7	9.1	0.96	7	8	5	5	1.1	9	0.083	0.104	0.772	0.60	Yes	No	SM				Yes	No	0.60	-
	28.5	11	SP	130	3703	1979	3693	1.0	1.3	H	8	1.15	S	11	1.10	1.00	7	9.9	0.97	10	16	10	10	1.1	18	0.124	0.104	0.904	1.19	Yes	No	SP				Yes	No	1.19	-
	29	2	SP	130	3798	2149	3788	1.0	1.3	H	8	1.15	S	2	1.10	1.00	7	10.7	0.97	3	3	5	5	1.1	3	0.041	0.104	0.937	0.40	Yes	No	SP				Yes	No	0.40	-
	31.5	4	SP	130	4053	2317	3935	0.9	1.3	H	8	1.15	S	4	1.10	1.00	7	11.4	0.98	5	6	5	5	1.1	5	0.060	0.103	0.968	0.49	Yes	Yes	SP				Yes	YES	0.49	Liquefiable
	34	9	SP	130	4368	2486	4064	0.9	1.3	H	8	1.15	S	7	1.12	1.00	7	12.2	0.98	12	11	5	5	1.0	11	0.074	0.103	0.989	0.72	Yes	Yes	SP				Yes	YES	0.72	Liquefiable
	36.5	8	SP	130	4683	2655	4233	0.8	1.3	H	8	1.15	S	7	1.12	1.00	7	13.0	0.99	12	11	5	5	1.0	11	0.071	0.103	0.997	0.69	Yes	Yes	SP				Yes	YES	0.69	Liquefiable
	39	21	SM	130	5008	2824	4402	0.8	1.3	H	8	1.15	S	18	1.30	1.00	7	13.7	0.99	32	27	20	20	1.1	30	0.293	0.103	0.999	2.86	No	Yes	SM				Yes	No	2.86	-
	42	8	SP	130	5338	3029	4603	0.8	1.3	H	8	1.15	S	7	1.11	1.00	7	14.5	0.99	12	10	5	5	1.0	10	0.066	0.101	0.663	0.65	Yes	Yes	SP				Yes	YES	0.65	Liquefiable
	44.25	12	ML	120	5668	3155	4735	0.8	1.3	H	8	1.15	S	10	1.16	1.00	7	15.3	0.99	19	15	80	35	1.3	18	0.150	0.100	0.906	1.20	Yes	Yes	ML				Yes	YES	1.20	Judgment Required
	46.75	9	SW-SM	130	5993	3335	4904	0.8	1.3	H	8	1.15	S	7	1.12	1.00	7	16.1	1.00	14	11	40	25	1.3	14	0.085	0.099	0.115	0.86	Yes	Yes	SW-SM				Yes	YES	0.86	Liquefiable
	49.5	12	SP-SM	130	6350	3511	5093	0.8	1.3	H	8	1.15	S	9	1.15	1.00	7	16.9	1.00	18	14	12	12	1.1	15	0.092	0.097	0.095	0.98	Yes	Yes	SP-SM				Yes	YES	0.98	Liquefiable
	52	14	SP-SM	130	6675	3690	5259	0.7	1.3	H	8	1.15	S	10	1.17	1.00	7	17.7	1.00	21	16	12	12	1.1	17	0.106	0.095	0.019	1.11	Yes	Yes	SP-SM				Yes	YES	1.11	Judgment Required
	54.5	15	SP-SM	130	7000	3869	5428	0.7	1.3	H	8	1.15	S	11	1.18	1.00	7	18.4	1.00	23	17	12	12	1.1	18	0.112	0.094	0.008	1.20	Yes	Yes	SP-SM				Yes	YES	1.20	Judgment Required
	57	29	SW	130	7325	4019	5597	0.7	1.3	H	9	1.15	S	14	1.25	1.00	7	19.2	1.00	31	22	5	5	1.0	22	0.154	0.092	0.000	1.67	No	Yes	SW				Yes	No	1.67	-
	59.5	20	SW	130	7650	4167	5766	0.7	1.3	H	8	1.15	S	14	1.24	1.00	7	20.0	1.00	31	21	5	5	1.0	22	0.148	0.091	0.000	1.64	No	Yes	SW				Yes	No	1.64	-
	62	24	SW	130	7975	4356	5935	0.7	1.3	H	8	1.15	S	16	1.23	1.00	7	20.7	1.00	37	25	5	5	1.0	26	0.199	0.090	0.000	2.17	No	Yes	SW				Yes	No	2.17	-
	63.75	25	SW	130	8305	4701	6218	0.7	1.3	H	8	1.15	S	28	1.30	1.00	7	19.2	0.99	38	29	5	5	1.0	31	0.219	0.090	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
	66.5	41	SW	130	8960	5368	6887	0.6	1.3	H	8	1.15	S	32	1.30	1.00	7	16.0	1.00	63	49	5	5	1.0	50	1.267	0.089	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
	51.5	87	GW	130	6410	3646	5225	0.7	1.3	H	8	1.15	S	94	1.30	1.00	7	17.5	1.00	133	99	6	6	1.0	99	47.969	0.095	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
	56	150	GW	130	7105	3950	5629	0.7	1.3	H	8	1.15	S	107	1.30	1.00	7	18.9	1.00	208	153	9	9	1.0	151	6134.944	0.093	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
	59.5	69	GW	130	7550	4187	5766	0.7	1.3	H	8	1.15	S	35	1.30	1.00	7	20.0	1.00	77	53	9	9	1.0	53	1.551	0.091	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
	64	66	GW	130	8235	4491	6070	0.7	1.3	H	8	1.15	S	64	1.30	1.00	7	21.3	1.00	151	67	9	9	1.0	67	4.474	0.089	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
	67.5	55	MH	120	8655	4693	6271	0.7	1.3	H	8	1.15	S	36	1.30	1.00	7	22.4	1.00	94	55	60	35	1.2	64	2.539	0.089	0.000	3.00	No	Yes	MH				Yes	No	3.00	-
	69.75	78	MH	120	8925	4822	6401	0.6	1.3	H	8	1.15	S	51	1.30	1.00	7	23.1	1.00	131	78	60	35	1.2	91	25.999	0.088	0.000	3.00	No	Yes	MH	50	13	27	No	No	3.00	-
	74.75	60	ML	120	9525	5110	6869	0.6	1.3	H	8	1.15	S	39	1.30	1.00	7	24.6	1.00	92	59	73	35	1.2	67	4.312	0.087	0.000	3.00	No	Yes	ML	35	7	36	No	No	3.00	-
	77.25	55	ML	120	9825	5254	6833	0.6	1.3	H	8	1.15	S	34	1.30	1.00	7	25.4	1.00	86	52	73	35	1.2	61	2.673	0.086	0.000	3.00	No	Yes	ML				Yes	No	3.00	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2008)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 5, March 2008.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.B. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on NCAL and SCAL sampler corrections)

PROJECT NAME	Hurricane Rose Corrosion Features CPRR
LEVEE SEGMENT	American River North Levees
PROJECT NUMBER	60216240.A5402
Reach ID	
Station	2526+00
Boring ID	SP_BH-5
Boring Location (Coord's and/or Mile/mile, and distance from Levee's and/or toe/mile/levee)	Levee Crest

Analyzed By:	Michael Kynett
Check By:	

Date:	10/1/2009
Date:	

Data Input (By Analyst)
Results of Analysis
Calculated Values

Ground Elevation (ft.)= +2.0
Groundwater Elev. During Drilling (ft.) = 22.0
Analyzed Groundwater Elevation (ft.)= 17.7

Note: Reported
Note: Water Depth in SP

Groundwater Depth Below GS During Drilling (ft.) = 20.0
Analyzed Groundwater Depth Below GS (ft.) = 26.3

Hammer Type =
Energy Ratio = 80

Earthquake Information
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.15
Location = Crest — Lower Cent, Lawnville, or Waterside

Sample ID	Depth to Sample (ft.)	N_{SPT}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code - IL SW, SCAL, NCAL	R_L for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler only	Sampler Correction for Analysis, C_S	Stick Up (Pushrod Rod Length - Above Ground) (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, α_{fines}	$H_{value,b}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Sustance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS_L < 1.0 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	First Assessment (Yes/No) Based on Column AE, AF, and AK	Factor of Safety, FS	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS< 1.3)
	0.5	18	GP	135	68	68	68	1.6	1.3	H	4	1.00	S	29	1.30	1.00	7	2.0	0.75	19	29	5	5	1.0	30	0.311	0.139	0.000	3.00	No	No	GP				Yes	No	3.00	-
	1	24	CL	110	123	123	123	1.5	1.3	H	4	1.00	S	38	1.30	1.00	7	2.1	0.75	24	38	90	35	1.2	48	2.646	0.139	0.000	3.00	No	No	CL				Yes	No	3.00	-
	2.5	10	MH	120	303	303	303	1.5	1.3	H	4	1.00	S	16	1.30	1.00	7	2.5	0.75	13	20	70	35	1.2	26	0.999	0.119	0.000	3.00	No	No	MH				Yes	No	3.00	-
	4.5	15	CL	110	503	503	503	1.6	1.3	H	4	1.00	S	24	1.30	1.00	7	3.0	0.75	15	24	95	35	1.2	29	0.466	0.117	0.000	3.00	No	No	CL	29	8		No	No	3.00	-
	6.5	7	CL	110	963	963	963	1.4	1.3	H	4	1.00	S	10	1.12	1.00	7	4.4	0.81	8	11	85	35	1.3	14	0.136	0.114	0.000	1.20	Yes	No	CL				Yes	No	1.20	-
	10.5	5	CL	110	1183	1183	1183	1.3	1.3	H	4	1.00	S	7	1.10	1.00	7	5.0	0.84	6	7	65	35	1.4	10	0.095	0.112	0.424	0.85	Yes	No	CL				Yes	No	0.85	-
	12.5	6	CL	110	1403	1403	1403	1.2	1.3	H	4	1.00	S	7	1.10	1.00	7	5.6	0.87	7	8	90	35	1.4	11	0.096	0.111	0.324	0.69	Yes	No	CL				Yes	No	0.69	-
	14.5	6	CL	110	1623	1623	1623	1.1	1.3	H	4	1.00	S	7	1.10	1.00	7	6.2	0.89	7	8	90	35	1.4	11	0.091	0.109	0.434	0.63	Yes	No	CL				Yes	No	0.63	-
	16.5	9	CL	110	1843	1843	1843	1.0	1.3	H	4	1.00	S	9	1.13	1.00	7	6.9	0.91	10	11	90	35	1.3	15	0.119	0.109	0.163	1.11	Yes	No	CL				Yes	No	1.11	-
	18.5	9	ML	120	2063	2063	2063	1.0	1.3	H	4	1.00	S	9	1.12	1.00	7	7.5	0.93	11	11	57	35	1.3	14	0.110	0.106	0.119	1.04	Yes	No	ML				Yes	No	1.04	-
	22	9	CL	110	2468	2343	2468	0.9	1.3	H	4	1.00	S	8	1.12	1.00	7	8.5	0.95	11	11	80	35	1.3	14	0.102	0.105	0.167	0.98	Yes	No	CL				Yes	No	0.98	-
	24.5	8	CL	110	2663	2509	2663	0.9	1.3	H	4	1.00	S	7	1.10	1.00	7	9.0	0.96	10	9	90	35	1.3	12	0.087	0.104	0.322	0.84	Yes	No	CL				Yes	No	0.84	-
	29	8	CL	110	3339	2876	3339	0.8	1.3	H	4	1.00	S	7	1.10	1.00	7	10.7	0.97	10	9	90	35	1.3	12	0.083	0.104	0.429	0.80	Yes	No	CL				Yes	No	0.80	-
	32.5	34	CL	110	3823	3243	3485	0.8	1.3	H	4	1.00	S	29	1.30	1.00	7	11.7	0.98	44	37	59	35	1.2	44	0.915	0.103	0.000	3.00	No	Yes	CL	29	15		No	No	3.00	-
	36	44	SM	130	4679	3679	3722	0.8	1.3	H	4	1.00	S	35	1.30	1.00	7	12.8	0.99	59	47	30	30	1.2	54	1.929	0.103	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
	39	71	SM	130	4468	3262	3925	0.8	1.3	H	4	1.00	S	55	1.30	1.00	7	13.7	0.99	94	73	30	30	1.1	83	16.762	0.103	0.000	3.00	No	Yes	SM				Yes	No	3.00	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)
2. URS Corporation 2008. *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Owens Nary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*. (used only for guidance on MCAL and SCAL sampler corrections)

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	American River North Levees
PROJECT NUMBER:	26618/60454408
Reach ID:	
Station:	0+00+00
Boring ID:	SP-51-003
Boring Location (Check: sublevee/floodside, sublevee/landside, floodside/landside)	Levee Crest

Analysis By:	Michael Kanoti
Check By:	

Date:	10/17/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 47.0
Groundwater Elev. During Drilling (ft.) = 37.0
Analyzed Groundwater Elevation (ft.)= 35.0

Hole: Free Boring Log
Hole: Water Taken At GS

Groundwater Depth Below GS During Drilling (ft.) = 10.0
Analyzed Groundwater Depth Below GS (ft.) = 12.0

Hammer Type = 0
Energy Ratio = 0.8

Earthquake Information
Return Period (years) = 200
M_w = 6.8

PGA (g) = 0.12
Location = Crest (Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Hammer Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1: SC, SCAL, MCAL)	R, for Sampler Correction Only (for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Extension) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS_a < 1.0 (Yes/No) Column AS	Below Analyzed Groundwater Level (Yes/No) Based on Column AS, AT, and AV	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Moist Content (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AX	Final Assessment (Yes/No) Based on Column AS, AT, and AV	Factor of Safety, FS	Comment (Liquefiable for FS<1 and Judgment Required for 1.0 <FS < 1.43)
	1.5	12	CL	110	165	165	165	1.8	1.3	H	9	1.15	S	10	1.20	1.00	7	2.3	0.75	16	22	95	35	1.2	27	0.360	0.119	0.000	3.00	No	No	CL				Not	No	3.00	-
	3.5	35	SP-SM	130	455	455	455	1.5	1.3	H	9	1.15	S	50	1.30	1.00	7	2.9	0.75	41	55	10	10	1.0	69	10.811	0.119	0.000	3.00	No	No	SP-SM				Not	No	3.00	-
	6.25	17	SM	130	793	662	783	1.5	1.3	H	9	1.15	S	27	1.30	1.00	7	3.7	0.75	29	32	24	24	1.1	36	0.736	0.116	0.000	3.00	No	No	SM	51	4		Yes	No	3.00	-
	8.75	15	SM	130	1108	911	1108	1.5	1.3	H	9	1.15	S	24	1.30	1.00	7	4.5	0.81	19	29	24	24	1.1	33	0.551	0.114	0.000	3.00	No	No	SM				Yes	No	3.00	-
	11.25	13	SM	130	1433	995	1433	1.4	1.3	H	9	1.15	S	17	1.30	1.00	7	5.3	0.85	16	22	24	24	1.1	26	0.291	0.112	0.000	2.60	No	No	SM				Yes	No	2.60	-
	13.75	9	SM	130	1758	1149	1758	1.3	1.3	H	9	1.15	S	11	1.15	1.00	7	6.0	0.86	13	14	24	24	1.1	17	0.141	0.110	0.002	1.28	No	No	SM				Yes	No	1.28	-
	16	13	SP	130	2310	1438	2310	1.2	1.3	H	9	1.15	S	15	1.25	1.00	7	7.3	0.92	18	22	24	24	1.2	28	0.241	0.106	0.000	2.27	No	No	SP				Yes	No	2.27	-
	21.25	5	ML	120	2700	1524	2700	1.1	1.3	H	9	1.15	S	6	1.10	1.00	7	8.3	0.94	7	8	60	25	1.4	11	0.060	0.103	0.338	0.74	Yes	No	ML				Yes	No	0.74	-
	24	5	SM	130	3058	1919	3058	1.1	1.3	H	9	1.15	S	5	1.10	1.00	7	9.1	0.95	7	8	5	5	1.1	9	0.063	0.104	0.772	0.80	Yes	No	SM				Yes	No	0.80	-
	26.5	11	SP	130	3383	1979	3293	1.0	1.3	H	9	1.15	S	11	1.18	1.00	7	9.9	0.97	16	16	10	10	1.1	18	0.125	0.104	0.006	1.20	Yes	Yes	SP				Yes	YES	1.20	Judgment Required
	29	2	SP	130	3708	2148	3408	1.0	1.3	H	9	1.15	S	2	1.10	1.00	7	10.7	0.97	3	3	5	5	1.1	3	0.042	0.104	0.997	0.40	Yes	Yes	SP				Yes	YES	0.40	Liquefiable
	31.5	6	SP	130	4053	2317	3527	0.9	1.3	H	9	1.15	S	4	1.10	1.00	7	11.4	0.98	6	6	5	5	1.1	6	0.051	0.103	0.948	0.49	Yes	Yes	SP				Yes	YES	0.49	Liquefiable
	34	9	SP	130	4358	2486	3646	0.9	1.3	H	9	1.15	S	7	1.12	1.00	7	12.2	0.98	12	11	5	5	1.0	11	0.076	0.103	0.880	0.73	Yes	Yes	SP				Yes	YES	0.73	Liquefiable
	36.5	8	SP	130	4663	2655	3975	0.8	1.3	H	9	1.15	S	7	1.12	1.00	7	13.0	0.99	12	11	5	5	1.0	11	0.072	0.103	0.551	0.70	Yes	Yes	SP				Yes	YES	0.70	Liquefiable
	39	21	SM	130	5008	2824	4144	0.8	1.3	H	9	1.15	S	18	1.30	1.00	7	13.7	0.99	22	27	20	20	1.1	30	0.299	0.103	0.000	2.91	No	Yes	SM				Yes	No	2.91	-
	42	6	SP	130	5358	3026	4347	0.8	1.3	H	9	1.15	S	7	1.11	1.00	7	14.6	0.99	12	10	5	5	1.0	10	0.067	0.103	0.660	0.66	Yes	Yes	SP				Yes	YES	0.66	Liquefiable
	44.25	12	ML	120	5668	3195	4476	0.8	1.3	H	9	1.15	S	10	1.16	1.00	7	15.3	0.99	16	16	80	35	1.3	19	0.122	0.102	0.356	1.22	No	Yes	ML				Yes	No	1.22	-
	46.75	9	SW-SM	120	5993	3325	4645	0.8	1.3	H	9	1.15	S	7	1.12	1.00	7	16.1	1.00	14	11	40	25	1.3	14	0.086	0.099	0.139	0.67	Yes	Yes	SW-SM				Yes	YES	0.67	Liquefiable
	49.5	12	SP-SM	130	6350	3511	4831	0.8	1.3	H	9	1.15	S	9	1.15	1.00	7	16.9	1.00	18	14	12	12	1.1	15	0.090	0.097	0.005	0.96	Yes	Yes	SP-SM				Yes	YES	0.96	Liquefiable
	52	14	SP-SM	130	6675	3660	5000	0.7	1.3	H	9	1.15	S	10	1.17	1.00	7	17.7	1.00	21	16	12	12	1.1	17	0.108	0.095	0.019	1.14	Yes	Yes	SP-SM				Yes	YES	1.14	Judgment Required
	54.5	15	SP-SM	130	7000	3849	5169	0.7	1.3	H	9	1.15	S	11	1.18	1.00	7	18.4	1.00	23	17	12	12	1.1	18	0.113	0.094	0.008	1.21	No	Yes	SP-SM				Yes	No	1.21	-
	57	25	SW	130	7326	4019	5338	0.7	1.3	H	9	1.15	S	14	1.25	1.00	7	19.2	1.00	31	22	5	5	1.0	22	0.156	0.092	0.000	1.70	No	Yes	SW				Yes	No	1.70	-
	59.5	20	SW	125	7650	4187	5507	0.7	1.3	H	9	1.15	S	14	1.24	1.00	7	20.0	1.00	31	21	5	5	1.0	22	0.149	0.091	0.000	1.65	No	Yes	SW				Yes	No	1.65	-
	62	24	SW	130	7975	4356	5676	0.7	1.3	H	9	1.15	S	16	1.28	1.00	7	20.7	1.00	37	25	5	5	1.0	26	0.197	0.090	0.000	2.20	No	Yes	SW				Yes	No	2.20	-
	43.75	25	SW	130	5603	3447	4482	0.8	1.3	H	9	1.15	S	22	1.30	1.00	7	15.2	0.99	38	30	5	5	1.0	31	0.224	0.100	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
	46.5	61	SW	120	5960	3308	4628	0.8	1.3	H	9	1.15	S	32	1.35	1.00	7	16.0	1.00	83	49	5	5	1.0	50	1.287	0.098	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
	51.5	87	GW	130	6610	3646	4966	0.7	1.3	H	9	1.15	S	94	1.50	1.00	7	17.5	1.00	133	99	5	5	1.0	99	49.020	0.095	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
	56	100	GW	130	7195	3959	5271	0.7	1.3	H	9	1.15	S	107	1.50	1.00	7	18.9	1.00	200	153	9	9	1.0	153	6217.934	0.093	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
	59.5	99	GW	130	7650	4187	5507	0.7	1.3	H	9	1.15	S	35	1.30	1.00	7	20.0	1.00	77	53	9	9	1.0	53	1.041	0.091	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
	64	66	GW	130	8235	4491	5811	0.7	1.3	H	9	1.15	S	44	1.30	1.00	7	21.3	1.00	101	67	9	9	1.0	67	4.328	0.089	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
	67.5	95	MH	120	8925	4693	6013	0.7	1.3	H	9	1.15	S	36	1.30	1.00	7	22.4	1.00	94	95	60	35	1.2	64	3.581	0.089	0.000	3.00	No	Yes	MH				Yes	No	3.00	-
	69.75	79	MH	120	9525	4972	6143	0.6	1.3	H	9	1.15	S	31	1.30	1.00	7	23.1	1.00	121	79	60	35	1.2	91	29.379	0.088	0.000	3.00	No	Yes	MH	50	13	37	No	No	3.00	-
	74.75	65	ML	120	9825	5110	6431	0.6	1.3	H	9	1.15	S	25	1.30	1.00	7	24.6	1.00	82	59	75	35	1.2	67	4.359	0.087	0.000	3.00	No	Yes	ML	25	7	36	No	No	3.00	-
	77.25	55	ML	120	9825	5254	6575	0.6	1.3	H	9	1.15	S	34	1.30	1.00	7	25.4	1.00	66	53	73	35	1.2	61	2.791	0.086	0.000	3.00	No	Yes	ML				Yes	No	3.00	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 130, No. 12, 1113-1140. and *Discussions and Closures (May, 2006)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2006.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.Bolton Seed Memorial Lecture, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on NCAL and SCAL sampler corrections)

PROJECT NAME:	Newtown, West Costocton Feature CMR
LEVEE SEGMENT:	Missouri River North Levees
PROJECT NUMBER:	26414700-45480
Reach ID:	
Station:	2816460
Boring ID:	SP-R6-8
Boring Location (Levee/Landside/Waterside, and distance from Levee toe/Landside/Waterside toe)	Levee Crest

Analyzed By:	Michael Kunert
Check By:	

Date:	10/1/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)=	42.0		
Groundwater Elev. During Drilling (ft.) =	22.0	Note:	Assumed
Analyzed Groundwater Elevation (ft.)=	15.0	Note:	Winter Mean WSE

Groundwater Depth Below GS During Drilling (ft.) = 20.0
Analyzed Groundwater Depth Below GS (ft.) = 26.0

Hammer Type =
Energy Ratio =

Earthquake Information
Return Period (years) = 500
M_w = 7.0

PGA (g) = 0.16
Location = Crest *Levee Crest, Landside, or Waterside*

Sample ID	Depth to Sample (ft.)	N_{SPT}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SV, SCAL, NCAL)	N_1 for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Protrusion) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Stress Ratio from Sustained Document, CSR	Cyclic Stress Ratio, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS_L < 1.0 (Yes/No) Column AS	Below Analyzed Groundwater Level (Yes/No) Column AT	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AV	Final Assessment (Yes/No) Based on Columns AS, AT, and AV	Factor of Safety, FS	Comment: Liquefiable for FS <1 and Judgment Required for 1.0 <FS< 1.25
	0.5	18	GP	125	63	63	63	1.6	1.3	H	4	1.00	S	23	1.30	1.00	7	2.0	0.75	19	29	5	5	1.0	30	0.011	0.133	0.000	3.00	No	No	GP				Non	No	3.00	-
	1	34	CL	110	123	123	123	1.5	1.3	H	4	1.00	S	38	1.30	1.00	7	2.1	0.75	34	50	59	59	1.2	46	2.846	0.120	0.000	3.00	No	No	CL				Non	No	3.00	-
	2.5	19	MH	120	303	303	303	1.5	1.3	H	4	1.00	S	25	1.30	1.00	7	2.6	0.75	19	39	70	25	1.2	35	0.899	0.119	0.000	3.00	No	No	MH				Non	No	3.00	-
	4.5	15	CL	110	523	523	523	1.6	1.3	H	4	1.00	S	24	1.30	1.00	7	3.2	0.75	15	24	95	35	1.2	29	0.496	0.117	0.000	3.00	No	No	CL	28	8		No	No	3.00	-
	6.5	7	CL	110	963	963	963	1.4	1.3	H	4	1.00	S	10	1.12	1.00	7	4.4	0.81	8	11	85	35	1.3	14	0.136	0.114	0.026	1.20	Yes	No	CL				Yes	No	1.20	-
	10.5	5	CL	110	1183	1183	1183	1.3	1.3	H	4	1.00	S	7	1.10	1.00	7	5.0	0.94	6	7	85	35	1.4	10	0.095	0.112	0.424	0.85	Yes	No	CL				Yes	No	0.85	-
	12.5	6	CL	110	1403	1403	1403	1.2	1.3	H	4	1.00	S	7	1.10	1.00	7	5.5	0.87	7	8	90	35	1.4	11	0.099	0.111	0.324	0.89	Yes	No	CL				Yes	No	0.89	-
	14.5	6	CL	110	1623	1623	1623	1.1	1.3	H	4	1.00	S	7	1.10	1.00	7	6.2	0.89	7	8	90	35	1.4	11	0.091	0.109	0.474	0.83	Yes	No	CL				Yes	No	0.83	-
	16.5	9	CL	110	1843	1843	1843	1.0	1.3	H	4	1.00	S	9	1.13	1.00	7	6.7	0.91	11	11	90	35	1.3	15	0.119	0.109	0.360	1.11	Yes	No	CL				Yes	No	1.11	-
	18.5	9	ML	120	2093	2093	2093	1.0	1.3	H	4	1.00	S	9	1.12	1.00	7	7.5	0.93	11	11	57	25	1.3	14	0.110	0.106	0.119	1.04	Yes	No	ML				Yes	No	1.04	-
	22	8	CL	110	2468	2343	2468	0.9	1.3	H	4	1.05	S	8	1.12	1.00	7	8.5	0.95	11	11	90	35	1.3	14	0.102	0.105	0.167	0.98	Yes	No	CL				Yes	No	0.98	-
	24.5	8	CL	110	2853	2599	2853	0.9	1.3	H	4	1.05	S	7	1.10	1.00	7	9.6	0.96	10	9	90	35	1.3	12	0.087	0.104	0.372	0.84	Yes	No	CL				Yes	No	0.84	-
	28	9	CL	110	3238	2676	3062	0.8	1.3	H	4	1.05	S	7	1.10	1.00	7	10.7	0.97	10	9	90	35	1.3	12	0.084	0.104	0.429	0.81	Yes	Yes	CL				Yes	YES	0.81	Liquefiable
	30.5	34	CL	110	3623	2943	3228	0.8	1.3	H	4	1.00	S	28	1.30	1.00	7	11.7	0.98	44	37	56	35	1.2	44	0.935	0.103	0.000	3.00	No	Yes	CL	29	15		No	No	3.00	-
	35	44	SM	135	4678	3679	3465	0.8	1.3	H	4	1.00	S	35	1.30	1.00	7	12.8	0.99	59	47	30	30	1.0	64	1.666	0.103	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
	39	71	SM	130	4469	3262	3688	0.8	1.3	H	4	1.00	S	55	1.30	1.00	7	13.7	0.99	94	73	30	30	1.1	83	17.070	0.103	0.000	3.00	No	Yes	SM				Yes	No	3.00	-

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SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Queens Navy, Long Beach, Ca .
4. Southern California Earthquake Center, *University of Southern California, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on MCAL and SCAL sampler correction)*

PROJECT NAME	American River Common Features CRR
LEVEE SEGMENT	American River North Levees
PROJECT NUMBER	25915/60434/60452
Reach ID	
Station	1956+35
Boring ID	MCSB&R_2008
Boring Location (Cover Cauldron/Watermain, and distance from Cover/Landmark/Reference Point)	Levee Crest

Analysis By:	Michael Kanski
Check By:	

Date:	9/17/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 53.5
Groundwater Elev. During Drilling (ft.) = 42.5
Analyzed Groundwater Elevation (ft.)= 38.6

Note: Boring Log
Note: Average Upper MSE

Groundwater Depth Below GS During Drilling (ft.) = 11.5
Analyzed Groundwater Depth Below GS (ft.) = 14.4

Hammer Type = Rod w/ SPT
Energy Ratio = 82

Earthquake Information
Return Period (years) = 200
S_a = 0.9

PGA (g) = 0.45
Location = Crest (Crest, Bottom, Levee Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ' (psf)	Effective Overburden Pressure During Earthquake, σ' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, M, SCAL, MCAL)	N_1 for Sampler Correction Only (for SM/ samples)	Sampler Correction, C_S for SM Sampler Only	Sampler Correction for Analysis, C_S	Stick-Up (Extension) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	PL < 1.0 (Yes/No) Column AS	Below Analyzed Groundwater Level (Yes/No) Column AT	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AW	Final Assessment (Yes/No) Based on Columns AS, AT, and AW	Factor of Safety, FS	Comment (Liquefiable for PL<1 and Judgment Required for 1.0 >FS > 1.3)
																																	Lab Test Results for CL, ML					Final Liquefaction Assessment		
S04A	5	22	ML	120	600	600	600	1.6	1.4	H	6	1.05	S	35	1.30	1.00	7	3.4	0.75	29	39	39	35	1.2	45	1.630	0.117	0.000	3.00	No	No	ML					No	3.00	-
S08A	10	20	SM	120	1250	1250	1250	1.3	1.4	H	6	1.05	S	26	1.20	1.00	7	4.9	0.83	26	31	15	16	1.1	33	0.528	0.113	0.000	3.00	No	No	SM				Yes	No	3.00	-
S09A	15	12	SM	120	1900	1900	1900	1.1	1.4	M	6	1.05	S	13	1.10	1.00	7	6.4	0.95	16	17	35	25	1.2	21	0.191	0.109	0.006	1.76	No	No	SM				Yes	No	1.76	-
S10A	20	12	SM	120	2550	2550	2550	1.0	1.4	M	6	1.05	S	12	1.10	1.00	7	7.9	0.94	16	16	30	30	1.2	28	0.155	0.105	0.009	1.51	No	No	SM				Yes	No	1.51	-
S13A	25	13	ML	120	3150	3150	3150	0.9	1.4	M	6	1.05	S	12	1.10	1.00	7	9.4	0.94	16	17	55	35	1.2	21	0.164	0.104	0.000	1.57	No	No	ML				Yes	No	1.57	-
S14A	30	17	SM	120	3800	3640	3800	0.9	1.4	M	6	1.05	S	16	1.24	1.00	7	11.0	0.95	24	21	20	20	1.1	24	0.150	0.104	0.000	1.63	No	No	SM				Yes	No	1.63	-
S16A	35	15	SM	120	4450	3990	4350	0.8	1.4	M	6	1.05	S	12	1.20	1.00	7	12.5	0.99	23	19	30	30	1.2	21	0.152	0.103	0.000	1.49	No	Yes	SM				Yes	No	1.49	-
S18A	40	41	GM	135	5125	4340	4713	0.8	1.4	M	6	1.05	S	33	1.30	1.00	7	14.0	0.99	62	48	15	15	1.1	51	1.442	0.102	0.000	3.00	No	Yes	GM				Yes	No	3.00	-
S23A	55	55	CL	110	6175	4561	5437	0.7	1.4	M	6	1.05	S	50	1.30	1.00	7	16.5	1.00	135	97	35	35	1.2	161	59.287	0.093	0.000	3.00	No	Yes	CL				Yes	No	3.00	-
S25A	60	60	SM	130	7425	5299	5765	0.7	1.4	M	6	1.05	S	40	1.30	1.00	7	20.1	1.00	97	69	30	25	1.2	69	4.360	0.090	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S27A	65	62	ML	120	8025	4687	5057	0.7	1.4	M	6	1.05	S	26	1.30	1.00	7	21.6	1.00	58	38	35	30	1.2	46	0.827	0.095	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
S29A	70	46	CL	110	8515	4925	5291	0.6	1.4	M	6	1.05	S	29	1.30	1.00	7	23.2	1.00	47	43	25	25	1.2	60	1.217	0.089	0.000	3.00	No	Yes	CL	25	8	18	Yes	No	3.00	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2009. *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2009.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queen Mary, Long Beach, Ca .
4. Southern California Earthquake Center, *University of Southern California, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on MCAL and SCAL sampler corrections)*

PROJECT NAME:	Interagency River Channels and Peninsula DWR
LEVEE SEGMENT:	Jarvis Ave/ North Levee
PROJECT NUMBER:	26134780.4442gt
Reach ID :	
Station:	CS9+135
Boring ID:	WC7BSPT_15.5ft
Boring Location (Check location(s) and sources that Could explain elevation/thickness)	Yuba-Coast

Analysis By: Michael Kimak
Check By:

Date: 6/17/2009
Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 0 (+)
Groundwater Elev. During Drilling (ft.) = 42.5
Analyzed Groundwater Elevation (ft.)= 21.5

Note: Boring Log
Note: Water Level

Groundwater Depth Below GS During Drilling (ft.) = 11.5
Analyzed Groundwater Depth Below GS (ft.) = 31.5

Hammer Type = Automatic
Energy Ratio = 80

Earthquake Information:
Return Period (years) = 200
R_d = 0.9

PGA (g) = 0.42
Location = Coast (Eureka, Crent, Lacolitas, or Whitewater)

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (If, MC, SCAL, MCAL)	R_L for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Rod Up (Protrusion) Rod Length Above Ground (Inch)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS < 1.0 (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Assessment (Yes/No) Based on Column AG, AF, and AK	Factor of Safety, FS	Comment (Liquefaction Risk if FS <1 and Judgment Required for 1.0 <FS< 1.3)
03AA	5	22	ML	120	600	600	600	1.6	1.4	H	6	1.05	S	35	1.30	1.00	7	3.4	0.75	24	39	89	35	1.2	45	1.630	0.117	0.000	3.00	No	No	ML				Yes	No	3.00	-
08BA	10	29	SM	130	1250	1250	1250	1.3	1.4	H	6	1.05	S	35	1.30	1.00	7	4.9	0.83	29	31	15	15	1.1	33	0.539	0.113	0.000	3.00	No	No	SM				Yes	No	3.00	-
03BA	15	17	SM	130	1900	1900	1900	1.1	1.4	M	6	1.05	S	13	1.19	1.00	7	6.4	0.95	16	17	35	35	1.2	21	0.191	0.109	0.000	1.75	No	No	SM				Yes	No	1.75	-
01BA	20	12	SM	130	2550	2550	2550	1.0	1.4	M	6	1.05	S	12	1.19	1.00	7	7.9	0.94	16	16	20	20	1.2	20	0.159	0.109	0.000	1.51	No	No	SM				Yes	No	1.51	-
01CA	25	13	ML	125	3150	3200	3150	0.9	1.4	M	6	1.05	S	12	1.19	1.00	7	9.4	0.86	19	17	55	55	1.2	21	0.164	0.104	0.000	1.57	No	No	ML				Yes	No	1.57	-
01AA	30	17	SM	130	3900	3845	3600	0.9	1.4	M	6	1.05	S	15	1.24	1.00	7	11.0	0.96	24	21	20	20	1.1	24	0.190	0.104	0.000	1.83	No	No	SM				Yes	No	1.83	-
01BA	35	15	SM	135	4450	4205	4213	0.8	1.4	M	6	1.05	S	12	1.30	1.00	7	12.5	0.99	23	19	20	20	1.2	21	0.153	0.103	0.000	1.49	No	Yes	SM				Yes	No	1.49	-
01BA	40	43	GM	135	5125	4847	4875	0.8	1.4	M	6	1.05	S	33	1.30	1.00	7	14.0	0.99	62	46	15	15	1.1	51	1.456	0.103	0.000	3.00	No	Yes	GM				Yes	No	3.00	-
02BA	50	66	CL	110	6175	4961	5295	0.7	1.4	M	6	1.05	S	60	1.30	1.00	7	16.5	1.00	125	87	75	75	1.2	101	59.799	0.093	0.000	3.00	No	Yes	CL				Yes	No	3.00	-
02BA	60	50	SM	130	7425	5399	5629	0.7	1.4	M	6	1.05	S	40	1.30	1.00	7	20.1	1.00	87	59	25	25	1.2	69	4.393	0.090	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
02CA	65	40	ML	120	8025	5687	5916	0.7	1.4	M	6	1.05	S	26	1.30	1.00	7	21.6	1.00	58	36	55	55	1.2	49	0.693	0.089	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
02BA	70	46	CL	110	8575	4925	6154	0.6	1.4	M	6	1.05	S	29	1.30	1.00	7	23.2	1.00	67	43	35	35	1.2	50	1.225	0.088	0.000	3.00	No	Yes	CL	25	9	19	Yes	No	3.00	-

AMERICAN RIVER SOUTH LEVEE

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1273-1240. and Discussions and Closures (May, 2004)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2008.
3. Youd, N.B., et al, 2001, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar; Keynote Presentation, H.M.B. Queens Marry, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	DWR Urban Levee Geotechnical Evaluations Program
LEVEE SEGMENT:	American River South Levee
PROJECT NUMBER:	26810782.47448
Exp'n ID:	
Station:	DWR Station 1078+00
Drawing ID:	RC12B01, 02/08
Drawing Location:	Cored Boring

Analysis By:	Gyeong-Taek Hong
Check By:	

Date:	9/24/2009
Date:	

Data Input By Example
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 30.7
Groundwater Elev. During Drilling (ft.) = 0.3
Analyzed Groundwater Elevation (ft.)= 10.3

Note: August WSE 5 (NAVD88)
Note: August WSE 5 (NAVD88)

Groundwater Depth Below GS During Drilling (ft.) = 29.5
Analyzed Groundwater Depth Below GS (ft.) = 19.5

Hammer Type = Automatic
Energy Ratio = 0.8

Earthquake Information
Return Period (years) = 200
ML = 5.0

PGA (g) = 0.13
Location = Latitude, Longitude: (38.5740, -121.5153)

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Barrel/No Liner (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SV, SCAL, MCAL)	$N_1$for Sampler Correction (Only for SVE Sampler)	Sampler Correction, C_S for SVE Sampler Only	Sampler Correction for Analysis, D_s	Stick Up (Protrusion) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, F_S	F_S < 1.2 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AC	Final Assessment (Yes/No) Based on Columns AE, AF, and AG	Factor of Safety, F_S	Comment (Liquefiable For F_S <1.2 and Judgment Required for 1.2 <F_S < 1.3)
																																	Lab Test Results for CL, ML				Post-Liquefaction Assessment		
S03A	7	-	CL	110	220	220	220	1.6	1.4	H	6	1.05	S	0	1.10	1.00	7	2.4	0.75			95	95				0.081	0.216	1.000	0.38	Yes	No	CL	32	16		Yes	No	0.38	-
S04A	5	31	SM	125	625	625	625	1.6	1.4	H	6	1.05	S	60	1.30	1.00	7	3.4	0.75	36	58	27	27	1.1	61	0.259	0.211	0.000	1.90	No	No	SM				Yes	No	2.00	-
S05A	7	-	CL	110	770	770	770	1.6	1.4	H	6	1.05	S	0	1.10	1.00	7	4.0	0.75				95				0.067	0.208	1.000	0.27	Yes	No	CL				Yes	No	0.27	-
S06A	11	9	SP-SM	125	1345	1345	1345	1.2	1.4	H	6	1.05	S	11	1.55	1.00	7	5.2	0.85	11	14	9	9	1.0	14	0.124	0.201	0.913	0.62	Yes	No	SP-SM				Yes	No	0.62	-
S08A	16	12	ML	120	1945	1945	1945	1.0	1.4	H	6	1.05	S	12	1.15	1.00	7	6.7	0.91	16	16	82	85	1.2	29	0.174	0.194	0.305	0.90	Yes	No	ML				Yes	No	0.90	-
S10A	21	19	SM	125	2570	2570	2570	0.9	1.4	H	6	1.05	S	17	1.27	1.00	7	9.0	0.94	26	23	44	95	1.2	29	0.231	0.195	0.001	1.58	No	No	SM				Yes	No	1.58	-
S14A	26	15	SM	125	3195	3195	3195	0.8	1.4	M	6	1.05	S	12	1.19	1.00	7	9.8	0.95	21	17		12	1.1	15	0.151	0.170	0.637	0.74	Yes	No	SM				Yes	No	0.74	-
S18A	31	11	ML	120	3725	3613	3515	0.8	1.4	M	6	1.05	S	8	1.13	1.00	7	11.3	0.98	16	12	58	95	1.3	15	0.101	0.161	0.891	0.64	Yes	Yes	ML				Yes	Yes	0.64	Liquefiable
S17A	33	-	CL	110	3630	3223	3223	0.9	1.4	M	6	1.05	S	0	1.10	1.00	7	11.9	0.98			66	95				0.036	0.166	1.000	0.24	Yes	Yes	CL	49	29		No	No	0.24	-
S19A	36	22	SM	130	4195	3801	3601	0.7	1.4	M	6	1.05	S	16	1.27	1.00	7	12.8	0.99	32	23	19	19	1.1	26	0.253	0.149	0.000	1.47	No	Yes	SM				Yes	No	1.47	-
S20A	41	17	SW-SM	125	5020	4114	4114	0.7	1.4	M	6	1.05	S	12	1.19	1.00	7	14.3	0.99	24	17	11	11	1.1	18	0.125	0.138	0.295	0.50	Yes	Yes	SW-SM				Yes	Yes	0.50	Liquefiable
S22A	46	21	SW-SM	125	5645	4427	4427	0.7	1.4	M	6	1.05	S	16	1.23	1.00	7	15.8	0.99	30	20		9	1.1	21	0.154	0.130	0.029	1.19	Yes	Yes	SW-SM				Yes	Yes	1.19	Judgment Required
S24A	51	26	SP-SM	120	6241	4715	4715	0.7	1.4	M	6	1.05	S	13	1.21	1.00	7	17.4	1.00	29	19	6	6	1.1	32	0.138	0.121	0.060	1.12	Yes	Yes	SP-SM				Yes	Yes	1.12	Judgment Required
-	56	44	GW	130	6995	5853	5853	0.6	1.4	M	6	1.05	S	21	1.30	1.00	7	19.3	1.00	49	35		3	1.0	37	0.321	0.112	0.000	2.89	No	Yes	GW				Yes	No	2.89	-
S28A	61	19	SW-SM	123	7620	5366	5366	0.6	1.4	M	6	1.05	S	12	1.19	1.00	7	20.9	1.00	28	17	11	11	1.1	18	0.114	0.105	0.076	1.09	Yes	Yes	SW-SM				Yes	Yes	1.09	Judgment Required
-	65	50	Gravel and Cobbles	135	8555	5656	5656	0.6	1.4	M	6	1.05	S	32	1.30	1.00	7	21.9	1.00	73	43		5	1.0	44	0.797	0.102	0.000	3.80	No	Yes	Gravel and Cobbles				Yes	No	3.80	-

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SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev 6, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	Dutch Slough Levee Geotechnical Evaluation Program
LEVEE SEGMENT:	Downstream River Seepm Levee
PROJECT NUMBER:	26810765.04400
Reach ID:	
Station:	Dutch Station: 1673+00
Boring ID:	WC08MW_B016
Boring Location: Enter Levee Alignment and distance from Levee Centerline/Waterside	Field Boring

Analysis By:	Guiseng Tsai Hong
Check By:	
Date:	9/24/2009
Date:	

Field Input by Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)=	16.7
Groundwater Elev. During Drilling (ft.)=	16.7
Analyzed Groundwater Elevation (ft.)=	16.0
Note:	Referenc WSE 8 (NAVD88)
Note:	Regularly WSE 8 (NAVD88)

Groundwater Depth Below GS During Drilling (ft.) = 21.0
Analyzed Groundwater Depth Below GS (ft.) = 21.3

Hammer Type = Automatic
Energy Ratio = 80

Earthquake Information:
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.13
Location = Levee (Inboard, Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ_v' (psf)	Effective Overburden Pressure During Earthquake, σ_v' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.0 for STD, MCAL, MCSL)	H_1 for Sampler Correction (Only for SPT Sampler)	Sampler Correction, C_S for SPT Sampler Only	Sampler Correction for Analysis, C_S	Size Up (Protrusion) Back Length Above Ground (feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	N_m	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, E_{fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, F_S	F_S < 1.2 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AI	Final Assessment (Yes/No) Based on Columns AG, AH, and AI	Factor of Safety, F_S	Comment (Liquefiable for F_S <1 and Judgment Required for 1.1 <F_S < 1.3)
																																					Last Two Results for CL, ML				Final Liquefaction Assessment		
S09A	2		CL	118	239	239	225	1.6	1.4	H	6	1.05	S	0	1.10	1.00	7	2.4	0.75			85	35			0.081	0.216	1.000	0.38	Yes	No	CL	39	18		Yes	No	0.38	
S06A	3	31	SM	123	603	603	575	1.5	1.4	H	6	1.05	S	50	1.00	1.00	7	3.4	0.75	34	66	27	27	1.1	51	0.259	0.211	0.000	3.60	Na	No	SM				Yes	No	3.60	-
S06A	7		CL	118	778	778	778	1.5	1.4	H	6	1.05	S	0	1.10	1.00	7	4.0	0.75				35			0.057	0.208	1.000	0.27	Yes	No	CL				Yes	No	0.27	-
S06A	11	9	SP-SM	125	1345	1345	1345	1.2	1.4	H	6	1.05	S	11	1.15	1.00	7	5.2	0.85	11	14	5	6	1.0	14	0.124	0.201	0.913	0.82	Yes	No	SP-SM				Yes	No	0.82	-
S08A	16	12	ML	128	1945	1945	1945	1.0	1.4	H	6	1.05	S	12	1.18	1.00	7	6.7	0.91	16	16	62	35	1.2	29	0.174	0.194	0.305	0.90	Yes	No	ML				Yes	No	0.90	-
S12A	21	19	SM	125	2570	2570	2570	0.9	1.4	H	6	1.05	S	17	1.27	1.00	7	8.2	0.94	26	23	44	35	1.2	28	0.291	0.195	0.001	1.56	No	No	SM				Yes	No	1.56	-
S14A	26	15	SM	125	3195	2905	2905	0.8	1.4	M	6	1.05	S	12	1.18	1.00	7	9.8	0.96	21	17		12	1.1	19	0.161	0.113	0.482	0.82	Yes	Yes	SM				Yes	No	0.82	Liquefiable
S16A	31	11	ML	128	3795	3223	3223	0.8	1.4	M	6	1.05	S	9	1.14	1.00	7	11.3	0.96	16	12	58	35	1.3	16	0.110	0.101	0.609	0.65	Yes	Yes	ML				Yes	Yes	0.65	Liquefiable
S17A	33		CL	118	3930	3504	3504	0.8	1.4	M	6	1.05	S	0	1.10	1.00	7	11.9	0.99			95	35			0.035	0.104	1.000	0.35	Yes	Yes	CL	49	29		Na	No	0.35	-
S19A	36	20	SM	128	4395	3811	3811	0.8	1.4	M	6	1.05	S	13	1.20	1.00	7	12.8	0.99	32	24	19	15	1.1	27	0.261	0.149	0.000	1.61	No	Yes	SM				Yes	No	1.61	-
S20A	41	17	SW-SM	125	5020	3624	3624	0.7	1.4	M	6	1.05	S	12	1.20	1.00	7	14.3	0.98	24	18	11	11	1.1	19	0.154	0.130	0.185	0.97	Yes	Yes	SW-SM				Yes	Yes	0.97	Liquefiable
S22A	46	21	SW-SM	128	5946	4137	4137	0.7	1.4	M	6	1.05	S	15	1.24	1.00	7	15.8	0.99	30	21	-	8	1.1	22	0.166	0.130	0.012	1.26	No	Yes	SW-SM				Yes	No	1.26	-
S24A	51	26	SP-SM	128	6345	4425	4425	0.7	1.4	M	6	1.05	S	13	1.22	1.00	7	17.4	1.00	29	19	6	9	1.1	58	0.144	0.121	0.030	1.19	Yes	Yes	SP-SM				Yes	Yes	1.19	Judgment Required
-	56	34	SW	130	6995	4753	4753	0.6	1.4	M	6	1.05	S	22	1.30	1.00	7	18.9	1.00	49	32	-	5	1.0	23	0.395	0.112	0.000	3.00	No	Yes	SW				Yes	No	3.00	
S28A	61	19	SW-SM	125	7625	5078	5078	0.6	1.4	M	6	1.05	S	12	1.19	1.00	7	20.4	1.00	26	17	14	11	1.1	13	0.132	0.105	0.043	1.14	Yes	Yes	SW-SM				Yes	Yes	1.14	Judgment Required
-	65	30	Gravel and Cobbles	135	8665	5387	5387	0.6	1.4	M	6	1.05	S	31	1.32	1.00	7	21.5	1.00	73	44		5	1.0	45	0.695	0.103	0.000	3.00	No	Yes	Gravel and Cobbles				Yes	No	3.00	

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1314-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queen Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME	DWR Urban Levee Geotechnical Evaluations Program
LEVEE SEGMENT:	American River South Levee
PROJECT NUMBER:	26619760.04000
Report By:	
Station:	DWR Station: 1004+15
Boring ID:	SP-BH-SM
Boring Location (Coordinates are Relative from Field Landmarks/Monuments)	endash Toe

Analysis By:	Dubrisky-Tasli Wong
Closely By:	

Date:	8/24/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 0
Groundwater Elev. During Drilling (ft.) = 7.5
Analyzed Groundwater Elevation (ft.) = 14.3

Note: Note: August 2009 (MW/SM)

Groundwater Depth Below GS During Drilling (ft.) = 21.0
Analyzed Groundwater Depth Below GS (ft.) = 13.9

Hammer Type = Rodgers etc.
Energy Ratio = 0.93

Earthquake Information:
Return Period (years) = 200
M_w = 7.9

PGA (g) = 0.45
Location = Landside (Slope, Crest, Landside, or Waterside)

| | | |

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*. Used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	DWR Urban Levee Geotechnical Evaluations Program
LEVEE SEGMENT:	American River South Levee
PROJECT NUMBER:	26619/27454/28
Reach ID:	
Station:	DWR Station: 1205+75
Boring ID:	SP-06-23
Boring Location (Levee Crest, Waterside, and distance from Crest, Landside) or Reference Line:	Crest Boring

Analysis By:	Cyberg-Tsai Hong
Check By:	

Date:	6/16/2006
Sheet	

Data Input by Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 46.0
Groundwater Elev. During Drilling (ft.)= 13.4
Analyzed Groundwater Elevation (ft.)= 19.4

Note: August 16'06 (Not Used)
Note: August 16'06 (Not Used)

Groundwater Depth Below GS During Drilling (ft.) = 33.3
Analyzed Groundwater Depth Below GS (ft.) = 39.3

Hammer Type = Automatic
Energy Ratio = 93

Earthquake relevance:
Return Period (years) = 200
M_w = 7.2

PGA (g) = 0.12
Location = Zone

Lab Test Results for CL - Lg

Plastic Liquefaction Assessment

Sample ID	Depth to Sample (ft.)	N_{60cs}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.15 for MCAL, NCAL)	N for Sampler Correction Only (for SW Sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Thick Up (Protrusion) Soil Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	$FS_L = 1.2$ (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AH	Fines Assessment (Yes/No) Point on Column AB or, and AH	Factor of Safety, FS	Comment (Liquefiable for FS_LT and Judgment Required for 1.0 <FS_< 1.2)
-	1	58	SM	125	125	125	125	1.7	1.0	M	6	1.05	S	34	1.30	1.00	7	2.1	0.75	46	74	15	15	1.1	80	32.569	0.139	0.000	3.00	No	No	SM				Yes	No	3.00	-
-	3	37	SM	125	375	375	375	1.4	1.0	M	6	1.05	S	53	1.30	1.00	7	3.7	0.75	35	48	15	15	1.1	42	1.601	0.114	0.000	3.00	No	No	SM				Yes	No	3.00	-
-	5	13	SM	125	625	625	625	1.2	1.0	M	6	1.05	S	21	1.20	1.00	7	5.4	0.75	16	16	15	15	1.1	18	0.357	0.117	0.000	1.78	No	No	SM				Yes	No	1.78	-
-	7	15	SM	125	875	875	875	1.0	1.0	M	6	1.05	S	23	1.23	1.00	7	6.8	0.78	18	18	29	29	1.1	21	0.333	0.113	0.000	2.03	No	No	SM				Yes	No	2.03	-
-	9	14	SP-SM	125	1125	1125	1125	1.0	1.0	M	6	1.05	S	19	1.19	1.00	7	8.0	0.81	13	16	8	8	1.0	17	0.157	0.112	0.004	1.39	No	No	SP-SM				Yes	No	1.39	-
-	11	9	SP-SM	125	1375	1375	1375	1.0	1.0	M	6	1.05	S	11	1.11	1.00	7	9.2	0.85	8	10	6	6	1.1	10	0.092	0.112	0.478	0.82	Yes	No	SP-SM				Yes	No	0.82	-
-	16	3	SM	125	1975	1975	1975	1.0	1.0	M	6	1.05	S	5	1.10	1.00	7	9.4	0.86	6	9	15	15	1.1	10	0.083	0.109	0.610	0.76	Yes	No	SM				Yes	No	0.76	-
-	18	15	SP-SM	125	2250	2250	2250	0.9	1.0	M	6	1.05	S	14	1.16	1.00	7	7.3	0.92	15	14	10	10	1.1	15	0.113	0.108	0.094	1.05	Yes	No	SP-SM				Yes	No	1.05	-
-	22	5	MH	130	2730	2730	2730	0.8	1.0	M	6	1.05	S	4	1.10	1.00	7	8.5	0.95	5	4	80	36	1.4	7	0.088	0.106	0.970	0.65	Yes	No	MH				Yes	No	0.65	-
-	23	4	ML	125	2890	2890	2890	0.8	1.0	M	6	1.05	C	3	1.10	1.00	7	9.4	0.96	4	3	75	35	1.3	5	0.051	0.104	0.883	0.49	Yes	No	ML	33	8		Yes	No	0.49	-
-	26.5	4	SP-SM	125	3329	3329	3329	0.8	1.0	M	6	1.05	S	3	1.10	1.00	7	10.5	0.97	4	3	10	10	1.2	4	0.043	0.104	0.993	0.41	Yes	No	SP-SM				Yes	No	0.41	-
-	32	6	SM	125	3965	3965	3965	0.7	1.0	M	6	1.05	S	6	1.15	1.00	7	11.8	0.99	6	6	15	15	1.2	7	0.054	0.103	0.996	0.52	Yes	No	SM				Yes	No	0.51	-
-	38	11	SP-SM	120	4465	4419	4419	0.7	1.0	M	6	1.05	C	7	1.10	1.00	7	12.8	0.99	11	9	10	10	1.1	8	0.058	0.103	0.992	0.56	Yes	Yes	SP-SM				Yes	YES	0.56	Liquefiable
-	39	17	CL	110	4693	4443	4443	0.7	1.0	M	6	1.05	C	15	1.13	1.00	7	13.1	0.99	18	12	89	89	1.3	15	0.097	0.103	0.226	0.93	Yes	Yes	CL				Yes	YES	0.93	Liquefiable
-	43	13	SM	125	5340	4856	4856	0.6	1.0	M	6	1.05	S	8	1.18	1.00	7	14.3	0.99	14	9	20	20	1.3	10	0.066	0.101	0.953	0.66	Yes	Yes	SM				Yes	YES	0.65	Liquefiable
-	44.5	25	SP-SM	125	5573	4793	4793	0.6	1.0	M	6	1.05	S	16	1.28	1.00	7	15.4	0.99	26	17	7	7	1.0	18	0.114	0.100	0.046	1.14	Yes	Yes	SP-SM				Yes	YES	1.14	Judgment Required

NOTE: Assumed values are used for Hammer Type, Energy Ratio, Boring Method and Sampler Type

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al. 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1314-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queen Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on NCAL and SCAL sampler corrections)

PROJECT NAME	DWR Urban Levee Geotechnical Evaluation Program
LEVEE SEGMENT:	American River South Levee
PROJECT NUMBER:	26451106.45400
Branch ID:	
Station:	DWR Station: 1558+75
Boring ID:	SP-06-SM
Boring Location (Levee Crest/Landside and distance from Crest/Landside toe/Referenced)	Landside Toe

Analysis By: Celeste Tasik-Hing
Check By:

Date: 6/24/2009
Sheet

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)=
Groundwater Elev. During Drilling (ft.) =
Analyzed Groundwater Elevation (ft.) =

ft	m
47.6	14.5
16.2	4.9

Note
Note

Laboratory Water (NAVD'88)

Groundwater Depth Below GS During Drilling (ft.) = 31.0
Analyzed Groundwater Depth Below GS (ft.) = 19.9

Hammer Type = Automatic
Energy Ratio = 80

Earthquake Information:
Return Period (years) = 200
M_w = 7.0

PGA *(g)* = 0.12
Locales = Lowlands *(Select Basin, Lowlands, or Waterside)*

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ'_v (psf)	Effective Overburden Pressure During Earthquake, σ'_v (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.0 for SPT, NCAL, SCAL)	N for Samples Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Sleeve Liner (Yes/blank) Soil Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	H_{20}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.2 (Yes/No) Causes All	Below Analyzed Groundwater Level (Yes/No) Causes All	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Causes All	Final Assessment (Yes/No) Based on Criteria in 7, 10 & 11	Factor of Safety, FS	Comment (Liquefiable for FS_<1 and Judgment, Required for 1.0_<FS_< 1.3)
-	5	11	SM	125	750	750	750	1.8	1.0	M	6	1.05	S	10	1.18	1.00	7	3.7	0.75	9	14	37	35	1.3	19	0.169	0.157	0.236	0.95	Yes	No	SM				Yes	No	0.41	
-	10	14	SM	125	1250	1250	1250	1.5	1.0	M	6	1.05	S	15	1.18	1.00	7	6.8	0.85	12	15		12	1.1	17	0.155	0.191	0.583	0.81	Yes	No	SM				Yes	No	0.41	
-	15	15	SM	125	1875	1875	1875	1.4	1.0	M	6	1.05	S	15	1.11	1.00	7	9.4	0.90	9	12		12	1.1	15	0.089	0.184	0.295	0.49	Yes	No	SM				Yes	No	0.42	-
-	21	10	ML	125	2595	2595	2595	0.9	1.0	M	6	1.05	S	9	1.10	1.00	7	8.2	0.94	10	9	54	25	1.1	12	0.085	0.174	0.093	0.48	Yes	Yes	ML				Yes	YES	0.46	Liquefiable
-	25	6	SM	125	3095	3095	2777	0.8	1.0	M	6	1.05	S	5	1.10	1.00	7	9.4	0.96	6	5		12	1.2	6	0.054	0.165	1.000	0.33	Yes	Yes	SM				Yes	YES	0.23	Liquefiable
-	31	19	SM	125	3845	3726	3102	0.7	1.0	M	6	1.05	S	7	1.00	1.00	7	11.3	0.99	19	9	16	16	1.1	8	0.083	0.152	1.000	0.43	Yes	Yes	SM				Yes	YES	0.43	Liquefiable
-	36	35	SM	125	4475	4013	3465	0.7	1.0	M	6	1.00	S	19	1.22	1.00	7	12.8	0.99	37	19	19	19	1.1	20	0.151	0.141	0.151	1.07	Yes	Yes	SM				Yes	YES	1.07	Judgment Required
-	45	21	SP-SM	125	4973	4354	3716	0.7	1.0	M	6	1.05	S	14	1.17	1.00	7	14.6	0.99	22	15		8	1.1	16	0.106	0.132	0.595	0.91	Yes	Yes	SP-SM				Yes	YES	0.61	Liquefiable

NOTE: Assumed values are used for Hammer Type, Energy Ratio, Boring Method and Sampler type

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1/1/2009

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al. 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1314-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2005, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2006.
3. Seed, R.B., et al. 2001, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on MCAL and SCAL sampler corrections)*

PROJECT NAME	DWR Urban Levee Geotechnical Evaluations Program
LEVEE SEGMENT:	American River South Levee
PROJECT NUMBER:	3881/1904/45428
Reach ID:	
Station:	Draft Station: 1099+15
Boring ID:	SP-IB-39
Boring Location (Coordinates, Stationing, and distance from Land/Landside/Waterside)	Crest Boring

Analysis By:	Cyndee-Trent Hong
Check By:	

Date:	6/24/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (f_t) =	68.6	
Groundwater Elev. During Drilling (f_t) =	16.7	Note: February 2006 (MW-0506)
Analyzed Groundwater Elevation (f_t) =	16.7	Note: February 2006 (MW-0506)

Groundwater Depth Below GS During Drilling (f_t) = 51.9
Analyzed Groundwater Depth Below GS (f_t) = 51.9

Hammer Type = Safety Hammer
Energy Ratio = 60

Earthquake Information:
Return Period (years) = 200
M_w = 7.5

PGA (g) = 0.12
Location = Crest (Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_{N_o}	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.125 SCR; NCR)	N_1 for Sampler Correction Only (for SW Samples)	Sampler Correction, C_S, for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Penetration) Rod Length Above Ground (ft)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.2 (Yes/No) Column AA	Below Analyzed Groundwater Level (Yes/No) Column AB	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AG	Final Assessment (Yes/No) Based on Columns AE and AH	Factor of Safety, FS	Comment (Liquefiable for FS, <1 and Assigned Required for 1.0 <FS, < 1.3)
-	1	59	SM	125	125	125	125	1.5	1.0	M	6	1.05	S	34	1.20	1.00	7	2.1	0.75	46	74	15	15	1.1	60	32.500	0.120	0.050	3.00	No	No	SM				Yes	No	3.00	-
-	3	32	SM	125	375	375	375	1.5	1.0	M	6	1.05	S	53	1.00	1.00	7	3.7	0.75	35	48	15	15	1.1	43	1.401	0.110	0.055	3.00	No	No	SM				Yes	No	3.00	-
-	5	13	SM	125	625	625	625	1.4	1.0	M	6	1.05	S	21	1.20	1.00	7	5.4	0.75	18	26	15	15	1.1	19	0.267	0.117	0.056	1.78	No	No	SM				Yes	No	1.78	-
-	7	15	SM	125	875	875	875	1.3	1.0	M	6	1.05	S	23	1.23	1.00	7	7.0	0.75	20	29	20	20	1.3	25	0.333	0.115	0.060	2.03	No	No	SM				Yes	No	2.03	-
-	9	14	SP-SM	125	1125	1125	1125	1.2	1.0	M	6	1.05	S	19	1.19	1.00	7	8.6	0.81	13	16	6	6	1.0	17	0.157	0.113	0.064	1.38	No	No	SP-SM				Yes	No	1.38	-
-	11	9	SP-SM	125	1375	1375	1375	1.2	1.0	M	6	1.05	S	11	1.11	1.00	7	9.2	0.85	8	10	6	6	1.1	10	0.092	0.112	0.070	0.82	Yes	No	SP-SM				Yes	No	0.82	-
-	13	9	SM	125	1675	1675	1675	1.0	1.0	M	6	1.05	S	9	1.10	1.00	7	9.4	0.86	8	9	15	15	1.1	10	0.093	0.109	0.075	0.76	Yes	No	SM				Yes	No	0.76	-
-	15	15	SP-SM	125	2250	2250	2250	0.9	1.0	M	6	1.05	S	14	1.15	1.00	7	7.3	0.92	15	14	10	10	1.1	15	0.113	0.096	0.094	1.06	Yes	No	SP-SM				Yes	No	1.06	-
-	22	5	NH	125	2730	2730	2730	0.9	1.0	M	6	1.05	S	4	1.10	1.00	7	9.5	0.95	5	4	90	35	1.6	7	0.069	0.105	0.070	0.65	Yes	No	NH				Yes	No	0.65	-
-	25	4	ML	125	3080	3080	3080	0.8	1.0	M	6	1.05	S	3	1.10	1.00	7	9.4	0.96	4	3	75	35	1.7	5	0.051	0.104	0.083	0.49	Yes	No	ML	35	3		Yes	No	0.49	-
-	29.5	4	SP-SM	125	3529	3529	3529	0.8	1.0	M	6	1.05	S	3	1.10	1.00	7	10.5	0.97	4	3	10	10	1.2	4	0.043	0.094	0.099	0.41	Yes	No	SP-SM				Yes	No	0.41	-
-	32	8	SM	125	3965	3959	3959	0.7	1.0	M	6	1.05	S	6	1.10	1.00	7	11.4	0.98	8	6	15	15	1.2	7	0.054	0.103	0.086	0.52	Yes	Yes	SM				Yes	YES	0.52	Liquefiable
-	36	11	SP-SM	125	4465	4289	4289	0.7	1.0	M	6	1.05	S	9	1.10	1.00	7	12.6	0.99	11	8	10	10	1.1	8	0.065	0.103	0.093	0.59	Yes	Yes	SP-SM				Yes	YES	0.59	Liquefiable
-	39	17	CL	110	4680	4235	4235	0.7	1.0	M	6	1.05	S	12	1.14	1.00	7	13.7	0.99	19	12	80	80	1.3	19	0.151	0.103	0.114	0.99	Yes	Yes	CL				Yes	YES	0.99	Liquefiable
-	43	13	SM	125	5382	4667	4667	0.7	1.0	M	6	1.05	S	9	1.10	1.00	7	14.5	0.99	14	9	20	20	1.2	11	0.087	0.101	0.026	0.67	Yes	Yes	SM				Yes	YES	0.67	Liquefiable
-	44.5	25	SP-SM	125	5573	4784	4784	0.7	1.0	M	6	1.05	S	17	1.29	1.00	7	15.4	0.99	26	17	7	7	1.0	18	0.118	0.100	0.029	1.19	Yes	Yes	SP-SM				Yes	YES	1.19	Judgment Required

NOTE: Numbered values are only for Hammer Type, Energy Ratio, Boring Method and Sampler type

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Idriss, I.M., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential*, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340, and Discussions and Closures (May, 2006)
2. URS Corporation 2006, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2006.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on NCAL and SCAL sampler corrections)

PROJECT NAME	DWR Urban Levee Geotechnical Evaluations Program
LEVEE SEGMENT:	Sherman Toe South Levee
PROJECT NUMBER:	26241100.45480
Reach ID:	
Station	2000 (Station: 1611+00)
Boring ID:	B-7
Boring Location (Use Levee centerline and station from Excel workbook/Worksheet)	Crest Boring

Analysis By:	Cyndia Teeh Hong
Check By:	

Date:	5/24/2006
Rev:	

Data Input By Excel
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 25.0
Groundwater Elev. During Drilling (ft.) = 25.0
Assigned Groundwater Elevation (ft.)= 25.0

Note: August WSE (NAVD88)
Note: August WSE (NAVD88)

Groundwater Depth Below GS During Drilling (ft.) = 31.6
Analyzed Groundwater Depth Below GS (ft.) = 31.6

Hammer Type = Automatic
Energy Ratio = 1.33

Earthquake Information:
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.14
Location = Crest

Enter Data, Liquefiable or Interbed

Sample ID	Depth to Sample (ft.)	N_{meas}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ_v' (psf)	Effective Overburden Pressure During Earthquake, σ_v' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (C_SV = SCAL; NCAL)	N for Sampler Correction Only (for SV Sampler)	Sampler Correction, C_S, for SPT Sampler Only	Sampler Correction for Analyses, C_S	Stick Up Protrusion Rod Length Above Ground (feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{FINES}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.2 (Yes/No) Column AK	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AH	Final Assessment (Yes/No) Same as Column AK, see AN	Factor of Safety, FS	Comment (Liquefiable for FS, <1 and Judgment Required for 1.0 <FS, < 1.2)
-	2.5	21	ML	120	300	300	300	1.5	1.3	M	6	1.05	S	30	1.20	1.00	7	2.5	0.70	19	39		35	1.2	50	0.997	0.111	0.000	3.00	No	No	ML				Yes	No	3.00	-
-	4.5	20	CL	115	495	495	495	1.5	1.3	M	6	1.05	S	32	1.20	1.00	7	4.5	0.75	16	34		35	1.2	50	0.938	0.102	0.000	3.00	No	No	CL				Yes	No	3.00	-
-	6.5	19	ML	120	780	780	780	1.5	1.3	M	6	1.05	S	29	1.20	1.00	7	6.5	0.75	15	31		35	1.2	50	0.859	0.108	0.000	3.00	No	No	ML				Yes	No	3.00	-
-	8.5	29	ML	120	1020	1020	1020	1.4	1.3	M	6	1.05	S	39	1.20	1.00	7	8.5	0.81	24	53		35	1.2	40	0.903	0.108	0.000	3.00	No	No	ML				Yes	No	3.00	-
-	11.5	24	CL	115	1265	1265	1265	1.3	1.3	M	6	1.05	S	30	1.20	1.00	7	11.5	0.95	22	47	55	55	1.2	33	0.599	0.104	0.000	3.00	No	No	CL	27	12		Yes	No	3.00	-
-	13.5	51	CL	115	1435	1435	1435	1.2	1.3	M	6	1.05	S	50	1.20	1.00	7	13.5	0.97	47	55		35	1.2	50	0.510	0.103	0.000	3.00	No	No	CL				Yes	No	3.00	-
-	17.5	52	GM	125	2235	2235	2235	0.9	1.3	M	6	1.05	S	49	1.20	1.00	7	17.5	0.92	59	47		12	1.1	49	1.519	0.109	0.000	3.00	No	No	GM				Yes	No	3.00	-
-	21.5	19	GW	135	2835	2835	2835	0.8	1.3	M	6	1.05	S	19	1.17	1.00	7	21.5	0.94	16	15	2	6	1.6	15	0.107	0.097	0.064	1.10	Yes	No	GW				Yes	No	1.10	-
-	31.0	65	GM	135	4185	4185	4185	0.7	1.3	M	6	1.05	S	56	1.20	1.00	7	31.3	0.99	66	67	7	7	1.0	70	5.624	0.246	0.000	3.00	No	No	GM				Yes	No	3.00	-
-	46.0	16	GW	135	6210	6315	6315	0.6	1.3	M	6	1.05	S	10	1.15	1.00	7	46.0	0.99	17	10		5	1.0	17	0.099	0.091	0.726	0.71	Yes	Yes	GW				Yes	Yes	0.71	Liquefiable
-	51.0	13	SP	130	6630	6421	6421	0.6	1.3	M	6	1.05	S	12	1.12	1.00	7	51.0	1.00	13	12		5	1.0	13	0.075	0.088	0.613	0.85	Yes	Yes	SP				Yes	Yes	0.85	Liquefiable
-	56.0	25	SP-SM	135	7290	6759	6759	0.6	1.3	M	6	1.05	S	15	1.15	1.00	7	56.0	1.00	20	16		6	1.1	18	0.096	0.085	0.045	1.15	Yes	Yes	SP-SM				Yes	Yes	1.15	Judgment Required
-	61.0	45	SP	130	7995	6731	6731	0.6	1.3	M	6	1.05	S	26	1.20	1.00	7	61.0	1.00	47	27		5	1.0	28	0.226	0.083	0.000	2.73	No	Yes	SP				Yes	No	2.73	-
-	66.0	56	SP	130	8580	6435	6435	0.6	1.3	M	6	1.05	S	31	1.20	1.00	7	71.0	1.00	58	32	14	14	1.1	35	0.275	0.082	0.000	3.00	No	Yes	SP				Yes	No	3.00	-
-	69.0	33	ML	120	8280	5946	5946	0.6	1.3	M	6	1.05	S	19	1.23	1.00	7	22.5	1.00	34	19		35	1.3	26	0.171	0.082	0.000	2.08	No	Yes	ML				Yes	No	2.08	-
-	76.0	66	ML	120	9120	6351	6351	0.6	1.3	M	6	1.05	S	31	1.20	1.00	7	25.5	1.00	59	33		35	1.2	39	0.535	0.081	0.000	3.00	No	Yes	ML				Yes	No	3.00	-

NOTE: Assumed values are used for Hammer Type, Energy Ratio, Drilling Method and Sampler type

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1314-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2006.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*. (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	DWR Urban Levee Geotechnical Evaluations Program
LEVEE SEGMENT:	American River South Levee
PROJECT NUMBER:	26619782.4542
Reach ID:	
Station:	DWR Station: 1611+00
Boring ID:	B-7
Boring Location (Coordinates and distance from Centerline/waterside toe)	Crest Boring

Analyzed By:	Cetenay Tsehaye
Check By:	

Date:	5/24/2006
Sheet	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft)=	47.5
Groundwater Elev. During Drilling (ft) =	29.1
Analyzed Groundwater Elevation (ft)=	29.4

Note:	February 06/06 (MW-03B)
Note:	February 06/06 (MW-03B)

Groundwater Depth Below GS During Drilling (ft.) =	18.4
Analyzed Groundwater Depth Below GS (ft.) =	18.1

Hammer Type =	Automatic
Energy Ratio =	0.8

Earthquake Information:

Return Period (years) =	200
fA, =	1.0

PGA (g) =	0.31
Location =	Crest (Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ'_v (psf)	Effective Overburden Pressure During Earthquake, σ'_v (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1, 1.2 (CSL, MCSL)	N for Sampler Correction Only (for SPT Sampler)	Sampler Correction, C_S for SPT Sampler Only	Sampler Correction for Analysis, C_S	Rod Up (Projected) Rod Length Above Ground (feet)	Rod Lengths (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, $\alpha_{(Fines)}$	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.2 (Yes/No) Column AA	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefiable Susceptibility Based on Soil Type (Yes/No) Column AH	Final Assessment (Yes/No) Perm ex. Column AG wt. use Air	Factor of Safety, FS	Comment (Liquefiable for FS,<1 and Judgment Required for 1.0 <FS, < 1.2)
-	2.5	24	ML	120	300	300	300	1.8	1.0	M	6	1.00	S	24	1.20	1.00	7	2.6	0.75	19	36		35	1.2	36	0.997	0.311	0.000	3.00	No	No	ML				Yes	No	3.00	-
-	4.5	20	CL	118	490	490	490	1.6	1.0	M	6	1.00	S	20	1.20	1.00	7	3.2	0.75	15	25		35	1.2	30	0.558	0.305	0.000	3.00	No	No	CL				Yes	No	3.00	-
-	6.5	19	ML	120	780	780	780	1.5	1.0	M	6	1.00	S	20	1.20	1.00	7	3.8	0.75	15	24		35	1.2	30	0.459	0.109	0.000	3.00	No	No	ML				Yes	No	3.00	-
-	9.5	29	ML	120	1020	1020	1020	1.4	1.0	M	6	1.00	S	29	1.20	1.00	7	4.4	0.81	24	33		35	1.2	40	0.933	0.109	0.000	3.00	No	No	ML				Yes	No	3.00	-
-	11.5	24	CL	110	1265	1265	1265	1.3	1.0	M	6	1.00	S	20	1.20	1.00	7	5.3	0.85	22	27	55	35	1.2	33	0.526	0.104	0.000	3.00	No	No	CL	27	12		Yes	No	3.00	-
-	13.5	51	CL	110	1430	1430	1430	1.2	1.0	M	6	1.00	S	50	1.20	1.00	7	5.8	0.87	47	55		35	1.2	60	5.510	0.103	0.000	3.00	No	No	CL				Yes	No	3.00	-
-	17.0	63	GM	135	2295	2295	2295	0.9	1.0	M	6	1.00	S	49	1.20	1.00	7	7.0	0.92	59	47		10	1.1	49	1.519	0.100	0.000	3.00	No	No	GM				Yes	No	3.00	-
-	21.0	16	GW	135	2835	2835	2835	0.8	1.0	M	6	1.00	S	15	1.17	1.00	7	9.0	0.94	18	15	2	6	1.0	15	0.167	0.097	0.054	1.10	Yes	No	GW				Yes	No	1.10	-
-	31.0	95	GM	135	4185	4089	4089	0.7	1.0	M	6	1.00	S	95	1.20	1.00	7	11.3	0.98	98	68	7	7	1.0	71	6.278	0.096	0.000	3.00	No	Yes	GM				Yes	No	3.00	-
-	46.0	16	GW	135	6210	5177	5177	0.5	1.0	M	6	1.00	S	16	1.11	1.00	7	15.4	0.99	17	10		6	1.0	11	0.067	0.091	0.047	0.73	Yes	Yes	GW				Yes	YES	0.73	Liquefiable
-	51.0	19	SP	130	6630	5285	5285	0.5	1.0	M	6	1.00	S	12	1.14	1.00	7	17.4	1.00	20	12		5	1.0	13	0.076	0.089	0.077	0.86	Yes	Yes	SP				Yes	YES	0.86	Liquefiable
-	56.0	25	SP-SM	135	7295	5423	5423	0.5	1.0	M	6	1.00	S	15	1.08	1.00	7	19.5	1.00	26	16		6	1.1	17	0.100	0.085	0.036	1.17	Yes	Yes	SP-SM				Yes	YES	1.17	Judgment Required
-	61.0	43	SP	130	7955	5994	5994	0.5	1.0	M	6	1.00	S	26	1.05	1.00	7	20.6	1.00	47	27		6	1.9	35	0.333	0.080	0.000	7.01	No	Yes	SP				Yes	No	2.81	-
-	66.0	56	SP	130	8580	6299	6299	0.4	1.0	M	6	1.00	S	31	1.02	1.00	7	21.9	1.00	58	33	14	14	1.1	39	0.538	0.082	0.000	3.00	No	Yes	SP				Yes	No	3.00	-
-	69.0	32	ML	130	8970	5911	5911	0.5	1.0	M	6	1.00	S	19	1.03	1.00	7	22.5	1.00	34	20		35	1.2	24	0.176	0.082	0.000	7.14	No	Yes	ML				Yes	No	2.14	-
-	76.0	56	ML	120	9120	6215	6215	0.5	1.0	M	6	1.00	S	52	1.30	1.00	7	25.8	1.00	59	33		35	1.2	40	0.535	0.081	0.000	3.00	No	Yes	ML				Yes	No	3.00	-

NOTE: Assumed values are used for Hammer Type, Energy Ratio, Boring Method and Sampler type

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE*, Vol. 130, No. 12, 1312-1340, and Discussions and Closures (May, 2009)
2. URS Corporation 2008, Guidance Document for Geotechnical Analysis , Urban Lense Geotechnical Evaluations Program Rev. 6, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queen Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME	OWR Urban Lense Geotechnical Evaluations Program
LEVEE SEGMENT	American River South Levee
PROJECT NUMBER	29181024.45400
Reach ID:	
Stations	OWR Station: 1065+00
Boring ID	ZT-19-23
Study Location	Circa Curving

Analyzed By: Cuiping Zeng Wang
Check By:
Date: 9/24/2008
Date:
Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation,ft,m: 33.5
Groundwater Elev. During Drilling (ft.) = 27.5 — Note: Between 4/5/06 (WL=27.5)
Analyzed Groundwater Elevation,ft,m: 27.5 — Note: February 9/28 (WL=28.8)

Groundwater Depth Below GS During Drilling (ft.) = 34.7
Analyzed Groundwater Depth Below GS (ft.) = 34.7

Hammer Type = Rod Safety
Energy Ratio = 0.80

Earthquake Information
Return Period (years) = 200
PGA (g) = 0.17
M_w = 6.5*
Location = Other (Major Creek, Landslide, or Watershed)

Sample/Pt	Depth to Sample (ft.)	N_{SPT}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ_v' (psf)	Effective Overburden Pressure During Earthquake, σ_v' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.0 for SVR / MCAL / SCAL)	H, for Sampler Correction C_S for SVR Samples)	Sampler Correction, C_S for SVR Sampler Only	Sampler Correction for Analysis, C_S	Shaft Up (Projection) or Shaft Length Above Ground, Feet	Rod Length (m)	Rod Length Correction Factor, C_R	M_{cs}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{FINES}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, FS	FS, < 1.2 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, w_c	Liquefaction Susceptibility Based on Soil Types (Yes/No) Column AH	Final Susceptibility (Yes/No) Based on Criteria of AF, and AH	Factor of Safety, FS	Comment (Liquefiable for FS, <1 and Sampler, Assumed as 1.2 <FS, < 1.5)
-	5.5	69	GM	135	743	743	743	1.8	1.0	M	6	1.05	6	36	1.30	1.00	7	3.5	0.75	47	76	15	15	1.1	81	21.548	0.189	0.000	3.00	Na	No	GM				Yes	No	3.00	-
-	8.0	51	ML	135	1055	1055	1055	1.4	1.0	M	6	1.05	6	64	1.30	1.00	7	4.5	0.80	51	70	75	35	1.2	62	21.277	0.187	0.000	3.00	Na	No	ML				Yes	No	3.00	-
-	12.5	71	GM	135	1353	1353	1353	1.2	1.0	M	6	1.05	0	169	1.30	1.00	7	6.0	0.84	69	86	15	15	1.1	153	99.975	0.185	0.000	3.00	Na	No	GM				Yes	No	3.00	-
-	72.0	42	ML	135	3705	1705	1705	1.1	1.0	M	6	1.05	0	45	1.30	1.00	7	8.8	0.87	39	42	62	35	1.2	48	1.606	0.193	0.000	2.01	No	No	ML				Yes	No	3.00	-
-	25.0	59	Gravel and Cobbles	135	3353	3353	3353	0.9	1.0	M	7	1.15	0	38	1.30	1.00	8	7.9	0.87	63	41	11	11	1.1	43	0.047	0.087	0.000	3.00	No	No	Gravel and Cobbles				Yes	No	3.00	-
-	45.5	60	ML	135	5568	5568	5568	0.6	1.0	M	6	1.05	0	31	1.30	1.00	7	14.1	0.99	53	53	72	35	1.2	59	0.506	0.092	0.000	3.00	Na	No	ML				Yes	No	3.00	-

NOTE : Input and Output are used for Material Type, Energy Ratio, Boring Method and Sampler type

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. **Cetin, K.O., et al. 2004.** *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340, and Discussions and Closure (May, 2006)*
2. **URS Corporation 2006.** *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2006.*
3. **Seed, R.B., et al. 2001.** *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.*
4. **Southern California Earthquake Center, University of Southern California.** *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999).* (used only for guidance on MCAL and SCAL sampler corrections)

PROJECT NAME	DWR Urban Levee Geotechnical Evaluation Program
LEVEE SEGMENT	American River South Levee
PROJECT NUMBER	26619268.45420
Reach ID:	
Station	DWR Station: 1054400
Boring ID/:	B-13
Boring Location (Enter Y for Boring Locations are Known and Don't Look to the Following Limit)	Levee Boring

Analysis By:	Dyanna Tarik Hong
Check By:	

Date:	6/14/2006
Sheet	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)=	53.7		
Groundwater Elev. During Drilling (ft.) =	27.8	Name	February MSE (mid-2006)
Assigned Groundwater Elevation (ft.)=	27.8	Name	February MSE (mid-2006)

Groundwater Depth Below GS During Drilling (ft.) =	25.7	Hammer Type =	Automatic
Analyzed Groundwater Depth Below GS (ft.) =	25.7	Energy Ratio =	80

Earthquake Information:

Return Period (years) =	200	PGA (g) =	0.17
M_w =	7.0	Location =	Calculate

Select Local, Calculate, or Worldwide

| | | |

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al. 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2008. *Guidance Document for Geotechnical Analysis , Urban Lenses Geotechnical Evaluations Program Rev. 0, March 2008.*
3. Seed, R.B., et al. 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on MCAL and SCAL sampler corrections)

PROJECT NAME	OMR Urban Lenses Geotechnical Evaluations Program
LATEST SEGMENT	American Gun South Lenses
PROJECT NUMBER	26813769.45400
Reach ID:	
Station:	OMR Station 1181400
Boring ID:	B-11
Boring Location (Latitude/Longitude, and address from Excel Latitude/Longitude tab)	Latitude on Boring

Analysis By:	Subang-Tank Hang
Check By:	

Date:	1/24/2008
Data:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft,m	39.5		
Groundwater Elev. During Drilling (ft,) =	27.2	Note:	August WSE (Mid/Dec)
Analyzed Groundwater Elevation (ft,m	37.5	here	August WSE (Mid/Dec)

Groundwater Depth Below GS During Drilling (ft) = 24.7
Analyzed Groundwater Depth Below GS (ft) = 26.7

Hammer Type = Automatic
Energy Ratio = 90

Earthquake Information:
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.11
Location = Landside (Water Side, Landside, or Alignment)

| | | |

NEMDC-EAST LEVEE

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering - A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Ocean Park, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	American River Common Feasibel CWN
LEVEE SEGMENT:	NEMDC - East
PROJECT NUMBER:	26418/60 44540
Reach ID:	
Station:	1023+00
Boring ID:	NEMDTC_0018
Boring Location (Client Levee/Watershed, and Reference Line Used) and Northing/Easting:	Levee Crest

Analysis By: Michael Kwiatt
Check By:

Date: 5/7/2008
Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft)=
Groundwater Elev. During Drilling (ft) =
Analyzed Groundwater Elevation (ft)=

43.0
-13.0
23.4

Note: From Modeling And Information
Note: 2.35' Tie Elev. (No ATC) Mean Available)

Groundwater Depth Below GS During Drilling (ft) = 56.0
Analyzed Groundwater Depth Below GS (ft) = 19.6

Hammer Type = Safety Hmr
Energy Ratio = 1.00

Earthquake Information:
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.45
Location = Creek (Enter: Crest, Landside, or Waterside

Sample ID	Depth to Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.0 for SCAL/MCAL)	N_c for Sampler Correction Only (for SW sampler)	Sampler Correction for, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Protrusion) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	R_d	$N_{1,60}$	Silica Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.0 (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Lab Test Results for CL, ML: Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AH	Final Liquefaction Assessment: Final Assessment (Yes/No) Based on Columns AG, AI, and AK	Factor of Safety, FS	Comment (Liquefiable for FS,<1 and Judgment Required for 1.0 <FS, < 1.3)
S01A	2.5	11	CL	110	275	275	1.5	1.2	H	10	1.15	MCAL	10	1.23	0.80	7	2.5	0.75	10	16	60	35	1.3	20	0.269	0.119	0.000	2.44	No	No	CL				No	No	2.44	-
S02A	5	10	CH	110	550	550	550	1.5	1.3	H	10	1.15	MCAL	10	1.21	0.80	7	3.4	0.75	8	14	69	85	1.3	18	0.211	0.117	0.000	1.81	No	No	CH	60	42	31	No	No	1.81	-
7	7.5	31	CH	110	825	825	825	1.5	1.3	H	10	1.15	MCAL	17	1.23	0.80	7	4.1	0.75	19	16	69	85	1.3	20	0.218	0.115	0.000	1.90	No	No	CH				No	No	1.90	-
S03A	10	5	CL	110	1100	1100	1100	1.3	1.3	H	10	1.15	MCAL	7	1.10	0.80	7	4.9	0.93	5	7	97	35	1.6	9	0.091	0.110	0.002	0.81	Yes	No	CL	55	36		No	No	0.81	-
S04A	12.5	11	CL	110	1375	1375	1375	1.2	1.3	H	10	1.15	MCAL	13	1.19	0.80	7	5.6	0.87	11	14	60	35	1.3	17	0.164	0.111	0.000	1.41	No	No	CL	46	34		No	No	1.41	-
S05A	15	7	SC	120	1780	1780	1780	1.1	1.3	H	10	1.15	S	8	1.11	1.00	7	6.4	0.90	9	10	32	20	1.3	13	0.105	0.109	0.187	0.97	Yes	No	SC				Yes	No	0.97	-
S06A	17.5	7	CL	110	1975	1975	1975	1.0	1.3	H	10	1.15	S	7	1.11	1.00	7	7.2	0.92	9	10	60	35	1.3	13	0.100	0.107	0.244	0.94	Yes	No	CL				Yes	No	0.94	-
S07B	20	6	CL	110	2250	2250	2225	0.9	1.3	H	10	1.15	S	6	1.11	1.00	7	7.9	0.94	11	10	60	35	1.3	14	0.104	0.105	0.195	0.89	Yes	Yes	CL				Yes	Yes	0.89	Liquefiable
S08A	22.5	5	ML	120	2550	2550	2363	0.9	1.3	H	10	1.15	S	4	1.10	1.00	7	9.7	0.95	7	6	50	35	1.4	9	0.071	0.103	0.822	0.69	Yes	Yes	ML				Yes	Yes	0.69	Liquefiable
S09A	25	5	CH	110	2825	2825	2488	0.8	1.3	H	10	1.15	S	4	1.10	1.00	7	9.4	0.95	7	9	99	85	1.6	9	0.069	0.104	0.883	0.66	Yes	Yes	CH	65	42	35	No	No	0.66	-
S11A	30	46	CL	110	3375	3375	2726	0.8	1.3	M	5	1.02	S	37	1.30	1.00	7	11.0	0.98	61	47	64	35	1.2	56	2.267	0.104	0.000	3.00	No	Yes	CL	33	19	17	No	No	3.00	-
S12A	35	81	CL	110	3925	3925	2964	0.7	1.3	M	5	1.02	S	55	1.30	1.00	7	12.5	0.99	104	75	60	35	1.2	87	22.238	0.103	0.000	3.00	No	Yes	CL	32	13	22	Yes	No	3.00	-
S13A	40	72	SP	130	4675	4675	3302	0.7	1.3	M	5	1.02	MCAL	69	1.30	0.80	7	14.0	0.99	75	49	95	35	1.2	59	2.615	0.102	0.000	3.00	No	Yes	SP			22	Yes	No	3.00	-
S17A	45	44	CL	115	5125	5125	3540	0.6	1.3	M	5	1.02	S	27	1.30	1.00	7	15.5	0.99	57	36	86	35	1.2	43	0.799	0.095	0.000	3.00	No	Yes	CL				Yes	No	3.00	-
S18A	50	57	SC	130	5775	5775	3978	0.6	1.3	M	5	1.02	MCAL	34	1.30	0.80	7	17.1	1.00	69	35	36	35	1.2	42	0.729	0.096	0.000	3.00	No	Yes	SC				Yes	No	3.00	-
S21A	55	51	SC	130	6425	6425	4218	0.6	1.2	M	5	1.02	S	28	1.30	1.00	7	18.6	1.00	67	37	36	35	1.2	44	0.858	0.093	0.000	3.00	No	Yes	SC	31	11	21	Yes	No	3.00	-
S23A	60	69	ML	120	7025	6775	4504	0.5	1.3	M	5	1.02	MCAL	48	1.30	0.80	7	20.1	1.00	93	61	62	35	1.2	59	2.491	0.089	0.000	3.00	No	Yes	ML			35	Yes	No	3.00	-
S25A	65	48	ML	120	7625	7063	4792	0.5	1.3	M	5	1.02	S	26	1.30	1.00	7	21.6	1.00	63	33	55	35	1.2	40	0.650	0.089	0.000	3.00	No	Yes	ML	31	3	31	Yes	No	3.00	-
S27A	70	94	ML	130	9225	7351	5089	0.5	1.3	M	5	1.02	S	64	1.30	1.00	7	23.2	1.00	110	57	98	35	1.2	67	4.570	0.089	0.000	3.00	No	Yes	ML	36	6	33	Yes	No	3.00	-
S29A	75	41	SM	130	9875	7639	5418	0.5	1.3	M	5	1.02	S	22	1.30	1.00	7	24.7	1.00	56	29	16	16	1.1	32	0.314	0.087	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S31A	80	92	ML	120	9475	7877	5786	0.5	1.3	M	5	1.02	S	46	1.30	1.00	7	26.2	1.00	100	50	80	35	1.2	70	5.762	0.086	0.000	3.00	No	Yes	ML	43	19	32	Yes	No	3.00	-
S34A	85	91	ML	125	10975	8295	5994	0.5	1.3	M	5	1.02	S	46	1.30	1.00	7	27.7	1.00	118	59	60	35	1.2	68	4.864	0.084	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
S37A	90	96	SM	135	10725	8663	6332	0.5	1.3	M	5	1.02	S	48	1.30	1.00	7	29.3	1.00	126	61	25	25	1.1	69	4.542	0.082	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S39A	95	43	SM	130	11375	8941	6670	0.5	1.3	M	5	1.02	S	22	1.30	1.00	7	30.8	1.00	56	27	14	14	1.1	29	0.239	0.080	0.000	2.97	No	Yes	SM				Yes	No	2.97	-
S41A	100	93	SM	130	12025	9279	7008	0.5	1.3	M	5	1.02	S	29	1.30	1.00	7	32.3	1.00	82	39	14	14	1.1	41	0.595	0.079	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S44B	105	53	SP	130	12675	9617	7346	0.5	1.3	M	5	1.02	S	24	1.30	1.00	7	33.8	1.00	68	32	55	35	1.2	36	0.456	0.077	0.000	3.00	No	Yes	SP				Yes	No	3.00	-
S46A	110	53	SM	130	13325	9955	7684	0.4	1.3	M	5	1.02	S	24	1.30	1.00	7	35.4	1.00	68	31	20	20	1.1	55	0.255	0.076	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S48A	115	73	CL	110	13875	10193	7922	0.4	1.3	M	5	1.02	S	32	1.30	1.00	7	36.9	1.00	96	42	70	70	1.2	80	1.119	0.075	0.000	3.00	No	Yes	CL				Yes	No	3.00	-

URS

REFERENCES:

1. Moss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1277.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1969. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal. (In press).

PROJECT NAME: LEVEE SECTION =	Antelope River Common Fea Levee CPT
PROJECT NUMBER: Reach ID:	26516782.45400
Station:	3029+56
CPT ID:	WRA-SCPT-3015
CPT Location:	Levee Crest

Note: Crest is Solid Waterside, and Riprap on Inboard Waterside Toe

Analysis by:	Michael Kunath	Date: 10/1/2008
Checked by:		Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (NAVD88) =	43.0	
Groundwater Elevation During Exploration (NAVD88) =	19.0	Note: From Monitoring Well Information
Design Groundwater Elevation (B) =	29.4	Note: 5ft Rise Elev.
Return Period (Years) =	200	
Peak Ground Acceleration (PGA_g) =	0.15	
Location (Crest/Landside/Waterside)	Crest	
Earthquake Magnitude (M_w) =	7.0	
Groundwater Depth bgs During Exploration (ft) =	36.0	
Groundwater Depth bgs During Earthquake(ft) =	19.0	
Total Number of Thin Layers (N) =	15	

| INPUT DATA FROM CPT SOUNDING | | | | | | OVERBURDEN STRESS | | TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES | | | | | | | | | | | | | | | | | | | | | | | | | | CPT-BASED SOIL BEHAVIOR | | | | | | | | | | | | LABORATORY TEST RESULTS | | | | LIQUEFACTION CRITERIA | | | | | | | | FINAL LIQUEFACTION ASSESSMENT | | | |
|---|---|---

URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2003. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata for Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1277.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M. 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1969. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, (pp. 442-459.

PROJECT NAME:	American River, Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	60160760.45466
Reach ID:	
Station:	3029+56
CPT ID:	WMARPC-3029
CPT Location:	Levee Crest

Analysis by:	Michael Kynett
Checked by:	
Date:	10/1/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

from: Crest/Landside/Waterside toe and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	43.2
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	22.4
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.19
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	56.0
Groundwater Depth bgs During Earthquake(ft) =	20.8
Total Number of Thin Layers (ft) =	15

Action: Click on Marker for more information
Action: Go Top Back

| INPUT DATA FROM CPT SOUNDING | | | | | | OVERBURDEN STRESS | | TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES | | | | | | | | | | | | | | CPT-BASED SOIL BEHAVIOR | | | | | | | | | | | | | |

URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata for Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional.
3. URS Corporation 2009. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.
4. Seed, R.B., Cetin, K.O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442–459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	25147/60.45400
Reach ID:	
Station:	3029+00
CPT ID:	W30AVG_2010
CPT Location:	Levee Crest

Analyses by:	Michael Kerwin
Checked by:	
Date:	10/1/2008
Date	

Data Input By Analyst
Results of Analysis
Calculated Value

Note: Check Landside/waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	40.0
Groundwater Elevation During Exploration (NAVD88) =	18.0
Design Groundwater Elevation (ft) =	23.4
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.42
Location: (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.8
Groundwater Depth bgs During Exploration (ft) =	22.0
Groundwater Depth bgs During Earthquake(ft) =	16.0
Total Number of Thin Layers (ft) =	100

Note: From Monitoring Well Information

Note: 0.75 bgs Dev.

| INPUT DATA FROM CPT SOUNDING | | | | | | | | OVERBURDEN STRESS | | TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES | | | | | | | | | | | | | | | | CPT-BASED SOIL BEHAVIOR | | | | | | | | | | | | | | | |

URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Rosenblueth, E.K., and Wirde (Fear), C.E., 1969. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442–459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	2561676G 454GG
Reach ID:	
Station:	3029+56
CPT ID:	BORAGIC_3075
CPT Location:	Levee Crest

Note: Cone/Landside/Waterside, p is distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	45.0
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	23.4
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.6
Groundwater Depth bgs During Exploration (ft) =	58.0
Groundwater Depth bgs During Earthquake(ft) =	39.6
Total Number of Thin Layers (N) =	3

Note: From Monitoring Well (Earthquake)
Note: US Top Elev.

Analysis by	Michael Kynett	Date:	10/1/2008
Checked by		Date	

Data Input By Analyst
Results of Analysis
Calculated Values

INPUT DATA FROM CPT SOUNDING						OVERBURDEN STRESS		TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES												CPT-BASED SOIL BEHAVIOR																		LABORATORY TEST RESULTS					LIQUEFACTION CRITERIA							FINAL LIQUEFACTION ASSESSMENT			
								Thin Layer			Normalization for Overburden		Normalization for Fines		Normalization for Energy					Soil Behavior Type, SBT					Normalized for Overburden, SBTn																													
Depth	Tip Resistance, q_c	Sleeve Friction, f_s	Friction Ratio, R_f	Total Unit Weight	Effective Unit Weight	Total Vertical Stress, σ_{vo}	Effective Vertical Stress, σ'_{vo}	Thin Layer Correction, K_{Hl}	Equivalent Tip Resistance, q_{c1}	Thin Layer Correction Flag	Normalized Tip Resistance, Q_{tn}	Normalized Tip Resistance, q_{c1N}	Normalized Sleeve Friction, f_{s1N}	Normalized Friction Ratio, R_{f1N}	Normalized Tip Resistance, q_{c1N}	Normalized Fines Content, $C_{Fines

URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M. 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. R, March 2008.
4. Seed, R.B., Cetin, K.O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1969. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	28910/60454/0
Reach ID:	
Station:	3029+56
CPT ID:	USBR/ACC - 3016
CPT Location:	Levee Crest

Analysis by: Michael Kamal Date: 10/1/2008
Checked by: Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Cross-Validation Iteration Is and Is Zero From Cross-Validation Not Necessary

Ground Elevation (NAVD88) =	43.0
Groundwater Elevation During Exploration (NAVD88) =	15.0
Design Groundwater Elevation (B) =	22.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Creek/Landside/Riverside)	Creek
Earthquake Magnitude (M_w) =	7.5
Groundwater Depth bgs During Exploration (B) =	50.0
Groundwater Depth bgs During Earthquake(F) =	19.0
Total Number of Thin Layers (N) =	10

Note: From Monitoring Well Information
Note: US Tide Elev.

| INPUT DATA FROM CPT SOUNDING | | | | | | OVERBURDEN STRESS | TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES | | | | | | | | | | | | | | | CPT-BASED SOIL BEHAVIOR | | | | | | | | | | | | | | |

URS

REFERENCES:

1. Moss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.D., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common FeatLiqfac CRR
LEVEE REACH(S):	
PROJECT NUMBER:	28616760.45400
Reach ID:	
Station:	3029+56
CPT ID:	WSAFCC_CPT0
CPT Location:	Levee Crest

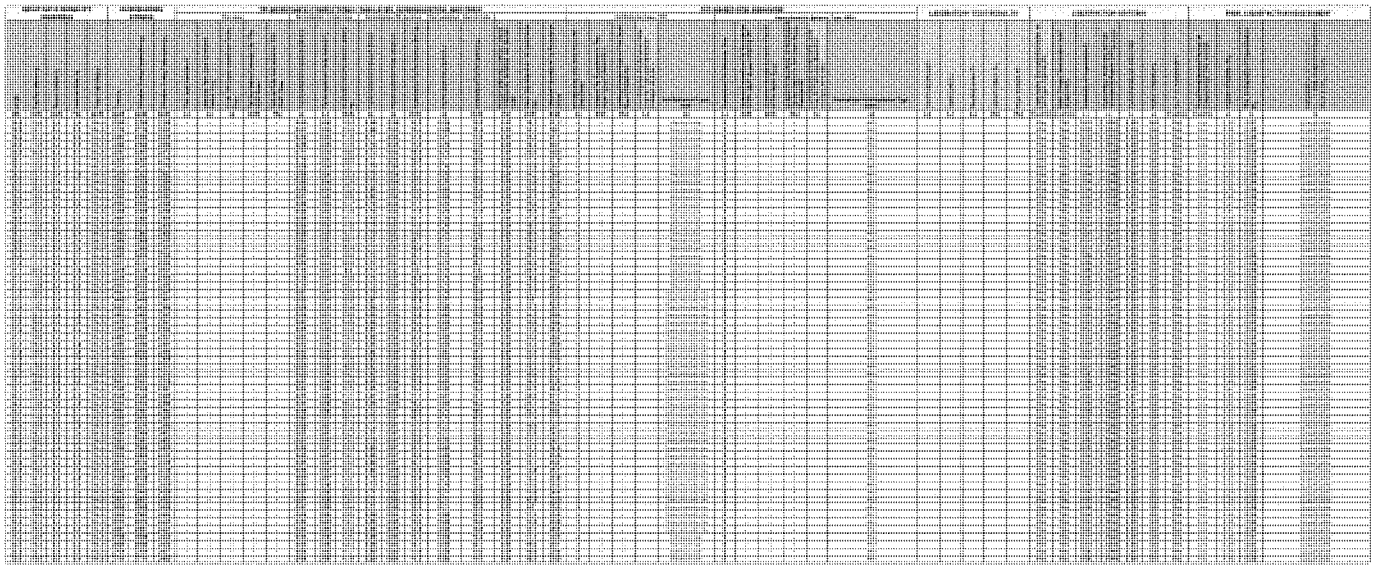
Analysis by:	Michele Kimball
Checked by:	
Date:	10/1/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check analyses for sensitivity and influence from Crest/Landside conditions as

Ground Elevation (NAVD88) =	45.0
Groundwater Elevation During Exploration (NAVD88) =	+33.0
Design Groundwater Elevation (ft) =	33.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.72
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.8
Groundwater Depth bgs During Exploration (ft) =	12.0
Groundwater Depth bgs During Earthquake(ft) =	12.0
Total Number of Thin Layers (N) =	1

Note: From Monitoring Well Information
Note: @ Toe Elev.



URS

REFERENCES:

1. Moss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	29510745.45490
Reach ID:	
Station:	3029+56
CPT ID:	WSSA-EC_3015C
CPT Location:	Levee Crest

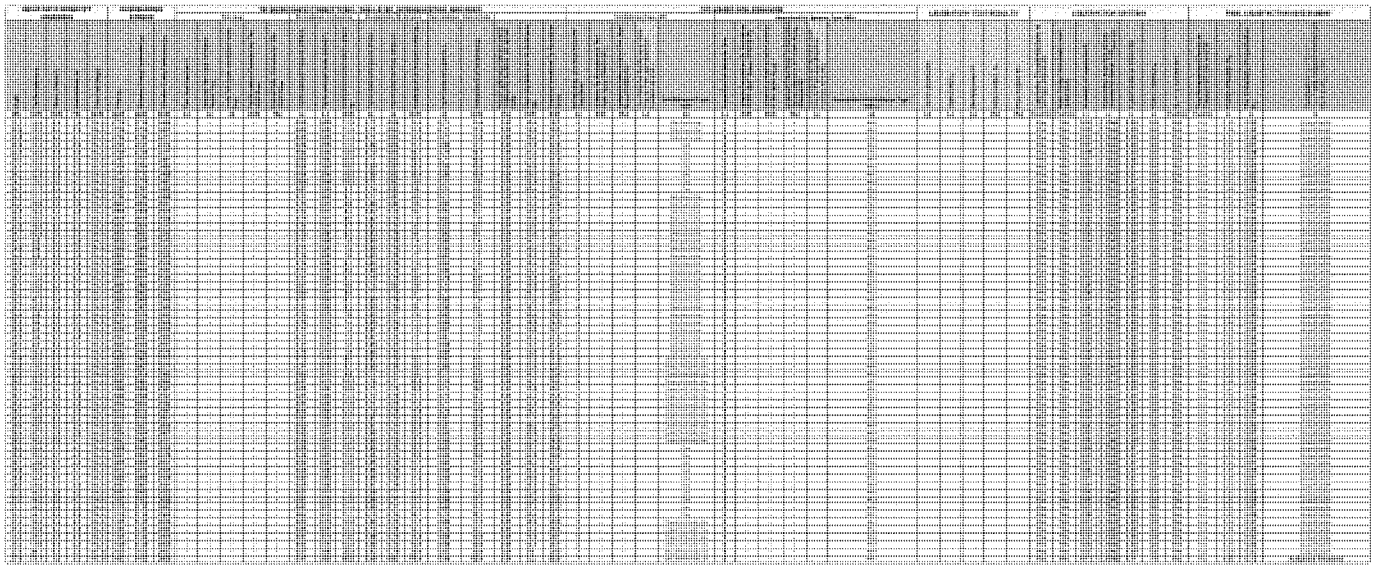
Analysis by:	Michael Kynett
Checked by:	
Date:	10/7/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check Landside/Waterside and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	47.0
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	22.4
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.42
Location (Check Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.8
Groundwater Depth bgs During Exploration (ft) =	56.0
Groundwater Depth bgs During Earthquake(ft) =	59.0
Total Number of Thin Layers (N) =	5

Note: Enter Monitoring Well Information
Note: At Toe Elev.



URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051; (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
   Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O., Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	26516700.40400
Reach ID:	
Station:	3029+56
CPT ID:	WGS84-C_3916
CPT Location:	Levee Crest

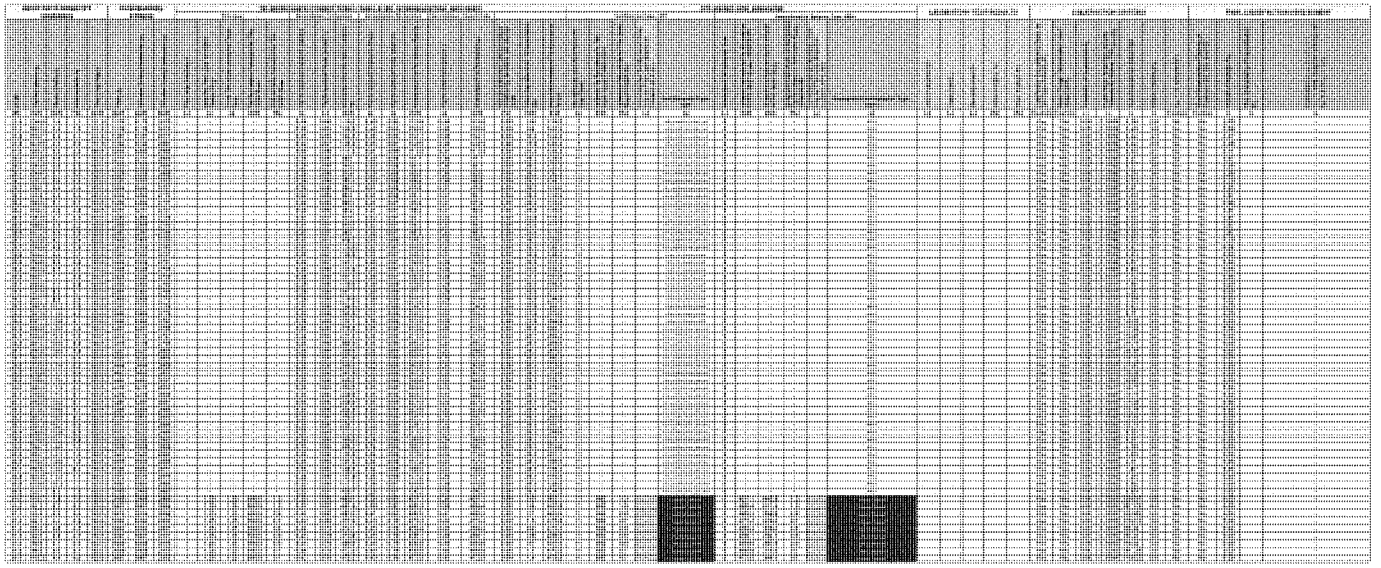
Analysis by:	Michael Kirwan
Checked by:	
Date:	10/1/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Green Levee Waterside, and Blue is from Geo-Analytic Waterside Toe

Ground Elevation (NAVD88) =	43.0
Groundwater Elevation During Exploration (NAVD88) =	17.0
Design Groundwater Elevation (ft) =	22.4
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.42
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.6
Groundwater Depth bgs During Exploration (ft) =	26.0
Groundwater Depth bgs During Earthquake(ft) =	20.6
Total Number of Thin Layers (ft) =	1

Note: Enter Monitoring Well Information
Note: US Toe Elev.



URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation, 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	26810760.45496
Reach ID:	
Station:	3029+56
CPT ID:	WB-0975-3016
CPT Location:	Levee Crest

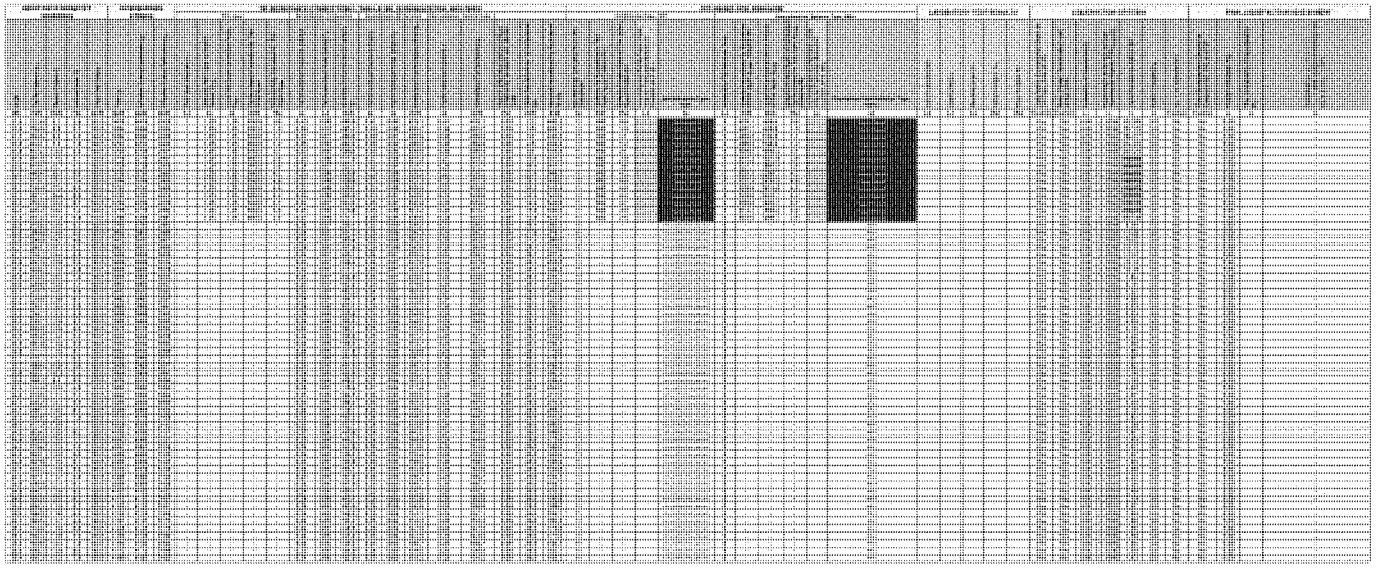
Analysis by:	Michael Kayen
Checked by:	
Date:	10/1/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check landside/waterside, and distance from CenterInside coordinates for

Ground Elevation (NAVD88) =	49.3
Groundwater Elevation, During Exploration (NAVD88) =	13.9
Design Groundwater Elevation (ft) =	23.4
Return Period (Years) =	200
Peak Ground Acceleration (**PGA, g**) =	0.72
Location (Creek/Landside/Waterside)	Creek
Earthquake Magnitude (**M_w**) =	7.8
Groundwater Depth bgs, During Exploration (ft) =	35.4
Groundwater Depth bgs, During Earthquake(ft) =	25.9
Total Number of Thin Layers (**N**) =	3

Note: Sonic Monitoring Well Information
Note: US Yolo Bypass



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SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2009)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analyses, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework* , 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on MCAL and SCAL sampler correction)*

PROJECT NAME:	American River Common Features, GRR
LEVEE SEGMENT:	NEMDC - East
PROJECT NUMBER:	29181161.4458
Reach ID:	
Station:	2644+00
Boring ID:	NARMW0_2026
Boring Location: (Levee/Landside/Waterside) and distance from Levee Centerline/Toe/Crest/Landside/Waterside	Levee Crest

Analysis By:	Michael Kanell
Check By:	
Date:	9/17/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)=
Groundwater Elev. During Drilling (ft.) =
Analyzed Groundwater Elevation (ft.)=

49.5	
33.5	
31.5	

Note: Piezo Monitoring Well Information
Note: Lot Two (See the ALTA Map in Addendum)

Groundwater Depth Below GS During Drilling (ft.) = 33.5
Analyzed Groundwater Depth Below GS (ft.) = 17.5

Hammer Type = Automatic
Energy Ratio =(%) 1.3

Earthquake Information
Return Period (years) = 200
M_w = 6.5

PGA-g= 0.15
Location = Crest (Enter: Crest, Landside, or Waterside

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (...IL, or MCAL, SCAL)	RL for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Protrusion) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	A_{FC}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	$FS_L < 1.0$ (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Lab Test Results for CL, ML Liquid Limit, LL	Plasticity Index, PI	Water Content (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Assessment (Yes/No) Based on Columns BS, BT, and BU	Factor of Safety, FS	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS, < 1.2)
S01A	2.5	22	CL	110	275	275	1.8	1.3	H	10	1.15	MCAL	35	1.30	0.90	7	3.0	0.75	19	31	61	35	1.2	37	1.095	0.116	0.000	3.00	No	No	CL				Yes	No	3.00	-
S03A	5	9	CL	110	550	550	550	1.6	1.3	H	10	1.15	MCAL	14	1.18	0.80	7	3.4	0.75	8	13	61	35	1.3	16	0.187	0.117	0.000	1.60	No	No	CL	27	14	16	Yes	No	1.60	-
S03A	7.5	6	CL	110	825	825	825	1.4	1.3	H	10	1.15	S	9	1.12	1.00	7	4.1	0.79	7	11	61	35	1.3	14	0.142	0.115	0.019	1.24	No	No	CL				Yes	No	1.24	-
S04A	10	9	CL	110	1100	1100	1100	1.3	1.3	H	10	1.15	S	4	1.10	1.00	7	4.9	0.83	4	5	61	35	1.5	7	0.079	0.113	0.759	0.70	Yes	No	CL				Yes	No	0.70	-
S05A	12.5	6	CL	110	1375	1375	1375	1.2	1.3	H	10	1.15	S	10	1.14	1.00	7	5.5	0.87	10	12	61	35	1.3	16	0.149	0.111	0.314	1.27	No	No	CL	27	15	16	Yes	No	1.27	-
S07A	17.5	7	CL	110	1925	1925	1632	1.0	1.3	H	10	1.15	S	7	1.11	1.00	7	7.2	0.92	9	10	48	25	1.3	10	0.106	0.107	0.217	0.95	Yes	Yes	CL	26	12	15	Yes	YES	0.95	Liquefiable
S08A	20	15	CL	110	2200	2200	1751	1.0	1.3	H	10	1.15	MCAL	14	1.23	0.80	7	7.9	0.94	17	16	57	35	1.3	20	0.176	0.105	0.001	1.68	No	Yes	CL				Yes	No	1.68	-
S10A	25	10	SP	110	2850	2850	2069	0.8	1.3	M	5	1.02	S	8	1.12	1.00	7	9.4	0.96	13	11	5	5	1.0	11	0.097	0.104	0.617	0.63	Yes	Yes	SP				Yes	YES	0.63	Liquefiable
S11A	30	59	ML	120	3450	3450	2377	0.8	1.3	M	5	1.02	S	45	1.30	1.00	7	11.0	0.99	79	57	51	35	1.2	67	0.680	0.104	0.000	3.00	No	Yes	ML	47	13	26	Yes	No	3.00	-
S12A	35	38	SP-SM	130	4100	4100	2715	0.7	1.3	M	5	1.02	S	21	1.30	1.00	7	12.5	0.99	38	27	12	12	1.1	28	0.310	0.103	0.000	3.00	No	Yes	SP-SM				Yes	No	3.00	-
S14A	40	39	SM	130	4750	4750	3051	0.8	1.3	M	5	1.02	S	23	1.30	1.00	7	14.0	0.99	51	33	28	28	1.2	38	0.568	0.102	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S16A	45	83	SM	130	5400	5400	3391	0.9	1.3	M	5	1.02	S	50	1.30	1.00	7	15.5	0.99	157	95	16	16	1.1	70	0.319	0.099	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S18A	50	73	ML	130	6500	6500	3679	0.8	1.3	M	5	1.02	S	42	1.30	1.00	7	17.1	1.00	36	35	73	35	1.2	64	0.691	0.096	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
S20A	55	72	ML	120	6600	6600	3967	0.8	1.3	M	5	1.02	S	40	1.30	1.00	7	18.6	1.00	94	52	95	35	1.2	81	3.044	0.093	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
S21A	60	65	SM	130	7150	7150	4305	0.8	1.3	M	5	1.02	S	45	1.30	1.00	7	20.1	1.00	111	68	20	20	1.1	67	4.750	0.090	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S23A	65	72	SM	130	7500	7500	4643	0.8	1.3	M	5	1.02	S	38	1.30	1.00	7	21.6	1.00	94	47	45	35	1.2	59	2.091	0.089	0.000	3.00	No	Yes	SM	35	10	36	Yes	No	3.00	-
S25A	70	77	ML	120	8500	8168	4931	0.8	1.3	M	5	1.02	S	38	1.30	1.00	7	23.2	1.00	101	50	56	35	1.2	59	2.419	0.089	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
S27A	75	86	CL	110	9050	8426	5193	0.8	1.3	M	5	1.02	S	37	1.30	1.00	7	24.7	1.00	73	38	67	35	1.2	42	0.715	0.087	0.000	3.00	No	Yes	CL	49	26	26	No	No	3.00	-

URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Data to Equation (9) were published by Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M. 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, (pp. 442-459.

PROJECT NAME:	Sheldon River Common Features CPT
PROJECT NUMBER:	26510263 #5490
Reach ID:	
Station:	3024+50
CPT ID:	WSAGRC_19115
CPT Location:	Levee Crest

Note: Check to see if data is acceptable, and if so, then check box to the right to lock the data.

Analysis by:	Michael Kunkel
Checked by:	
Date:	10/11/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (NAVD88) =	48.5
Groundwater Elevation During Exploration (NAVD88) =	39.5
Design Groundwater Elevation (ft) =	31.7
Return Period (Years) =	200
Peak Ground Acceleration (PGA_g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	9.0
Groundwater Depth bgs During Earthquake(ft) =	12.0
Total Number of Thin Layers (N) =	6

Note: Monitoring Well Used
Note: US Toe Drn

INPUT DATA FROM CPT SOUNDING						OVERBURDEN STRESS	TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES														CPT-BASED SOIL BEHAVIOR											LABORATORY TEST RESULTS					LIQUEFACTION CRITERIA								FINAL LIQUEFACTION ASSESSMENT	
Depth	Tip Resistance, q_c	Sleeve Friction, f_s	Friction Ratio, R_f	Total Unit Weight	Water Content, w_c	Effective Overburden Stress, σ'_{vo}	Thin Layer Correction Flag	Thin Layer Correction to Tip Resistance, q_{c1}	Thin Layer Correction Factor, K_{thin}	Normalized Tip Resistance, Q_{tn}	Normalized Tip Resistance Exponent, n	Normalized Tip Resistance, Q_{tn}	Normalized Sleeve Friction, F	Normalized Sleeve Friction, F	Normalized Tip Resistance, Q_{tn}	Normalized Tip Resistance, Q_{tn}	Fines Content Correction, ΔQ	Fines Content Correction, ΔF	Normalized Tip Resistance, Q_{tn}	Normalized Tip Resistance, Q_{tn}	Normalized Soil Behavior Type, I_c	Soil Behavior Type, SBT	Normalized Soil Behavior Type, I_c	Soil Behavior Type, SBT	Normalized Soil Behavior Type, I_c	Soil Behavior Type, SBT	Normalized Soil Behavior Type, I_c	Soil Behavior Type, SBT	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Fines Content, %	Plastic Content, %	Liquefaction Susceptibility Based on Soil Type (Y=Yes, N=No)	Stress Reduction Coefficient, r_d	Cyclic Stress Ratio from Earthquake, CSR_{eq}	Liquefaction Resistance Ratio, $CRR_{7.5}$	Magnitude Scaling Factor, MSF	Liquefaction Resistance Ratio, CRR	Factor of Safety, FS_{liq}	Probability of Liquefaction, P_L	P_L > Threshold?	Total Accumulated Strain in Each Layer, ε_{vol}	Total Accumulated Strain, ε_{vol}	Thickness of Layer, H_n	Product of Strain and Thickness, $\varepsilon_{vol} H_n$	Total Accumulated Strain in Profile, ε_{vol}	Thickness of Liquefiable Zone, H_1	Liquefaction Potential Index, LPI
(ft)	(tsf)	(tsf)	(%)	(pcf)	(pcf)	(psf)	(-)	(-)	(-)	(-)	(-)	(tsf)	(%)	(tsf)	(tsf)	(%)	(tsf)	(%)	(tsf)	(tsf)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
0.07	0.0	0.02	#####	121	9	8	8	-	-	-	-	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	########	#DIV/0!	######	8	-	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A												
0.13	18.3	0.0	0.1	120.6	15	16	16	-	-	-	-	1.11	1.70	97.8	1.03	1.70	171.8	1.33	27.8	0.00	0.0	22.5	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.1304	0.0000	0.0000	#VALUE!	#VALUE!	0.0000	0.0000	#VALUE!
0.20	32.7	0.0	0.1	120.9	24	24	24	-	-	-	-	1.08	1.70	99.5	1.02	1.70	55.5	1.32	55.5	0.00	0.0	22.5	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.09	0.7	Yes	Na	0.14	-	-	-
0.26	49.0	0.0	0.1	120.9	31	31	31	-	-	-	-	1.06	1.70	99.5	1.01	1.70	83.3	0.99	83.3	0.00	0.0	22.5	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.14	1.1	No	Na	1.12	-	-	-
0.33	65.4	0.0	0.1	120.9	40	40	40	-	-	-	-	1.05	1.70	111.1	1.01	1.70	111.1	1.01	111.1	0.00	0.0	0.0	111.1	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.21	1.7	No	Na	1.73	-	-	-
0.39	81.7	0.2	0.2	120.9	47	47	47	-	-	-	-	0.91	1.70	138.6	0.79	1.70	138.9	0.79	138.9	0.00	0.0	0.0	138.6	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.12	2.7	No	Na	2.95	-	-	-
0.46	98.0	0.2	0.2	120.9	56	56	56	-	-	-	-	0.75	1.70	166.6	0.72	1.70	166.6	0.72	166.6	0.00	0.0	0.0	166.6	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.09	4.2	No	Na	4.16	-	-	-
0.52	114.3	0.3	0.3	120.9	63	63	63	-	-	-	-	0.68	1.70	194.3	0.64	1.70	194.3	0.64	194.3	0.00	0.0	0.0	194.3	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.19	5.0	No	Na	5.00	-	-	-
0.59	113.6	0.4	0.4	120.9	71	71	71	-	-	-	-	0.64	1.70	193.1	0.60	1.70	193.1	0.60	193.1	0.00	0.0	0.0	193.1	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.19	5.0	No	Na	5.00	-	-	-
0.66	109.4	0.5	0.5	120.9	80	80	80	-	-	-	-	0.67	1.70	186.3	0.64	1.70	184.3	0.64	184.3	0.00	0.0	0.0	184.4	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.12	5.0	No	Na	5.00	-	-	-
0.72	97.5	0.7	0.7	120.9	87	87	87	-	-	-	-	0.64	1.70	166.8	0.69	1.70	166.8	0.69	166.8	0.00	0.0	1.2	167.1	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.05	4.8	No	Na	4.59	-	-	-
0.79	93.1	0.78	0.9	120.9	95	95	95	-	-	-	-	0.61	1.70	141.2	0.67	1.70	141.2	0.67	141.2	0.00	0.0	2.8	144.0	9	-	-	-	-	-	-	-	-	Sand to clay sand	0	-	-	-	#N/A	Yes	No	0.00	0.1304	0.08	5.2	No	Na	5.20	-	-	-
0.85	71.7	0.9	1.3	117.8	103	103	105	-	-	-	-	0.48	1.70	137.9	0.43	1.70	121.8	0.40	121.9	0.00	0.0	5.4	127.3	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1200	0.05	2.5	No	Na	2.49	-	-	-
0.92	45.8	1.2	1.3	117.8	111	111	111	-	-	-	-	0.44	1.70	91.3	0.38	1.70	91.3	0.36	91.3	0.00	0.0	9.2	101.2	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1200	0.08	3.3	No	Na	3.35	-	-	-
0.98	53.7	1.4	2.3	117.8	118	118	118	-	-	-	-	0.43	1.70	106.5	0.38	1.70	106.5	0.38	106.5	0.00	12.5	11.8	118.3	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1200	0.07	2.3	No	Na	2.27	-	-	-
1.05	60.5	1.5	2.5	117.8	126	126	126	-	-	-	-	0.42	1.70	103.9	0.37	1.70	103.9	0.37	103.9	0.00	13.4	11.8	116.4	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1196	0.07	2.5	No	Na	2.47	-	-	-
1.10	61.8	1.5	2.4	117.8	134	134	134	-	-	-	-	0.42	1.70	104.9	0.37	1.70	104.9	0.37	104.9	0.00	12.6	11.7	117.7	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1196	0.07	2.5	No	Na	2.47	-	-	-
1.15	63.9	1.5	2.4	117.8	141	141	141	-	-	-	-	0.42	1.70	108.7	0.37	1.70	108.7	0.37	108.7	0.00	12.8	12.1	121.5	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1196	0.08	2.5	No	Na	2.43	-	-	-
1.25	67.4	1.5	2.2	117.8	150	150	150	-	-	-	-	0.44	1.70	115.0	0.39	1.70	115.0	0.39	115.0	0.00	9.5	12.5	124.5	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1196	0.08	2.5	No	Na	2.49	-	-	-
1.31	70.3	1.7	2.4	117.8	157	157	157	-	-	-	-	0.44	1.70	118.5	0.40	1.70	118.5	0.40	118.5	0.00	9.3	12.9	127.9	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1196	0.11	2.5	No	Na	2.61	-	-	-
1.39	76.4	1.7	2.3	117.8	165	165	165	-	-	-	-	0.45	1.70	129.8	0.41	1.70	129.8	0.41	129.8	0.00	7.0	13.2	136.9	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1196	0.08	3.0	No	Na	3.04	-	-	-
1.44	81.3	1.8	2.3	117.8	172	172	172	-	-	-	-	0.45	1.70	136.1	0.42	1.70	136.1	0.42	136.1	0.00	5.8	14.0	143.0	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1196	0.05	3.4	No	Na	3.36	-	-	-
1.53	85.1	1.9	2.3	117.8	180	180	180	-	-	-	-	0.45	1.70	140.4	0.41	1.70	140.4	0.41	140.4	0.00	6.2	15.0	147.4	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1196	0.07	3.9	No	Na	3.85	-	-	-
1.57	91.0	1.5	1.8	117.8	187	187	187	-	-	-	-	0.43	1.70	154.8	0.39	1.70	154.8	0.38	154.8	0.00	7.4	16.1	162.1	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1192	0.07	4.8	No	Na	4.78	-	-	-
1.64	95.8	2.0	2.1	117.8	196	196	196	-	-	-	-	0.39	1.70	162.9	0.36	1.70	162.9	0.35	162.9	0.00	6.9	17.5	169.8	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1192	0.08	5.0	No	Na	5.00	-	-	-
1.71	100.7	2.7	2.7	117.8	204	204	204	-	-	-	-	0.34	1.70	171.2	0.33	1.70	171.2	0.33	171.2	0.00	14.6	18.8	185.8	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1192	0.07	5.0	No	Na	5.00	-	-	-
1.77	109.8	3.3	3.1	117.8	211	211	211	-	-	-	-	0.34	1.70	190.2	0.31	1.70	190.2	0.31	190.2	0.00	17.4	20.2	207.4	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1192	0.07	5.0	No	Na	5.00	-	-	-
1.84	115.1	3.9	3.4	117.8	219	219	219	-	-	-	-	0.33	1.70	195.6	0.29	1.70	195.6	0.29	195.6	0.00	19.8	21.2	216.8	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1192	0.07	5.0	No	Na	5.00	-	-	-
1.90	120.2	4.4	3.7	117.8	226	226	226	-	-	-	-	0.32	1.70	204.4	0.28	1.70	204.4	0.28	204.4	0.00	21.7	22.1	226.1	7	-	-	-	-	-	-	-	-	silty sand to clayey sand	0	-	-	-	#N/A	Yes	No	0.00	0.1192	0.13	5.0	No	Na	5.00	-	-	-
1.97	122.8	4.9	4.0	120.6	235	235	235	-	-	-	-	0.31	1.70	209.0	0.28	1.70	209.0	0.28	209.0	0.00	23.1	23.2	232.1	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1192	0.32	5.0	No	Na	5.00	-	-	-
2.04	103.1	5.2	4.2	120.6	243	243	243	-	-	-	-	0.33	1.70	207.9	0.27	1.70	207.9	0.27	207.9	0.00	25.4	23.8	231.8	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	0.48	5.0	No	Na	5.00	-	-	-
2.10	117.7	5.4	4.6	120.6	252	252	252	-	-	-	-	0.33	1.70	220.0	0.27	1.70	220.0	0.27	220.0	0.00	27.8	24.3	237.8	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	0.32	5.0	No	Na	5.00	-	-	-
2.17	117.0	5.7	4.9	120.6	260	260	260	-	-	-	-	0.32	1.70	219.7	0.27	1.70	219.7	0.27	219.7	0.00	30.6	25.0	241.0	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	0.07	5.0	No	Na	5.00	-	-	-
2.23	109.4	5.9	5.4	120.6	269	269	269	-	-	-	-	0.32	1.70	175.9	0.28	1.70	175.9	0.28	175.9	0.00	30.9	25.1	206.1	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	2.53	5.0	No	Na	5.00	-	-	-
2.30	98.3	5.9	6.0	120.6	278	278	278	-	-	-	-	0.29	1.70	163.7	0.26	1.68	161.7	0.26	161.7	0.00	30.6	24.2	192.2	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.22	5.0	No	Na	5.00	-	-	-
2.36	94.8	5.8	6.2	120.6	286	286	286	-	-	-	-	0.29	1.70	161.5	0.26	1.67	159.7	0.25	159.7	0.00	30.4	24.3	190.3	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.85	5.0	No	Na	5.00	-	-	-
2.42	96.7	5.5	5.5	120.6	295	295	295	-	-	-	-	0.29	1.70	166.9	0.26	1.67	166.6	0.26	166.6	0.00	30.6	24.2	197.2	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	2.00	5.0	No	Na	5.00	-	-	-
2.49	99.4	5.4	5.4	120.6	303	303	303	-	-	-	-	0.29	1.70	171.2	0.26	1.67	171.2	0.26	171.2	0.00	30.6	24.2	202.2	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.98	5.0	No	Na	5.00	-	-	-
2.56	97.7	5.2	5.4	120.6	312	312	312	-	-	-	-	0.30	1.70	145.2	0.26	1.68	139.5	0.26	161.3	0.00	30.5	24.1	191.9	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.98	5.0	No	Na	5.00	-	-	-
2.62	90.2	5.1	5.6	120.6	320	320	320	-	-	-	-	0.30	1.70	153.3	0.27	1.69	148.0	0.27	148.0	0.00	30.5	23.4	178.4	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.35	5.0	No	Na	5.00	-	-	-
2.69	89.8	4.8	5.7	120.6	329	329	329	-	-	-	-	0.30	1.70	148.8	0.27	1.64	141.0	0.27	141.0	0.00	30.5	23.5	171.5	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.15	5.0	No	Na	5.00	-	-	-
2.75	90.8	4.8	5.6	120.6	338	338	338	-	-	-	-	0.30	1.70	149.2	0.27	1.64	141.7	0.27	141.7	0.00	30.5	23.5	171.2	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.10	5.0	No	Na	5.00	-	-	-
2.82	94.4	4.6	5.4	120.6	348	348	348	-	-	-	-	0.31	1.70	143.8	0.27	1.64	136.3	0.27	136.3	0.00	30.5	23.5	166.8	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.01	5.0	No	Na	5.00	-	-	-
2.88	95.8	4.4	5.1	120.6	355	355	355	-	-	-	-	0.31	1.70	149.0	0.28	1.64	140.5	0.28	140.5	0.00	31.2	23.6	171.2	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.00	5.0	No	Na	5.00	-	-	-
2.95	98.8	4.2	4.8	120.6	363	363	363	-	-	-	-	0.32	1.70	151.2	0.28	1.64	145.8	0.28	145.8	0.00	28.9	23.7	174.7	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.07	5.0	No	Na	5.00	-	-	-
3.02	92.4	4.4	4.8	120.6	372	372	372	-	-	-	-	0.32	1.70	147.3	0.28	1.64	141.0	0.28	141.0	0.00	30.5	23.5	171.5	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.07	5.0	No	Na	5.00	-	-	-
3.08	91.7	3.9	4.3	120.6	380	380	380	-	-	-	-	0.32	1.70	156.9	0.29	1.64	156.4	0.29	156.4	0.00	25.8	24.0	175.8	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.01	5.0	No	Na	5.00	-	-	-
3.15	102.5	3.8	4.2	120.6	389	389	389	-	-	-	-	0.32	1.70	167.2	0.29	1.64	167.2	0.29	167.2	0.00	25.8	24.0	176.0	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.09	5.0	No	Na	5.00	-	-	-
3.22	91.3	3.9	4.3	120.6	399	399	399	-	-	-	-	0.32	1.70	155.6	0.29	1.62	146.1	0.29	146.1	0.00	25.8	23.8	173.9	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	0.97	5.0	No	Na	5.00	-	-	-
3.28	96.5	4.2	4.4	120.6	408	408	408	-	-	-	-	0.32	1.70	140.9	0.28	1.62	140.9	0.28	142.0	0.00	30.5	23.5	170.2	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	0.97	5.0	No	Na	5.00	-	-	-
3.35	92.3	4.3	4.7	120.6	416	415	415	-	-	-	-	0.31	1.70	153.9	0.28	1.59	146.0	0.28	146.0	0.00	28.4	23.4	174.4	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.01	5.0	No	Na	5.00	-	-	-
3.43	100.5	4.6	4.4	120.6	425	423	423	-	-	-	-	0.31	1.70	170.4	0.28	1.59	160.5	0.28	160.5	0.00	24.9	23.5	184.1	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	1.37	5.0	No	Na	5.00	-	-	-
3.48	121.3	4.7	3.9	120.6	432	432	432	-	-	-	-	0.31	1.64	188.8	0.28	1.57	190.4	0.28	189.4	0.00	25.7	23.3	213.1	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1189	2.14	5.0	No	Na	5.00	-	-	-
3.54	122.8	4.9	3.9	120.6	440	440	440	-	-	-	-	0.31	1.63	190.7	0.28	1.56	191.5	0.28	191.5	0.00	22.5	24.4	214.0	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1177	2.21	5.0	No	Na	5.00	-	-	-
3.61	119.7	4.8	4.1	120.6	449	449	449	-	-	-	-	0.31	1.61	187.1	0.28	1.54	189.5	0.28	189.5	0.00	24.3	23.7	213.2	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1177	1.97	5.0	No	Na	5.00	-	-	-
3.67	111.8	5.0	4.4	120.6	457	457	457	-	-	-	-	0.33	1.58	177.9	0.28	1.53	178.7	0.28	178.7	0.00	26.6	23.7	197.4	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1177	1.68	5.0	No	Na	5.00	-	-	-
3.74	107.1	5.1	4.7	120.6	466	466	466	-	-	-	-	0.33	1.58	169.0	0.27	1.51	170.3	0.27	167.3	0.00	28.5	23.5	190.9	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1177	1.47	5.0	No	Na	5.00	-	-	-
3.81	109.4	5.2	5.1	120.6	476	476	476	-	-	-	-	0.33	1.56	161.3	0.27	1.50	155.1	0.27	155.1	0.00	30.4	23.5	178.7	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1177	1.35	5.0	No	Na	5.00	-	-	-
3.87	90.8	5.2	5.2	120.6	483	483	483	-	-	-	-	0.32	1.55	134.8	0.27	1.49	148.8	0.27	148.8	0.00	30.4	23.4	179.2	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1177	1.22	5.0	No	Na	5.00	-	-	-
3.94	101.8	5.1	5.0	120.6	492	492	492	-	-	-	-	0.33	1.55	157.9	0.27	1.49	151.6	0.27	151.9	0.00	30.4	23.4	182.3	11	-	-	-	-	-	-	-	-	Very stiff fine grained	0	-	-	-	#N/A	Yes	No	0.00	0.1177	1.25	5.0	No	Na	5.00	-	-	-

URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata for Equation (5) were published in the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1277.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2009. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1969. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	25510765 #1400
Reach ID:	
Station:	3004+00
CPT ID:	M06CPT_20100
CPT Location:	Levee Crest

Note: Check Included Materials, and Balance from Cone Materials Tab Worksheet

Ground Elevation (NAVD88) =	44.5
Groundwater Elevation During Exploration (NAVD88) =	28.5
Design Groundwater Elevation (ft) =	31.7
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.50
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.81
Groundwater Depth bgs During Exploration (ft) =	16.0
Groundwater Depth bgs During Earthquake(ft) =	12.8
Total Number of Thin Layers (N) =	0

Analysis by: Michael Rymer Date: 10/1/2008
Checked By: Date:

Note: Monitoring Well Data
Note: All for Dwr

Data Input By Analyst
Results of Analysis
Calculated Values

INPUT DATA FROM CPT SOUNDING							OVERBURDEN STRESS	TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES																CPT-BASED SOIL BEHAVIOR																LABORATORY TEST RESULTS				LIQUEFACTION CRITERIA										FINAL LIQUEFACTION ASSESSMENT			
								"Thin Layer"				Thin Layer Correction for Fines		Normalization for Overburden		Normalization for Overburden		Normalization for Internal Energy							Soil Behavior Type, SBT																														
Depth	Tip Resistance, q_c	Sleeve Friction, f_s	Friction Ratio, R_f	Total Unit Weight	Total Stress, σ_{vo}	Effective Overburden Stress, σ'_{vo}	Pore Pressure, u_o	Thin Layer Correction?	Is Thin Layer Corrected for Thin Layer Effects?	Thickness of Thin Layer (inches)	Is Thin Layer Corrected for Fines Content?	Tip Resistance Exponent (stress)	Normalized Tip Resistance, q_{c1}	Sleeve Friction Exponent (stress)	Normalized Sleeve Friction, f_{s1}	Tip Resistance Exponent (energy)	Normalized Tip Resistance, q_{c1N}	Normalized Friction Ratio, Q_{tn}	Soil Behavior Type Index, I_c	Is Soil Behavior Type Zone Transitional?	Soil Behavior Type, SBT	Soil Behavior Type, SBT	Soil Behavior Type Zone	Normalized Soil Behavior Type, SBTn	Is Soil Behavior Type Zone Transitional?	Normalized Soil Behavior Type, SBTn	Is Soil Behavior Type Zone Transitional?	Normalized Soil Behavior Type, SBTn	Is Soil Behavior Type Zone Transitional?	Normalized Soil Behavior Type, SBTn	Is Soil Behavior Type Zone Transitional?	Normalized Soil Behavior Type, SBTn	Is Soil Behavior Type Zone Transitional?	Normalized Soil Behavior Type, SBTn	Is Soil Behavior Type Zone Transitional?	Overwritten Soil Behavior Type, SBTn	Overwritten Soil Behavior Type, SBTn	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Fines Content, FC	Plastic Content, PC	Liquefiable Soil Based on Ic Value (Ic < 2.6)	Liquefiable Soil Based on Ic Value and Clay Like Behavior (Ic < 2.6 and Qtn > 160)	Liquefiable Soil Based on Ic Value and Sand Like Behavior (2.6 < Ic < 2.95)	Probability of Liquefaction, P_L	Liquefiable Soil Based on Ic, Clay Like Behavior, Qtn, and Fines Criteria	Liquefiable Soil Based on Ic, Sand Like Behavior, Qtn, and Fines Criteria	Probability of Liquefaction, P_L	Cyclic Stress Ratio Causing Liquefaction, CSR*	Cyclic Resistance Ratio, CRR	Factor of Safety, F_S	Thickness of Liquefiable Layer, ft	Thickness of Liquefiable Layer, ft	Liquefaction Induced Settlement (in.)
(ft)	(tsf)	(tsf)	(%)	(pcf)	(psf)	(psf)	(psf)	(-)	(-)	(inch)	(%)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
4.95	109.6	5.1	4.6	130.5	646	500	500	-	-	-	-	0.39	1.54	163.1	0.29	1.68	157.7	0.28	157.7	0.00	29.1	196.2	11	-	-	Very stiff fine grained	0	-	-	-																		

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REFERENCES:
1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Data for Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007 Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M. 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Boulanger, P.K. and Wilde (Feak), C.E., 1905, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal. 35, (pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	25510760.40446
Reach ID:	
Station:	359+00
CPT ID:	WRA08C-3915
CPT Location:	Levee Crest

Note: Check Annotations/Interpretation, and reference from Check Materials for more info

Ground Elevation (NAVD88) =	48.5
Groundwater Elevation During Exploration (NAVD88) =	28.5
Design Groundwater Elevation (ft) =	37.7
Return Period (Years) =	500
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.6
Groundwater Depth bgs During Exploration (ft) =	19.8
Groundwater Depth bgs During Earthquake(ft) =	12.8
Total Number of Thin Layers (N) =	67

Analysis by	Michael Kuhrt
Checked by	
Date	12/12/08
Date	

Note: Monitoring Well Data
As Built Data

Data Input By Analyst
Results of Analysis
Calculated Values

| INPUT DATA FROM CPT SOUNDING | | | | | | | | | OVERBURDEN STRESS | | TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES | | | | | | | | | | | | | | CPT-BASED SOIL BEHAVIOR | | | | | | | | | | | | LABORATORY TEST RESULTS | | | | LIQUEFACTION CRITERIA | | | | | | FINAL LIQUEFACTION ASSESSMENT | | | | | | | |
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REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
(Data for Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	28616760.4549C
Reach ID:	
Station:	350+00
CPT ID:	USACE_9310
CPT Location:	Levee Crest

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	44.5
Groundwater Elevation During Exploration (NAVD88) =	29.5
Design Groundwater Elevation (ft) =	31.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.72
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.6
Groundwater Depth bgs During Exploration (ft) =	65.0
Groundwater Depth bgs During Earthquake(ft) =	33.0
Total Number of Thin Layers (N) =	60

Note: Monitoring Well Data
Note: Pz Well Elev.

Analyses by:	Michael Kanelli
Checked By:	

Date: 10/1/2008
Date:

Data Input By Analyst
Results of Analysis
Calculated Values

INPUT DATA FROM CPT SOUNDING							OVERBURDEN STRESS		TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES																CPT-BASED SOIL BEHAVIOR												LABORATORY TEST RESULTS				LIQUEFACTION CRITERIA								FINAL LIQUEFACTION ASSESSMENT							
Depth	Depth to Waterside, z_w	Layer Thickness, h_i	Tip Resistance, q_c	Sleeve Friction, f_s	Friction Ratio, R	Total Unit Weight	Total Vertical Stress, σ_{vo}	Effective Vertical Stress, σ'_{vo}	Thin Layer Indicator	Thin Layer Correction Factor, K_{thin}	Tip Resistance Corrected for Thin Layers, q_{c1}	Overburden Correction Factor, C_N	Normalized Dimensionless Tip Resistance, q_{c1N}	Normalized Tip Resistance, q_{c1Ncs}	Fines Content, FC	Fines Correction, Δq_{c1N}	Normalized Clean Sand Tip Resistance, q_{c1Ncs}	Normalized Dimensionless Friction Ratio, F_R	Normalized Friction Ratio, R_n	Soil Behavior Type Index, I_c	Soil Behavior Type, SBT	Normalized Soil Behavior Type, SBT_n	Layering Sensitivity Flag	Material Sensitivity Flag	Sensitivity Factor, S_t	Soil Behavior Type, SBT	Normalized Soil Behavior Type, SBT_n	Undrained Shear Strength, s_u	Unit Weight, γ	Liquid Limit, LL	Plasticity Index, PI	Fines Content, FC	Liquefiable Soil by Chinese Criteria	Clay Like Behavior Flag	Accounting for Strength Ratio	Accounting for Aging	Accounting for Layer Thickness	Accounting for Fines Content	Accounting for Plasticity	Final Liquefaction Decision	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio Induced by Earthquake, CSR	Factor of Safety, F_s	Probability of Liquefaction, P_L	Post-Liquefaction Strength Ratio, s_u/σ'_{vo}	Post-Liquefaction Undrained Shear Strength, s_u	Post-Liquefaction Strength Flag	Post-Liquefaction Displacement, Δz	Post-Liquefaction Displacement, Δz
(ft)	(ft)	(ft)	(tsf)	(tsf)	(%)	(pcf)	(psf)	(psf)	(-)	(-)	(tsf)	(-)	(tsf)	(-)	(%)	(tsf)	(tsf)	(%)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(pcf)	(%)	(%)	(%)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
11.69	39.2	0.6	2.1	134.6	1418	1418	1418	-	-	-	-	-	0.59	1.24	36.5	0.91	1.23	35.8	0.51	35.8	0.01	16.2	46.9	9	-	-	Silty to silty clay to cl	0	-	-	-	#N/A																							
11.94	39.4	0.3	1.9	134.6	1425	1425	1425	-	-	-	-	-	0.52	1.23	43.5	0.88	1.20	42.9	0.49	43.1	0.02	8.9	50.0	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.01	41.4	0.8	2.0	134.6	1433	1433	1433	-	-	-	-	-	0.49	1.21	50.1	0.97	1.20	49.6	0.47	48.0	0.00	9.8	58.4	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.07	44.3	0.9	2.0	134.6	1440	1440	1440	-	-	-	-	-	0.49	1.20	52.7	0.96	1.19	52.7	0.46	52.7	0.00	10.0	62.8	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.14	46.4	0.9	2.0	134.6	1448	1448	1448	-	-	-	-	-	0.47	1.20	55.6	0.95	1.19	55.2	0.45	55.2	0.00	9.8	66.0	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.20	48.0	1.0	2.1	134.6	1454	1454	1454	-	-	-	-	-	0.47	1.19	54.3	0.93	1.19	54.0	0.45	54.5	0.00	10.2	64.7	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.27	49.8	0.9	2.1	134.6	1461	1461	1461	-	-	-	-	-	0.49	1.19	52.3	0.85	1.18	51.8	0.45	51.8	0.00	10.6	62.4	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.34	51.7	0.9	2.1	134.6	1471	1471	1471	-	-	-	-	-	0.49	1.19	49.7	0.68	1.18	49.2	0.46	49.2	0.00	10.2	59.5	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.40	53.5	0.8	2.3	134.6	1477	1477	1477	-	-	-	-	-	0.50	1.20	47.7	0.48	1.19	46.8	0.48	46.8	0.00	9.6	56.5	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.47	55.2	0.7	1.8	134.6	1486	1486	1486	-	-	-	-	-	0.51	1.20	47.7	0.48	1.19	47.2	0.49	45.6	0.00	9.7	54.1	9	-	-	Silty to silty clay to cl	0	-	-	-	#N/A																							
12.53	56.8	0.6	1.7	134.6	1492	1492	1492	-	-	-	-	-	0.53	1.20	44.3	0.99	1.19	43.9	0.50	43.9	0.01	7.9	51.8	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.60	58.7	0.6	1.5	134.6	1500	1500	1500	-	-	-	-	-	0.56	1.21	42.6	0.92	1.20	42.6	0.52	42.6	0.01	6.8	49.4	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.66	34.2	0.6	1.9	134.6	1507	1507	1507	-	-	-	-	-	0.53	1.20	40.9	0.90	1.19	40.5	0.50	40.5	0.01	9.9	48.5	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.73	33.7	0.8	2.4	134.6	1515	1515	1515	-	-	-	-	-	0.50	1.19	38.5	0.84	1.17	38.0	0.48	38.5	0.00	12.2	46.7	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.80	34.2	0.9	2.5	134.6	1523	1523	1523	-	-	-	-	-	0.49	1.17	40.2	0.97	1.17	39.9	0.47	39.9	0.00	13.5	53.4	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.86	37.8	0.6	2.5	134.6	1530	1530	1530	-	-	-	-	-	0.48	1.17	43.8	1.04	1.16	43.8	0.46	43.8	0.00	12.4	56.2	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.93	39.6	0.8	2.5	134.6	1538	1538	1538	-	-	-	-	-	0.48	1.17	48.1	0.98	1.16	48.0	0.46	48.0	0.00	11.6	57.4	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
12.99	38.2	0.9	2.2	134.6	1545	1545	1545	-	-	-	-	-	0.48	1.17	44.9	0.87	1.16	44.3	0.47	44.3	0.00	10.9	55.2	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.06	37.2	0.6	2.1	134.6	1553	1553	1553	-	-	-	-	-	0.50	1.17	43.4	0.48	1.16	43.2	0.48	43.2	0.00	10.2	53.4	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.12	35.9	0.7	1.9	134.6	1560	1560	1560	-	-	-	-	-	0.52	1.17	42.1	0.56	1.16	41.8	0.50	41.8	0.01	9.1	50.8	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.19	34.1	0.6	1.7	134.6	1568	1568	1568	-	-	-	-	-	0.54	1.17	40.9	0.51	1.17	40.5	0.51	40.5	0.01	7.8	48.3	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.25	33.4	0.6	1.6	134.6	1575	1575	1575	-	-	-	-	-	0.55	1.16	39.3	0.52	1.17	39.0	0.52	39.0	0.01	7.4	46.4	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.32	32.5	0.6	1.8	134.6	1583	1583	1583	-	-	-	-	-	0.54	1.17	39.0	0.61	1.16	37.7	0.51	37.7	0.01	8.6	46.2	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.39	31.7	0.6	2.0	134.6	1591	1591	1591	-	-	-	-	-	0.53	1.16	38.0	0.91	1.16	36.6	0.51	36.7	0.01	9.8	46.5	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.45	31.0	0.7	2.2	134.6	1598	1598	1598	-	-	-	-	-	0.52	1.16	36.9	0.80	1.15	35.7	0.50	35.7	0.01	11.5	47.2	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.52	29.8	0.7	2.4	134.6	1606	1606	1606	-	-	-	-	-	0.52	1.15	34.2	0.95	1.15	33.9	0.50	34.0	0.01	12.5	46.5	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.59	27.7	0.8	2.7	134.6	1613	1613	1594	-	-	-	-	-	0.52	1.15	31.9	0.90	1.14	31.7	0.50	31.7	0.01	14.3	46.0	9	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
13.65	25.8	0.6	3.1	134.6	1621	1621	1598	-	-	-	-	-	0.52	1.15	29.4	0.48	1.14	29.2	0.48	29.2	0.00	17.0	46.2	6	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
13.71	23.1	0.8	3.3	134.6	1628	1628	1571	-	-	-	-	-	0.52	1.15	28.3	0.95	1.14	28.3	0.50	28.3	0.01	16.6	46.4	6	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
13.78	20.8	0.8	4.3	134.6	1636	1636	1574	-	-	-	-	-	0.53	1.15	29.9	0.91	1.14	29.8	0.51	29.8	0.01	23.2	46.1	5	-	-	Clays: silty to clay CL	0	-	-	-	#N/A																							
13.84	18.4	0.8	4.8	134.6	1642	1642	1598	-	-	-	-	-	0.54	1.15	31.1	0.91	1.14	31.0	0.51	31.0	0.01	26.4	47.5	5	-	-	Clays: silty to clay CL	0	-	-	-	#N/A																							
13.91	17.1	0.9	5.5	134.6	1652	1652	1581	-	-	-	-	-	0.55	1.15	18.5	0.52	1.14	18.5	0.53	18.5	0.01	38.8	48.6	3	-	-	Clay	0	-	-	-	#N/A																							
13.98	14.9	0.9	5.9	134.6	1658	1658	1598	-	-	-	-	-	0.57	1.15	17.7	0.53	1.14	17.6	0.53	17.6	0.01	39.2	48.1	3	-	-	Clay	0	-	-	-	#N/A																							
14.04	13.3	0.8	6.2	134.6	1665	1665	1598	-	-	-	-	-	0.58	1.15	15.3	0.50	1.14	15.4	0.55	15.4	0.01	39.1	44.2	3	-	-	Clay	0	-	-	-	#N/A																							
14.11	12.2	0.9	6.3	134.6	1673	1673	1592	-	-	-	-	-	0.60	1.15	14.2	0.50	1.14	14.3	0.56	14.3	0.01	38.1	42.4	3	-	-	Clay	0	-	-	-	#N/A																							
14.17	11.8	0.9	6.4	134.6	1680	1680	1595	-	-	-	-	-	0.62	1.15	13.8	0.54	1.15	13.8	0.58	13.8	0.01	38.1	42.6	3	-	-	Clay	0	-	-	-	#N/A																							
14.24	10.8	0.7	6.7	134.6	1688	1688	1598	-	-	-	-	-	0.64	1.16	12.4	0.60	1.15	12.3	0.60	12.3	0.01	37.1	41.4	3	-	-	Clay	0	-	-	-	#N/A																							
14.30	10.1	0.4	6.4	134.6	1695	1695	1601	-	-	-	-	-	0.66	1.16	11.6	0.58	1.15	11.6	0.61	11.6	0.01	36.1	40.7	3	-	-	Clay	0	-	-	-	#N/A																							
14.37	10.5	0.8	6.5	134.6	1703	1703	1600	-	-	-	-	-	0.67	1.16	12.1	0.63	1.15	12.0	0.63	12.0	0.01	29.1	41.1	3	-	-	Clay	0	-	-	-	#N/A																							
14.44	12.2	0.8	4.8	134.6	1711	1711	1605	-	-	-	-	-	0.64	1.16	14.0	0.61	1.15	13.9	0.61	13.9	0.01	25.4	40.3	5	-	-	Clays: silty to clay CL	0	-	-	-	#N/A																							
14.50	13.7	0.6	3.7	134.6	1718	1718	1612	-	-	-	-	-	0.60	1.15	17.7	0.67	1.15	17.6	0.57	17.6	0.01	20.7	39.3	5	-	-	Clays: silty to clay CL	0	-	-	-	#N/A																							
14.57	15.7	0.8	2.8	134.6	1726	1726	1616	-	-	-	-	-	0.58	1.15	21.1	0.74	1.15	21.0	0.55	21.0	0.01	14.6	39.9	5	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
14.63	23.5	0.5	2.3	134.6	1733	1733	1619	-	-	-	-	-	0.59	1.15	29.3	0.55	1.12	29.1	0.55	29.1	0.01	11.7	39.8	5	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
14.70	24.8	0.5	1.9	134.6	1741	1741	1622	-	-	-	-	-	0.58	1.15	27.8	0.58	1.12	27.5	0.58	27.5	0.01	9.2	36.8	5	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
14.75	26.1	0.5	1.8	134.6	1748	1748	1626	-	-	-	-	-	0.58	1.12	28.2	0.58	1.12	28.1	0.58	28.1	0.01	8.7	37.2	5	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
14.80	27.5	0.5	1.8	134.6	1756	1756	1629	-	-	-	-	-	0.58	1.12	29.7	0.58	1.12	29.6	0.58	29.6	0.01	8.7	38.3	5	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
14.89	29.8	0.4	1.4	134.6	1763	1763	1632	-	-	-	-	-	0.59	1.11	32.2	0.57	1.11	32.1	0.57	32.1	0.01	5.9	38.0	5	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
14.96	30.2	0.4	1.3	134.6	1771	1771	1636	-	-	-	-	-	0.60	1.11	32.8	0.56	1.11	32.7	0.58	32.7	0.01	5.6	38.3	5	-	-	Sandy silty to silty cla	0	-	-	-	#N/A																							
15.03	31.5	0.4	1.3	134.6	1778	1778	1640	-	-	-	-	-	0.59	1.11	34.9	0.58	1.10	34.8	0.58	34.8	0.01	5.0	39.7	5	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
15.09	33.1	0.5	1.5	134.6	1786	1786	1643	-	-	-	-	-	0.54	1.10	36.3	0.54	1.10	36.1	0.54	36.1	0.01	5.9	41.9	5	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
15.18	34.0	0.7	2.2	134.6	1794	1794	1646	-	-	-	-	-	0.51	1.09	37.3	0.50	1.09	36.8	0.50	36.9	0.01	10.8	47.7	9	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
15.27	35.3	0.9	2.5	134.6	1801	1801	1650	-	-	-	-	-	0.49	1.08	38.1	0.48	1.08	38.0	0.48	38.0	0.00	13.0	51.1	9	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
15.29	36.6	1.0	2.7	134.6	1809	1809	1653	-	-	-	-	-	0.47	1.08	41.5	0.46	1.07	41.4	0.46	41.4	0.00	14.2	55.6	9	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
15.35	40.9	1.2	2.9	134.6	1815	1815	1656	-	-	-	-	-	0.45	1.07	43.4	0.44	1.07	43.4	0.44	43.4	0.00	15.2	58.1	9	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
15.42	38.8	1.3	3.4	134.6	1823	1823	1660	-	-	-	-	-	0.44	1.07	41.5	0.43	1.07	41.5	0.43	41.5	0.00	19.0	60.4	5	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
15.49	33.8	1.4	4.8	134.6	1832	1832	1664	-	-	-	-	-	0.43	1.06	38.5	0.42	1.06	38.1	0.42	38.1	0.00	22.6	60.8	6	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
15.56	29.2	1.5	4.6	134.6	1838	1838	1667	-	-	-	-	-	0.43	1.06	35.5	0.42	1.06	34.9	0.42	34.9	0.00	24.6	61.6	5	-	-	Sands: silty to clayey SA	0	-	-	-	#N/A																							
15.62	31.2	1.6	5.2	134.6	1846	1846	1670	-	-	-	-	-	0.43	1.06	39.0	0.42	1.06	38.6	0.42	39.0	0.00	28.9	71.9	3	-	-	Clay	0	-	-	-	#N/A																							
15.68	31.8	1.6	4.9	134.6	1853	1853	1674	-	-	-	-	-	0.43	1.06	39.8	0.42	1.06	39.4	0.42	39.7	0.00	26.3	72.0	3	-	-	Clay	0	-	-	-	#N/A																							
15.75	33.7	1.5	4.3	134.6	1861	1861	1677	-	-	-	-	-	0.43	1.06	36.5	0.43	1.06	35.8	0.43	35.8	0.00	24.6	60.2	3	-	-	Clay	0	-	-	-	#N/A																							

URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O., Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features CRT
LEVEE SEGMENT:	
PROJECT NUMBER:	26516765.40400
Reach ID:	
Station:	3029+66
CPT ID:	WBARPC_0045
CPT Location:	Levee Crest

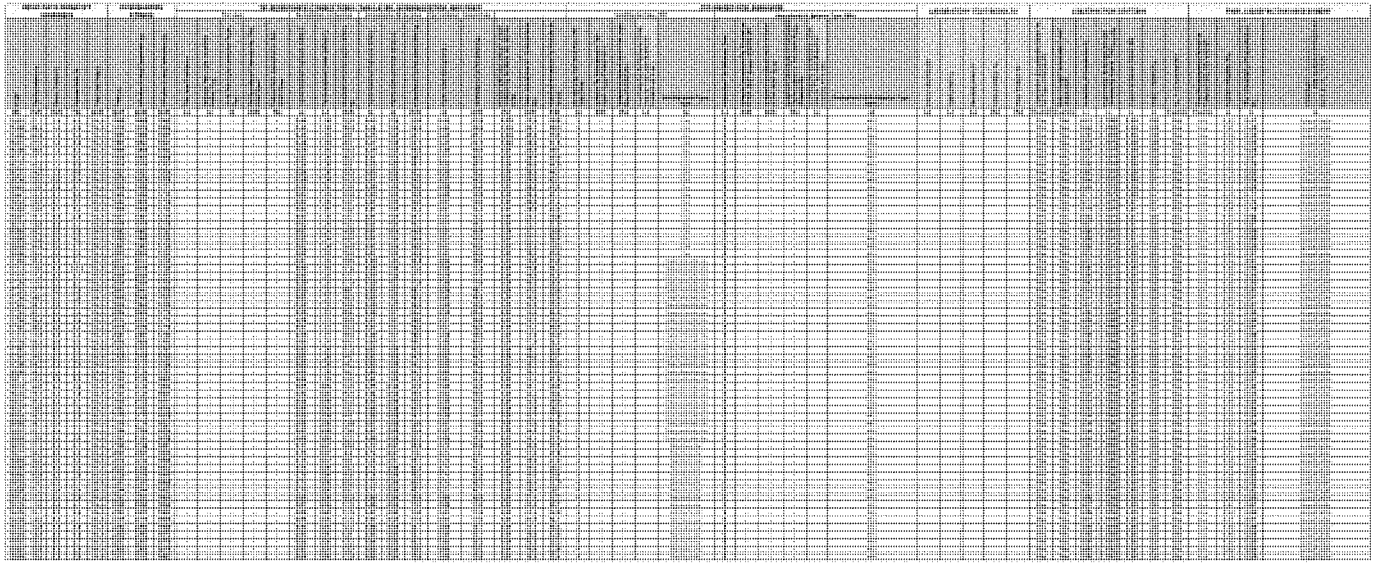
Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Analysis by:	Michael Kunath
Checked by:	
Date:	10/12/08
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (NAVD88) =	44.5'
Groundwater Elevation During Exploration (NAVD88) =	26.5
Design Groundwater Elevation (ft) =	31.7
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	85.0'
Groundwater Depth bgs During Earthquake(ft) =	12.8'
Total Number of Thin Layers (N) =	0

Note: Monitoring Well Data
Note: CPT Not Elev



URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation, 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geoetechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, (pp. 442–459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	28516760.40400
Reach ID	
Station	3024+00
CPT ID:	WILLIAMS_3015
CPT Location:	Levee Crest

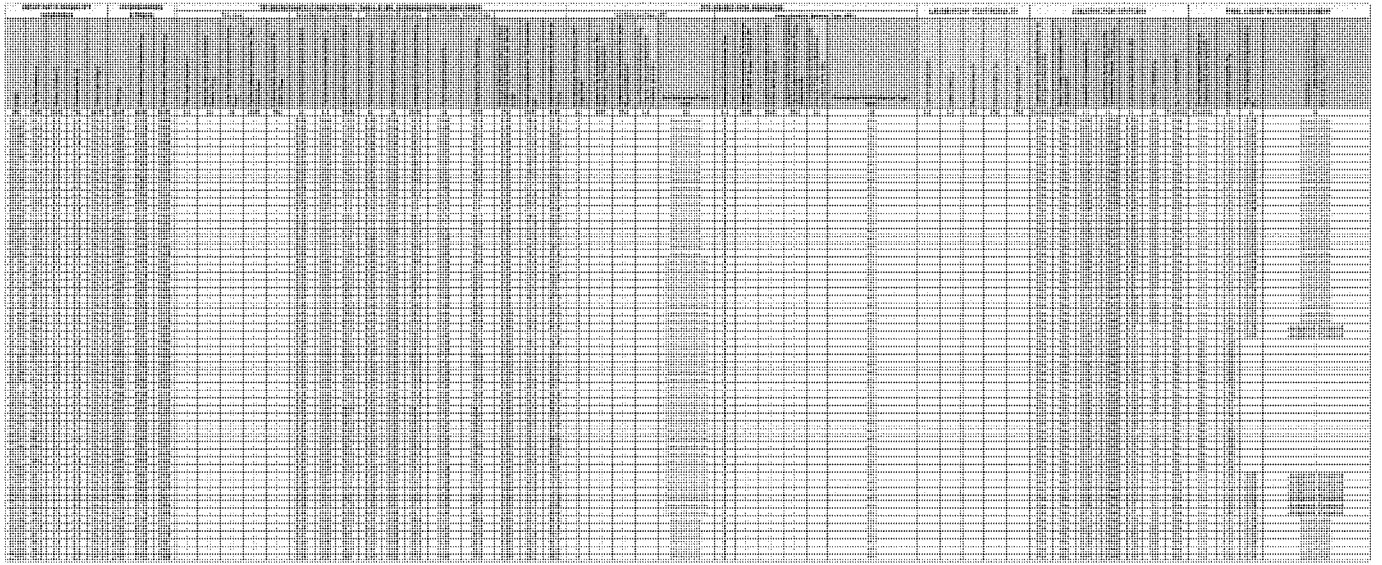
Analysis by:	Michael Kanell
Checked By:	
Date:	12/1/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside/Waterside toe

Ground Elevation (NAVD88) =	44.5
Groundwater Elevation During Exploration (NAVD88) =	29.0
Design Groundwater Elevation (ft) =	31.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	6.6
Groundwater Depth bgs During Exploration (ft) =	15.5
Groundwater Depth bgs During Earthquake(ft) =	13.5
Total Number of Thin Layers (N) =	0

Note: Monitoring Well Data
Note: @ Toe Elev.



URS

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis. Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of "Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1969. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal. 35, (pp. 442)-459

PROJECT NAME:	American River Common Features GRR
PROJECT SITE(S):	
PROJECT NUMBER:	29810/60.45400
Reach ID:	
Station:	302+00
CPT ID:	WB3APC_3915
CPT Location:	Levee Crest

Note: Check/Landside/Waterside, and distance from Centerline/Levee Toe/Waterside Toe

Analysis by:	Michael Rinehart
Checked By:	
Date:	10/1/2026
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (NAVD88) =	44.5
Groundwater Elevation During Exploration (NAVD88) =	29.5
Design Groundwater Elevation (fs) =	31.7
Return Period (Years) =	200
Peak Ground Acceleration (PGA_g) =	0.42
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.8
Groundwater Depth bgs During Exploration (fs) =	15.0
Groundwater Depth bgs During Earthquake(fs) =	12.8
Total Number of Thin Layers (N) =	63

Note: Monitoring Well Data
Note: CS Tip Data

INPUT DATA FROM CPT SOUNDING							OVERBURDEN STRESS		TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES																CPT-BASED SOIL BEHAVIOR															LABORATORY TEST RESULTS				LIQUEFACTION CRITERIA								FINAL LIQUEFACTION ASSESSMENT			
Depth	Tip Resistance, q_c	Sleeve Friction, f_s	Friction Ratio, R_f	Peak Load Height	Effective Overburden Stress, σ'_{vo}	Total Overburden Stress, σ_{vo}	Pore Pressure Behavior Type	Is Pore Pressure Behavior Type Thin Layer Interbedded?	Is Pore Pressure Behavior Type Thin Layer Interbedded?	Is Pore Pressure Behavior Type Thin Layer Interbedded?	Pore Pressure Behavior Type Thin Layer Interbedded Flag	Tip Resistance Corrected for Thin Layer Interbedding, q_{c1}	Pore Pressure Behavior Type Thin Layer Interbedded Flag	Tip Resistance Exponent (Unitless), n	Normalized Tip Resistance, q_{c1N}	Normalized Friction Ratio, F_R	Normalized Tip Resistance Behavior Type Index, I_c	Soil Behavior Type Index, I_c Zone	Normalized Tip Resistance, K_c	Normalized Tip Resistance, q_{c1N}

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REFERENCES:

1. Moss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442–459.

PROJECT NAME:	American River Common Features GRR
PURE SEGMENT:	
PROJECT NUMBER:	28140/26540/40486
Reach ID:	
Station:	2054+00
CPT ID:	WBL-UEC_2H10
CPT Location:	Levee Crest

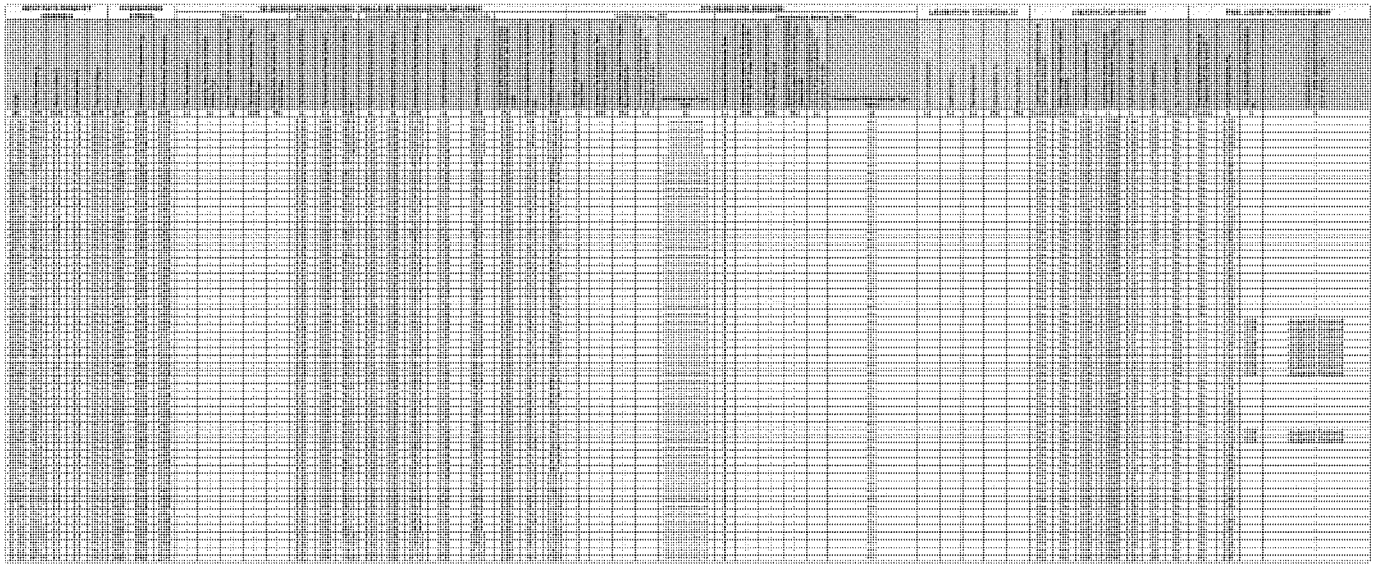
Analysis by:	Michael Kayen
Checked by:	
Date:	10/4/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check Levee Side/Waterside, and distance from Crest Landside toe/Waterside toe

Ground Elevation (NAVD88) =	44.5
Groundwater Elevation During Exploration (NAVD88) =	19.0
Design Groundwater Elevation (ft) =	31.7
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	6.6
Groundwater Depth bgs During Exploration (ft) =	25.0
Groundwater Depth bgs During Earthquake(ft) =	12.8
Total Number of Thin Layers (#) =	85

Note: Monitoring Well Data
Note: @ Toe Elev



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REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to publication (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M. 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2009. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.D., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE REACH:	
PROJECT NUMBER:	25810760;45400
Reach ID:	
Station	3009+96
CPT ID:	W9AMFC-3016
CPT Location:	Levee Crest

Note: Check if water is present, and observe from Crest, and side toe if water is present

Ground Elevation (NAVD88) =	44.5
Groundwater Elevation During Exploration (NAVD88) =	29.5
Design Groundwater Elevation (ft) =	31.7
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.6
Groundwater Depth bgs During Exploration (ft) =	15.0
Groundwater Depth bgs During Earthquake(ft) =	12.8
Total Number of Thin Layers (N) =	0

Analysis by:	Michael Kowski
Checked by:	
Date:	10/1/2008
Date:	

Note: Monitoring Well Data
Note: 45 Year Data

Data Input By Analyst
Results of Analysis
Calculated Values

INPUT DATA FROM CPT SOUNDING						OVERBURDEN STRESS		TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES																				CPT-BASED SOIL BEHAVIOR																LABORATORY TEST RESULTS				LIQUEFACTION CRITERIA								FINAL LIQUEFACTION ASSESSMENT			
Depth	Tip Resistance, q_c	Sleeve Friction, f_s	Friction Ratio, R_f	Pore Pressure, u_2	Total Unit Weight	Total Vertical Stress, σ_{vo}	Effective Vertical Stress, σ'_{vo}	Thin Layer Transition Flag	Thin Layer Correction to q_c	Thin Layer Correction to f_s	Thin Layer Correction to R_f	Thin Layer Correction to Clean Sand q_c	Thin Layer Correction to Clean Sand f_s	Thin Layer Correction to Clean Sand R_f	Normalized Exponent (stress)	Normalized q_c (stress)	Normalized f_s (stress)	Normalized R_f (stress)	Normalized Exponent (fines)	Normalized q_c (fines)	Normalized f_s (fines)	Normalized R_f (fines)	Normalized q_c	Normalized f_s	Normalized R_f	Equivalent Physical Medium Sand Clean Tip Resistance (q_{c1N})	Equivalent Physical Medium Sand Clean Sleeve Friction (f_{s1N})	Equivalent Physical Medium Sand Clean Friction Ratio (R_{f1N})	Soil Behavior Type, SBT	Normalized Soil Behavior Chart	Normalized Soil Behavior Type	Overburden Stress Exponent (Robertson 2009)	Overburden Stress Correction Factor (K_{σ})	Overburden Stress Corrected Tip Resistance ($q_{c

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REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
(Errata to Equation (9) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2009, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 8, March 2009.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME	American River Common Features GRR
LEVEE REACH(S)	
PROJECT NUMBER	2081670/5.4/420
Reach ID:	
Station	3004+66
CPT ID:	WSAFRC_3010
CPT Location:	Levee Crest

Analyes by	Michael Kayen
Checked by	
Date:	10/5/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check units and decimal places

Ground Elevation (NAVD88) =	44.9
Groundwater Elevation During Exploration (NAVD88) =	29.5
Design Groundwater Elevation (ft) =	31.7
Return Period (Years) =	500
Peak Ground Acceleration (PGA, g) =	0.42
Location (Cresl/Landside/Waterside)	Creat
Earthquake Magnitude (M_w) =	6.8
Groundwater Depth bgs During Exploration (ft) =	65.0
Groundwater Depth bgs During Earthquake(ft) =	13.2
Total Number of thin Layers (N) =	0

Note: Check units and decimal places

Note: Monitoring Well Data
Note: CPT Log Data

| INPUT DATA FROM CPT SOUNDING | | | | | | | | | | OVERBURDEN STRESS | | TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES | | | | | | | | | | | | | | | | CPT-BASED SOIL BEHAVIOR | | | | | | | | | | | | | | | |

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REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis. Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Navy, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442–459.

PROJECT NAME:	American River Common Features Crest
LEVEE SEGMENT:	
PROJECT NUMBER:	26510700.40400
Reach ID:	
Station:	3094+00
CPT ID:	WSAMPC-3016
CPT Location:	Levee Crest

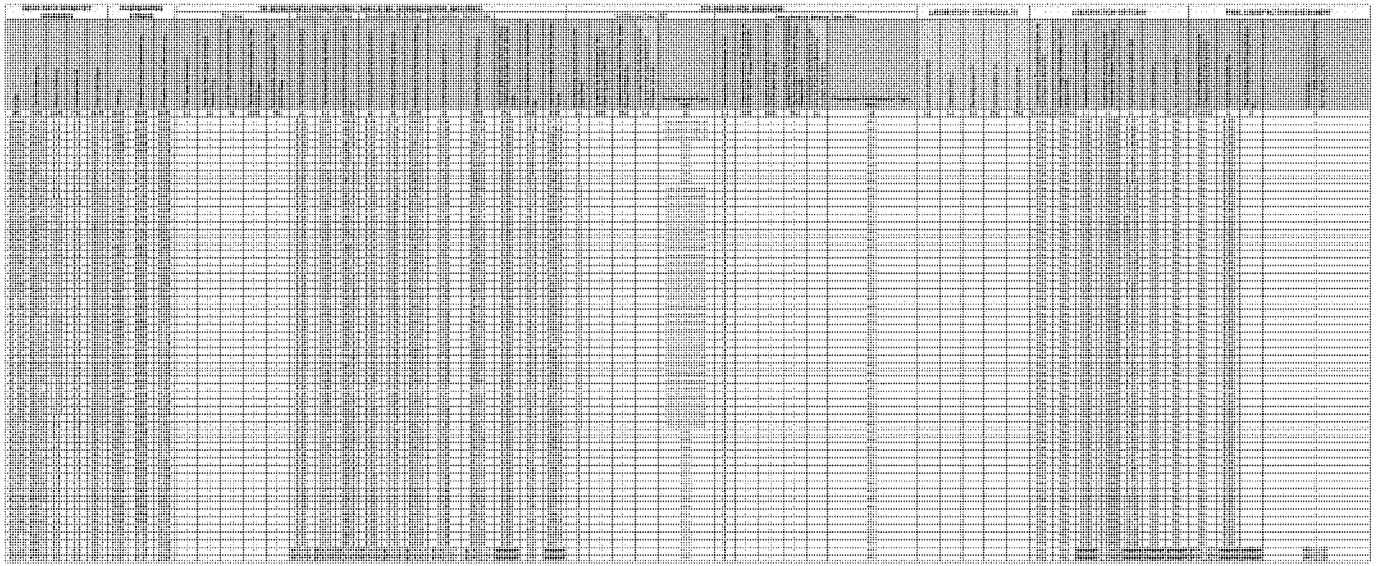
Analysis by:	Michael Kayhoe
Checked by:	
Date:	10/1/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Celtics embedded Materials, and Settings from C:\Documents and Settings\Diego_Cobos-Roa\Desktop\CPTBasedLiquefaction 5048+89Calculation Sheet.xls

Ground Elevation (NAVD88) =	44.5
Groundwater Elevation During Exploration (NAVD88) =	29.5
Design Groundwater Elevation (ft) =	31.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.42
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth Ibg During Exploration (ft) =	65.0
Groundwater Depth Ibg During Earthquake(ft) =	62.0
Total Number of Thin Layers (N) =	6

Note: Monitoring Well Data
Note: At Toe Berm



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REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, ; doi 10.1061/ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O. Moss, R. E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistant Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal. 35. pp. 442–459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT#:	
PROJECT NUMBER:	29510760.40400
Reach ID:	
Station:	3029+00
CPT ID:	"WCUAPC_1915_"
CPT Location:	Levee Crest

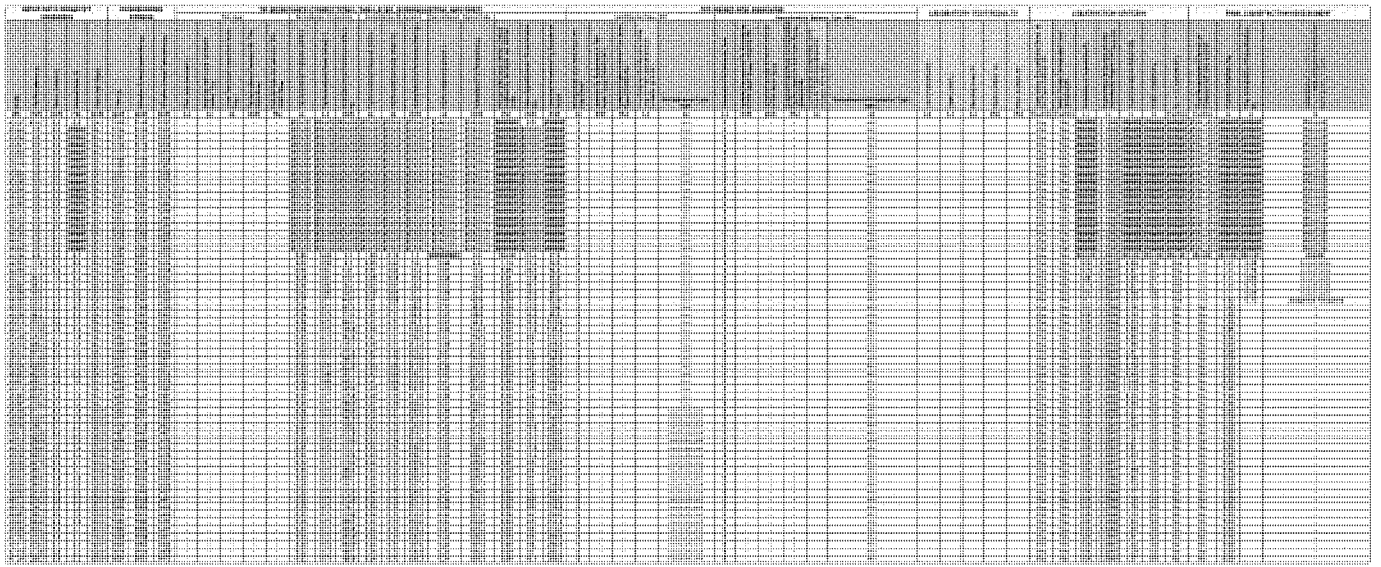
Analysis by:	Michael Kayen
Checked by:	
Date:	10/1/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check Landside/Waterside use distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	48.5
Groundwater Elevation During Exploration (NAVD88) =	29.0
Design Groundwater Elevation (ft) =	31.7
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.8
Groundwater Depth bgs During Exploration (ft) =	19.5
Groundwater Depth bgs During Earthquake(ft) =	16.8
Total Number of Thin Layers (N) =	63

NOTE: Monitoring Well Data
NOTE: At Toe Elev



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REFERENCES:

1. Idriss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart J.P., Der Kiureghian, A. and Cetin, K.O., 2009. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, August 2006, pp. 1032-1051. (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007 Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M. 1997. Cone Penetration Testing in Geotechnical Practice. Blakie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B. Cetin, K. O. Moss, R. E. S., Kammerer, A. M. Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Seach, Ca.
5. Bray, J.D., Sancio, R.D., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE REGION:	
PROJECT NUMBER:	25810700.45466
Reach ID:	
Station:	3022+56
CPT ID:	WBL-CPT-3015
CPT Location:	Levee Crest

Note: Crest/Landside/Waterside, is not instance from Crest/Landside/Waterside toe

Analysis by:	Michael Kamell
Checked by:	
Date:	10/1/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (NAVD88) =	44.5
Groundwater Elevation During Exploration (NAVD88) =	29.5
Design Groundwater Elevation (ft) =	31.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	15.0
Groundwater Depth bgs During Exploration(ft) =	13.5
Total Number of Thin Layers (N) =	3810

Note: Monitoring Well Data
Note: US Toe Elev.

| INPUT DATA FROM CPT SOUNDING | | | | | | OVERBURDEN STRESS | | TIP RESISTANCE CORRECTIONS: THIN LAYER, NORMALIZATION, AND FINES | | | | | | | | | | | | | | | | | | CPT-BASED SOIL BEHAVIOR | | | | | | | | | | | | | | | | | | | | | | | LABORATORY TEST RESULTS | | | | LIQUEFACTION CRITERIA | | | | | | FINAL LIQUEFACTION ASSESSMENT | | |
|---|---|---

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REFERENCES:

1. Moss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
   Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, (pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	
PROJECT NUMBER:	28148785.47446
Reach ID:	
Station:	Segment
CPT ID:	WNA-PC-3815
CPT Location:	Levee Crest

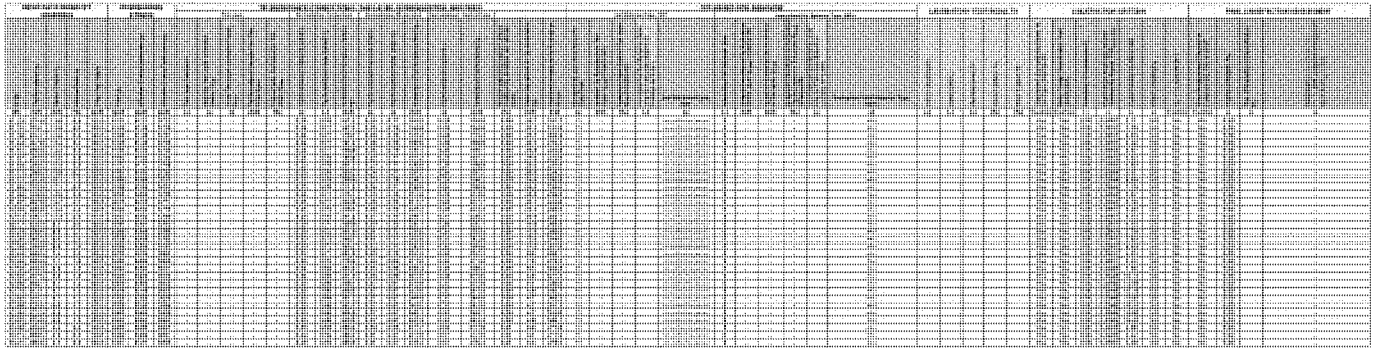
Analysis by:	Michael Kynett
Checked By:	
Date:	10/1/2008
Date:	

Only Input By Anlyst
Results of Analysis
Calculated Values

Note: Check Ambient Materials, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	44.5
Groundwater Elevation During Exploration (NAVD88) =	26.5
Design Groundwater Elevation (ft) =	31.7
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.19
Location (Creek/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.16
Groundwater Depth bgs During Exploration (ft) =	18.0
Groundwater Depth bgs During Earthquake(ft) =	12.8
Total Number of Thin Layers (N) =	85

Note: Monitoring Well Data
Note: @ Toe Berm



NEMDC-WEST LEVEE

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SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. **Cetin, K.O., et al, 2004.** *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340.* **and Discussions and Closures (May, 2006)**
2. **URS Corporation 2006.** *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
3. **Seed, R.B., et al, 2003.** *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Queens Navy, Long Beach, Ca .
4. **Southern California Earthquake Center, University of Southern California,** *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* **(1999), (used only for guidance on MCAL and SCAL sampler correction)**

PROJECT NAME:	American River Common Feasibility GRR
LEVEE SEGMENT:	SEASDE - West
PROJECT NUMBER:	29416749.65400
Reach ID:	
Station:	0+47
Boring ID:	WR RWC 0039
Boring Location (Check, sketch or Waterside, and distance from Check, sketch and Waterside Levee)	Levee Crest

Analysis By:	Michele Talleyrand
Check By:	

Date:	4/20/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 43.2
Groundwater Elev. During Drilling (ft.) = -53.2
Analyzed Groundwater Elevation (ft.)= -53.2

Note: Average of Check and Sonded Log
Note: C-F Tire Elevation Change for F39 Marker

Groundwater Depth Below GS During Drilling (ft.) = 96.5
Analyzed Groundwater Depth Below GS (ft.) = 96.5

Hammer Type = Automatic
Energy Ratio = 70

Earthquake Information:
Return Period (years) = 200
R_d = 0.0

PGA (g) = 0.12
Location = Creek (Levee Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SS, SCAL, MCAL)	N_1 for Sampler Correction Only (for SW sampler)	Sampler Correction for C_N for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Fraction) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1,60,CS}$	Cyclic Stress Ratio from Guidance Document, CSR	Cyclic Stress Ratio, CRR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS < 1.0 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Fine Assessment (Yes/No) Based on Columns AE, AF, and AK	Factor of Safety, FS	Comment is applicable for FS <1 and Judgment Required for 1.0 <FS < 1.3
S01A	1	10	SC	110	120	120	120	1.6	1.2	H	10	1.15	S	14	1.19	1.00	7	2.1	0.75	12	17		12	1.1	18	0.235	0.139	0.000	1.96	No	No	SC					Yes	No	1.96	-
S02A	2.5	14	CL	110	285	285	285	1.6	1.2	H	10	1.15	S	22	1.28	1.00	7	2.6	0.75	16	23		38	1.2	29	0.463	0.158	0.000	3.00	No	No	CL					Yes	No	3.00	-
S03A	5	16	CL	110	570	570	570	1.5	1.2	H	10	1.15	S	16	1.19	1.00	7	3.4	0.75	19	27	57	25	1.2	21	0.191	0.117	0.000	1.64	No	No	CL					Yes	No	1.64	-
S04A	7.5	9	CL	110	845	845	845	1.5	1.2	H	10	1.15	S	14	1.17	1.00	7	4.1	0.75	10	15		35	1.2	19	0.160	0.115	0.000	1.31	No	No	CL					Yes	No	1.31	-
S05A	10	9	CL	110	1120	1120	1120	1.3	1.2	H	10	1.15	S	12	1.15	1.00	7	4.9	0.85	10	14		35	1.3	17	0.125	0.113	0.001	1.11	Yes	No	CL					Yes	No	1.11	-
S06A	12.5	10	CL	110	1395	1395	1395	1.2	1.2	H	10	1.15	S	12	1.16	1.00	7	5.5	0.87	12	14		35	1.3	18	0.123	0.111	0.000	1.11	Yes	No	CL					Yes	No	1.11	-
S07A	15	9	CL	110	1670	1670	1670	1.1	1.2	H	10	1.15	S	10	1.13	1.00	7	6.4	0.90	13	12	62	35	1.3	59	0.057	0.109	0.013	0.69	Yes	No	CL					Yes	No	0.69	-
S08A	17.5	10	CL	110	1945	1945	1945	1.0	1.2	H	10	1.15	S	10	1.14	1.00	7	7.2	0.92	13	13		25	1.3	16	0.059	0.107	0.257	0.50	Yes	No	CL					Yes	No	0.50	-
S09A	20	6	CL	110	2320	2320	2320	0.9	1.2	H	10	1.15	S	6	1.10	1.00	7	7.9	0.94	8	7		25	1.4	10	0.059	0.105	0.961	0.56	Yes	No	CL					Yes	No	0.56	-
S10A	22.5	23	SM	120	2945	2945	2945	0.9	1.2	H	10	1.15	MCAL	29	1.30	0.80	7	9.7	0.95	24	21	50	25	1.2	26	0.199	0.103	0.000	1.62	No	No	SM				61	Yes	No	1.62	-
S11A	25	27	SM	130	2970	2875	2970	0.8	1.2	H	10	1.15	S	23	1.30	1.00	7	9.4	0.96	35	30		12	1.1	32	0.264	0.104	0.000	2.73	No	No	SM					Yes	No	2.73	-
S12A	27.5	51	SM	130	3195	3195	3195	0.8	1.2	H	10	1.15	MCAL	65	1.30	0.80	7	10.2	0.97	55	43		12	1.1	46	0.765	0.104	0.000	3.00	No	No	SM					Yes	No	3.00	-
S13A	30	16	CL	110	3470	3470	3470	0.8	1.2	M	5	1.02	S	27	1.30	1.00	7	11.0	0.98	43	33	65	35	1.3	29	0.457	0.104	0.000	3.00	No	No	CL	42	22	28	No	No	3.00	-
S14A	35	9	CL	110	4020	4020	4020	0.7	1.2	M	5	1.02	S	6	1.10	1.00	7	12.5	0.99	11	8		35	1.4	10	0.052	0.103	0.991	0.50	Yes	No	CL					Yes	No	0.50	-
S15A	40	67	ML	120	4620	4620	4620	0.7	1.2	M	5	1.02	S	64	1.30	1.00	7	14.0	0.99	81	53	51	35	1.2	63	2.916	0.102	0.000	3.00	No	No	ML					Yes	No	3.00	-
S16A	45	26	CH	110	5170	5170	5170	0.6	1.2	M	5	1.02	S	17	1.25	1.00	7	16.5	0.99	34	23		25	1.2	28	0.154	0.099	0.001	1.55	No	No	CH	69	36	44	No	No	1.55	-
S20A	55	66	ML	120	6170	6170	6170	0.6	1.2	M	5	1.02	S	51	1.30	1.00	7	17.1	1.00	105	62	67	35	1.2	72	4.797	0.096	0.000	3.00	No	No	ML					Yes	No	3.00	-
S22A	55	76	ML	120	6370	6370	6370	0.6	1.2	M	5	1.02	S	42	1.30	1.00	7	18.6	1.00	93	52		25	1.2	61	2.026	0.093	0.000	3.00	No	No	ML					Yes	No	3.00	-
S24A	60	87	ML	120	6970	6792	6792	0.5	1.2	M	5	1.02	S	67	1.30	1.00	7	20.1	1.00	106	59		35	1.2	69	3.295	0.090	0.000	3.00	No	No	ML					Yes	No	3.00	-
S26A	65	53	ML	120	7570	7040	7040	0.5	1.2	M	5	1.02	S	29	1.30	1.00	7	21.6	1.00	63	35		35	1.2	41	0.442	0.085	0.000	3.00	No	Yes	ML					Yes	No	3.00	-
S28A	70	78	ML	120	8170	7329	7329	0.5	1.2	M	5	1.02	S	61	1.30	1.00	7	23.2	1.00	96	50	54	35	1.2	59	1.926	0.080	0.000	3.00	No	Yes	ML					Yes	No	3.00	-
S31A	80	93	ML	120	9370	7904	7904	0.5	1.2	M	5	1.02	S	82	1.39	1.00	7	26.2	1.00	102	51	60	35	1.2	60	1.764	0.069	0.000	3.00	No	Yes	ML	35	7	22	Yes	No	3.00	-
S33A	85	87	ML	120	9870	8192	8192	0.5	1.2	M	5	1.02	S	43	1.30	1.00	7	27.7	1.00	106	53		35	1.2	62	1.989	0.064	0.000	3.00	No	Yes	ML	40	12	27	Yes	No	3.00	-
S34A	90	100	ML	120	10570	9480	9480	0.5	1.2	M	5	1.02	S	43	1.30	1.00	7	29.3	1.00	122	59	62	35	1.2	70	3.533	0.062	0.000	3.00	No	Yes	ML					Yes	No	3.00	-
S36A	95	53	SM	130	11020	8918	8918	0.5	1.2	M	5	1.02	S	25	1.30	1.00	7	30.9	1.00	64	30	37	25	1.2	34	0.289	0.060	0.000	3.00	No	Yes	SM					Yes	No	3.00	-
S38A	100	61	SM	130	11870	9156	9156	0.5	1.2	M	5	1.02	S	24	1.30	1.00	7	32.3	1.00	62	28	22	22	1.3	33	0.220	0.075	0.000	2.90	No	Yes	SM					Yes	No	2.90	-
S40A	105	51	SM	130	12520	9694	9694	0.5	1.2	M	5	1.02	S	23	1.30	1.00	7	33.8	1.00	62	29		12	1.1	31	0.185	0.077	0.000	2.39	No	Yes	SM					Yes	No	2.39	-
S42A	110	95	SM	130	13170	9932	9932	0.5	1.2	M	5	1.02	S	25	1.30	1.00	7	35.4	1.00	67	30	24	24	1.1	34	0.244	0.075	0.000	3.00	No	Yes	SM					Yes	No	3.00	-
					13170	13170	13170	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		6	#DIV/0!	#DIV/0!	0.017	0.125	1.000	0.14	Yes	No	0						No	0.14	-
					13170	13170	13170	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		6	#DIV/0!	#DIV/0!	0.017	0.125	1.000	0.14	Yes	No	0						No	0.14	-
					13170	13170	13170	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		6	#DIV/0!	#DIV/0!	0.017	0.125	1.000	0.14	Yes	No	0						No	0.14	-
					13170	13170	13170	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		6	#DIV/0!	#DIV/0!	0.017	0.125	1.000	0.14	Yes	No	0						No	0.14	-
					13170	13170	13170	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		6	#DIV/0!	#DIV/0!	0.017	0.125	1.000	0.14	Yes	No	0						No	0.14	-
					13170	13170	13170	0.4	1.2			1.00		0	1.10	0.00		-0.3	0.75	0	0		6	#DIV/0!	#DIV/0!	0.017	0.125	1.000	0.14	Yes	No	0						No	0.14	-

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DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of *in Situ* Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep. 2007, Page 1177.
2. Lunne, T., Robertson, P. K., and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2009, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2009.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003 "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006 "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	RD000 - WR0
PROJECT NUMBER:	29613810
Reach ID:	WR1000
Station:	1000+26
CPT ID:	WR1000_058C
CPT Location:	Levee Crest

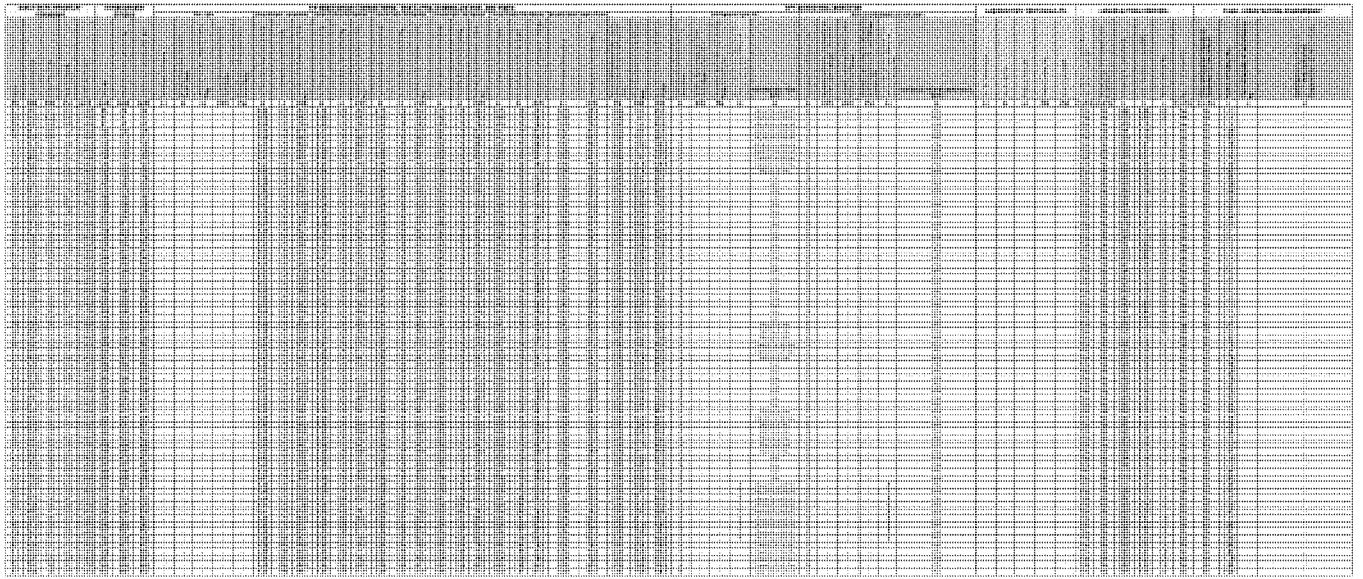
Assumptions and distinctions from Geotechnical Report

Ground Elevation (NAVD88) =	47.3
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	29.7
Return Period (Years) =	2000
Peak Ground Acceleration (PGA, g) =	0.62
Liquefaction (Yes/Liquefiable-Vulnerable)	Yes
Earthquake Magnitude (M_w) =	7.2
Groundwater Depth bgs During Exploration (ft) =	34.3
Groundwater Depth bgs During Earthquake (ft) =	29.7
Total Number of Data Layers =	81

Assumed by: Rogelio Tolentino Date: 12/15/09
Checked by: Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Input: From Dissipation Testing
Note: Typical White Sedimentary Mean



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DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2006, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2006.
4. Seed, R.B., Cetin, K.O., Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	RD000_WR1
PROJECT NUMBER:	26/28(b)
Reach ID	
Name	SJ-CPT-06
CPT ID:	WR1000_058C
CPT Location:	Levee Crest

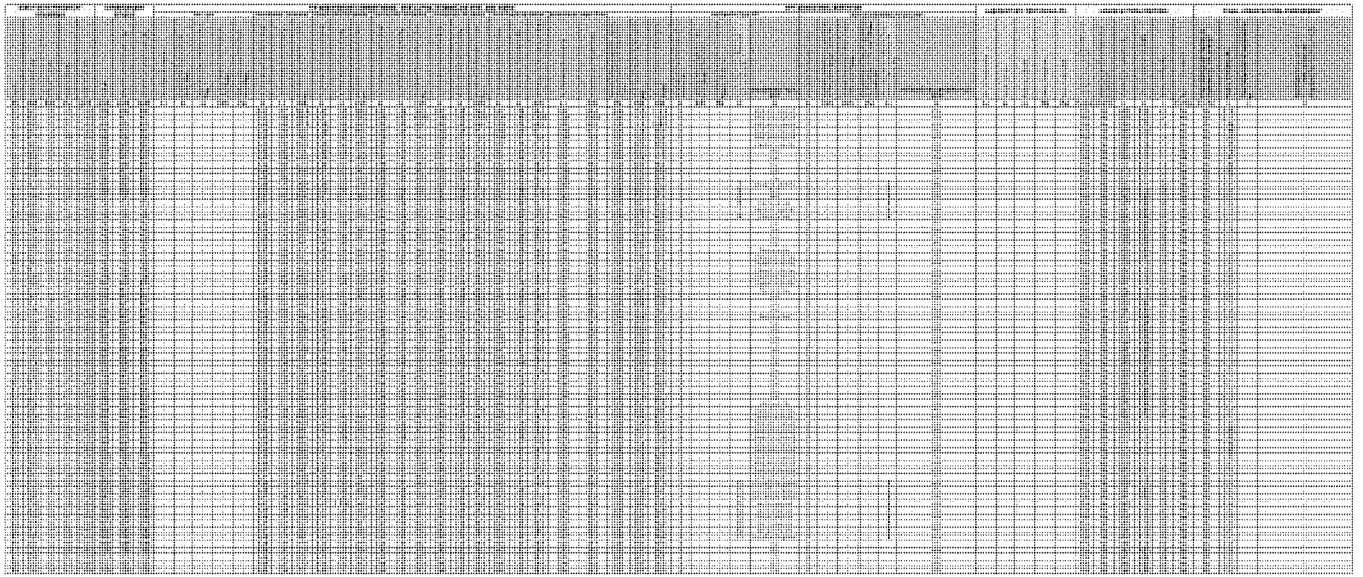
Prepared by: Nicholas Tollefson | Date: 12/15/2009
Checked by: | Date:

Data Input by Analyst
Results of Analysis
Calculated Values

Input Check parameters and values from Cone Evaluation worksheet

Ground Elevation (RAVD88) =	67.0
Groundwater Elevation During Exploration (RAVD88) =	39.0
Design Groundwater Elevation (h) =	56.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA_g) =	0.15
Location (Creek/Eastside/Waterside)	Creek
Earthquake Magnitude (M_w) =	7.2
Groundwater Depth bgs During Exploration (h) =	28.0
Groundwater Depth bgs During Earthquake(h) =	17.0
Total Number of Test Locations (N) =	1

Note: From Exploration Geology
Note: Typical Winter Preliminary Mean



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032))
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program, Rev. 6, March 2006.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

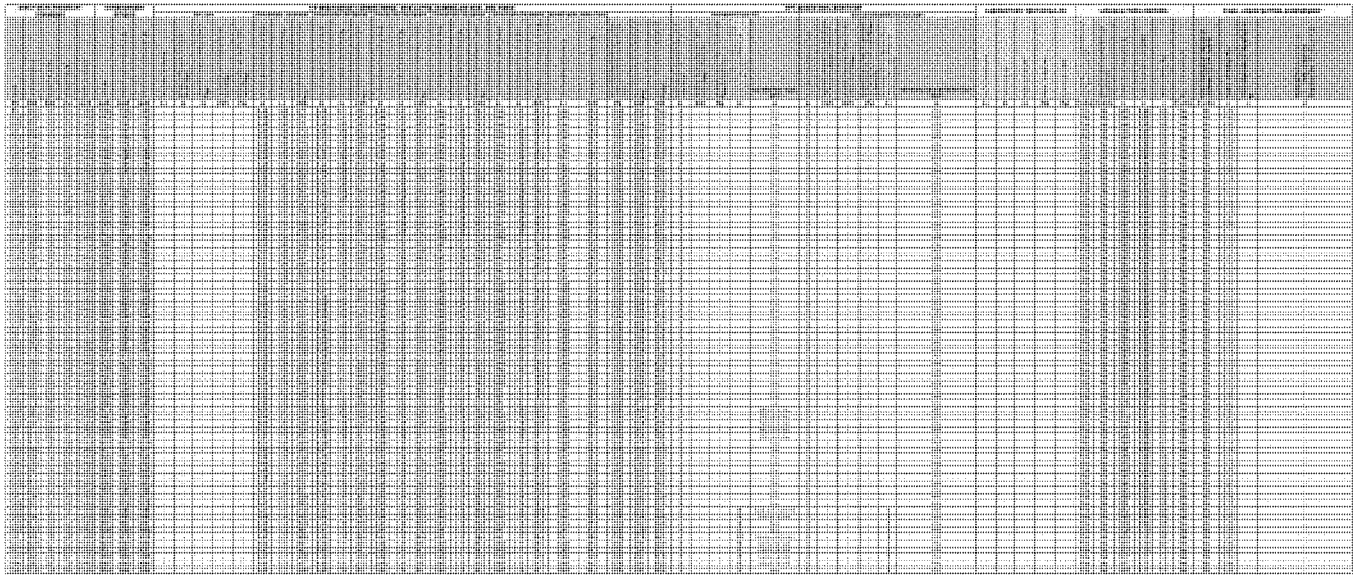
PROJECT NAME:	American River Common Features (ARC)
LEVEE SEGMENT:	RD#1000 - 058C
PROJECT NUMBER:	39-19750
Reach ID:	
Station:	1000+26
CPT ID:	WR1000_058C
CPT Location:	Levee Crest

Prepared by: Michael Tolentino | Date: 12/1/2009
Checked by: | Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest=Landside/Waterside and Slope=Top/Landside or Waterside

Ground Elevation (TAW/USB) =	37.2		
Groundwater Elevation During Exploration (NAVD88) =	13.0	Area	From Dissipation Tests
Design Groundwater Elevation (1) =	26.2	Area	Typical Winter Preliminary Mean
Return Period (Years) =	200		
Peak Ground Acceleration (**PGA**), g =	0.43		
Location (Crest/Landside/Waterside)	Crest		
Earthquake Magnitude (M_w) =	7.5		
Groundwater Depth (ft) During Exploration (ft) =	24.2		
Groundwater Depth (ft) During Calculation (ft) =	24.2		
Total Number of Data Points =	2000		



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003 "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
5. Bray, J.D., Sancio, R.B., 2006 "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features SRA
LEVEE SEGMENT:	RS42C (Arden)
PROJECT NUMBER:	3561895
Reach ID:	WR1000
Station:	1000+00
CPT ID:	WR1000_06BC
CPT Location:	Levee Crest

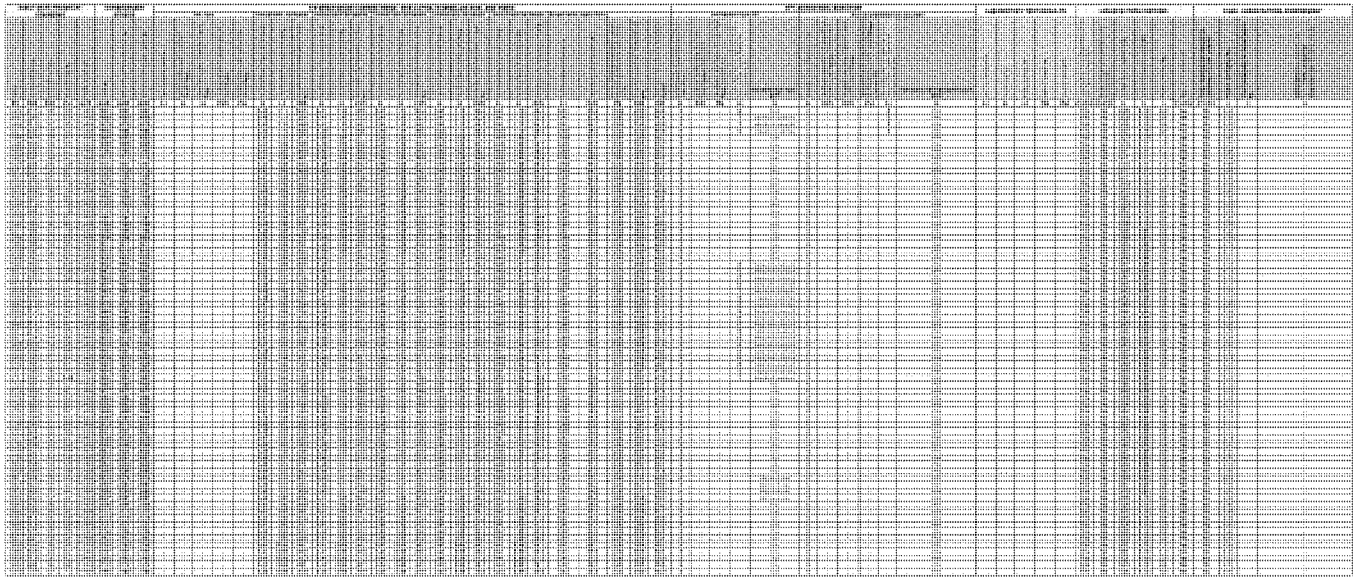
Prepared by: CC Mathias Sobedoye | Date: 12/15/2008
Checked by: | Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check all data/parameters and update as necessary in the yellow cells

Ground Elevation (NAVD88) =	97.2	ft
Groundwater Elevation During Exploration (NAVD88) =	43.0	ft
Design Groundwater Elevation (h) =	79.7	ft
Return Period (Years) =	200	
Peak Ground Acceleration (**PGA**, g) =	0.22	g
Location (Creek/Levee/Wall/Valley/etc)	Levee	
Earthquake Magnitude (M_w) =	7.0	
Groundwater Depth bgs During Exploration (ft) =	54.2	ft
Groundwater Depth bgs During Earthquake (ft) =	17.5	ft
User Number of Soil Layers = N =	8	Enter

Note: From Geospatial Testing
Note: Typical Winter Creekbed Mean



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051 (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2008.
4. Seed, R.B., Cetin, K.O., Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, 71 pp., Queens Many, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (AR)
LEVEE SEGMENT:	RD 800 (Unit)
PROJECT NUMBER:	2061676C
Reach ID:	
Sta/mi:	1000+26
CPT ID:	WR1000_058C
CPT Location:	Levee Crest

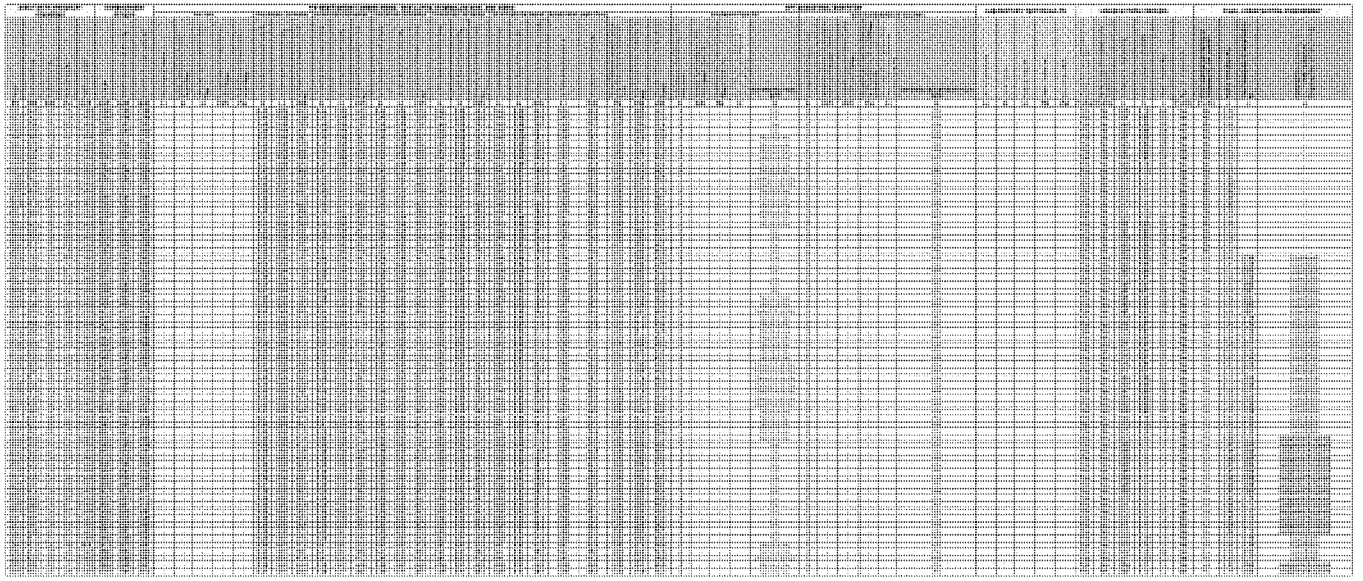
Analyzed by: Nicholas Toolsdad Date: 12/19/08
Checked by: Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Apply Crest/Landside/Waterside and Seismic Hyd Gradient per Recommendations

Ground Elevation (NAVD88) =	47.3
Groundwater Elevation During Exploration (NAVD88) =	15.0
Design Groundwater Elevation (h) =	29.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	32.3
Groundwater Depth bgs During Earthquake(ft) =	18.3
Data Sources:	CPT
Total Number Of Thin Layers (N_L) =	4

Note: From Discussion Testing:
Note: Depth Within Stratigraphy Meets



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)). Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6 March 2008
4. Seed, R.B., Cetin, K.O, Moss, R. S. E., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features SRFR
LEVEE SEGMENT:	RM000 - RM6
PROJECT NUMBER:	842-0745
Reach ID:	WR1000_058C
Mean:	200+28
CPT ID:	WR1000_058C
CPT Location:	Levee Crest

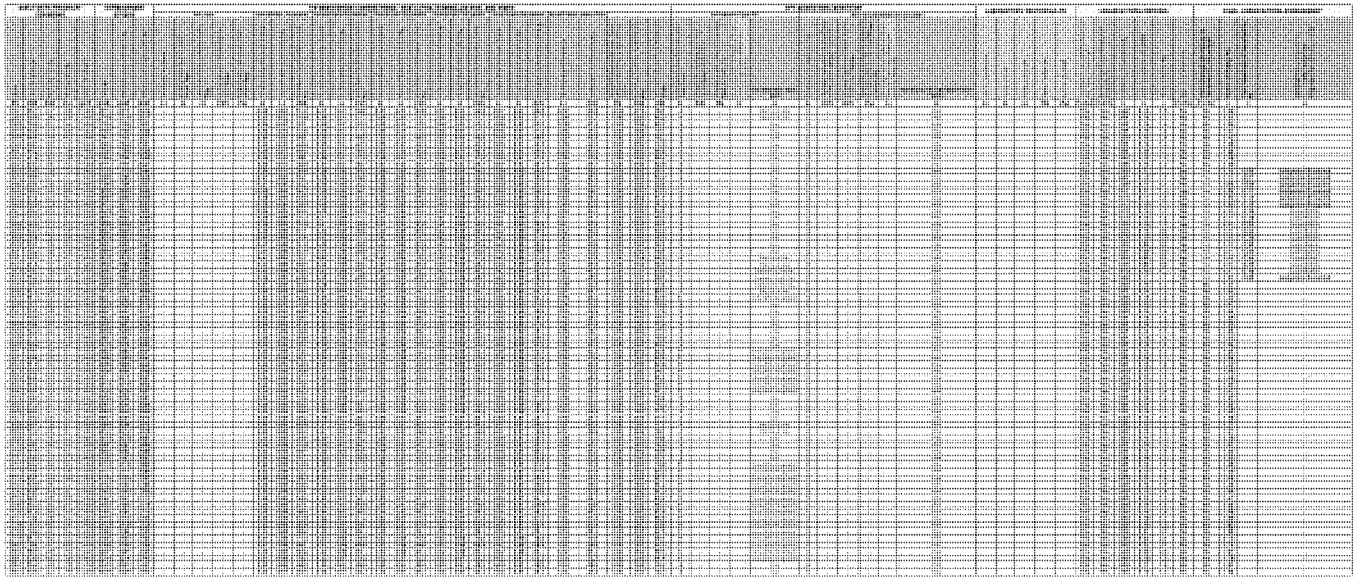
Analyzed by: JD Nichols-Tollefson | Date: 02/19/09
Checked by: | Date:

Note: Cells Highlighted Yellow are Input or from Spreadsheet Calculations

Data Input By Analyst
Result of Analysis
Estimated Values

Ground Elevation (NAVD88) =	47.0
Groundwater Elevation During Exploration (NAVD88) =	29.07
Design Groundwater Elevation (h) =	29.07
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Cmss/Landside/Waterside)	Cmss
Earthquake Magnitude (M_w) =	7.2
Groundwater Depth bgs During Exploration (ft) =	17.9
Groundwater Depth bgs During Earthquake(ft) =	17.9
Total Number of Soil Layers = N =	40

Note: From Dissipation Testing
Note: Approx. Winter Creek(very Mean)



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
State to Equation (6) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep. 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 0. March 2008.
4. Seed, R.B., Cetin, K.O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003 "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006 "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
9. Robertson, P.K. and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features SWF
LEVEE SEGMENT:	Natomas Levee
PROJECT NUMBER:	32B1696
Reach ID:	
Name:	WR1000
Sta (+):	WR1000_058C
CPT Location:	Levee Crest

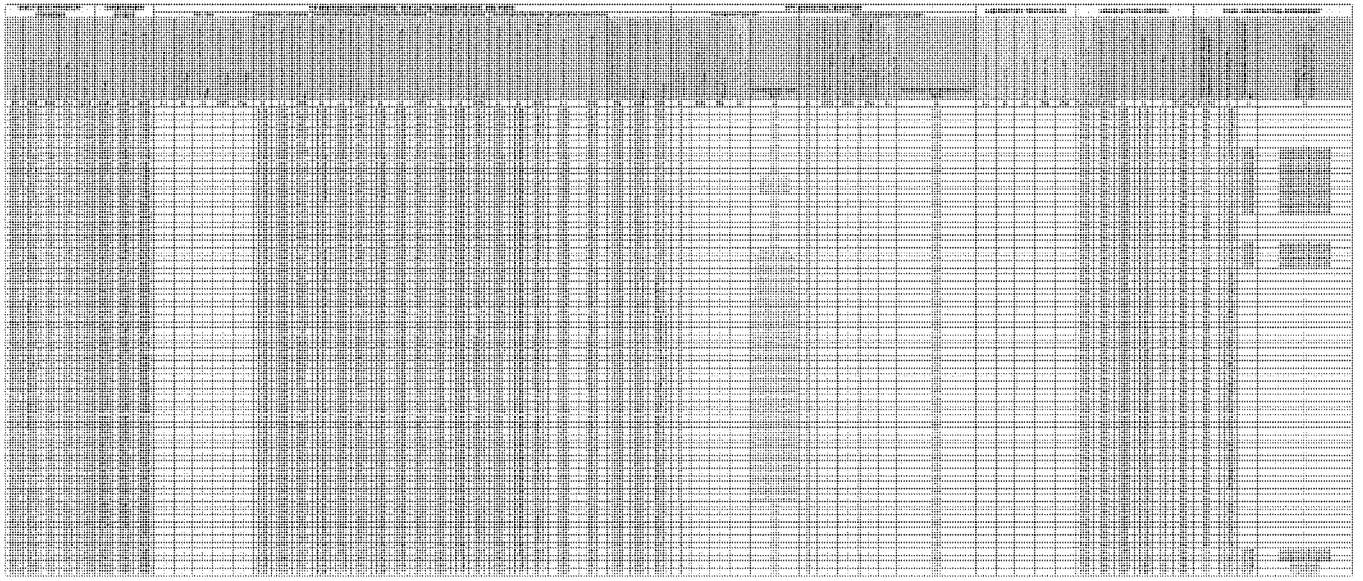
Analyzed by:	Nicholas Sigmon
Checked by:	
Date:	12/5/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (NAVD88) =	17.2
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	15.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Creek/Eastside/Waterside)	Creek
Earthquake Magnitude (M_w) =	7.2
Groundwater Depth bgs During Exploration (ft) =	32.0
Groundwater Depth bgs During Earthquake (ft) =	30.0
Total Number of Test Layers =	6

Note: Input Values in Yellow Cells

Note: From Desaturation Testing
Note: Typical Winter / Frequent Mean



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (6) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2006, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, PEMS, Queens Many, Long Beach, Ca.,
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	WR1000_058C
PROJECT NUMBER:	60178782
Reach ID:	200+26
Taken:	2007
CPT ID:	WR1000_058C
CPT Location:	Levee Crest

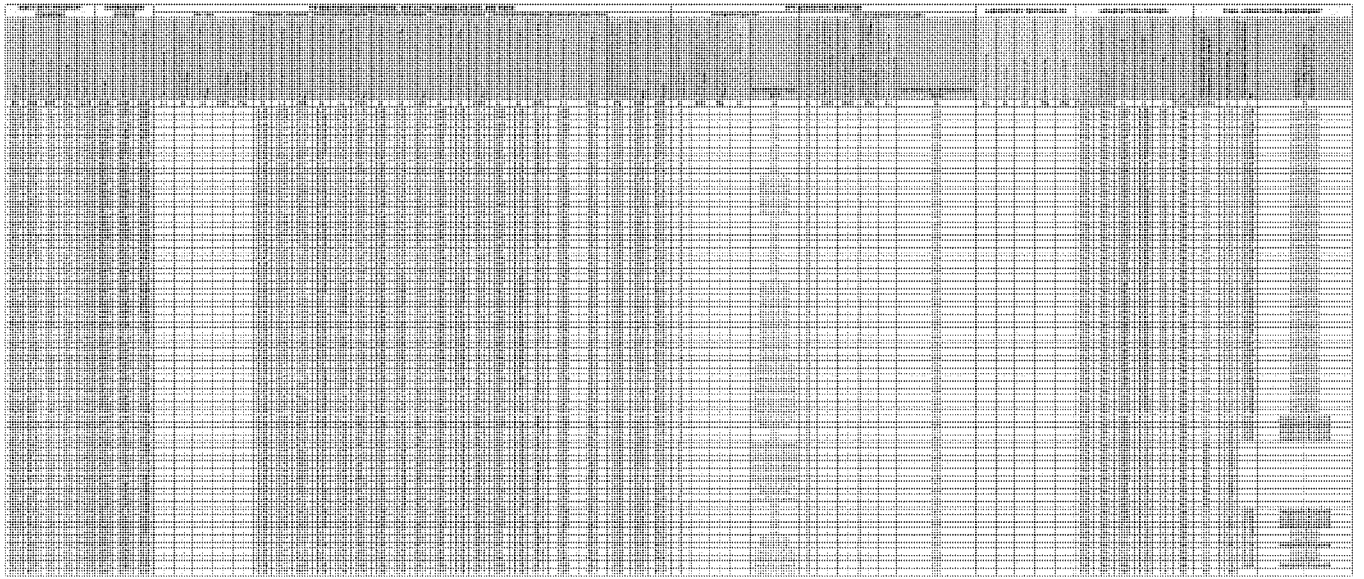
Input, Check and Save Worksheet Specific Data in Cells Below

Ground Elevation (NAVD88) =	47.2
Groundwater Elevation During Exploration (NAVD88) =	33.0
Design Groundwater Elevation (1) =	35.2
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Over/Landside/Waterside)	Over
Earthquake Magnitude (M_w) =	7.3
Groundwater Depth bgs During Exploration (ft) =	37.2
Groundwater Depth bgs During Earthquake(ft) =	35.0
Total Number of CPT Samples =	6

Note: From Dissipation Testing
Note: Typical Minor Overcurve Noted

Entered by: Andrew Tasillos | Date: 10/1/2009
Checked by: | Date:

Data Input By Analyst
Results of Analysis
Calculated Values



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2006, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
4. Seed, R.B., Cetin, K.O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.,
5. Bray, J.D., Sancio, R.B., 2006 "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features 2002
LEVEE SEGMENT:	RM1000 - 056C
PROJECT NUMBER:	3687/060
Reach ID:	
Station:	1034+26
CPT ID:	WR1000_056C
CPT Location:	Levee Crest

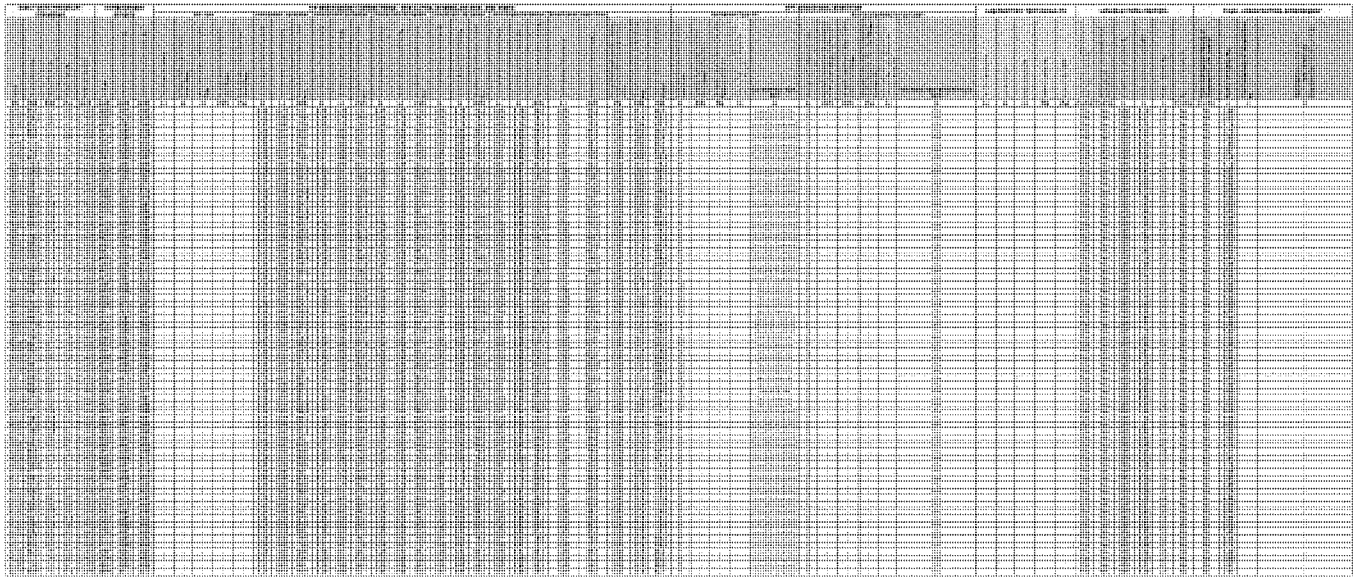
Analyst: | Michael Tomlinson | Date: | 12/15/2008
Checked by: | | Date: |

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check sample descriptions and stratigraphy for consistency with CPT profile before interpretation.

Ground Elevation (NAVD88) =	47.0
Groundwater Elevation During Exploration (NAVD88) =	29.0
Design Groundwater Elevation (h) =	29.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Liquefy (Yes/Liquefiable/Materials)	Other
Earthquake Magnitude (M_w) =	7.2
Groundwater Depth bgs During Exploration (ft) =	18.0
Groundwater Depth bgs During Earthquake(ft) =	18.0
Total Number of Soil Layers =	8

Note: From Liquefaction Testing
Note: Typical Value (Temporary value)



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2006, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
9. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features LSAC
LEVEE SEGMENT:	RM000 to RM1
PROJECT NUMBER:	38078740
Reach ID:	
Taken:	Landside
CPT ID:	WR1000_058C
CPT Location:	Levee Crest

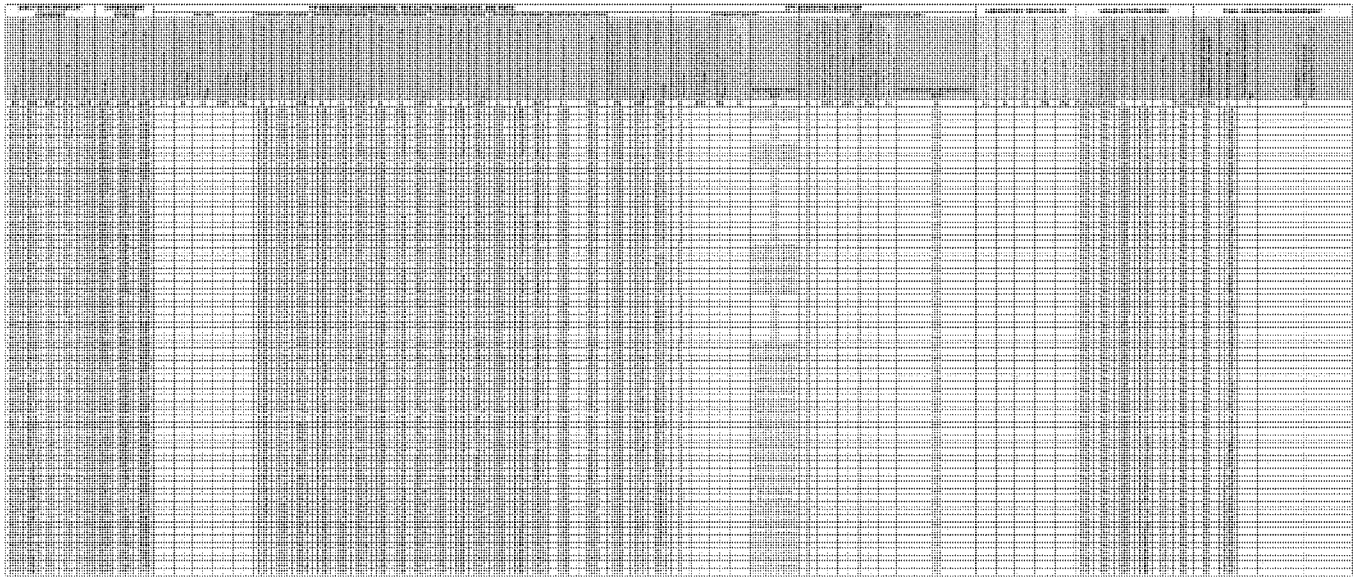
Prepared by: Brandon Townsend Date: 12/1/2008
Checked by: Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Input: Enter positive values and values less than or equal to zero will terminate input

Ground Elevation (NAVD88) =	47.0
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (3) =	26.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Cres/Landside/Waterside)	Cres
Earthquake Magnitude (M_w) =	7.3
Groundwater Depth bgs During Exploration (ft) =	34.0
Groundwater Depth bgs During Earthquake(ft) =	21.0
Total Number of Data Layers (No.) =	60

Note: From Dissipation Testing
Note: Typical Winter Frequency Mean



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032–1051. Ltd 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis. Urban Levee Geotechnical Evaluations Program Rev. 6. March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442–459.

PROJECT NAME:	American River Common Features SRR
LEVEE SEGMENT:	REMEC WR6
PROJECT NUMBER:	13615798
Reach ID	
Station	Wilkinson
CPT ID:	WR1000_058C
CPT Location:	Levee Crest

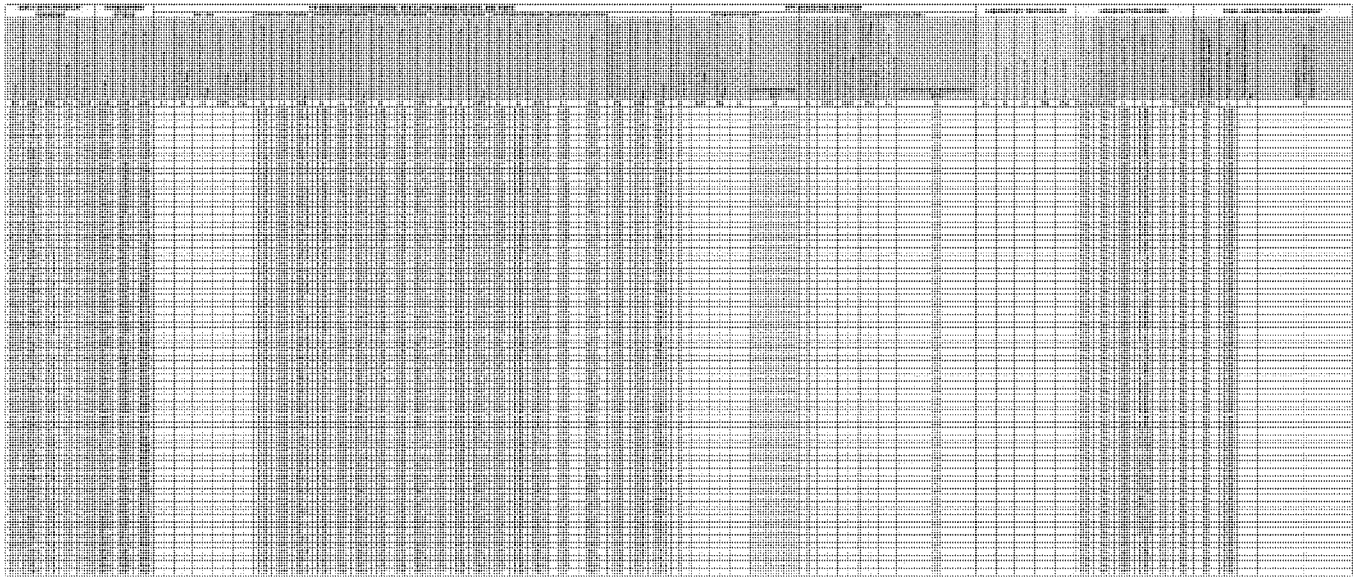
Analyst: Jose Gonzalez Checked by: Alex Sancio Date: 02/17/2009

Analyzed by:	Nicholas Tolentino
Checked by:	
Date:	02/17/2009
Date:	

Data Input By Analyst
Results of Analyses
Calculated Values

Ground Elevation (NAVD88) =	49.2
Groundwater Elevation During Exploration (NAVD88) =	23.0
Design Groundwater Elevation (9) =	39.2
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.42
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (9) =	49.2
Groundwater Depth bgs During Earthquake(ft) =	33.0
Total Number of Data Layers =	1

Note: From Geospatial Testing
Note: Typical Winter Fluctuating Mean



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2006, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
4. Seed, R.B., Cetin, K.O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K. and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	REMOVE WAY
PROJECT NUMBER:	60139750
Reach ID:	Reach 1
Taluvs:	Approx.
CPT ID:	WR1000_06BC
CPT Location:	Levee Crest

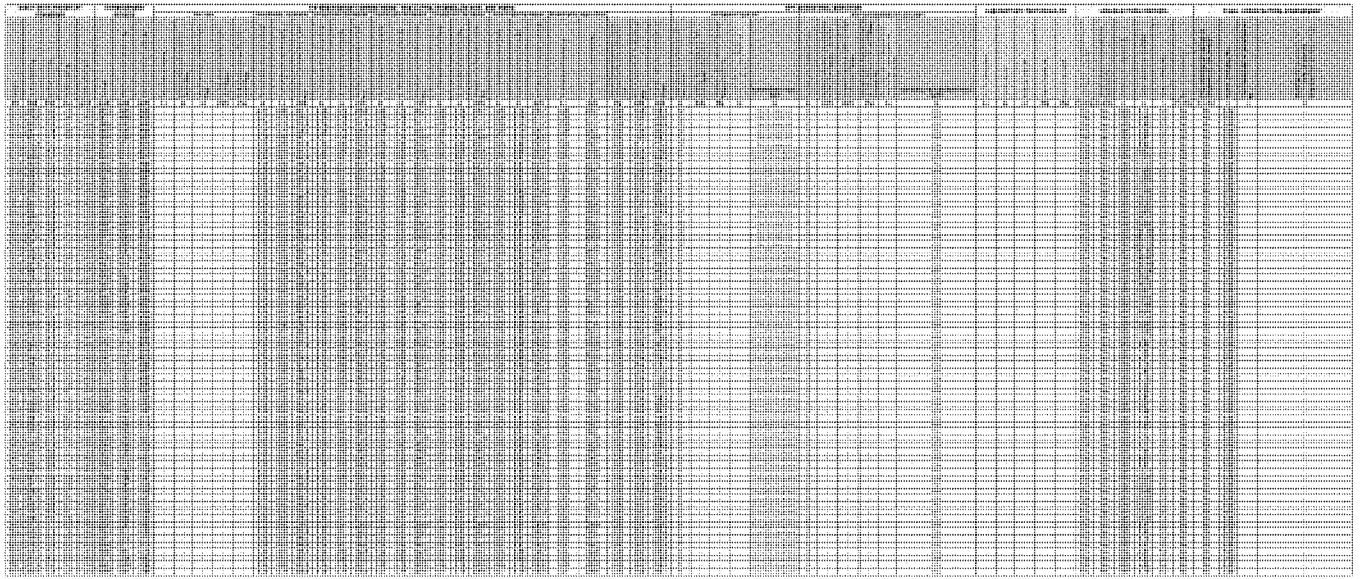
Analyzed by: Co-Author Technician | Date: 02/2009
Checked by: | Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest Location Type Kips, and Schema Was Used to Locate Test Relative to Toe

Ground Elevation (NAVD88) =	49.2
Groundwater Elevation During Exploration (NAVD88) =	12.0
Design Groundwater Elevation (h) =	29.2
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	36.2
Groundwater Depth bgs During Earthquake(ft) =	20.0
Total Number of Test Layers =	90

Note: From Dissipation Testing
Note: Typical Where Necessary Manually



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032–1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Route to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6. March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (2008)
LEVEE SEGMENT:	REMOC Levee
PROJECT NUMBER:	36810740
Report ID	
Station	70+00
CPT ID	WR1000_068C
CPT Location:	Levee Crest

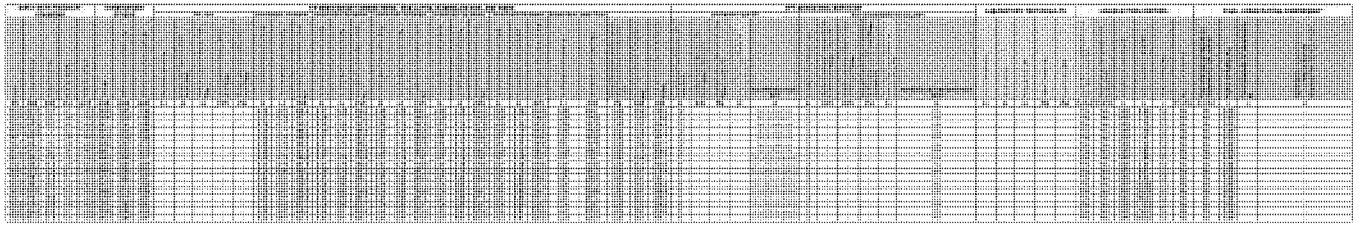
Prepared by: Eric Michels Tallabas | Date: 02/16/09
Checked by: | Date:

Geotechnical Engineering Analysis
Results of Analysis
Calculated Values

Note: Check Liquefaction Potential and Seismic Slope Stability for Levee Embankment

Ground Elevation (NAVD88) =	47.2
Groundwater Elevation During Exploration (NAVD88) =	33.0
Design Groundwater Elevation (ft) =	29.7
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Creek/Levee/Watershed)	Creek
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	14.2
Groundwater Depth bgs During Earthquake(ft) =	17.5
Total Number of Test Layers =	1000

Note: Pore Dissipation Testing
Note: Typical Value for Preliminary Design



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi: 10.1061/ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Navy, Long Beach, Ca .
5. Bray, J.D., Sancio, R.B., 2006 "Assessment of the Liquefaction Susceptibility of Fine Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	Arbuckle River Crossings Feasibility Study
LEVEE SEGMENT:	Middle Creek
PROJECT NUMBER:	26810780
Reach ID:	
Station:	252+47
CPT ID:	WR1000_006C
CPT Location:	Levee Crest

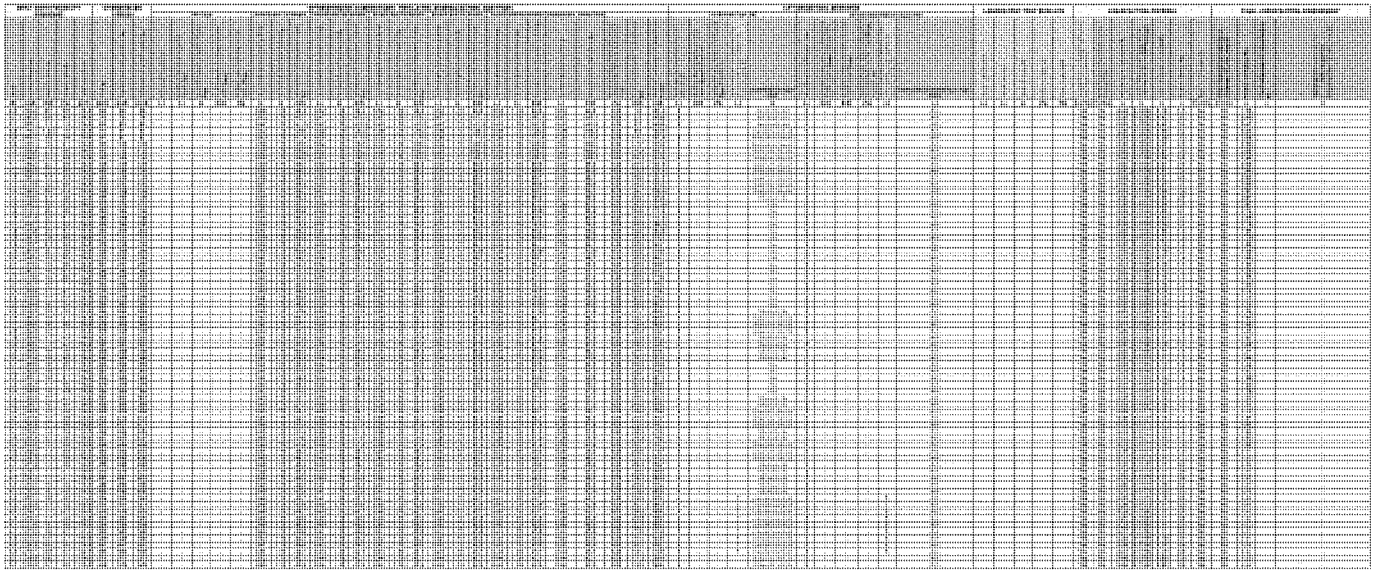
Analyzed by: Joe Bonkoski (jbonkos) Date: 10/15/08
Checked by: Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check Liquefiable Materials and Sample Every Change in Material Type

Note: From Liquefaction Testing
Note: Typical Values (Reference Manual)

Ground Elevation (NAVD88) =	42.5
Groundwater Elevation During Exploration (NAVD88) =	2.5
Design Groundwater Elevation (ft) =	24.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.47
Location (Coastal,Inland,Watershed)	Inland
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth during Exploration (ft) =	40.0
Groundwater Depth during Earthquake(ft) =	20.0
Total Number of Thin Layers (N) =	0



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006 "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997 Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.B. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006 "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	Hydrologic River Cumm.(s) Failures (HEC
LEVEE SEGMENT:	RDMC_0000
PROJECT NUMBER:	25147.06
Reach ID:	
Station:	0+00
CPT ID:	WR1000_006C
CPT Location:	Levee Crest

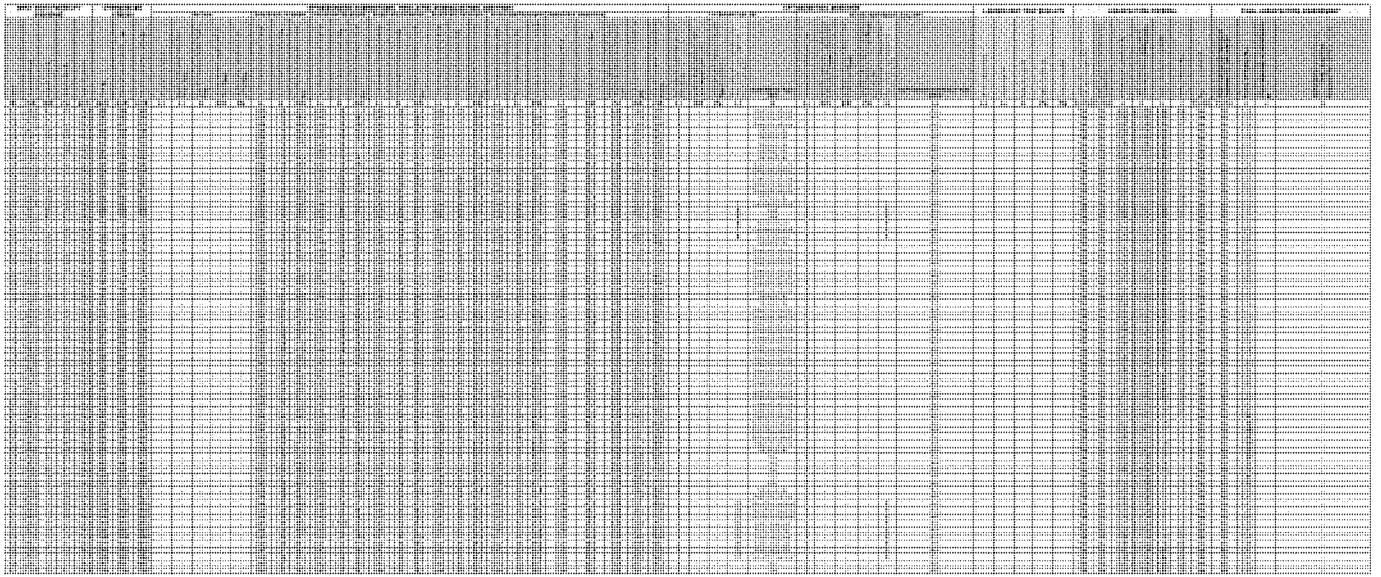
Analyzed by: Nicholas Valentine Date: 2/17/2009
Checked by: Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check Liquefied Materials very Sensitive from Overall Soil Behavior Type (SBT) Index Ic

Ground Elevation (NAVD88) =	42.5
Groundwater Elevation During Exploration (NAVD88) =	32
Depth Groundwater Elevation (ft) =	10.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.43
Location (Cmte/Levee/Watershed)	Cache
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth/gs During Exploration (ft) =	40.0
Groundwater Depth/gs During Earthquake(ft) =	32.0
Total Number of Thin Layers (N) =	40

Note: Front Dissipation Testing
Note: Typical Sandy / Non-Clay Material



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu J., Pestana, J. M., Riemer, M. F., Sancio, R.B, Bray, J. D., Kayen, R. E., Faris, A., 2002, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.B. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	Natomas West
PROJECT NUMBER:	25L1982
Reach ID:	WR1000_006C
Station:	252+47
CPT ID:	WR1000_006C
CPT Location:	Levee Crest

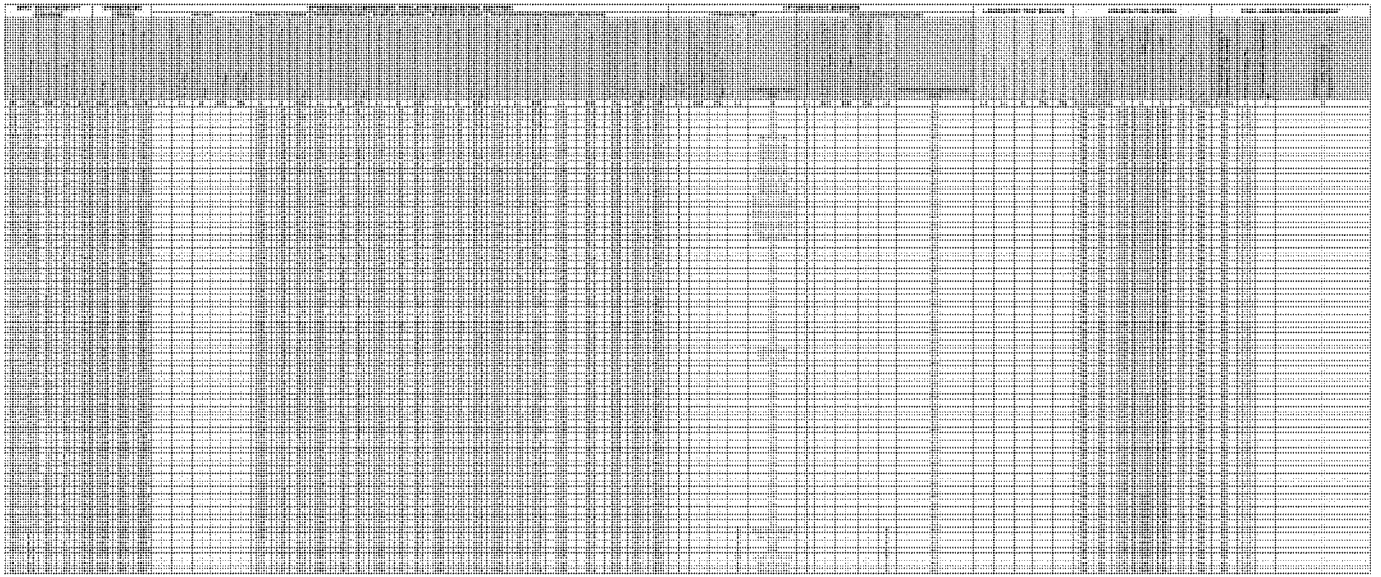
Note: Check/Analyst/Reviewer to fill in items from Checklist (Attachment A) for

Analyzed by:	Nichole Tollefson
Checked by:	
Date:	10/13/08
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (NAVD88) =	47.5
Groundwater Elevation During Exploration (NAVD88) =	23
Design Groundwater Elevation (ft) =	23.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA_g) =	0.22
Location (Creek/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	6.0
Groundwater Depth-bgs During Exploration (ft) =	40.0
Groundwater Depth-bgs During Earthquake(ft) =	30.0
Total Number of Soil Layers (N) =	7

Note: From Geophysical Testing
Note: Typical Winter (Recovery Month)



730

URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of *in Situ* Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)). Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	Analysis Sheet Copyright Exercises 2008
LEVEE SEGMENT:	Natomas Levee
PROJECT NUMBER:	2981.0160
Reach #:	1
Station:	252+47
CPT ID:	WR1000_006C
CPT Location:	Levee Crest

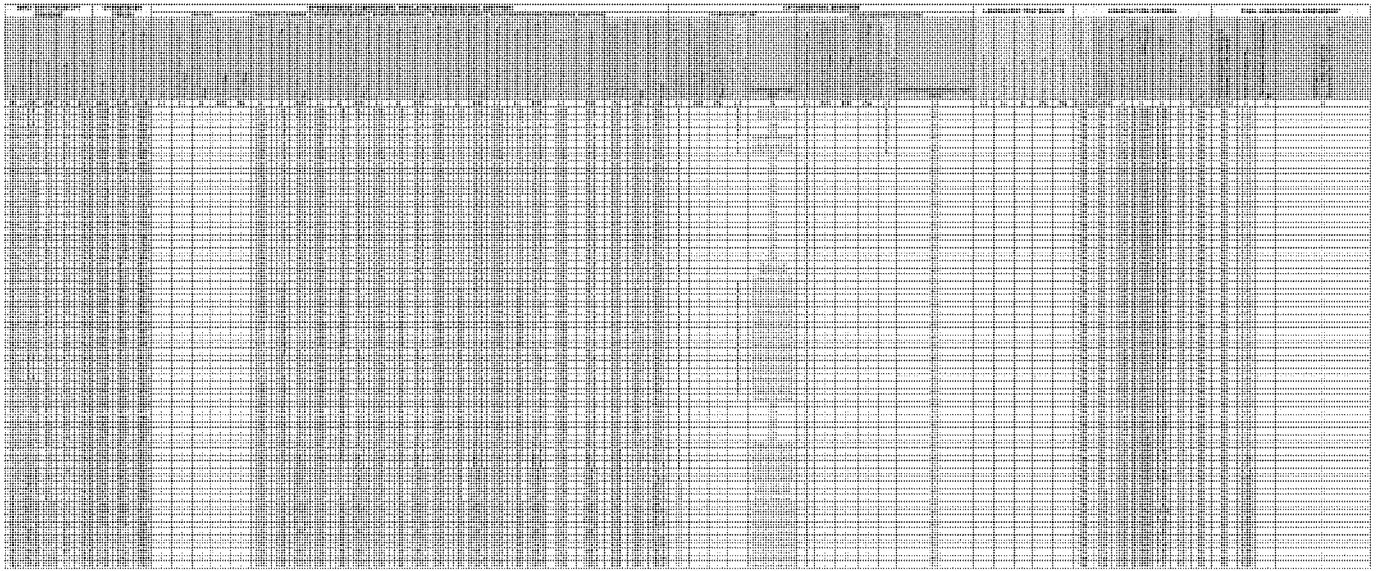
Analysis by:	Barbara Robertson
Checked by:	
Date:	02/13/09

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check assumed values and update from CPT data as necessary.

Ground Elevation (NAVD88) =	42.5
Groundwater Elevation During Exploration (NAVD88) =	24.5
Design Groundwater Elevation (ft) =	24.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Creek/Levee/Watershed)	Creek
Earthquake Magnitude (M_w) =	6.0
Groundwater Depth bgs During Exploration (ft) =	18.0
Groundwater Depth bgs During Earthquake(ft) =	18.0
Total Number of Thin Layers (N) =	0

Note: Enter From Deposition Testing
Typical Winter (Fall-Spring) Levee



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442–459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	REMCF_Area
PROJECT NUMBER:	25819150
Reach ID:	
Station:	Reach 1
CPT ID:	WR1000_006C
CPT Location:	Levee Crest

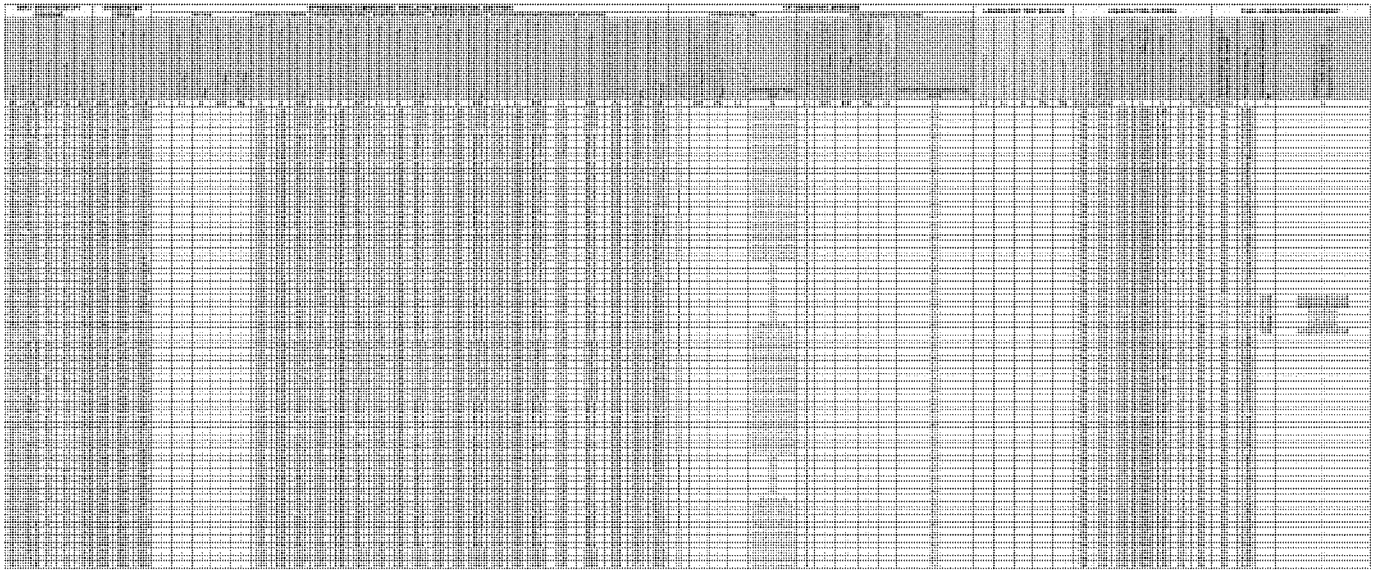
Analyzed by: Richard Toleman Date: 08/2008
Checked by: Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Depth and Soil Parameters are all Taken from Data Input Worksheet

Ground Elevation (NAVD88) =	42.0
Groundwater Elevation During Exploration (NAVD88) =	23
Design Groundwater Elevation (ft) =	24.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.52
Location (Creek/Levee/Watershed)	Creek
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth ogs During Exploration (ft) =	40.0
Groundwater Depth ogs During Earthquake(ft) =	18.0
Total Number of Soil Layers (N) =	5

Input: From Geoprobe® Testing
Output: Shifted (Robertson) Method



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DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published in the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, 71 M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features 2008
LEVEE REACH:	Natomas West
PROJECT NUMBER:	32810760
Reach ID:	
Station:	Various
CPT ID:	WR1000_096C
CPT Location:	Levee Crest

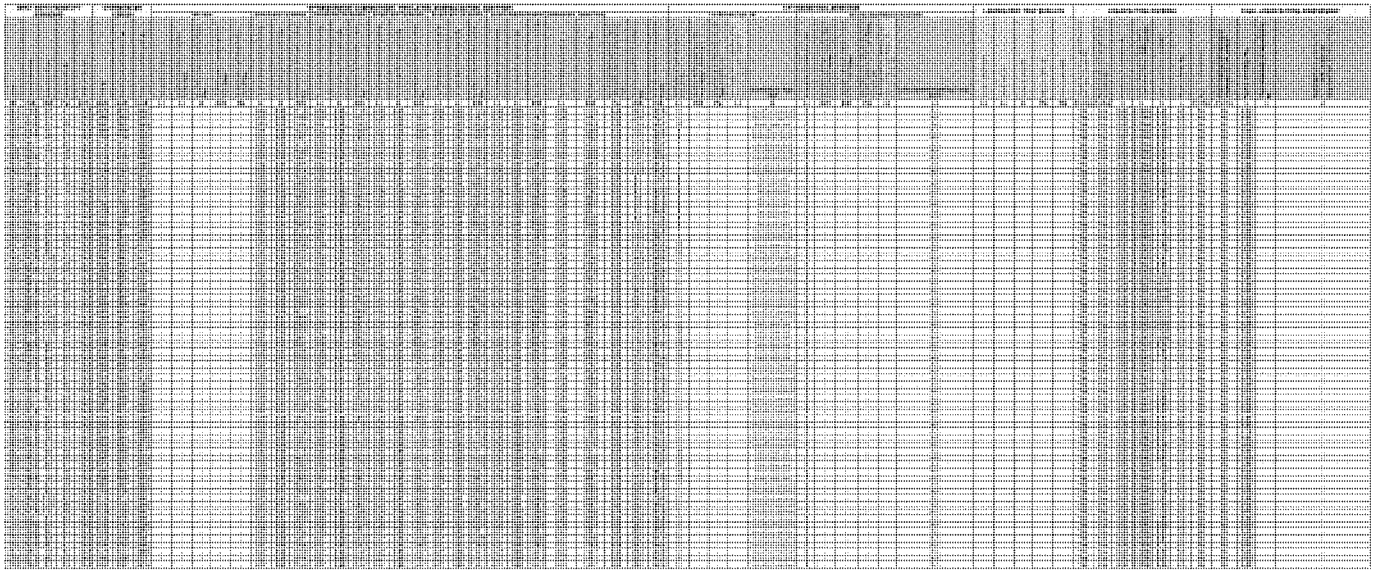
Prepared by: Nicholas Tollefson Date: 10/13/08
Checked by: Date:

Data Input By Anwrst
Length of Analysis
Calculated Values

Note: Consult Geotechnical Memorandum and Appendix Form Checklist for Guidance on Preferred Use

Ground Elevation (NAVD88) =	42.5
Groundwater Elevation During Exploration (NAVD88) =	23
Design Groundwater Elevation (ft) =	26.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth.bgs During Exploration (ft) =	19.5
Groundwater Depth.bgs During Earthquake(ft) =	19.5
Total Number of Top Layers (N) =	11

Note: From Geophysics Testing
Note: Typical Value (Recovery Model)



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DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.B. Queens Many, Long Beach, Ca.,
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	NEMEC WEST
PROJECT NUMBER:	28138G
Reach ID:	Reach 1
Station:	252+47
CPT ID:	WR1000_008C
CPT Location:	Levee Crest

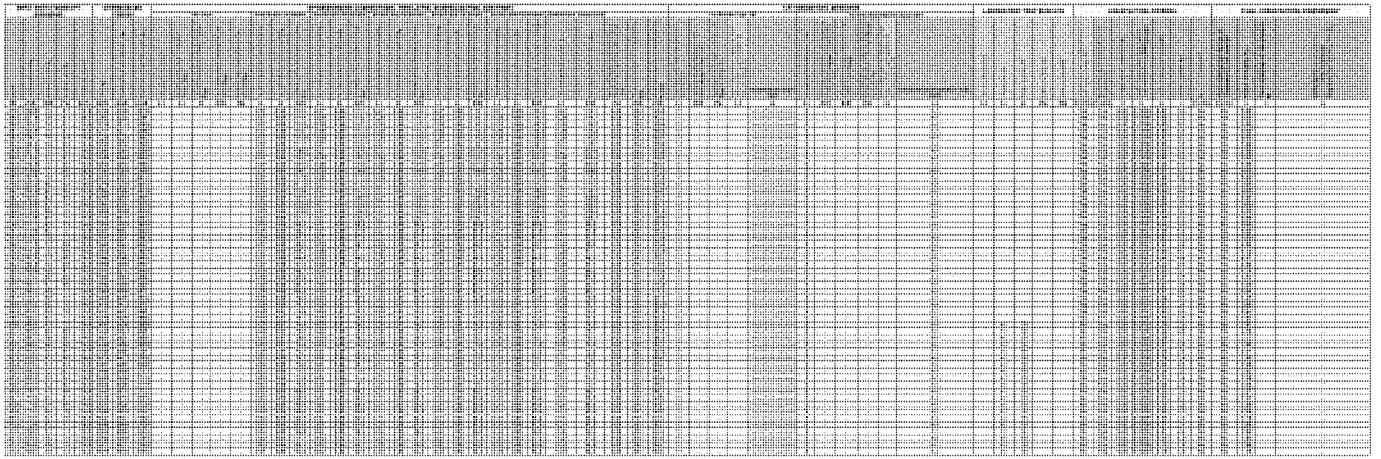
Analyzed by: Michele Tolentino Date: 10/1/2008
Checked by: Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest, toe, and Riverside, and values from Google spreadsheet Reference.xls

Ground Elevation (NAVD88) =	42.5
Groundwater Elevation During Exploration (NAVD88) =	2.5
Design Groundwater Elevation (ft) =	24.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.52
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth during Exploration (ft) =	40.0
Groundwater Depth during Earthquake(ft) =	24.5
Total Number of Pre-Drilled Soil Layers =	4

Note: From Dissipation Testing
Note: Typical Water Density Used



URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2008. *Guidance Document for Geotechnical Analysis , Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Queens Marry, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on NCAL and SCAL sampler corrections)*

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	RERIEC - RM46
PROJECT NUMBER:	29416/14.4500
Reach ID:	357447
Boring ID:	MR1GEC_0039
Boring Location (Coord. system/Datum/etc. and distance from/coord. and bearing to/name)	Levee Crest

Analysis By:	Michael Tollefson
Check By:	

Date:	9/24/2009
Date:	

Data Input (By Analyst)
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 47.0
Groundwater Elev. During Drilling (ft.) = 29
Assigned Groundwater Elevation (ft.)= 29

Note: Moisture Content and Boring Log
Note: Lab Test Revelved (Change to FES Name)

Groundwater Depth Below GS During Drilling (ft.) = 18.0
Analyzed Groundwater Depth Below GS (ft.) = 18.0

Hammer Type = Automatic
Energy Ratio = 72

Earthquake Information
Return Period (years) = 200
M_w = 6.8

PGA (g) = 0.12
Location = Crest (Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o'(psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (i.e. for SCAL, NCAL)	H_s for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Slide Up (Fraction) Rod Length Above Ground (Ref)	Rod Length (m)	Rod Length Correction Factor, C_R	M_{fd}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Sustance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS_L = 1.2 (Yes/No) Column AC	Below Analyzed Groundwater Level (Yes/No) Column AT	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Assessment (Yes/No) Based on Columns AJ, AK, and AM	Factor of Safety, FS	Comment (Liquefiable for FS<1 and Judgment Required for 1.0<FS<1.3)
S01A	6.5	15	SC	130	65	65	65	1.8	1.2	H	10	1.15	S	24	1.20	1.00	7	2.0	0.75	16	25		12	1.1	27	0.547	0.139	0.000	3.93	No	No	SC				Yes	No	3.00	-
S02A	2.5	13	SC	130	325	325	325	1.8	1.2	H	10	1.15	S	21	1.20	1.00	7	2.5	0.75	13	22	44	35	1.2	26	0.341	0.118	0.000	2.89	No	No	SC	30	14	14	Yes	No	2.88	-
S03A	5	6	SC	120	650	650	650	1.5	1.2	H	10	1.15	S	10	1.11	1.00	7	3.4	0.75	6	10		12	1.1	11	0.089	0.117	0.000	0.76	Yes	No	SC				Yes	No	0.74	-
S04A	7.5	11	CL	110	925	925	925	1.5	1.2	H	10	1.15	S	16	1.20	1.00	7	4.1	0.79	12	18	57	70	1.2	22	0.191	0.115	0.000	1.66	No	No	CL	35	19	18	Yes	No	1.58	-
S05A	10	5	CL	110	1200	1200	1200	1.3	1.2	H	10	1.15	S	6	1.10	1.00	7	4.9	0.83	5	7	65	55	1.4	10	0.071	0.113	0.000	0.63	Yes	No	CL	37	24	18	No	No	0.61	-
S06A	12.5	7	CL	110	1475	1475	1475	1.2	1.2	H	10	1.15	S	8	1.11	1.00	7	5.6	0.87	8	10		35	1.3	13	0.092	0.111	0.675	0.74	Yes	No	CL				Yes	No	0.74	-
S08A	17.5	16	CL	110	2925	2925	2925	1.0	1.2	H	10	1.15	S	18	1.27	1.00	7	7.2	0.92	23	23		99	1.2	28	0.228	0.107	0.000	2.12	No	No	CL				Yes	No	2.12	-
S10A	22.5	27	SC	130	3675	3675	3675	0.9	1.2	H	10	1.15	S	23	1.30	1.00	7	8.7	0.95	35	31	40	35	1.2	37	0.413	0.105	0.000	3.90	No	No	SC				Yes	No	3.90	-
S11A	25	45	SC	130	3900	3900	3900	0.8	1.2	H	10	1.15	S	37	1.30	1.00	7	9.4	0.96	60	49		72	1.1	52	1.236	0.104	0.000	3.90	No	No	SC				Yes	No	3.90	-
S15A	35	46	CL	110	3850	3850	3850	0.8	1.2	M	5	1.02	S	35	1.30	1.00	7	11.9	0.98	59	41		35	1.2	49	0.349	0.104	0.000	3.00	No	No	CL	41	19	26	Yes	No	3.00	-
S16A	35	49	CL	110	4100	4100	4100	0.7	1.2	M	5	1.02	S	34	1.30	1.00	7	12.5	0.99	58	46		35	1.2	49	0.350	0.103	0.000	3.00	No	No	CL				Yes	No	3.00	-
S18A	40	44	CL	110	5200	4890	4890	0.6	1.2	M	5	1.02	S	29	1.30	1.00	7	16.5	0.99	56	36	56	73	1.2	43	0.545	0.099	0.000	3.00	No	Yes	CL	26	9	21	Yes	No	3.00	-
S20A	50	95	ML	120	5800	5178	5178	0.6	1.2	M	5	1.02	S	22	1.30	1.00	7	17.1	1.00	43	27	80	95	1.2	52	0.343	0.096	0.000	2.51	No	Yes	ML				Yes	No	2.51	-
S22A	55	35	MH	120	6400	5466	5466	0.6	1.2	M	5	1.02	S	21	1.30	1.00	7	18.6	1.00	43	26	84	35	1.2	31	0.225	0.093	0.000	2.41	No	Yes	MH	65	47	68	No	No	2.41	-
S24A	60	91	SM	130	7800	5894	5894	0.6	1.2	M	5	1.02	S	30	1.30	1.00	7	20.1	1.00	62	37	49	91	1.2	43	0.556	0.090	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S26A	65	33	SM	130	7100	6142	6142	0.6	1.2	M	5	1.02	S	32	1.30	1.00	7	21.6	1.00	69	37		72	1.1	39	0.402	0.089	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S28A	70	46	SM	130	8350	6490	6490	0.6	1.2	M	5	1.02	S	36	1.30	1.00	7	23.2	1.00	86	51	30	76	1.2	57	0.720	0.089	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S29A	75	100	CL	110	8900	6718	6718	0.5	1.2	M	5	1.02	S	65	1.30	1.00	7	24.7	1.00	122	67		25	1.2	76	7.354	0.087	0.000	3.00	No	Yes	CL	40	19	21	Yes	No	3.00	-
S32B	80	56	SM	130	9550	7056	7056	0.5	1.2	M	5	1.02	S	32	1.30	1.00	7	26.2	1.00	69	36		72	1.1	39	0.372	0.086	0.000	3.00	No	Yes	SM				Yes	No	3.00	-
S33A	80.5	56	ML	120	9610	7085	7085	0.5	1.2	M	5	1.02	S	35	1.30	1.00	7	26.4	1.00	69	36	67	25	1.2	43	0.517	0.085	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
S34A	85	100	ML	120	10155	7344	7344	0.5	1.2	M	5	1.02	S	52	1.30	1.00	7	27.7	1.00	110	64	67	55	1.2	75	5.970	0.084	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
S36A	90	100	ML	135	10799	7632	7632	0.5	1.2	M	5	1.02	S	51	1.30	1.00	7	29.3	1.00	122	63	78	33	1.2	73	4.789	0.082	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
S38A	95	100	ML	125	11350	7920	7920	0.5	1.2	M	5	1.02	S	50	1.30	1.00	7	30.8	1.00	122	62		35	1.2	72	4.206	0.080	0.000	3.00	No	Yes	ML				Yes	No	3.00	-
S40A	100	100	ML	120	11900	8209	8209	0.5	1.2	M	5	1.02	S	43	1.30	1.00	7	32.3	1.00	122	58		35	1.2	71	3.676	0.079	0.000	3.00	No	Yes	ML	40	6	33	Yes	No	3.00	-
S42A	105	58	CL	110	12595	8446	8446	0.5	1.2	M	5	1.02	S	28	1.30	1.00	7	33.8	1.00	71	35		35	1.2	41	0.429	0.077	0.000	3.00	No	Yes	CL	36	15	17	Yes	No	3.00	-

URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 4, March 2008.
4. Seed, R.B., Cetin, K.O., Moss, R. E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	SMDC West
PROJECT NUMBER:	39557690
Reach ID:	
Station:	334+74
CPT ID:	WR1000_050C
CPT Location:	Levee Crest

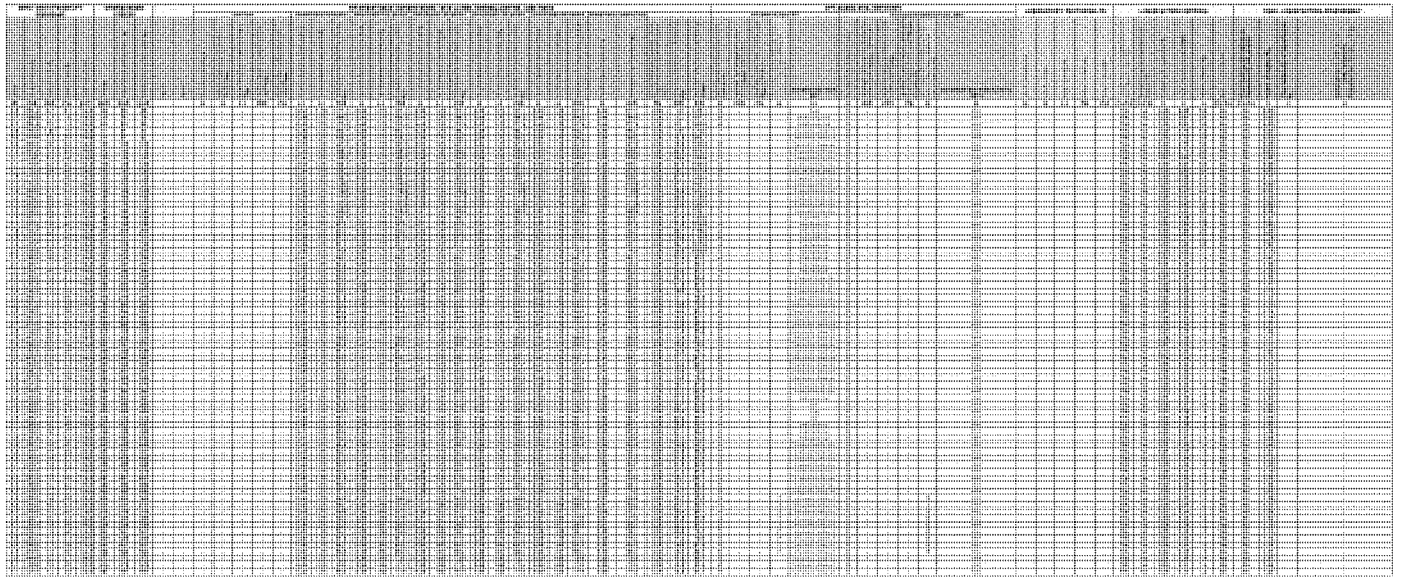
Analyzed by: Nicholas Tallenbach | Date: 02/04/09
Checked By: | Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest Landside/Waterside are distinct from Crest Landside/Waterside toe

Ground Elevation (NAVD88) =	41.0
Groundwater Elevation During Exploration (NAVD88) =	37.0
Design Groundwater Elevation (ft) =	23.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.12
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	4.0
Groundwater Depth bgs During Earthquake(ft) =	17.5
Total Number of Thin Layers (< 2") =	0

Note: From Geophysics Tested
Note: Typical Water Recovery Week



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DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
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2. Lunne, T., Robertson, P. K. and Powell, J.J.M. 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
4. Seed, R.B., Cetin, K.O. Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A. 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Idriss, I.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering. Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR
LEVEE SEGMENT:	NEMDC West
PROJECT NUMBER:	29510766
Reach ID	
Station	334+74
CPT ID:	WR1000_050C
CPT Location:	Levee Crest

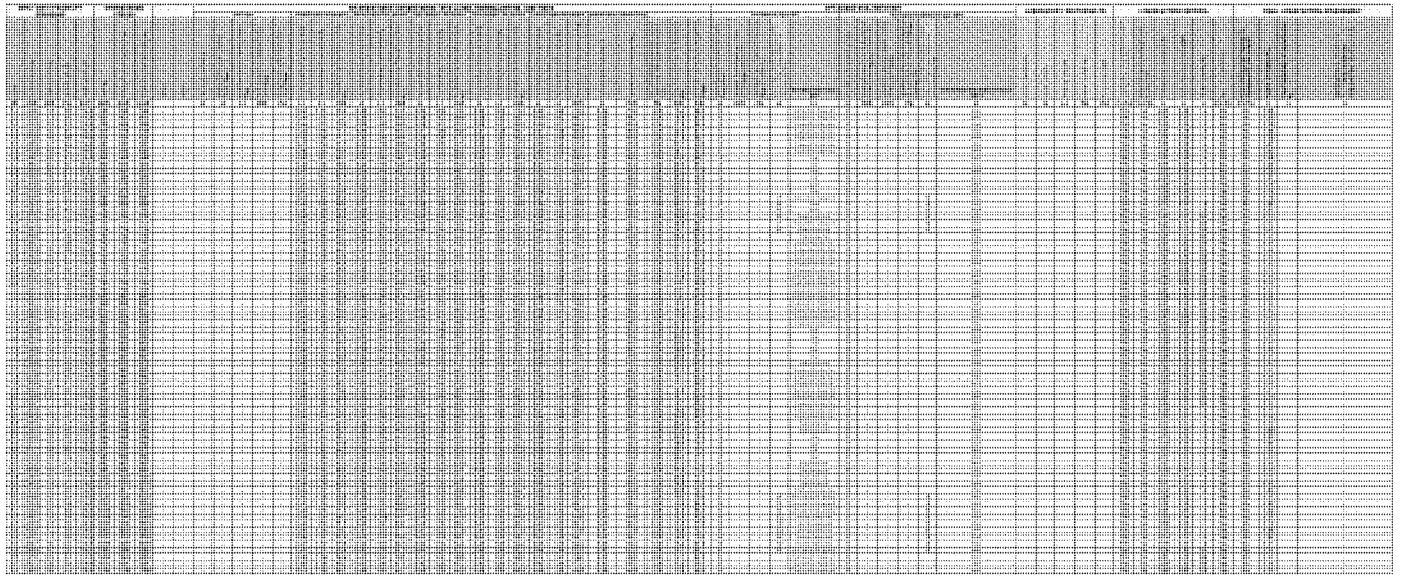
Analyzed by:	Nikola Tableski
Checked by:	
Date:	2/17/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest, Landside/Waterside, and Distance from Crest/Levee Toe Information

Ground Elevation (NAVD88) =	41.0
Groundwater Elevation During Exploration (NAVD88) =	19.0
Design Groundwater Elevation (ft) =	23.5
Return Period (Years) =	200
Peak Ground Acceleration	PGA, g) =	0.52
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude	M_w	=	7.0
Groundwater Depth bgs During Exploration (ft) =	22.0
Groundwater Depth bgs During Earthquake(ft) =	17.5
Total Number of Thin Layers	N =	8

Note: High Resolution Testing
Note: Typical Mixed Soil Behavior Type



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
State to Equation (5) were published in the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 4, March 2006.
4. Seed, R.B., Cetin, K.O. Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME	American River Common Features (2ARI)
LEVEE SECTION ID	NEMDC West
PROJECT NUMBER	965.9750
Reach ID	Reach 7
Station	334+74
CPT ID	WR1000_050C
CPT Location:	Levee Crest

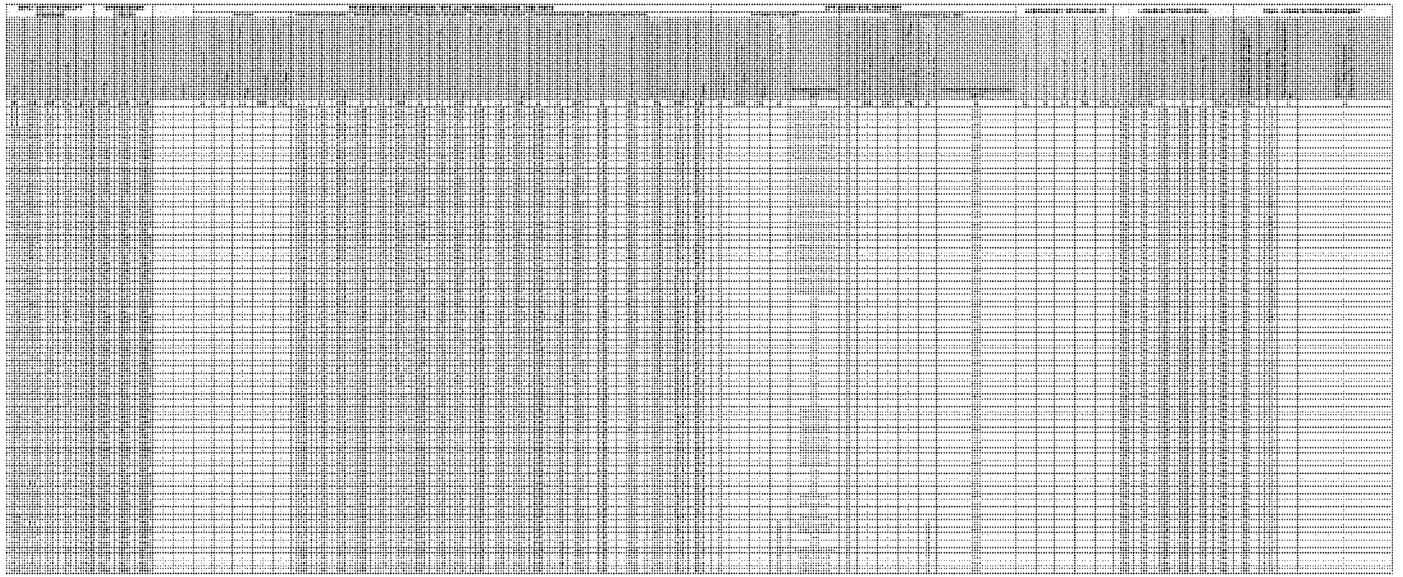
Ground Elevation (NAVD88) =	44.9
Groundwater Elevation During Exploration (NAVD88) =	13.9
Design Groundwater Elevation (fh) =	23.9
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.35
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.2
Groundwater Depth bgs During Exploration (fl) =	31.0
Groundwater Depth bgs During Earthquake(fl) =	21.0
Total Number of Thin Layers (N) =	0

Note: Crest/Landside/Waterside, and distance from Crest, must be consistent for

Note	From Orodisation Testing
Note	Typical Water (Hydrology Mean)

Analyzed by:	Natalie Tollefson	Date:	2/17/2009
Checked by:		Date:	

Drill Hole By Analyst
Results of Analysis
Estimated Values



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis: Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Sitar, J.D., Sancio, R.B., 2008. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME	Interstate Route 5 Levee Feature Grid
LEVEE SEGMENT	Merced West
PROJECT NUMBER	26178.06
Reach ID	
Station	
CPT ID	WR1000_050C
CPT Location	Levee Crest

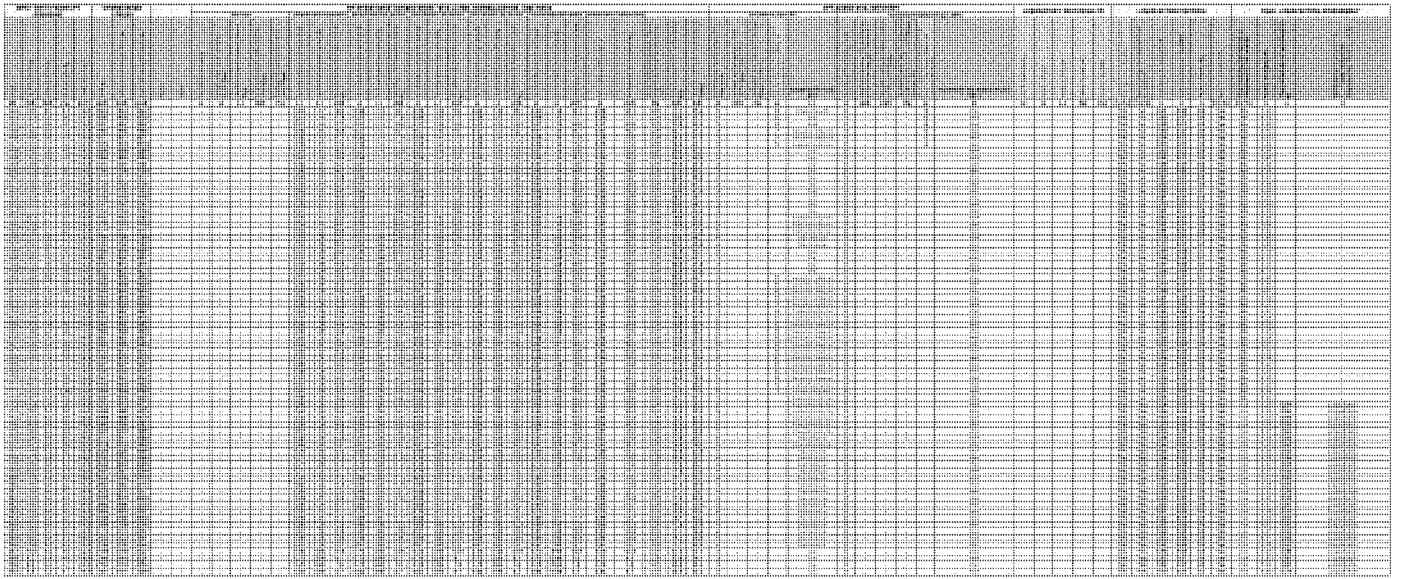
Assigned by: Nicholas Tallman — Date: 2/17/2009
Checked by: — Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Consult geotechnical/seismic and historic flood/landside specialists for use

Ground Elevation (NAVD88) =	41.0
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	28.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.52
Location (Crest/Landward/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	28.0
Groundwater Depth bgs During Earthquake(ft) =	13.0
Total Number of Thin Layers =	0

Note: High Dissipation Testing
Typical Winter (February Mean)



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
State to Equation (6) were published in Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
4. Seed, R.B., Cetin, K.O. Moss, R. E. S., Kammerer, A. M., Wu, J. Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. E., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.,
5. Gray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features Levee
LEVEE SEGMENT:	Sewer West
PROJECT NUMBER:	26516795
Reach ID:	
Station:	334+74
CPT ID:	WR1000_050C
CPT Location:	Levee Crest

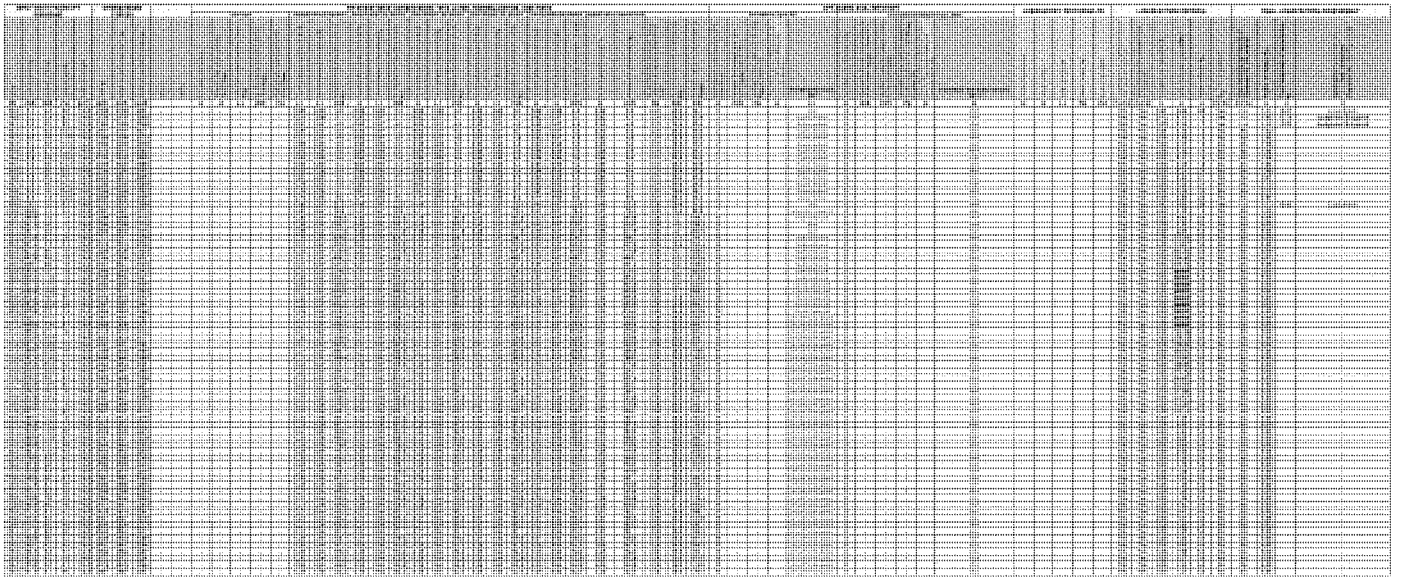
Analyzed by:	Multiple Teleflexes
Checked by:	
Date:	10/15/08
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check input data/values by and inform Geotechnical Engineer

Ground Elevation (NAVD88) =	41.0	feet
Groundwater Elevation During Exploration (NAVD88) =	13.0	feet
Design Groundwater Elevation (fl) =	24.5	feet
Return Period (Years) =	200	
Peak Ground Acceleration (PGA, g) =	0.52	g
Location (Crest/Landside/Waterside)	Crest	
Earthquake Magnitude (M_w) =	7.0	
Groundwater Depth bgs During Exploration (ft) =	28.0	feet
Groundwater Depth bgs During Earthquake(ft) =	17.5	feet
Total Number of Thin Layers (N) =	0	

Note: From Disposition Testing
Note: Typical Water (Fresh) Value



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B. Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (6) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 4, March 2006.
4. Seed, R.B., Cetin, K.O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.R. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (ARCF)
LEVEE SEGMENT:	NEMDC West
PROJECT NUMBER:	28516780
Reach ID:	
Station:	334+74
CPT ID:	WR1000_050C
CPT Location:	Levee Crest

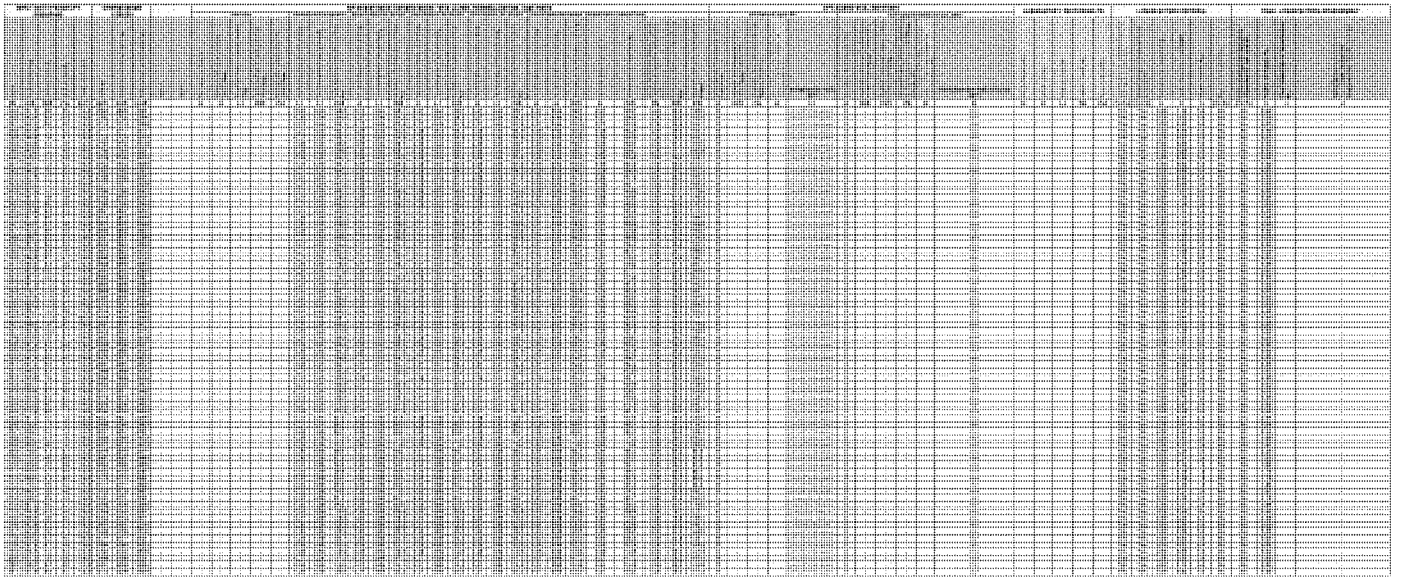
Analysis by:	Nicholas Tollefson
Checked by:	
Date:	2/17/2009
Date:	

Data Read By Analyst
Results of Analysis
Calculated Values

Note: Check protected cells for, and remove any Crest, unless top of waterside toe

Ground Elevation (NAVD88) =	41.9
Groundwater Elevation During Exploration (NAVD88) =	13.9
Design Groundwater Elevation (ft) =	23.9
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.32
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.2
Groundwater Depth bgs During Exploration (ft) =	28.0
Groundwater Depth bgs During Earthquake(ft) =	18.0
Total Number of Thin Layers (N) =	0

Note: Enter Exploration Testing
Note: Typical Water (Recovery Mesh)



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, [doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)].
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M. 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
4. Seed, R.B., Cetin, K.O. Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Stray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 5, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	Riverside River Gateway Feasibility Study
LEVEE SEGMENT:	SEMDC West
PROJECT NUMBER:	38419120
Reach ID:	WR1000
Station:	334+74
CPT ID:	WR1000_050C
CPT Location:	Levee Crest

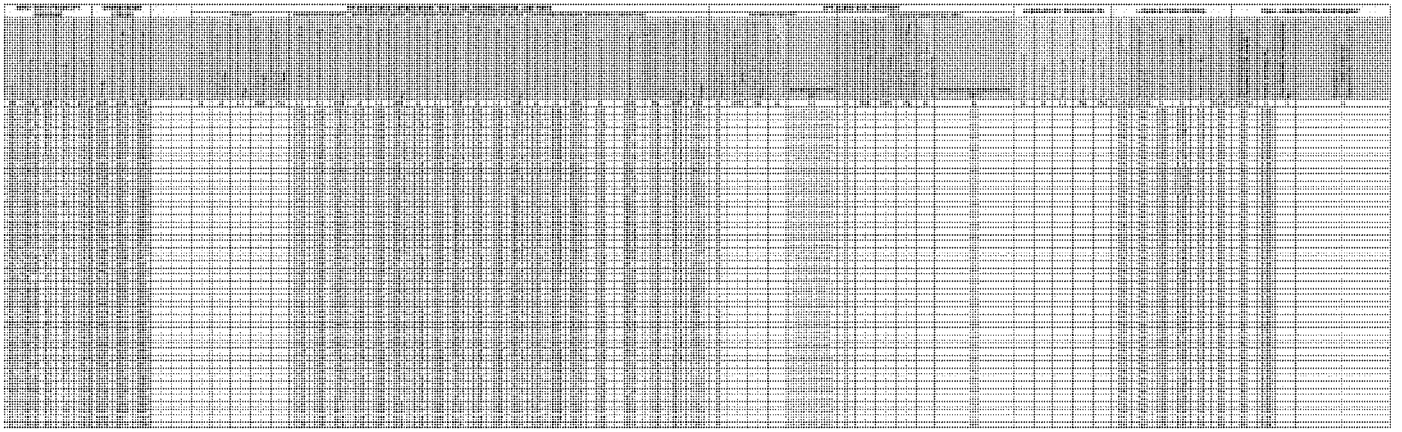
Analysis by: Nicholas Tollefson | Date: 09/08/08
Checked by: | Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Ground surface elevation and soil data from Deep Levee Soil Borehole Survey

Ground Elevation (NAVD88) =	41.0
Groundwater elevation During Exploration (MAVD88) =	13.0
Design Groundwater Elevation (fg) =	27.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA_g) =	0.42
Location (Coast/Lakeside/Waterside)	Coast
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (fg) =	28.0
Groundwater Depth bgs During Earthquake(fg) =	13.5
Total Number of Thin Layers (N) =	5

Note: From Dissipation Testing
Note: Typical Winter Precipitation Months



SACRAMENTO RIVER NORTH

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1314-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Queens Marv, Long Beach, Ca
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	Natomas River Common Features GRR Project
LEVEE SEGMENT:	Sacramento River East Levee (North of American River Confluence)
PROJECT NUMBER:	29414760.4.4400
Reach ID:	
Station:	LNER Station 1446+00
Boring ID:	SF-01-00
Boring Location (Check: velocity/downhole, and distance from Levee centerline/toe/crest)	Landside Boring

Analysis By:	Sung P. Park
Check By:	

Date:	10/17/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)[1]: 32.2
Groundwater Elev. During Drilling (ft.) = 16.2 Note: Depth during drilling
Analyzed Groundwater Elevation (ft.)= 16.4 Note: Summer water in canal/delta

Groundwater Depth Below GS During Drilling (ft.) = 16.0
Analyzed Groundwater Depth Below GS (ft.) = 15.8

Hammer Type = Automatic
Energy Ratio = 80

Earthquake Information:
Return Period (years) = 500
M_w = 7.0

PGA (g) = 0.44
Location = Landside (Crest, Levee, Landside, or Waterside)

Sample ID	Depth to Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SS, MCAL, SCAL)	H_s for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick-Up (Penetration) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, α_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS < 1.0 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Assessment (Yes/No) Based on Column AG, AH, and AI	Factor of Safety, FS	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS, < 1.3)
S1	10	3	ML	120	60	60	60	1.8	1.3	M	4	1.00	S	11	1.12	1.00	7	2.9	0.75	7	11		33	1.3	15	0.303	0.231	0.009	1.31	No	No	ML				Yes	No	1.31	-
S2	5	4	CL	110	225	225	225	1.8	1.3	M	4	1.00	S	8	1.10	1.00	7	2.4	0.75	5	8		35	1.4	11	0.159	0.228	0.710	0.70	Yes	No	CL				Yes	No	0.70	-
S3	7	5	CL	115	445	445	445	1.8	1.3	M	4	1.00	S	9	1.10	1.00	7	3.0	0.75	5	9		35	1.4	11	0.132	0.225	0.945	0.59	Yes	No	CL	N	N		Yes	No	0.59	-
S4	9	7	SM	120	705	705	705	1.8	1.3	M	4	1.00	S	10	1.11	1.00	7	3.7	0.75	6	10		12	1.1	11	0.114	0.222	0.967	0.51	Yes	No	SM				Yes	No	0.51	-
S5	11	5	SM	120	965	965	965	1.4	1.3	M	4	1.00	S	7	1.16	1.00	7	4.3	0.80	5	9		12	1.1	9	0.080	0.218	1.000	0.41	Yes	No	SM				Yes	No	0.41	-
S6	13	9	SM	130	1225	1225	1225	1.3	1.3	M	4	1.00	S	6	1.19	1.00	7	4.9	0.83	6	7		12	1.1	8	0.069	0.215	1.000	0.37	Yes	No	SM				Yes	No	0.37	-
S7	15	8	SM	130	1485	1485	1448	1.2	1.3	M	4	1.00	S	5	1.19	1.00	7	5.5	0.86	5	9		12	1.2	6	0.067	0.212	1.000	0.32	Yes	Yes	SM				Yes	YES	0.32	Liquefiable
S8	17	6	SM	130	1745	1620	1593	1.1	1.3	M	4	1.00	S	4	1.19	1.00	7	6.1	0.89	5	5	**	35	1.5	8	0.073	0.208	1.000	0.35	Yes	Yes	SM				Yes	YES	0.35	Liquefiable
S9	19	7	ML	120	1985	1735	1698	1.1	1.2	M	4	1.00	S	1	1.19	1.00	7	6.7	0.91	1	1		35	2.5	3	0.051	0.205	1.000	0.25	Yes	Yes	ML				Yes	YES	0.25	Liquefiable
S10	21	7	ML	120	2225	1851	1813	1.0	1.3	M	4	1.00	S	1	1.19	1.00	7	7.3	0.92	1	1		35	2.5	3	0.050	0.201	1.000	0.25	Yes	Yes	ML				Yes	YES	0.25	Liquefiable
S11	23	7	ML	120	2465	1966	1928	1.0	1.3	M	4	1.00	S	1	1.19	1.00	7	7.9	0.94	1	1		35	2.5	3	0.049	0.198	1.000	0.25	Yes	Yes	ML	N	N	N	Yes	YES	0.25	Liquefiable
S12	25	7	ML	120	2705	2081	2044	1.0	1.3	M	4	1.00	S	4	1.19	1.00	7	8.5	0.95	5	5		25	1.8	7	0.067	0.193	1.000	0.35	Yes	Yes	ML				Yes	YES	0.35	Liquefiable
S13	27	7	CL	115	2920	2178	2139	1.0	1.3	M	4	1.00	S	3	1.19	1.00	7	9.1	0.96	4	4		35	1.9	5	0.059	0.189	1.000	0.31	Yes	Yes	CL				Yes	YES	0.31	Liquefiable
S14	29	6	CL	115	3145	2271	2234	0.9	1.3	M	4	1.00	S	6	1.19	1.00	7	9.6	0.96	8	7		35	1.4	10	0.079	0.183	0.999	0.43	Yes	Yes	CL				Yes	YES	0.43	Liquefiable
S15	31	11	SP-SM	130	3405	2407	2369	0.9	1.3	M	4	1.00	S	15	1.23	1.00	7	10.4	0.97	22	30		9	1.1	21	0.179	0.179	0.156	1.61	Yes	Yes	SP-SM				Yes	YES	1.61	Judgment Required
S16	33	9	SP-SM	130	3665	2542	2504	0.9	1.3	M	4	1.00	S	7	1.30	1.00	7	11.0	0.98	19	9		9	1.1	10	0.076	0.173	0.959	0.44	Yes	Yes	SP-SM				Yes	YES	0.44	Liquefiable
S17	35	10	SP	130	4555	2745	2707	0.9	1.3	M	4	1.00	S	9	1.13	1.00	7	11.9	0.98	13	11	1	5	1.0	12	0.086	0.164	0.589	0.51	Yes	Yes	SP				Yes	YES	0.51	Liquefiable
S18	37	11	SP	130	4445	2947	2910	0.9	1.3	M	4	1.00	S	9	1.13	1.00	7	12.5	0.99	16	12		5	1.0	12	0.086	0.159	0.378	0.56	Yes	Yes	SP				Yes	YES	0.56	Liquefiable
S19	39.5	8	SP	130	4770	3176	3079	0.8	1.3	M	4	1.00	S	7	1.10	1.00	7	13.6	0.99	12	10		5	1.0	10	0.072	0.152	0.096	0.47	Yes	Yes	SP				Yes	YES	0.42	Liquefiable

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1314-1340. and Discussions*
2. URS Corporation 2009. *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.*
3. Seed, R.B., et al, 2003. *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on M

PROJECT NAME:	American River Common Features (SMR Project)
LEVEE SEGMENT:	Garcia-Arc Road East Levee North of American River (Upstream)
PROJECT NUMBER:	[illegible]4.55432
Reach ID:	
Station:	CMR Station: 1499+02
Boring ID:	SP-01-14
Boring Location (Used Levee/Channel/Slough, and distance from Levee/Channel/Slough centerline, e.g.	Landside Toeing

Analysis By:	Juan F. Perez
Check By:	
Date:	10/10/2009
Date:	

Data Input (By Analyst)
Results of Analysis
Calculated Values

Ground Elevation (ft.)=
Groundwater Elev. During Drilling (ft.) =
Analyzed Groundwater Elevation (ft.)=

24.0	
14.0	
10.0	

Note: Depth during drilling
Note: Water level is observed

Groundwater Depth Below GS During Drilling (ft.) = 10.0
Analyzed Groundwater Depth Below GS (ft.) = 12.0

Hammer Type = Automatic
Energy Ratio = 80

Earthquake Information:
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.24
Location = Landside *(other: Crest, Landside, or Waterside*

Sample ID	Depth to Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (= 1/0.75 SCAL, MCAL)	N_1 for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Protrusion) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, α_{Fines}	$N_{1,60,CS}$	Cyclic Stress Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS < 1.0 (Yes/No) Column AC	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AM	Fine Assessment (Yes/No) Based on Column AS, AT, and AU	Factor of Safety, FS	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS< 1.3)
S1	12	4	ML	120	80	80	80	1.8	1.3	M	4	1.00	S	11	1.12	1.00	7	2.0	0.75	7	11		35	1.3	15	0.203	0.231	0.009	1.31	No	No	ML				Yes	No	1.31	-
S2	7	6	CL	115	225	225	225	1.8	1.3	M	4	1.00	S	8	1.16	1.00	7	2.4	0.75	5	9		35	1.4	11	0.159	0.228	0.770	0.70	Yes	No	CL				Yes	No	0.74	-
S3	9	5	CL	115	445	445	445	1.8	1.3	M	4	1.00	S	9	1.19	1.00	7	3.0	0.75	5	9		35	1.4	11	0.122	0.225	0.345	0.59	Yes	No	CL	M	M		Yes	No	0.58	-
S4	8	4	SM	130	705	705	705	1.6	1.3	M	4	1.00	S	10	1.11	1.00	7	3.7	0.75	5	10		12	1.1	11	0.114	0.222	0.907	0.51	Yes	No	SM				Yes	No	0.51	-
S5	7	5	SM	130	965	965	953	1.4	1.3	M	4	1.00	S	7	1.16	1.00	7	4.3	0.89	5	8		12	1.1	9	0.090	0.218	1.000	0.41	Yes	Yes	SM				Yes	YES	0.40	Liquefiable
S6	12	6	SM	130	1225	1225	1093	1.3	1.3	M	4	1.00	S	6	1.10	1.00	7	4.9	0.83	4	7		12	1.1	9	0.085	0.215	1.000	0.39	Yes	Yes	SM				Yes	YES	0.39	Liquefiable
S7	13	6	SM	130	1485	1485	1223	1.2	1.3	M	4	1.00	S	5	1.10	1.00	7	5.5	0.86	5	9		12	1.2	6	0.070	0.212	1.000	0.33	Yes	Yes	SM				Yes	YES	0.32	Liquefiable
S8	14	5	SM	130	1745	1620	1368	1.1	1.3	M	4	1.00	S	4	1.16	1.00	7	6.1	0.89	5	9	**	25	1.6	8	0.076	0.208	1.000	0.37	Yes	Yes	SM				Yes	YES	0.37	Liquefiable
S9	11	7	ML	120	1965	1755	1473	1.1	1.2	M	4	1.00	S	7	1.10	1.00	7	6.7	0.91	7	9		25	2.5	3	0.053	0.205	1.000	0.26	Yes	Yes	ML				Yes	YES	0.26	Liquefiable
S10	13	9	ML	120	2225	1957	1583	1.0	1.2	M	4	1.00	S	7	1.19	1.00	7	7.3	0.92	7	11		25	2.5	3	0.052	0.201	1.000	0.26	Yes	Yes	ML				Yes	YES	0.26	Liquefiable
S11	15	8	ML	120	2465	1968	1704	1.0	1.3	M	4	1.00	S	7	1.10	1.00	7	7.9	0.94	7	11		25	2.5	3	0.051	0.198	1.000	0.26	Yes	Yes	ML	M	M		Yes	YES	0.26	Liquefiable
S12	16	9	ML	120	2705	2061	1919	1.0	1.3	M	4	1.00	S	8	1.10	1.00	7	8.5	0.95	5	9		25	1.5	7	0.069	0.193	1.000	0.36	Yes	Yes	ML				Yes	YES	0.36	Liquefiable
S13	17	7	CL	115	2905	2175	1914	1.0	1.3	M	4	1.00	S	5	1.10	1.00	7	9.1	0.96	4	6		35	1.6	6	0.061	0.189	1.000	0.32	Yes	Yes	CL				Yes	YES	0.32	Liquefiable
S14	18	8	CL	115	3145	2371	2008	0.9	1.3	M	4	1.00	S	6	1.10	1.00	7	9.8	0.96	6	7		35	1.4	10	0.091	0.183	0.999	0.44	Yes	Yes	CL				Yes	YES	0.44	Liquefiable
S15	20	17	SP-SM	130	3405	2497	2145	0.9	1.2	M	4	1.00	S	15	1.23	1.00	7	10.4	0.97	22	28		8	1.1	21	0.184	0.179	0.159	1.83	Yes	Yes	SP-SM				Yes	YES	1.83	Judgment Required
S16	21	9	SP-SM	130	3665	2542	2280	0.9	1.3	M	4	1.00	S	7	1.10	1.00	7	11.0	0.98	10	9		8	1.1	10	0.078	0.173	0.959	0.49	Yes	Yes	SP-SM				Yes	YES	0.48	Liquefiable
S17	23	10	SP	130	4055	2745	2483	0.9	1.3	M	4	1.00	S	9	1.12	1.00	7	11.9	0.98	13	11	-	8	1.0	12	0.097	0.168	0.980	0.60	Yes	Yes	SP				Yes	YES	0.59	Liquefiable
S18	25	11	SP	130	4445	2947	2685	0.9	1.3	M	4	1.00	S	9	1.13	1.00	7	12.8	0.99	14	12		5	1.0	12	0.090	0.159	0.919	0.57	Yes	Yes	SP				Yes	YES	0.57	Liquefiable
S19	27	4	SP	130	4770	3116	2954	0.8	1.3	M	4	1.00	S	7	1.19	1.00	7	13.6	0.99	12	10		5	1.9	10	0.073	0.153	0.596	0.48	Yes	Yes	SP				Yes	YES	0.48	Liquefiable

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: Liquefaction-Triggering Analysis for ULGEP

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential*, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1973-1340, and Discussions and Closures (May, 2006)
2. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2008.
3. Seed, R.B., et al, 2003, Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999). (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	American River Common Features (2016) Project
LEVEE SEGMENT:	Sacramento River East Levee North of American River (Alpha=66)
PROJECT NUMBER:	26810 / M.44449
Reach ID:	
Station:	Draft Station: 1+00+00
Boring ID:	SC-01-17
Boring Location (Check vehicle/Waterside, and stream bank (Levee, landside/landward) or top)	Landside Toeing

Analyzed By:	Juan F. Perez
Check By:	
Date:	10/1/2020
Date:	

Data Input by Analyst
Results of Interest
Calculated Values

Ground Elevation (ft.)=	27.0	
Groundwater Elev. During Drilling (ft.) =	15.2	Note: Depth during Drilling
Analyzed Groundwater Elevation (ft.)=	16.2	Note: Water level in CPT (GEI)

Groundwater Depth Below GS During Drilling (ft.) = 12.8
Analyzed Groundwater Depth Below GS (ft.) = 10.8

Hammer Type = Automatic
Energy Ratio = 1.30

Earthquake Information:
Return Period (years) = 200
M_w = 6.0

PGA (g) = 0.18
Location = Landside

Source: Unit, Location, or Watershed

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Corrective Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction For Borehole Diameter, C_B	Sampler Code (= SC, SCAL, MCAL)	N_1 for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Pressure) Rod Length Above Ground (feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, <1.3 (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Assessment (Yes/No) Based on Columns AG, AF, and AH	Factor of Safety, FS	Comment (Liquefiable for FS, <1 and Judgment Required for 1.0 <FS, < 1.3)
SC	3	11	ML	123	0	0	0	#DIV/0!	1.2	M	4	1.00	S	#DIV/0!	#DIV/0!	1.20		3.5	0.75	11	#DIV/0!		38	#DIV/0!	#DIV/0!	#DIV/0!	0.232	#DIV/0!	#DIV/0!	#DIV/0!	No	ML				Yes	#DIV/0!	#DIV/0!	#DIV/0!
SC	5	4	CL	115	123	123	123	1.6	1.2	M	4	1.00	S	5	1.10	1.10		5.5	0.75	4	5		35	3.4	5	0.140	0.238	0.511	2.97	Yes	No	CL	28	12		Yes	No	0.51	-
SC	8	6	CL	119	440	440	440	1.5	1.2	M	4	1.00	S	8	1.10	1.10		8.5	0.75	6	8		75	7.4	8	0.115	0.222	0.892	0.51	Yes	No	CL				Yes	No	0.51	-
SC	9	5	CL	119	660	660	660	1.4	1.2	M	4	1.00	S	9	1.10	1.10		10	0.75	5	6		64	6.4	11	0.118	0.222	0.867	0.53	Yes	No	CL				Yes	No	0.53	-
SC	9	1	CL	119	660	660	660	1.4	1.2	M	4	1.00	S	9	1.10	1.10		10	0.75	1	2		15	3.3	4	0.053	0.214	0.068	0.25	Yes	Yes	CL			33	Yes	No	0.25	-
SC	10	2	CL	119	1100	1100	1100	1.2	1.2	M	4	1.00	S	2	1.10	1.10		11.5	0.75	2	4		27	5.2	7	0.077	0.203	0.096	0.35	Yes	Yes	CL				Yes	Yes	0.35	Liquefiable
SC	12	4	ML	123	1320	1320	1320	1.2	1.2	M	4	1.00	MCAL	5	1.10	0.93		13.5	0.75	4	4		78	7.5	7	0.074	0.172	0.062	0.22	Yes	Yes	ML			29	Yes	Yes	0.22	Liquefiable
SC	14	7	ML	123	1650	1650	1650	1.2	1.2	M	4	1.00	S	7	1.10	1.10		15.5	0.85	7	7		36	2.4	3	0.055	0.206	0.067	0.27	Yes	Yes	ML	24	5	26	Yes	Yes	0.27	Liquefiable
SC	16	5	ML	123	1925	1870	1870	1.1	1.0	M	4	1.00	MCAL	7	1.10	0.91		17.5	0.91	5	5		30	2.7	3	0.052	0.208	0.064	0.25	Yes	Yes	ML				Yes	Yes	0.25	Liquefiable
SC	18	3	SM	124	2085	1726	1726	1.1	1.0	M	4	1.00	S	5	1.10	1.00		19.5	0.91	3	3		41	2.9	3	0.049	0.201	0.052	0.21	Yes	Yes	SM				Yes	Yes	0.21	Liquefiable
SC	20	4	SM	124	2340	1921	1920	1.0	1.0	M	4	1.00	S	6	1.10	1.00		21.5	0.94	4	4	23	28	2.9	3	0.051	0.195	0.059	0.24	Yes	Yes	SM				Yes	Yes	0.24	Liquefiable
SC	22	3	ML	123	2699	1955	1955	1.0	1.0	M	4	1.00	S	5	1.10	1.00		23.5	0.95	3	3		36	2.9	3	0.050	0.189	0.055	0.23	Yes	Yes	ML				Yes	Yes	0.23	Liquefiable
SC	24	3	SM	124	2999	2091	1990	1.0	1.0	M	4	1.00	S	5	1.10	1.00		25.5	0.96	3	3		41	3.2	3	0.054	0.188	0.058	0.25	Yes	Yes	SM				Yes	Yes	0.25	Liquefiable
SC	26	2	SM	125	3250	2226	2016	0.9	1.0	M	4	1.00	S	3	1.10	1.00		27.5	0.96	2	2		42	3.3	3	0.048	0.182	0.052	0.22	Yes	Yes	SM				Yes	Yes	0.22	Liquefiable
SC	28	13	SW-SM	130	3640	2352	2034	0.9	1.0	M	4	1.00	S	8	1.10	1.00		29.5	0.97	13	12		9	3.1	10	0.167	0.179	0.382	1.72	Yes	Yes	SW-SM				Yes	No	1.72	Liquefiable
SC	30	11	SW-SM	130	3900	2497	2045	0.9	1.0	M	4	1.00	S	15	1.10	1.00		31.5	0.98	28	27	6	9	3.1	10	0.167	0.173	0.345	1.64	Yes	Yes	SW-SM				Yes	No	1.64	Liquefiable
SC	32	13	SW-SM	130	4043	2585	2041	0.8	1.0	M	4	1.00	S	17	1.10	1.00		33.5	0.98	15	14		9	3.1	10	0.165	0.168	0.357	1.65	Yes	Yes	SW-SM				Yes	No	1.65	Liquefiable
SC	34	12	SW-SM	130	4420	2820	2040	0.8	1.0	M	4	1.00	S	9	1.10	1.00		35.5	0.98	12	11		9	3.1	10	0.164	0.162	0.302	1.53	Yes	Yes	SW-SM				Yes	No	1.53	Liquefiable
SC	36	13	SW-SM	130	4680	3055	2052	0.8	1.0	M	4	1.00	S	15	1.10	1.00		37.5	0.98	21	17		9	3.1	10	0.162	0.157	0.315	2.00	Yes	Yes	SW-SM				Yes	No	2.00	Liquefiable
SC	42	13	SW-SM	130	5198	3369	2070	0.8	1.0	M	4	1.00	S	9	1.10	1.00		43.5	0.98	16	12		9	3.1	10	0.161	0.148	0.307	2.07	Yes	Yes	SW-SM				Yes	No	2.07	Liquefiable
SC	52	13	SW-SM	130	6370	3911	2092	0.8	1.0	M	4	1.00	S	9	1.10	1.00		53.5	0.98	15	11		9	3.1	10	0.160	0.135	0.341	2.53	Yes	Yes	SW-SM				Yes	No	2.53	Liquefiable
SC	62.5	15	SW-SM	130	7825	5047	2580	0.7	1.0	M	4	1.00	S	11	1.10	1.00		64.5	1.00	20	15		9	3.1	10	0.159	0.131	0.457	3.49	Yes	Yes	SW-SM				Yes	No	3.49	Liquefiable

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: Liquefaction-Triggering Analysis for ULGEP

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analysis , Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.A.L. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999).* (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	American River Correction Factors (SRK Project)
LEVEE SEGMENT:	Sacramento River East Levee North of American River Confluence
PROJECT NUMBER:	2841NT01 (SAMA)
Reach ID:	
Sutter:	DWR Station: 1+65+00
Boring ID:	W-B1-07
Boring Location (Check: Include Waterside, and Backside Seal Levee)	Landside Berm

Analyzed By:	Jose P. Perez
Check By:	

Date:	10/15/2007
Date:	

Data Used for Analysis
Results of Analysis
Calculated Values

Ground Elevation (ft.)=	37.4
Groundwater Elev. During Drilling (ft.) =	15.4
Analyzed Groundwater Elevation (ft.)=	14.0

Note: Depth based on drilling
Note: Survey# WSE-R (NAVD88)

Groundwater Depth Below GS During Drilling (ft.) = 12.8
Analyzed Groundwater Depth Below GS (ft.) = 13.2

Hammer Type = Automatic
Energy Ratio = 80

Earthquake Information:
Return Period (years) = 200
M_w = 6.79

PGA (g) = 0.19
Location = Landside

Enter Check, Landside, or Waterside

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction For Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction For Borehole Diameter, C_B	Sampler Code (S, SH, SCAL, MCAL)	N_m for Sampler Correction Only (for SW sampler)	Sampler Correction Factor, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Shoe Up (Protrusion) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, FS	FS, <1.2 (Yes/No) Column AS	Better Analyzed Overwritten Level (Yes/No) Column AT	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AV	Final Assessment (Yes/No) Based on Science All SF, and Al.	Factor of Safety, FS	Comment (Liquefiable for FS,<1 and Judgment Required for 1.2 >FS > 1.0)
S1	5	11	ML	123	615	615	615	1.7	1.3	M	6	1.05	S	#DIV/0!	#DIV/0!	#DIV/0!	1	1.5	0.75	11	#DIV/0!	#DIV/0!	98	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	ML				Yes	#DIV/0!	#DIV/0!	#DIV/0!
S2	7.5	8	CL	119	732	732	732	1.6	1.3	M	6	1.05	S	6	1.12	1.02	1	2.5	0.75	8	6	6	35	1.4	0	0.145	0.226	0.317	1.61	Yes	No	CL	48	32		Yes	No	1.61	-
S3	9	6	CL	112	945	945	945	1.5	1.3	M	6	1.05	S	5	1.12	1.02	1	3.0	0.75	6	5	5	35	1.4	0	0.145	0.225	0.184	0.81	Yes	No	CL				Yes	No	0.81	-
S4	11	9	CL	116	1272	1272	1272	1.5	1.3	M	6	1.05	S	8	1.12	1.02	1	3.7	0.75	9	8	8	35	1.4	11	0.112	0.222	0.067	0.30	Yes	Yes	CL				Yes	Yes	0.30	-
S5	4	1	CL	110	870	870	870	1.6	1.3	M	4	1.05	S	2	1.12	1.02	1	2.2	0.90	1	2	2	20	2.2	4	0.083	0.218	0.053	0.24	Yes	No	CL			33	Yes	No	0.24	-
S6	7.5	2	CL	110	1103	1103	1103	1.5	1.3	M	4	1.05	S	4	1.12	1.02	1	4.2	0.90	3	4	4	20	2.2	4	0.083	0.217	0.023	0.10	Yes	No	CL				Yes	No	0.10	-
S7	12	6	ML	113	1367	1367	1367	1.3	1.3	M	6	1.05	MCAL	5	1.12	0.92	1	5.5	0.85	5	6	6	70	1.5	7	0.072	0.212	0.030	0.14	Yes	No	ML			39	Yes	No	0.14	-
S8	14	1	ML	121	1693	1693	1527	1.2	1.3	M	4	1.05	S	1	1.13	1.02	1	6.1	0.85	1	1	1	85	2.4	3	0.053	0.206	0.028	0.14	Yes	Yes	ML	28	5	38	Yes	Yes	0.14	Liquefiable
S9	16	5	ML	122	1951	1935	1662	1.1	1.3	M	6	1.05	MCAL	4	1.13	0.93	1	6.7	0.85	4	5	5	85	2.4	3	0.051	0.205	0.022	0.11	Yes	Yes	ML				Yes	Yes	0.11	Liquefiable
S10	18	9	SM	133	2483	2196	1777	1.1	1.2	M	4	1.05	S	7	1.13	1.02	1	7.3	0.80	7	9	9	12	4.5	3	0.049	0.204	0.062	0.30	Yes	Yes	SM				Yes	Yes	0.30	Liquefiable
S11	20	5	SM	134	2680	2441	1913	1.0	1.2	M	4	1.05	S	4	1.13	1.02	1	7.9	0.80	4	5	5	20	2.2	3	0.045	0.198	0.026	0.13	Yes	Yes	SM				Yes	Yes	0.13	Liquefiable
S12	22	7	ML	133	2949	2688	2107	1.0	1.2	M	4	1.05	S	5	1.13	1.02	1	8.5	0.80	5	7	7	85	2.4	3	0.049	0.193	0.015	0.08	Yes	Yes	ML				Yes	Yes	0.08	Liquefiable
S13	24	3	SM	130	3949	2931	2183	1.0	1.2	M	4	1.05	S	3	1.13	1.02	1	9.1	0.80	3	4	4	12	4.5	5	0.053	0.188	0.020	0.11	Yes	Yes	SM				Yes	Yes	0.11	Liquefiable
S14	26	2	SM	132	3158	3026	2256	0.9	1.2	M	4	1.05	S	2	1.13	1.02	1	9.8	0.80	2	2	2	12	4.5	3	0.047	0.183	0.062	0.34	Yes	Yes	SM				Yes	Yes	0.34	Liquefiable
S15	28	12	SW-SM	132	3697	3252	2433	0.9	1.2	M	4	1.05	S	8	1.13	1.02	1	10.4	0.80	7	12	12	5	5.1	12	0.264	0.178	0.000	0.00	Yes	Yes	SW-SM				Yes	Yes	0.00	Liquefiable
S16	30	13	SW-SM	134	4029	3477	2589	0.9	1.2	M	4	1.05	S	13	1.13	1.02	1	11.0	0.80	10	14	4	3	5.1	16	0.143	0.173	0.000	0.00	Yes	Yes	SW-SM				Yes	Yes	0.00	Liquefiable
S17	31	11	SW-SM	135	4549	3702	2721	0.8	1.2	M	4	1.05	S	11	1.13	1.02	1	11.3	0.80	13	15	3	3	5.1	16	0.113	0.168	0.000	0.00	Yes	Yes	SW-SM				Yes	Yes	0.00	Liquefiable
S18	34	11	SW-SM	132	4849	3952	2874	0.8	1.2	M	4	1.05	S	9	1.13	1.02	1	12.0	0.80	13	15	3	3	5.1	15	0.092	0.165	0.000	0.00	Yes	Yes	SW-SM				Yes	Yes	0.00	Liquefiable
S19	36	13	SW-SM	130	4760	3879	2977	0.8	1.2	M	4	1.05	S	13	1.13	1.02	1	12.7	0.80	21	17	3	3	5.1	20	0.128	0.161	0.000	0.00	Yes	Yes	SW-SM				Yes	Yes	0.00	Liquefiable
S20	41	17	SW-SM	131	5108	3969	3086	0.8	1.2	M	4	1.05	S	8	1.14	1.03	1	14.6	0.80	16	12	3	3	5.1	13	0.080	0.145	0.000	0.00	Yes	Yes	SW-SM				Yes	Yes	0.00	Liquefiable
S21	51	11	SW-SM	130	6572	4511	3540	0.8	1.2	M	4	1.05	S	9	1.12	1.02	1	15.9	0.80	15	15	3	3	5.1	12	0.078	0.136	0.000	0.00	Yes	Yes	SW-SM				Yes	Yes	0.00	Liquefiable
S22	55.5	11	SW-SM	130	7217	4747	3719	0.7	1.2	M	4	1.05	S	11	1.12	1.02	1	16.8	0.80	20	15	4	4	5.1	15	0.102	0.130	0.000	0.00	Yes	Yes	SW-SM				Yes	Yes	0.00	Liquefiable

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: Liquefaction-Triggering Analysis for ULGEP

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol 130, No. 12, 1313-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levees Geotechnical Evaluations Program Rev. 5, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publications 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*. (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	Riverian River Correction Features (RRR Project)
LEVEE SEGMENT:	Sacramento River East Levee North of Sycamore Slough (Nicholas)
PROJECT NUMBER:	234-10760.04423
Reach ID:	
Station:	DWR Station: 1459+45
Boring ID:	DP-01-06
Boring Location (Delhi, Isleton/Walnut Grove, and Arcade Twin Cities: establish northwesting and	Liquefaction Testing

Analysis By:	Matt P. Hall
Check By:	

Date:	09/15/2008
Date:	

Data Used By Analyst:
Results of Analysis
Calculated Values

Ground Elevation (ft.)=	24.5
Groundwater Elev. During Drilling (ft.) =	10.1
Analyzed Groundwater Elevation (ft.)=	10.1

Note: Depth during drilling
Note: Either (A) or (B) used (2009)

Groundwater Depth Below GS During Drilling (ft.) = 12.6
Analyzed Groundwater Depth Below GS (ft.) = 10.1

Hammer Type = Automatic
Energy Ratio = 1.00

Earthquake Information:
Return Period (years) = 200
M_w = 7.0
PGA (g) = 0.1
Location = Landside (Other Cases, Landside or Waterside)

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ'_v (psf)	Effective Overburden Pressure During Earthquake, σ'_v (psf)	Overburden Correction Factor, C_N	Correction For Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction For Borehole Diameter, C_B	Sampler Code (S, SS, MCAL, SCAL)	N_1 for Sampler Correction Only (for SW Sampler Only)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Wire Up (Fastening) Rod Length Above Ground (feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content	Fines Content for Analysis (%)	Correction Factor for Fines Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, F_S	P_S, < 1.2 (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Lab Test Results for CL, ML: Liquid Limit, LL	Plasticity Index, PI	Water Content, W_c (%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AH	Final Assessment (Yes/No) Based on Column AB, AF, and AH	Factor of Safety, FS	Conclusion (Liquefiable for FS <1 and Judgment Required for 1.0 <FS < 1.3)
S1	0	10	CL	110	0	0	0	#DIV/0!	1.3	M	4	1.00	S	#DIV/0!	#DIV/0!	1.00	7	1.8	0.75	10	####		35	#DIV/0!	#DIV/0!	0.232	#DIV/0!	#DIV/0!	#DIV/0!	No	CL				Yes	No	0.41	-
S2	2	6	CL	110	220	220	220	1.8	1.3	M	4	1.00	S	10	1.11	1.00	7	2.4	0.75	9	10		35	1.3	13	0.184	0.228	0.512	0.81	Yes	No	CL				Yes	No	0.41	-
S3	4	1	CL	110	440	440	440	1.6	1.3	M	4	1.00	S	2	1.16	1.00	7	3.0	0.75	1	2		35	2.2	4	0.077	0.235	1.000	0.34	Yes	No	CL			34	Yes	No	0.34	-
S4	6		ML	120	680	680	680	1.5	1.3	M	4	1.00	SHELBY	0	1.18	0.00	7	3.7	0.75	0	0		35	#DIV/0!	#DIV/0!	0.059	0.222	1.000	0.37	Yes	No	ML			38	Yes	No	0.37	-
S5	9	6	CL	130	940	940	940	1.5	1.3	M	4	1.00	S	6	1.19	1.00	7	4.3	0.80	4	6		35	1.4	9	0.091	0.218	0.994	0.42	Yes	No	CL			31	Yes	No	0.42	-
S6	10	5	SM	130	1300	1300	1144	1.3	1.2	M	4	1.00	MCAL	5	1.10	0.91	7	4.6	0.85	4	5		12	1.2	7	0.074	0.215	1.000	0.34	Yes	Yes	SM				Yes	Yes	0.34	Liquefiable
S7	13	2	ML	120	1640	1640	1259	1.2	1.2	M	4	1.00	S	2	1.19	1.00	7	5.5	0.90	2	2		35	1.9	5	0.063	0.210	1.000	0.36	Yes	Yes	ML	21	1		Yes	Yes	0.36	Liquefiable
S8	14	4	ML	120	1680	1665	1374	1.1	1.3	M	4	1.00	S	5	1.16	1.00	7	6.1	0.89	5	5		35	1.5	8	0.077	0.208	1.000	0.37	Yes	Yes	ML				Yes	Yes	0.37	Liquefiable
S9	16	1	ML	120	1920	1470	1495	1.1	1.3	M	4	1.00	S	1	1.19	1.00	7	6.7	0.91	1	1		35	2.5	3	0.053	0.205	1.000	0.26	Yes	Yes	ML				Yes	Yes	0.26	Liquefiable
S10	18	2	SM	120	2160	1699	1625	1.1	1.3	M	4	1.00	S	3	1.19	1.00	7	7.3	0.92	4	4		12	1.2	5	0.059	0.201	1.000	0.29	Yes	Yes	SM				Yes	Yes	0.29	Liquefiable
S11	20	5	SM	130	2600	1961	1749	1.0	1.3	M	4	1.00	MCAL	5	1.19	0.00	7	7.9	0.94	5	5		12	1.2	6	0.062	0.199	1.000	0.31	Yes	Yes	SM				Yes	Yes	0.31	Liquefiable
S12	22	2	ML/SM	120	2880	2096	1875	1.0	1.3	M	4	1.00	S	2	1.19	1.00	7	8.5	0.95	3	2	52	35	1.9	5	0.055	0.193	1.000	0.29	Yes	Yes	ML/SM				Yes	YES	0.29	Liquefiable
S13	24	2	ML/SM	120	2920	2171	1910	1.0	1.3	M	4	1.00	S	2	1.19	1.00	7	9.1	0.96	3	2		5	1.1	5	0.047	0.188	1.000	0.25	Yes	Yes	ML/SM				Yes	YES	0.25	Liquefiable
S14	26	3	ML/SM	120	3160	2286	2105	0.9	1.3	M	4	1.00	S	3	1.19	1.00	7	9.8	0.96	4	4		5	1.1	4	0.051	0.183	1.000	0.28	Yes	Yes	ML/SM				Yes	YES	0.28	Liquefiable
S15	28	4	ML/SM	120	3400	2402	2221	0.9	1.3	M	4	1.00	S	4	1.19	1.00	7	10.4	0.97	5	5		5	1.1	5	0.053	0.178	1.000	0.31	Yes	Yes	ML/SM				Yes	YES	0.31	Liquefiable
S16	30	11	SW-SM	120	3640	2527	2336	0.9	1.3	M	4	1.00	S	10	1.14	1.00	7	11.0	0.98	14	13	9	8	1.1	14	0.161	0.173	0.906	0.58	Yes	Yes	SW-SM				Yes	YES	0.58	Liquefiable
S17	33	10	SW-SM	130	4355	2746	2559	0.9	1.3	M	4	1.00	S	9	1.12	1.00	7	11.9	0.98	13	11		5	1.1	12	0.088	0.166	0.860	0.53	Yes	Yes	SW-SM				Yes	YES	0.53	Liquefiable
S18	36	12	SW-SM	130	4680	2942	2761	0.8	1.3	M	4	1.00	S	10	1.14	1.00	7	12.8	0.99	16	13		8	1.1	14	0.099	0.158	0.811	0.62	Yes	Yes	SW-SM				Yes	YES	0.62	Liquefiable
S19	39	13	SP-SM	130	4940	3145	2964	0.8	1.3	M	4	1.00	S	10	1.15	1.00	7	13.7	0.99	17	14	7	7	1.1	14	0.102	0.151	0.838	0.66	Yes	Yes	SP-SM				Yes	YES	0.66	Liquefiable
S20	42	11	SP-SM	130	5200	3348	3167	0.8	1.3	M	4	1.00	S	10	1.15	1.00	7	14.6	0.99	17	13		8	1.1	14	0.098	0.145	0.824	0.68	Yes	Yes	SP-SM				Yes	YES	0.68	Liquefiable
S21	45	10	SP-SM	130	5616	3521	3370	0.8	1.3	M	4	1.00	S	9	1.11	1.00	7	15.5	0.99	13	10		9	1.1	11	0.074	0.139	0.784	0.53	Yes	Yes	SP-SM				Yes	YES	0.53	Liquefiable
S22	48	15	SP-SM	130	6200	3764	3573	0.7	1.3	M	4	1.00	S	11	1.16	1.00	7	16.5	1.00	20	15		8	1.1	15	0.104	0.134	0.612	0.79	Yes	Yes	SP-SM				Yes	YES	0.79	Liquefiable
S23	50	11	SM	130	6760	4227	4046	0.7	1.3	M	4	1.00	S	9	1.11	1.00	7	17.5	1.00	15	10		12	1.2	11	0.072	0.132	0.538	0.68	Yes	Yes	SM				Yes	YES	0.68	Liquefiable
S24	60	12	SM	130	7800	4963	4784	0.7	1.3	M	4	1.00	S	7	1.10	1.00	7	20.1	1.00	13	9		12	1.2	10	0.065	0.113	0.361	0.58	Yes	Yes	SM				Yes	YES	0.58	Liquefiable
S25	65	14	CH/MH	110	8110	4883	4622	0.6	1.3	M	4	1.00	S	9	1.13	1.00	7	21.6	1.00	19	12		5	1.0	13	0.078	0.110	0.782	0.71	Yes	Yes	CH/MH	54	26		No	No	0.71	-
S26	70	11	CH/MH	110	8660	5041	4880	0.6	1.3	M	4	1.00	S	7	1.10	1.00	7	23.2	1.00	15	9		5	1.0	10	0.062	0.107	0.669	0.58	Yes	Yes	CH/MH				No	No	0.58	-
S27	75	11	CH/MH	110	9210	5279	5098	0.6	1.3	M	4	1.00	S	7	1.10	1.00	7	24.7	1.00	15	9		5	1.0	9	0.058	0.104	0.557	0.56	Yes	Yes	CH/MH				No	No	0.56	-
S28	80	13	CH/MH	110	9765	5517	5336	0.6	1.3	M	4	1.00	S	8	1.11	1.00	7	26.2	1.00	17	10		5	1.0	11	0.066	0.101	0.644	0.65	Yes	Yes	CH/MH				No	No	0.65	-
S29	85	12	CH/MH	110	10310	5755	5574	0.5	1.3	M	4	1.00	S	7	1.10	1.00	7	27.7	1.00	16	9		5	1.0	10	0.061	0.101	0.593	0.61	Yes	Yes	CH/MH				No	No	0.61	-
S30	90	23	CH	110	10860	6052	5812	0.5	1.3	M	4	1.00	S	13	1.20	1.00	7	29.3	1.00	31	19		20	1.2	22	0.148	0.100	0.902	1.49	No	Yes	CH				No	No	1.49	-
S31	95	31	CL	110	11410	6251	6050	0.5	1.3	M	4	1.00	S	19	1.25	1.00	7	30.8	1.00	41	23		35	1.2	28	0.238	0.099	0.298	2.42	No	Yes	CL				Yes	No	2.42	-
S32	99	30	CL	110	11795	6397	6218	0.5	1.3	M	4	1.00	S	18	1.27	1.00	7	31.9	1.00	40	25		35	1.2	30	0.253	0.098	0.265	2.68	No	Yes	CL				Yes	No	2.68	-
					11795	11795	11795	0.4	1.3			1.00		0	1.19	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.024	0.222	1.000	0.16	Yes	na	0				Yes	No	0.16	-
					11795	11795	11795	0.4	1.3			1.00		0	1.19	0.00		-0.3	0.75	0	0		5	#DIV/0!	#DIV/0!	0.024	0.222	1.000	0.16	Yes	No	0				Yes	No	0.16	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential*, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1314-1340, and Discussions and Closures (May, 2006)
2. URS Corporation 2008, *Guidance Document for Geotechnical Analyses*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on MCAL and SCAL sample correction)

PROJECT NAME:	American River Common Features (SRS Project)
LEVEE SEGMENT:	Sacramento River East Levee North of American River Bifurcation
PROJECT NUMBER:	26810256 (45423)
Reach ID:	
Station:	RAW Station: 1405+00
Boring ID:	RF-01-07
Boring Location (Enter E, w, and/or N/S letter, and distance from Levee Centerline/Waterside Edge	Landside Berm

Analysis By:	Juan F. Font
Check By:	

Date:	10/13/2009
Date:	

Data Input By Analyst
Radius of Influence
Calculated Values

Ground Elevation (ft.)= 27
Groundwater Elev. During Drilling (ft.) = 15.1
Analyzed Groundwater Elevation (ft.)= 14.9

Note: Seeps during drilling
Note: Borehole Wall Caved/Sloughed

Groundwater Depth Below GS During Drilling (ft.) = 12.0
Analyzed Groundwater Depth Below GS (ft.) = 12.2

Hammer Type = Rollerhole
Energy Ratio = 90

Earthquake Information:
Return Period (years) = 2500
M_w = 6.50

PGA (g) = 0.54
Location = Sacramento

Fault: Great, Location, w Hollywood

Sample ID	Depth to Sample (ft.)	H_{max}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ_v' (psf)	Effective Overburden Pressure During Earthquake, σ_v' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SS, SHELBY, MCAL)	N_1 for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick-Up (Protrusion) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$H_{max/CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, FS	If P_L < 1.2 (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w %)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AG	Final Assessment (Yes/No) based on Criteria for AC and AF	Factor of Safety, FS	Comment (Liquefiable for FS, PI and Judgment, Required for 1.0 <FS< 1.3)
S1	8	10	CL	110	8	8	0	#DIV/0!	1.3	M	4	1.00	S	#DIV/0!	#DIV/0!	1.00	7	1.9	0.75	10	#####		35	#DIV/0!	#DIV/0!	#DIV/0!	0.332	#DIV/0!	#DIV/0!	#DIV/0!	No	CL				Yes	#DIV/0!	#DIV/0!	#DIV/0!
S2	2	5	CL	110	220	220	220	1.6	1.3	M	4	1.00	S	10	1.11	1.00	7	2.4	0.75	6	10		35	35	1.3	13	0.164	0.220	0.910	0.81	Yes	No	CL				Yes	No	0.81	-
S3	4	1	CL	110	440	440	440	1.6	1.3	M	4	1.00	S	2	1.10	1.00	7	3.0	0.75	1	3		35	35	2.2	4	0.077	0.225	1.000	0.34	Yes	No	CL			34	Yes	No	0.34	-
S4	6		ML	120	680	680	680	1.6	1.3	M	4	1.00	SHELBY	0	1.10	0.99	7	3.7	0.75	0	0		35	#DIV/0!	#DIV/0!	#DIV/0!	0.059	0.222	1.000	0.27	Yes	No	ML			36	Yes	No	0.27	-
S5	9	4	CL	130	940	940	940	1.5	1.3	M	4	1.00	S	9	1.10	1.00	7	4.3	0.80	4	9		35	35	1.4	9	0.092	0.218	0.999	0.42	Yes	No	CL			31	Yes	No	0.42	-
S6	10	5	SM	130	1300	1300	1300	1.3	1.3	M	4	1.00	MCAL	6	1.10	0.93	7	4.9	0.85	4	5		12	12	7	0.673	0.215	1.000	0.34	Yes	No	SM				Yes	No	0.34	-
S7	12	2	ML	120	1440	1440	1440	1.2	1.3	M	4	1.00	S	2	1.10	1.00	7	5.5	0.95	2	3		35	35	1.8	5	0.061	0.212	1.000	0.29	Yes	No	ML	21	1		Yes	No	0.29	-
S8	14	4	ML	120	1680	1680	1680	1.1	1.3	M	4	1.00	S	6	1.10	1.00	7	6.1	0.95	6	9		35	35	1.8	8	0.074	0.208	1.000	0.36	Yes	No	ML				Yes	Yes	0.36	Liquefiable
S9	16	1	ML	120	1920	1672	1714	1.1	1.2	M	4	1.00	S	1	1.10	1.00	7	6.7	0.91	1	1		35	35	2.5	3	0.051	0.205	1.000	0.29	Yes	Yes	ML				Yes	YES	0.29	Liquefiable
S10	18	3	SM	130	2180	1900	1949	1.1	1.3	M	4	1.00	S	3	1.10	1.00	7	7.3	0.92	4	4		12	12	5	0.656	0.201	1.000	0.28	Yes	Yes	SM				Yes	YES	0.28	Liquefiable
S11	20	5	SM	130	2440	1941	1994	1.0	1.2	M	4	1.00	MCAL	5	1.10	0.82	7	7.9	0.94	5	5		12	12	5	0.656	0.198	1.000	0.30	Yes	Yes	SM				Yes	YES	0.30	Liquefiable
S12	22	2	ML/SM	120	2640	2004	2160	1.0	1.3	M	4	1.00	S	2	1.10	1.00	7	8.5	0.95	3	2	52	35	35	1.8	5	0.054	0.193	1.000	0.28	Yes	Yes	ML/SM				Yes	YES	0.28	Liquefiable
S13	24	2	ML/SM	120	2820	2171	2215	1.0	1.3	M	4	1.00	S	2	1.10	1.00	7	9.1	0.96	3	2		5	5	1.1	3	0.046	0.188	1.000	0.24	Yes	Yes	ML/SM				Yes	YES	0.24	Liquefiable
S14	26	3	ML/SM	120	3160	2280	2330	0.9	1.3	M	4	1.00	S	3	1.10	1.00	7	9.8	0.96	4	4		8	8	1.1	4	0.049	0.183	1.000	0.27	Yes	Yes	ML/SM				Yes	YES	0.27	Liquefiable
S15	28	4	ML/SM	120	3400	2402	2445	0.9	1.3	M	4	1.00	S	4	1.10	1.00	7	10.4	0.97	5	5		9	9	1.1	5	0.053	0.178	1.000	0.30	Yes	Yes	ML/SM				Yes	YES	0.29	Liquefiable
S16	30	11	SW-SM	130	3850	2537	2585	0.9	1.3	M	4	1.00	S	10	1.14	1.00	7	11.0	0.98	14	13	9	9	1.1	16	0.099	0.173	0.956	0.67	Yes	Yes	SW-SM				Yes	YES	0.67	Liquefiable
S17	33	10	SW-SM	130	4059	2740	2783	0.9	1.2	M	4	1.00	S	9	1.12	1.00	7	11.9	0.98	13	11		9	9	1.1	12	0.086	0.166	0.986	0.52	Yes	Yes	SW-SM				Yes	YES	0.52	Liquefiable
S18	36	12	SW-SM	130	4449	2942	3006	0.8	1.3	M	4	1.00	S	10	1.14	1.00	7	12.9	0.99	16	13		8	8	1.1	14	0.097	0.159	0.911	0.63	Yes	Yes	SW-SM				Yes	YES	0.63	Liquefiable
S19	39	15	SP-SM	130	4830	3145	3169	0.8	1.3	M	4	1.00	S	10	1.15	1.00	7	13.7	0.99	17	14	7	7	1.1	14	0.100	0.151	0.838	0.66	Yes	Yes	SP-SM				Yes	YES	0.66	Liquefiable
S20	42	15	SP-SM	130	5200	3349	3392	0.8	1.3	M	4	1.00	S	10	1.15	1.00	7	14.6	0.99	17	13		9	9	1.1	14	0.096	0.145	0.636	0.66	Yes	Yes	SP-SM				Yes	YES	0.66	Liquefiable
S21	45	10	SP-GM	130	5619	3551	3594	0.8	1.3	M	4	1.00	S	9	1.11	1.00	7	15.3	0.99	13	10		8	8	1.1	11	0.073	0.139	0.394	0.52	Yes	Yes	SP-GM				No	YES	0.52	Liquefiable
S22	48	10	SP-SM	120	6000	3754	3797	0.7	1.3	M	4	1.00	S	11	1.14	1.00	7	16.0	1.00	20	15		8	8	1.1	15	0.102	0.134	0.412	0.76	Yes	Yes	SP-SM				Yes	YES	0.76	Liquefiable
S23	55	11	SM	120	6618	4227	4270	0.7	1.3	M	4	1.00	S	8	1.11	1.00	7	18.6	1.00	15	10		12	12	1.1	11	0.072	0.122	0.339	0.69	Yes	Yes	SM				Yes	YES	0.69	Liquefiable
S24	62	10	SM	130	7969	4565	4608	0.7	1.3	M	4	1.00	S	7	1.10	1.00	7	20.1	1.00	13	9		12	12	1.1	10	0.064	0.113	0.561	0.57	Yes	Yes	SM				Yes	YES	0.57	Liquefiable
S25	65	14	CH/MH	110	8119	4903	4945	0.6	1.2	M	4	1.00	S	9	1.13	1.00	7	21.6	1.00	18	12		5	5	1.0	13	0.077	0.110	0.762	0.70	Yes	Yes	CH/MH	54	26		No	No	0.70	-
S26	70	11	CH/MH	110	8690	5241	5284	0.6	1.3	M	4	1.00	S	7	1.10	1.00	7	22.2	1.00	15	9		5	5	1.0	10	0.061	0.107	0.356	0.57	Yes	Yes	CH/MH				No	No	0.57	-
S27	75	11	CH/MH	110	9219	5279	5322	0.6	1.3	M	4	1.00	S	7	1.10	1.00	7	24.7	1.00	15	9		5	5	1.0	9	0.060	0.104	0.357	0.58	Yes	Yes	CH/MH				No	No	0.58	-
S28	80	15	CH/MH	110	9769	5617	5660	0.6	1.3	M	4	1.00	S	9	1.11	1.00	7	26.2	1.00	17	10		5	5	1.0	11	0.066	0.101	0.866	0.65	Yes	Yes	CH/MH				No	No	0.65	-
S29	85	12	CH/MH	110	10310	5793	5796	0.6	1.3	M	4	1.00	S	7	1.10	1.00	7	27.7	1.00	16	9		5	5	1.0	10	0.060	0.101	0.553	0.60	Yes	Yes	CH/MH				No	No	0.44	-
S30	90	23	CH	110	10860	5993	6030	0.5	1.3	M	4	1.00	S	13	1.20	1.00	7	29.3	1.00	31	19		25	25	1.2	23	0.147	0.105	0.002	1.48	No	Yes	CH				No	No	1.48	-
S31	95	31	CL	110	11419	6231	6274	0.5	1.3	M	4	1.00	S	18	1.29	1.00	7	30.8	1.00	41	23		35	35	1.2	28	0.237	0.099	0.000	2.49	No	Yes	CL				Yes	No	2.49	-
S32	99	35	CL	110	11795	6397	6441	0.5	1.3	M	4	1.00	S	18	1.29	1.00	7	31.9	1.00	44	25		35	35	1.2	30	0.260	0.098	0.000	2.65	No	Yes	CL				Yes	No	2.65	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1312-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analyses, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.E. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME	Jackson Slough Corrosion Features (URS Project)
LEVEE SEGMENT:	Sacramento River East Levee North of American River (Subreach)
PROJECT NUMBER:	26015478.03.0400
Reach ID:	
Station:	CPT-B (Setup: 150+00)
Boring ID:	CPT-B-02
Boring Location (Insert Levee/Waterside, and distance from Levee/Landside/Waterside toe)	Landside Setting

Analysis By:	Juan F. Perez
Check By:	
Date:	10/15/2010
Date:	

Cyclic Log (CPT) Analysis
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 21.0
Groundwater Elev. During Drilling (ft.)= 13.5
Analyzed Groundwater Elevation (ft.)= 13.4
Note: Depth during drilling
Note: Based on WSE 4 mos(+/-)day

Groundwater Depth Below GS During Drilling d1 = 14.0
Analyzed Groundwater Depth Below GS (ft.) = 14.1

Hammer Type = Automatic
Energy Ratio = 90

Earthquake Information
Return Period (years) = 200
PGA (g) = 0.16
ML = 7.8
Location = Levee (Enter: Levee, Landside, or Waterside)

Sample ID	Depth to Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ'_v (psf)	Effective Overburden Pressure During Earthquake, σ'_v(psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter, C_B	Correction for Borehole Diameter, C_B	Sampler Code (if, no SCAL: MCAL)	N_m for Sampler Correction Only (for SW sampler)	Sampler Correction for Sampler Only, C_S	Sampler Correction for Analysis, C_S	Stick Up (Extension) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{cs}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$H_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS < 1.2 (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Assessment (Yes/No) Based on columns AB, W, and AK	Factor of Safety, FS	Comment (Liquefiable for FS <1 and Judgment Required for 1 < FS < 1.3)
S1	2.5	2	SM	110	13	13	13	1.8	1.0	M	4	1.00	S	40	1.20	1.00	7	1.9	0.75	19	20		12	1.1	32	1.725	0.232	0.000	3.00	No	No	SM				Yes	No	3.00	-
S2	5	7	SM	130	296	296	296	1.6	1.0	M	4	1.00	S	18	1.15	1.00	7	2.4	0.75	8	13		12	1.1	14	0.250	0.228	0.351	0.89	Yes	No	SM				Yes	No	0.45	-
S3	7.5	7	CL	110	480	480	480	1.5	1.0	M	4	1.00	S	11	1.10	1.00	7	3.0	0.75	5	8		25	1.3	11	0.134	0.225	0.837	0.60	Yes	No	CL				Yes	No	0.45	-
S4	9	4	CL	110	756	756	756	1.5	1.0	M	4	1.00	S	10	1.10	1.00	7	3.7	0.75	5	7		35	1.6	10	0.109	0.222	0.959	0.49	Yes	No	CL	32	13	17	Yes	No	0.45	-
S5	11	5	ML	120	940	940	940	1.5	1.0	M	4	1.00	MCAL	13	1.12	0.90	7	4.3	0.85	8	8	N	35	1.3	11	0.111	0.218	0.995	0.51	Yes	No	ML				Yes	No	0.51	-
S6	13	6	ML	120	1160	1160	1160	1.3	1.0	M	4	1.00	S	10	1.10	1.00	7	4.9	0.93	7	9		35	1.3	12	0.107	0.215	0.995	0.50	Yes	No	ML				Yes	No	0.50	-
S7	15	5	SP-SM	120	1440	1440	1440	1.2	1.0	M	4	1.00	S	9	1.10	1.00	7	5.5	0.95	7	8		8	1.1	9	0.091	0.212	1.000	0.48	Yes	No	SP-SM				Yes	No	0.34	-
S8	17	6	ML	120	1680	1680	1680	1.1	1.0	M	4	1.00	S	8	1.10	1.00	7	6.1	0.89	4	5		35	1.6	7	0.070	0.208	1.000	0.34	Yes	No	ML				Yes	No	0.34	-
S9	19	3	ML	120	1920	1795	1795	1.1	1.0	M	4	1.00	S	3	1.10	1.00	7	6.7	0.91	3	3		35	1.7	5	0.056	0.205	1.000	0.28	Yes	Yes	ML				Yes	YES	0.28	Liquefiable
S10	21	7	SM	130	2190	1935	1935	1.0	1.0	M	4	1.00	S	5	1.10	1.00	7	7.3	0.92	5	5		12	1.2	6	0.059	0.201	1.000	0.29	Yes	Yes	SM				Yes	YES	0.29	Liquefiable
S11	23	9	SM	130	2440	2065	2065	1.0	1.0	M	4	1.00	S	6	1.10	1.00	7	7.9	0.94	6	6		12	1.2	8	0.082	0.198	1.000	0.31	Yes	Yes	SM				Yes	YES	0.31	Liquefiable
S12	25	9	SM	130	2700	2201	2201	1.0	1.0	M	4	1.00	S	6	1.10	1.00	7	8.5	0.95	5	6	c	20	1.5	7	0.063	0.193	1.000	0.33	Yes	Yes	SM				Yes	YES	0.33	Liquefiable
S13	27	3	SM	130	2960	2335	2335	0.9	1.0	M	4	1.00	S	3	1.10	1.00	7	9.1	0.96	3	3		12	1.3	3	0.047	0.189	1.000	0.25	Yes	Yes	SM				Yes	YES	0.25	Liquefiable
S14	29	3	SM	130	3220	2471	2471	0.9	1.0	M	4	1.00	S	2	1.10	1.00	7	9.8	0.96	2	2		12	1.2	3	0.053	0.183	1.000	0.29	Yes	Yes	SM				Yes	YES	0.29	Liquefiable
S15	31	3	SM	130	3480	2606	2606	0.9	1.0	M	4	1.00	S	4	1.10	1.00	7	10.4	0.97	5	4		12	1.2	5	0.052	0.178	1.000	0.29	Yes	Yes	SM				Yes	YES	0.29	Liquefiable
S16	33	3	ML	120	3720	2722	2722	0.9	1.0	M	4	1.00	S	3	1.10	1.00	7	11.0	0.98	3	3		35	1.8	5	0.050	0.173	1.000	0.29	Yes	Yes	ML				Yes	YES	0.29	Liquefiable
S17	35	7	SM	130	4110	2924	2924	0.8	1.0	M	4	1.00	S	7	1.10	1.00	7	11.8	0.99	7	7	d	70	3.3	9	0.042	0.169	1.000	0.25	Yes	Yes	SM				Yes	YES	0.25	Liquefiable
S18	37	11	SM	130	4500	3127	3127	0.8	1.0	M	4	1.00	S	13	1.14	1.00	7	12.5	0.99	16	13		12	1.1	14	0.096	0.159	0.924	0.61	Yes	Yes	SM				Yes	YES	0.61	Liquefiable
S19	39	17	SW-SM	130	4890	3330	3330	0.8	1.0	M	4	1.00	S	13	1.15	1.00	7	12.7	0.99	17	13		9	1.1	14	0.094	0.151	0.908	0.62	Yes	Yes	SW-SM				Yes	YES	0.62	Liquefiable
S20	41	31	SW-SM	130	5280	3533	3533	0.8	1.0	M	4	1.00	S	16	1.18	1.00	7	14.8	0.99	21	16	n	11	1.1	17	0.117	0.145	0.890	0.81	Yes	Yes	SW-SM				Yes	YES	0.81	Liquefiable
S21	43	14	SW-SM	130	5570	3736	3736	0.7	1.0	M	4	1.00	S	13	1.15	1.00	7	15.5	0.99	19	13		9	1.1	14	0.092	0.139	0.866	0.66	Yes	Yes	SW-SM				Yes	YES	0.66	Liquefiable
S22	45	15	SP-SM	130	5125	3972	3975	0.7	1.0	M	4	1.00	S	13	1.14	1.00	7	16.6	1.00	19	13		8	1.1	14	0.089	0.133	0.847	0.66	Yes	Yes	SP-SM				Yes	YES	0.66	Liquefiable

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1312-1340. and Discussions and Closures (May, 2006)
2. URS Corporation 2009. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.
3. Seed, R.B., et al, 2003, Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on NCAL and SCAL sampler correction)

PROJECT NAME:	Sacramento River Cantonment Features (ORD Project)
LEVEE SEGMENT:	Sacramento River East Levee North of American River (Mathematical)
PROJECT NUMBER:	26618780.65459
Reach ID:	
Station:	RIVER Station: 7462+00S
Boring ID:	SPT-01-D
Boring Location (Use Lat/Lon/Warnings and Advisors from Lat/Lon/Lat/Lon/Project Lat/Lon)	Latitude: Boring

Analyst: Reid F. Plant
Check By:

Date: 4/6/2009
Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 27.5
Groundwater Elev. During Drilling (ft.) = 23.5
Analyzed Groundwater Elevation (ft.)= 15.0

Note: Depth during drilling
Note: Water level is predicted

Groundwater Depth Below GS During Drilling dft = 16.0
Analyzed Groundwater Depth Below GS (ft.) = 16.5

Hammer Type = Safety/donut
Energy Ratio = 0.87

Earthquake Information
Return Period (years) = 200
M_w = 7.8

PGA (g) = 0.34
Location = Levee Toe: Clay, Lean Clay, Lean/Silty, or Gravelly

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URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2006. *Guidance Document for Geotechnical Analysis , Urban Levee Geotechnical Evaluations Program Rev. 5, March 2006.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Queens Natty, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (press only for guidance on NCAL and SCAL sampler correction)

PROJECT NAME:	American River Common Features (2autho Project
LEVEE SEGMENT:	Sacramento River East Levee North of American River (Gatorway)
PROJECT NUMBER:	38418160.45459
Reach ID:	
Station:	DWR Station: 1622+00
Boring ID:	SP-EB-03
Boring Location (Depth Controlled Materials, and Variance from Used Audit Limit Materials Use)	Sampler Tips

Analyzed By: Juan P. Perez
Check By:

Date: 06/12/2008
Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 34.0
Groundwater Elev. During Drilling (ft.) = 31.0
Analyzed Groundwater Elevation (ft.)= 27.0

Note: Depth during drilling
Note: Water level 4 mos later

Groundwater Depth Below GS During Drilling (ft.) = 13.0
Analyzed Groundwater Depth Below GS (ft.) = 17.0

Hammer Type = Automatic
Energy Ratio = 80

Earthquake Information:
Return Period (years) = 200
R_L = 1.0

PGA up = 0.74
Location = Landslide (Levee Crest, Landside, or Waterside

Sample ID	Depth to Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (IS, SS, SCAL, NCAL)	N_1 for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Penetration) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	M_{cf}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$R_{M,CSR}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS < 1.0 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Assessment (Yes/No) Based on Columns AE, AF, and AK	Factor of Safety, FS	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS< 1.3)
SP1	3.1	4	ML	120	12	12	12	1.9	1.0	M	4	1.00	S	10	1.10	1.00	7	1.9	0.75	5	7		35	1.4	10	0.126	0.232	0.002	1.45	No	No	ML					No	No	1.45	-
SP2	7	9	ML	120	360	360	360	1.6	1.0	M	4	1.00	S	13	1.11	1.00	7	2.4	0.75	8	10	15	35	1.3	13	0.160	0.228	0.568	0.79	Yes	No	ML					Yes	No	0.79	-
SP3	9	11	ML	120	480	480	480	1.6	1.0	M	4	1.00	S	16	1.16	1.00	7	2.9	0.75	9	13		35	1.3	17	0.202	0.225	0.311	0.90	Yes	No	ML	NP	NP			Yes	No	0.90	-
SP4	9	12	ML	120	720	720	720	1.6	1.0	M	4	1.00	NCAL	21	1.19	0.90	7	3.7	0.75	8	12		35	1.3	16	0.169	0.222	0.515	0.76	Yes	No	ML					Yes	No	0.76	-
SP5	8	11	ML	120	960	960	956	1.4	1.0	M	4	1.00	S	16	1.15	1.00	7	4.3	0.95	8	13	05	35	1.3	16	0.169	0.218	0.707	0.73	Yes	Yes	ML					Yes	YES	0.73	Liquefiable
SP6	10	6	ML	120	1200	1200	1071	1.3	1.0	M	4	1.00	S	10	1.10	1.00	7	4.9	0.93	7	9	70	95	1.3	12	0.169	0.215	0.853	0.51	Yes	Yes	ML	NP	NP			Yes	YES	0.51	Liquefiable
SP7	13	7	ML	120	1440	1440	1186	1.2	1.0	M	4	1.00	S	9	1.10	1.00	7	5.5	0.95	6	7		35	1.4	10	0.093	0.212	0.599	0.44	Yes	Yes	ML					Yes	YES	0.44	Liquefiable
SP8	14	9	ML	120	1680	1649	1301	1.1	1.0	M	4	1.00	S	3	1.10	1.00	7	6.1	0.93	3	3	30	35	1.7	5	0.063	0.208	1.000	0.30	Yes	Yes	ML					Yes	YES	0.30	Liquefiable
SP9	15	3	ML	120	1920	1744	1416	1.1	1.0	M	4	1.00	S	3	1.10	1.00	7	6.7	0.91	3	3		35	1.7	5	0.062	0.205	1.000	0.30	Yes	Yes	ML					Yes	YES	0.30	Liquefiable
SP10	16	7	SM	130	2160	1898	1532	1.0	1.0	M	4	1.00	S	7	1.10	1.00	7	7.3	0.92	5	7		12	1.1	8	0.073	0.201	1.000	0.36	Yes	Yes	SM					Yes	YES	0.36	Liquefiable
SP11	20	8	SM	130	2440	2034	1667	1.0	1.0	M	4	1.00	S	8	1.10	1.00	7	7.9	0.94	7	7	35	35	1.4	10	0.087	0.196	0.999	0.44	Yes	Yes	SM					Yes	YES	0.44	Liquefiable
SP12	21.5		SM	130	2605	2136	1749	1.0	1.0	M	4	1.00		6	1.10	0.00	7	8.4	0.95	5	6		12	#DIV/0!	#DIV/0!	0.041	0.194	1.000	0.21	Yes	Yes	SM			12		Yes	YES	0.21	Liquefiable
SP13	23.0		SM	130	2990	2271	1833	0.9	1.0	M	4	1.00		0	1.12	0.00	7	9.0	0.96	0	0		12	#DIV/0!	#DIV/0!	0.041	0.189	1.000	0.22	Yes	Yes	SM			10		Yes	YES	0.22	Liquefiable
SP14	25	10	SM	130	3220	2440	2002	0.9	1.0	M	4	1.00	S	9	1.15	1.00	7	9.6	0.96	10	9		12	1.1	10	0.078	0.183	1.000	0.43	Yes	Yes	SM					Yes	YES	0.43	Liquefiable
SP15	27	5	SP	130	3480	2675	2229	0.9	1.0	M	4	1.00	S	5	1.15	1.00	7	10.4	0.97	6	5		5	1.1	5	0.056	0.178	1.000	0.21	Yes	Yes	SP					Yes	YES	0.21	Liquefiable
SP16	29	7	SM	130	3740	2710	2263	0.9	1.0	M	4	1.00	S	6	1.19	1.00	7	11.0	0.99	7	6		12	1.2	7	0.061	0.173	1.000	0.26	Yes	Yes	SM					Yes	YES	0.26	Liquefiable
SP17	30	4	SP-SM	130	4130	2913	2566	0.8	1.0	M	4	1.00	S	3	1.19	1.00	7	11.8	0.98	4	3		6	1.2	4	0.049	0.168	1.000	0.29	Yes	Yes	SP-SM					Yes	YES	0.29	Liquefiable
SP18	32	8	ML	120	4490	3066	2739	0.8	1.0	M	4	1.00	S	6	1.19	1.00	7	12.6	0.99	8	6		35	1.4	9	0.069	0.166	0.999	0.44	Yes	Yes	ML					Yes	YES	0.44	Liquefiable
SP19	34.5	11	SM	130	4915	3255	2907	0.8	1.0	M	4	1.00	S	9	1.19	1.00	7	13.5	0.99	15	9		12	1.1	10	0.071	0.162	0.999	0.47	Yes	Yes	SM					Yes	YES	0.47	Liquefiable

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. **Cetin, K.O., et al, 2004.** *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. **URS Corporation 2008.** *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 5, March 2008.*
3. **Seed, R.B., et al, 2003.** *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework.* 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Queens Navy, Long Beach, Ca .
4. **Southern California Earthquake Center, University of Southern California,** *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999),* (used only for guidance on MCAL and SCAL sampler corrections)

PROJECT NAME:	Mossdale (Bob Cecil) to Fabian's (URS Project)
LEVEE SEGMENT:	Sacramento River East Levee North of American River (Galloway)
PROJECT NUMBER:	28414167.65439
Reach ID:	
Station:	(with Station, USACE)
Boring ID:	SP-SB-63
Boring Location (Cetin, Lee/Seed/Idriss/Harder/Youd, and Boulanger/Idriss/Kayen/Moss/Seed/Wu/Juang)	Levee Toe

Analysis By:	Saad F. Parvi
Check By:	
Date:	09/4/2008
Date:	

Ground Elevation (F_L)= 21.5
Groundwater Elev. During Drilling (F_L) = 11.4
Assigned Groundwater Elevation (F_L)= 13.5

Note: Depth during drilling
Note: Summer WSE is May/Oct

Groundwater Depth Below GS During Drilling (ft.) = 10.1
Assigned Groundwater Depth Below GS (ft.) = 11.5

Hammer Type = Automatic
Energy Ratio = 80

Earthquake Information:
Return Period (years) = 500
M_w = 7.9

PGA (g) = 0.16
Location = Levee Toe

Enter: Cetin, Landslide, or Whitman

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (C, SC, SCAL, MCAL)	N_1 for Sampler Correction Only (for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Pushpoint) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{FINES}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, FS_L	FS < 1.0 (Yes/No) Column AC	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Assessment (Yes/No) Based on Columns AC, AF, and AK	Factor of Safety, FS_L	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS< 1.3)
S1	3.5	3	ML	120	12	12	12	1.5	1.0	M	4	1.00	S	10	1.10	1.00	7	0.75	3	7		35	1.4	10	0.136	0.232	0.602	1.45	No	No	ML				Yes	No	1.45	-
S2	5	6	ML	120	360	360	240	1.5	1.0	M	4	1.00	S	13	1.11	1.00	7	2.4	0.75	6	10	10	35	1.3	13	0.160	0.228	0.540	0.79	Yes	No	ML				Yes	No	0.79	-
S3	8	11	ML	120	480	480	480	1.5	1.0	M	4	1.00	S	18	1.16	1.00	7	3.6	0.75	8	13		35	1.3	17	0.202	0.225	0.311	0.90	Yes	No	ML	NP	NP		Yes	No	0.90	-
S4	9	13	ML	120	720	720	720	1.5	1.0	M	4	1.00	MCAL	21	1.19	0.90	7	3.7	0.75	8	12		35	1.3	16	0.189	0.222	0.615	0.76	Yes	No	ML				Yes	No	0.76	-
S5	10	11	ML	120	960	960	960	1.4	1.0	M	4	1.00	S	16	1.15	1.00	7	4.3	0.95	8	13	65	35	1.3	16	0.189	0.218	0.707	0.72	Yes	No	ML				Yes	No	0.72	-
S6	12	8	ML	120	1200	1200	1200	1.3	1.0	M	4	1.00	S	10	1.10	1.00	7	4.9	0.93	7	9	70	35	1.3	12	0.165	0.215	0.693	0.49	Yes	No	ML	NP	NP		Yes	No	0.49	-
S7	13	7	ML	120	1440	1440	1411	1.2	1.0	M	4	1.00	S	9	1.10	1.00	7	5.5	0.88	6	7		35	1.4	10	0.089	0.212	0.959	0.42	Yes	Yes	ML				Yes	YES	0.42	Liquefiable
S8	14	7	ML	120	1680	1649	1535	1.1	1.0	M	4	1.00	S	9	1.10	1.00	7	6.1	0.89	6	8	60	35	1.3	9	0.091	0.208	1.000	0.29	Yes	Yes	ML				Yes	YES	0.29	Liquefiable
S9	15	9	ML	120	1920	1784	1641	1.1	1.0	M	4	1.00	S	9	1.10	1.00	7	6.7	0.91	6	8		35	1.7	9	0.089	0.205	1.000	0.29	Yes	Yes	ML				Yes	YES	0.29	Liquefiable
S10	17	7	SM	130	2180	1993	1776	1.0	1.0	M	4	1.00	S	7	1.10	1.00	7	7.3	0.92	6	7		12	1.1	9	0.070	0.201	1.000	0.35	Yes	Yes	SM				Yes	YES	0.35	Liquefiable
S11	20	5	SM	130	2440	2054	1911	1.0	1.0	M	4	1.00	S	8	1.16	1.00	7	7.9	0.94	7	7	30	25	1.4	10	0.094	0.198	0.999	0.42	Yes	Yes	SM				Yes	YES	0.42	Liquefiable
S12	21.5		SM	130	2635	2194	2013	1.0	1.0	M	4	1.00		0	1.16	0.00	7	8.4	0.95	0	0		12	#DIV/0!	#DIV/0!	0.040	0.194	1.000	0.21	Yes	Yes	SM			30	Yes	YES	0.21	Liquefiable
S13	23.5		SM	130	2895	2271	2149	0.9	1.0	M	4	1.00		0	1.16	0.00	7	9.0	0.96	0	0		12	#DIV/0!	#DIV/0!	0.039	0.189	1.000	0.21	Yes	Yes	SM			31	Yes	YES	0.21	Liquefiable
S14	26	10	SM	135	3250	2440	2317	0.9	1.0	M	4	1.00	S	9	1.16	1.00	7	9.8	0.96	10	9		12	1.1	10	0.077	0.183	1.000	0.42	Yes	Yes	SM				Yes	YES	0.42	Liquefiable
S15	28	6	SP	130	3640	2675	2452	0.9	1.0	M	4	1.00	S	5	1.16	1.00	7	10.4	0.97	5	5		5	1.1	5	0.055	0.178	1.000	0.31	Yes	Yes	SP				Yes	YES	0.31	Liquefiable
S16	30	7	SM	130	3742	2710	2587	0.9	1.0	M	4	1.00	S	6	1.16	1.00	7	11.0	0.98	7	6		12	1.2	7	0.059	0.173	1.000	0.34	Yes	Yes	SM				Yes	YES	0.34	Liquefiable
S17	33	4	SP-SM	130	4160	2913	2790	0.8	1.0	M	4	1.00	S	3	1.16	1.00	7	11.9	0.98	4	3		8	1.2	4	0.046	0.166	1.000	0.28	Yes	Yes	SP-SM				Yes	YES	0.28	Liquefiable
S18	35	9	ML	120	4490	3065	2943	0.8	1.0	M	4	1.00	S	6	1.16	1.00	7	12.8	0.99	9	9		25	1.8	9	0.080	0.159	0.999	0.43	Yes	Yes	ML				Yes	YES	0.43	Liquefiable
S19	38.5	11	SM	130	4915	3295	3132	0.8	1.0	M	4	1.00	S	9	1.16	1.00	7	13.6	0.99	11	9		12	1.4	10	0.089	0.152	0.998	0.46	Yes	Yes	SM				Yes	YES	0.46	Liquefiable

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et. al., 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussion and Closures (May, 2006)*
2. URS Corporation 2009, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.B.E. Queens Natty, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on MCAI, and SCAL Sampler correction)

PROJECT NAME:	Merrickville Flood Protection Feasibility Study
LEVEE SEGMENT:	Approximately 800m East Levee North of the Mississippi River (Instrument)
PROJECT NUMBER:	60418700.03400
Reach ID:	
Station:	CWR Station : 1+420+00
Boring ID:	BH13MW
Boring Location (Insert easting/Northing and distance from CWR Centerline/Baseline)	Waterside Slope

Analysis By:	Saeid F. Fard
Check By:	
Date:	7/6/2012
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 73.4
Groundwater Elev. During Drilling (ft.) = 63.4
Analyzed Groundwater Elevation (ft.)= 63.4

Hole: Not measured, assumed same as hole borings
Note: Summer water is high water

Groundwater Depth Below GS During Drilling (ft.) = 10.0
Analyzed Groundwater Depth Below GS (ft.) = 10.0

Hammer Type = Automatic
Energy Ratio = 90
pending confirmation ER

Earthquake Information
Return Period (years) = 2500
M_w = 7.0

PGA (g) = 0.154
Location = Waterside (Near Cent. Landside of Waterside)

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (...III, SS, SCAL, MCAL)	N_1 for Sampler Correction Only (for SW Sampler Only	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Antsykh, C_S	Stick Up (Protrusion) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.0 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Lab Test Results for CL, ML: Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Liquefaction Assessment: Final Assessment (Yes/No) Based on Criteria in AE, AF, and AG	Factor of Safety, FS	Comment (Liquefiable for FS,<1 and Judgment Required for 1.0<FS, to 1.3)
S1	5	3	SP-SM	130	650	650	1.5	1.3	M	4	1.00	S	40	1.30	1.00	7	3.4	9.75	25	49	12	10	1.1	42	1.238	0.235	0.000	3.00	No	No	SP-SM				Yes	No	3.00	-
S2	10	8	ML	120	1250	1250	1250	1.3	1.3	M	4	1.00	S	11	1.14	1.00	7	4.8	9.83	10	13	74	35	1.3	16	0.147	0.219	0.816	0.67	Yes	No	ML				Yes	No	0.67	-
S3	15	11	ML	130	1950	1950	1950	1.2	1.3	M	4	1.00	SCAL	16	1.22	0.95	7	9.4	9.95	12	12		35	1.3	16	0.126	0.201	0.456	0.63	Yes	No	ML	NP	NP	19.2	Yes	No	0.63	-
S4	20	13	CL	110	2400	2400	2400	0.9	1.3	M	4	1.00	SCAL	13	1.19	0.95	7	7.9	9.94	11	10		35	1.3	14	0.101	0.144	0.972	0.50	Yes	No	CL				Yes	No	0.50	-
S5	25	7	ML	125	3000	3000	3000	0.8	1.3	M	4	1.00	SCAL	6	1.10	0.95	7	9.4	9.96	6	5	61	28	1.3	7	0.059	0.176	1.000	0.34	Yes	No	ML				Yes	No	0.34	-
S6	30	6	SM	120	3550	3375	3375	0.8	1.3	M	4	1.00	SCAL	6	1.10	0.95	7	11.0	9.98	7	5		12	1.2	6	0.052	0.168	1.000	0.31	Yes	Yes	SM				Yes	YES	0.31	Liquefiable
S7	35	7	ML	125	4350	3863	3863	0.7	1.3	M	4	1.00	S	1	1.10	1.00	7	12.5	9.99	3	2	55	33	2.0	4	0.044	0.169	1.000	0.28	Yes	Yes	ML				Yes	YES	0.28	Liquefiable
S8	40	4	SM	120	4800	4001	4001	0.7	1.3	M	4	1.00	S	3	1.10	1.00	7	14.0	9.99	5	4	47	25	1.6	6	0.050	0.152	1.000	0.33	Yes	Yes	SM				Yes	YES	0.33	Liquefiable
S9	45	6	SM	120	5550	4329	4329	0.7	1.3	M	4	1.00	S	4	1.10	1.00	7	15.5	0.39	8	5	30	25	1.5	9	0.056	0.145	1.000	0.39	Yes	Yes	SM				Yes	YES	0.39	Liquefiable
S10	50	12	SP-SM	130	6200	4677	4677	0.7	1.3	M	4	1.00	S	9	1.11	1.00	7	17.1	1.00	16	10		9	1.1	11	0.070	0.139	0.969	0.51	Yes	Yes	SP-SM				Yes	YES	0.51	Liquefiable
S11	55	17	SP-SM	130	6850	5016	5016	0.6	1.3	M	4	1.00	S	11	1.16	1.00	7	19.6	1.00	23	14		8	1.1	15	0.095	0.131	0.747	0.71	Yes	Yes	SP-SM				Yes	YES	0.71	Liquefiable
S12	60	32	SP	130	7150	5151	5151	0.6	1.3	M	4	1.00	S	14	1.21	1.00	7	19.2	1.00	29	16		5	1.0	19	0.122	0.129	0.217	0.95	Yes	Yes	SP				Yes	YES	0.95	Liquefiable
S13	65	35	SP-SM	130	7800	5393	5393	0.6	1.3	M	4	1.00	S	12	1.18	1.00	7	20.1	1.00	27	16	6	6	1.0	17	0.104	0.124	0.424	0.84	Yes	Yes	SP-SM				Yes	YES	0.84	Liquefiable
S14	70	43	SP	130	8150	5691	5691	0.6	1.3	M	4	1.00	S	14	1.21	1.00	7	21.6	1.00	31	16		5	1.0	19	0.118	0.119	0.183	0.99	Yes	Yes	SP				Yes	YES	0.99	Liquefiable
S15	75	33	SP-SM	130	8900	6029	6029	0.6	1.3	M	4	1.00	S	19	1.30	1.00	7	23.2	1.00	44	25	5	5	1.0	26	0.200	0.114	0.000	1.75	No	Yes	SP-SM				Yes	No	1.75	-
S16	80	22	SP	130	9450	6367	6367	0.6	1.3	M	4	1.00	S	12	1.19	1.00	7	24.7	1.00	28	16		5	1.0	17	0.100	0.109	0.272	0.92	Yes	Yes	SP				Yes	YES	0.92	Liquefiable
S17	85	33	SP	130	10155	6705	6705	0.5	1.3	M	4	1.00	S	19	1.30	1.00	7	26.2	1.00	51	17	5	5	1.0	17	0.101	0.104	0.180	0.97	Yes	Yes	SP				Yes	YES	0.97	Liquefiable
S18	90	65	GP	135	10775	7068	7068	0.5	1.3	M	4	1.00	S	31	1.36	1.00	7	27.7	1.00	53	28		5	1.0	29	0.242	0.099	0.006	2.44	No	Yes	GP				No	No	2.44	-
S19	95	80	GP	135	11650	7431	7431	0.5	1.3	M	4	1.00	S	31	1.36	1.00	7	29.3	1.00	53	28		5	1.0	29	0.226	0.094	0.009	2.40	No	Yes	GP				No	No	2.40	-
S20	100	50	GP	135	12125	7794	7794	0.5	1.3	M	4	1.00	S	29	1.36	1.00	7	30.9	1.00	77	39		5	1.0	40	0.539	0.089	0.000	3.00	No	Yes	GP				No	No	3.00	-
S21	105	92	SP	135	12600	8157	8157	0.5	1.3	M	4	1.00	S	35	1.39	1.00	7	32.3	1.00	59	34		5	1.0	35	0.367	0.084	0.000	3.00	No	Yes	SP				Yes	No	3.00	-
S22	110	75	GP	135	13475	8529	8529	0.5	1.3	M	4	1.00	S	12	1.17	1.00	7	33.8	1.00	32	15		5	1.0	16	0.086	0.084	0.127	1.02	Yes	Yes	GP				No	No	1.83	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340.* and *Discussions and Closures (May, 2006)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.B.E. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	Sumerian River Control on Explosive USAR Project
LEVEE SEGMENT:	Sacramento River East Levee North of Sumerian River (Robinson)
PROJECT NUMBER:	24419760.65430
Reach ID:	
Station:	2000 (Station: 1982+00)
Boring ID:	SC-LM2F
Boring Location (Cent.Line/Left/Waterside, and Distance from Cent.Line/Left/Waterside)	Waterside Berm

Analyzed By:	Joan P. Patel
Check By:	

Date:	5/21/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (E_g) =
Groundwater Elev. During Drilling (E_i) =
Analyzed Groundwater Elevation (E_w) =

13.0	
13.0	
11.0	

Note: Pile measured, assumed same as top berm
Note: Summer WSE is NAVD88

Groundwater Depth Below GS During Drilling (d_i) = 2.0
Analyzed Groundwater Depth Below GS (d_w) = 2.0

Hammer Type = Automatic
Energy Ratio = 80
pending calibration ER

Earthquake Information
Return Period (years) = 500
R_w = 7.6

PGA (g) = 0.16
Location = Hydrority

Enter: Crest, Landside, or Waterside

Sample ID	Depth to Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_i' (psf)	Effective Overburden Pressure During Earthquake, σ_o'(psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (C, W, SCAL, MCAL)	N, for Sampler Correction Only (for SW Sampler)	Sampler Correction for C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Penetration) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$R_{d,M\&S}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Sustance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.2 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	First Assessment (Yes/No) Based on Columns AE, AF, and AK	Factor of Safety, FS	Comment Liquefiable for FS <1 and Judgment Required for 1.0 <FS, < 1.2
S1	3	3	SP-SM	130	650	650	650	1.5	1.3	M	4	1.00	S	40	1.30	1.00	7	3.4	0.75	25	40	13	10	1.1	42	1.239	0.235	0.000	3.00	No	No	SP-SM				Yes	No	3.00	
S2	10	9	ML	120	1250	1250	1250	1.3	1.3	M	4	1.00	S	11	1.14	1.00	7	4.9	0.83	10	13	75	75	1.3	16	0.147	0.218	0.818	0.67	Yes	No	ML				Yes	No	0.67	-
S3	11	10	ML	120	1350	1350	1350	1.2	1.3	M	4	1.00	SCAL	16	1.22	0.95	7	6.4	0.95	12	13		25	1.3	16	0.126	0.203	0.606	0.60	Yes	No	ML	NP	NP	11.2	Yes	No	0.60	-
S4	20	14	CL	110	2400	2400	2400	0.9	1.3	M	4	1.00	SCAL	13	1.18	0.95	7	7.9	0.84	11	10		93	1.3	14	0.101	0.164	0.302	0.55	Yes	No	CL				Yes	No	0.55	-
S5	25	7	ML	120	3000	3000	2913	0.8	1.3	M	4	1.00	SCAL	6	1.10	0.95	7	9.4	0.76	6	5	56	56	1.5	7	0.090	0.175	1.000	0.34	Yes	Yes	ML				Yes	YES	0.34	Liquefiable
S6	30	6	SM	130	3450	3375	3151	0.8	1.3	M	4	1.00	SCAL	5	1.10	0.95	7	11.0	0.99	7	5		12	1.3	8	0.093	0.169	1.000	0.32	Yes	Yes	SM				Yes	YES	0.32	Liquefiable
S7	35	3	ML	130	4250	3663	3419	0.7	1.3	M	4	1.00	S	1	1.10	1.00	7	12.5	0.99	3	2	15	35	2.0	4	0.045	0.169	1.000	0.28	Yes	Yes	ML				Yes	YES	0.28	Liquefiable
S8	40	4	SM	130	4900	4201	3777	0.7	1.3	M	4	1.00	S	3	1.10	1.00	7	14.0	0.99	5	4	47	35	1.6	6	0.051	0.152	1.000	0.34	Yes	Yes	SM				Yes	YES	0.34	Liquefiable
S9	45	5	SM	130	5550	4339	4119	0.7	1.2	M	4	1.00	S	4	1.10	1.00	7	15.5	0.99	5	5	70	35	1.6	8	0.057	0.145	1.000	0.39	Yes	Yes	SM				Yes	YES	0.39	Liquefiable
S10	50	12	SP-SM	120	6000	4677	4453	0.7	1.3	M	4	1.00	S	9	1.15	1.00	7	17.1	1.00	16	10		8	1.1	11	0.071	0.139	0.989	0.51	Yes	Yes	SP-SM				Yes	YES	0.51	Liquefiable
S11	55	17	SP-SM	130	6850	5015	4791	0.6	1.2	M	4	1.00	S	11	1.16	1.00	7	18.6	1.00	23	14		9	1.1	15	0.094	0.131	0.747	0.72	Yes	Yes	SP-SM				Yes	YES	0.72	Liquefiable
S12	57	22	SP	130	7115	5151	4926	0.6	1.2	M	4	1.00	S	14	1.21	1.00	7	19.2	1.00	29	16		5	1.0	19	0.123	0.129	0.217	0.96	Yes	Yes	SP				Yes	YES	0.96	Liquefiable
S13	60	20	SP-SM	130	7500	5353	5129	0.6	1.3	M	4	1.00	S	12	1.19	1.00	7	20.1	1.00	27	16	6	6	1.0	17	0.106	0.124	0.436	0.85	Yes	Yes	SP-SM				Yes	YES	0.85	Liquefiable
S14	65	21	SP	130	8150	5491	5467	0.6	1.3	M	4	1.00	S	14	1.21	1.00	7	21.6	1.00	31	18		5	1.0	19	0.119	0.119	0.183	1.00	Yes	Yes	SP				Yes	YES	1.00	Judgment Required
S15	70	31	SP-SM	130	8800	5829	5805	0.6	1.3	M	4	1.00	S	19	1.30	1.00	7	23.2	1.00	44	25	5	5	1.0	26	0.203	0.114	0.000	1.79	No	Yes	SP-SM				Yes	No	1.79	-
S16	75	22	SP	130	9450	6307	6143	0.6	1.2	M	4	1.00	S	12	1.19	1.00	7	24.7	1.00	29	16		5	1.0	17	0.101	0.109	0.272	0.93	Yes	Yes	SP				Yes	YES	0.93	Liquefiable
S17	80	72	SP	130	10105	6785	6481	0.5	1.3	M	4	1.00	S	53	1.19	1.00	7	26.2	1.00	71	37	5	5	1.0	37	0.102	0.103	0.150	0.69	Yes	Yes	SP				Yes	YES	0.69	Liquefiable
S18	85	65	GP	135	10775	7258	6884	0.5	1.3	M	4	1.00	S	31	1.30	1.00	7	27.7	1.00	53	28		5	1.0	29	0.244	0.099	0.058	2.46	No	Yes	GP				No	No	2.46	-
S19	90	40	GP	135	11650	7431	7287	0.5	1.3	M	4	1.00	S	31	1.30	1.00	7	29.3	1.00	53	28		5	1.0	29	0.229	0.094	0.000	2.43	No	Yes	GP				No	No	2.43	-
S20	95	59	GP	135	12125	7744	7570	0.5	1.3	M	4	1.00	S	29	1.30	1.00	7	30.8	1.00	77	39		5	1.0	40	0.343	0.089	0.000	3.00	No	Yes	GP				No	No	3.00	-
S21	100	52	SP	135	12850	8157	7931	0.5	1.3	M	4	1.00	S	26	1.29	1.00	7	32.3	1.00	69	34		5	1.0	35	0.370	0.084	0.000	3.00	No	Yes	SP				Yes	No	3.00	-
S22	105	31	GP	135	13475	8629	8236	0.5	1.3	M	4	1.00	S	12	1.17	1.00	7	33.8	1.00	42	16		5	1.0	16	0.086	0.084	0.127	1.02	Yes	Yes	GP				No	No	1.02	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al., 2004. *Standard Penetration Test-based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)
2. URS Corporation 2006. *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.J.S. Queens Navy, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999). (used only for guidance on NCAL and SCAL sampler correction)

PROJECT NAME:	Arvanitas Flare Corner on Features (SRS Project)
LEVEE SEGMENT:	Sacramento River East Levee North of Interstate Water Diversion
PROJECT NUMBER:	39314760.65000
Reach ID:	
Station:	DWR Station: 1827+00
Boring ID:	SF-65-14 (65AH05F)
Boring Location (Levee Landside/Waterside, and distance from Crest)	Crest, Boring

Analyzed By: Geoff F. Fiehl
Check By:

Date: 10/1/2008
Date:

Cone Data By Andrejs?
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 23.5
Groundwater Elev. During Drilling (ft.) = 13.2
Analyzed Groundwater Elevation (ft.)= 15.2

Note: Elevations from Water Elevation
Note: Based on WSE & Well Data

Groundwater Depth Below GS During Drilling (ft.) = 10.3
Analyzed Groundwater Depth Below GS (ft.) = 10.3

Hammer Type = Automatic
Energy Ratio = 90
Confirm ER

Earthquake Information
Return Period (years) = 1000
R_d = 0.9

PGA (g) = 0.34
Location = Landside (Levee Crest, Landside, or Waterside

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ'_v (psf)	Effective Overburden Pressure During Earthquake, σ'_v (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SV, NCAL, SCAL)	N_1 for Sampler Correction Only (for SV sampler)	Sampler Correction for N_1 for SV Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Factorium) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$H_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	PL < 1.0 (Yes/No) Column AS	Below Analyzed Groundwater Level (Yes/No) Column AT	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AK	Final Assessment (Yes/No) Based on Columns AS, AT, and AK	Factor of Safety, FS	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS, < 1.3)
S1	5	10	CL	110	550	550	1.9	1.3	M	4	1.00	S	16	1.19	1.00		7	3.4	0.75	10	16		25	1.2	20	0.247	0.233	0.064	1.11	Yes	No	CL				Yes	No	1.11	-
S2	10	19	ML	120	1160	1076	1190	1.4	1.3	M	4	1.00	SCAL	98	1.30	0.85	7	4.9	0.93	52	71		38	1.2	82	21.917	0.216	0.000	3.00	No	No	ML	28	14	24	No	No	3.00	-
S3	15	31	ML	120	1750	1363	1680	1.2	1.3	M	4	1.00	SCAL	38	1.30	0.95	7	5.4	0.90	24	29		25	1.2	35	0.366	0.295	0.000	2.74	No	Yes	ML	45	12	23	No	No	2.74	-
S4	20		ML	120	2350	1651	1934	1.1	1.2	M	4	1.00	Shelby	9	1.19	4.00	7	7.9	0.94	8	9		95	#DIV/0!	#DIV/0!	9.044	0.190	1.000	0.22	Yes	Yes	ML				No	No	5.72	-
S5	22	21	ML	120	2590	1766	2010	1.1	1.2	M	4	1.00	S	23	1.30	1.00	7	8.5	0.95	28	30		35	1.2	39	0.551	0.193	0.000	2.86	No	Yes	ML				No	No	2.86	-
S7	25	24	ML	120	2950	1938	2192	1.0	1.2	M	4	1.00	S	34	1.30	1.00	7	9.4	0.96	34	31		35	1.2	37	0.650	0.185	0.000	3.00	No	Yes	ML	37	10	19	No	No	3.00	-
S9	30	90	GW	135	3626	2382	2545	0.9	1.2	M	4	1.00	S	47	1.30	1.00	7	11.0	0.96	63	61	11	35	1.2	71	7.363	0.173	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
S9	35	24	SP-SM	130	4375	2640	2883	0.9	1.2	M	4	1.00	S	21	1.30	1.00	7	12.5	0.99	32	27	6	6	1.0	28	0.293	0.161	0.000	1.82	No	Yes	SP-SM				Yes	No	1.82	-
S10	39	9	ML	120	4705	2871	3134	0.8	1.2	M	4	1.00	S	8	1.11	1.00	7	13.7	0.99	12	10	5	5	1.1	10	0.074	0.151	0.000	0.49	Yes	Yes	ML				Yes	Yes	0.49	Liquefiable
S11	45	45	CL	110	5415	3155	3393	0.8	1.1	M	4	1.00	SCAL	14	1.22	0.95	7	15.5	0.99	16	12		25	1.3	16	0.109	0.139	0.533	0.78	Yes	Yes	CL				Yes	Yes	0.78	Liquefiable
S12	50	83	ML	125	6015	3444	3667	0.8	1.1	M	4	1.00	SCAL	40	1.30	0.85	7	17.1	1.00	45	34		25	1.2	41	0.692	0.131	0.000	3.00	No	Yes	ML				Yes	No	3.00	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340.* and Discussions and Closures (May, 2006)
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering - A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Owners Naty, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999),* (used only for guidance on MGAL and SCAL sampler correction)

PROJECT NAME:	American River Common Features GRR Project
LEVEE SEGMENT:	Discovery into River East Levee North of Interstate Four (Interceptor)
PROJECT NUMBER:	26416/01.09400
Reach ID:	
Station:	Draft Station: 1927+00
Boring ID:	SPB-14
Boring Location (Coord.'s,stick-in/Manmade, and distance from Coord.'s,stick-in/Manmade)	Creek Rotary

Analyst By: Sam P. Patel
Check By:

Date: 10/15/2009
Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 47.3
Groundwater Elev. During Drilling (ft.) = 25.6
Analyzed Groundwater Elevation (ft.)= 19.3

Note: Depth at time of drilling
Note: Summer WSEL (Used/Not)

Groundwater Depth Below GS During Drilling (ft.) = 21.7
Analyzed Groundwater Depth Below GS (ft.) = 28.0
Confirm ER

Hammer Type = Automatic
Energy Ratio = 82

Earthquake Information
Return Period (years) = 200
EL = 47.3

PGA (g) = 0.15
Location = Creek *(Inner Creek, Levee/Dry, or Waterside*

Sample ID	Depth to Sample (ft.)	N_{field}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ'_v (psf)	Effective Overburden Pressure During Earthquake, σ'_v (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (i.e. no SCAL, MCAL)	R_d for Sampler Correction Only (for SW sample)	Sampler Correction, for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Positive) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Slope Gradient (°)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS < 1.0 (Yes/No) Column AS	Below Analyzed Groundwater Level (Yes/No) Column AT	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (WC)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AC	Final Assessment (Yes/No) Based on Column AS, AT, and AV	Factor of Safety, FS	Comment (Liquefiable For FS <1 and Judgment Required for 1.0 <FS< 1.25)
S1	2.5	12	ML	130	309	309	1.6	1.3	M	4	1.00	SCAL	21	1.25	0.95	7	2.5	0.75	8	14		39	1.3	17	0.226	0.134	0.000	1.75	No	No	ML	28	6		Yes	No	1.75	-
S2	5	36	CL	110	575	575	1.5	1.3	M	4	1.00	SCAL	58	1.20	0.95	7	5.8	0.75	25	37	45	35	1.2	44	1.536	0.192	0.000	3.00	No	No	CL				Yes	No	3.00	-
S3	7.5	25	CL	110	950	950	1.3	1.3	M	4	1.00	SCAL	35	1.20	0.95	7	8.1	0.79	16	24		35	1.2	29	0.434	0.190	0.000	3.00	No	No	CL				Yes	No	3.00	-
S4	10	47	CL	110	1125	1125	1.3	1.3	M	4	1.00	SCAL	81	1.20	0.95	7	10.9	0.83	49	64		35	1.2	76	12.706	0.190	0.000	3.00	No	No	CL				Yes	No	3.00	-
S5	12.5	46	CL	110	1400	1400	1.2	1.3	M	4	1.00	SCAL	57	1.20	0.95	7	13.6	0.87	36	43		35	1.2	51	1.949	0.226	0.000	3.00	No	No	CL				Yes	No	3.00	-
S6	15	39	CL	110	1675	1675	1.1	1.3	M	4	1.00	SCAL	32	1.20	0.95	7	16.4	0.90	23	25		35	1.2	30	0.379	0.224	0.000	3.00	No	No	CL				Yes	No	3.00	-
S7	17.5	53	CL	110	1950	1950	1.0	1.3	M	4	1.00	SCAL	13	1.18	0.95	7	7.2	0.92	10	10		35	1.3	14	0.109	0.122	0.323	0.69	Yes	No	CL				Yes	No	0.69	-
S8	20	65	CL	110	2225	2225	0.9	1.3	M	4	1.00	SCAL	14	1.20	0.95	7	7.9	0.94	12	12		35	1.3	15	0.114	0.120	0.208	0.96	Yes	No	CL				Yes	No	0.96	-
S9	22.5	37	CL	110	2500	2500	0.9	1.3	M	4	1.00	SCAL	33	1.20	0.95	7	9.7	0.95	20	27		35	1.2	33	0.425	0.119	0.000	3.00	No	No	CL				Yes	No	3.00	-
S10	25	25	ML	120	2900	2900	0.8	1.3	M	4	1.00	SCAL	22	1.20	0.95	7	9.4	0.96	22	18		35	1.3	23	0.191	0.119	0.000	1.60	No	No	ML				Yes	No	1.60	-
S11	27.5	86	SW	130	3125	2969	0.8	1.3	M	4	1.00	SCAL	71	1.30	0.85	7	10.2	0.97	72	58		5	1.0	61	3.246	0.119	0.000	3.00	No	No	SW				Yes	No	3.00	-
S12	30	39	SW	130	3450	3139	0.8	1.3	M	4	1.00	SCAL	29	1.30	0.85	7	11.0	0.98	39	24	4	5	1.0	24	0.295	0.119	0.000	1.73	No	No	SW				Yes	No	1.73	-
S13	32.5	97	GW	135	3788	3309	0.8	1.3	M	4	1.00	SCAL	38	1.30	0.85	7	11.7	0.98	43	33		5	1.0	34	0.414	0.119	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
S14	35	77	GW	135	4113	3489	0.8	1.3	M	4	1.00	SCAL	58	1.30	0.85	7	12.5	0.99	66	50		5	1.0	51	1.478	0.118	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
S15	37.5	90	GW	135	4438	3669	0.7	1.3	M	4	1.00	SCAL	64	1.30	0.85	7	13.3	0.99	81	58		5	1.0	59	0.995	0.118	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
S16	40	44	SW	130	4763	3837	0.7	1.3	M	4	1.00	SCAL	35	1.30	0.85	7	14.0	0.99	42	30	5	5	1.0	31	0.328	0.119	0.000	2.78	No	Yes	SW				Yes	No	2.78	-
S17	42.5	39	SW	130	5088	3986	0.7	1.3	M	4	1.00	SCAL	17	1.25	0.85	7	14.8	0.99	21	15		5	1.0	15	0.097	0.118	0.403	0.84	Yes	Yes	SW				No	No	0.41	-
S18	45	35	CH	110	5263	4175	0.7	1.3	M	4	1.00	SCAL	17	1.27	0.85	7	15.5	0.99	22	15		35	1.3	19	0.127	0.114	0.949	1.11	Yes	Yes	CH				No	No	1.11	-
S19	47.5	23	CH	110	5638	4234	0.7	1.3	M	4	1.00	SCAL	16	1.24	0.85	7	16.3	1.00	20	14		35	1.3	17	0.112	0.113	0.156	0.99	Yes	Yes	CH				No	No	0.99	-
S20	50	9	CH	110	5915	4353	0.7	1.3	M	4	1.00	SCAL	6	1.18	0.85	7	17.1	1.00	8	5		35	1.5	9	0.054	0.111	0.992	0.49	Yes	Yes	CH				No	No	0.49	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2006. *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999), (used only for guidance on NCAL and SCAL sampler correction)*

PROJECT NAME:	Mangrum Park Common Features CSRC Project
LEVEE SEGMENT:	Sacramento River East Levee North of American River (Historic)
PROJECT NUMBER:	26414780.4549
Reach ID:	
Station:	EXPL Station: 1827+00
Boring ID:	SP-03 (19.1535+00SP)
Boring Location (Used to estimate Elevation):	Crest Setback

Analysis By: Jose P. Perez
Check By:
Date: 08/15/2008
Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 43.5
Groundwater Elev. During Drilling (ft.) = 34.7
Analyzed Groundwater Elevation (ft.)= 16.5

Note: Elevation from River Elevation
Note: Mean Water & Elevation

Groundwater Depth Below GS During Drilling (ft.) = 8.8
Analyzed Groundwater Depth Below GS (ft.) = 27.0

Hammer Type = Safety Hz
Energy Ratio = 80
Confirm ER

Earthquake Information:
Return Period (years) = 200
SL = 0.4

PGA (g) = 0.16
Location = Sample Site (Near Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft.)	N_{SPT}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (C, IS, SS, NCAL, SCAL)	N_1 for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler only	Sampler Correction for Analysis, C_S	Stick Up (Protrusion) Rod Length, Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	PL < 1.2 (Yes/No) Column AS	Below Analyzed Groundwater Level (Yes/No) Column AT	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AV	Final Assessment (Yes/No) Based on Columns AS, AT, and AV	Factor of Safety, FS	Comment (Liquefiable for FS<1 and Judgment Required for 1.0<FS<1.2)
S1	5	10	CL	110	550	550	550	1.9	1.3	M	4	1.00	S	16	1.19	1.00	7	3.4	0.75	19	16		25	1.2	20	0.247	0.223	0.064	1.11	Yes	No	CL				No	No	1.11	-
S2	10	22	ML	120	1150	1075	994	1.4	1.3	M	4	1.00	SCAL	30	1.30	0.85	7	4.9	0.93	52	71		35	1.2	82	22.823	0.215	0.000	3.00	No	Yes	ML	31	14	24	No	No	3.00	-
S3	15	31	ML	120	1750	1363	1282	1.2	1.3	M	4	1.00	SCAL	38	1.30	0.85	7	6.4	0.90	26	29		35	1.2	35	0.693	0.206	0.000	2.92	No	Yes	ML	25	12	23	No	No	2.92	-
S4	20	28	ML	120	2350	1651	1570	1.1	1.3	M	4	1.00	Shelby	0	1.10	0.00	7	7.9	0.94	0	0		35	#DIV/0!	#DIV/0!	0.647	0.169	1.000	0.24	Yes	Yes	ML				No	No	0.24	-
S5	25	33	ML	120	2990	1758	1695	1.1	1.3	M	4	1.00	S	23	1.30	1.00	7	9.5	0.95	28	35		35	1.2	35	0.579	0.193	0.000	3.00	No	Yes	ML				No	No	3.00	-
S7	35	74	ML	130	3950	1939	1858	1.0	1.3	M	4	1.00	S	54	1.30	1.00	7	9.4	0.96	51	51		35	1.2	37	0.648	0.185	0.000	3.00	No	Yes	ML	SR	NP	37	Yes	No	3.00	-
S8	40	90	GW	130	3625	2392	2221	0.9	1.3	M	4	1.00	S	67	1.30	1.00	7	11.0	0.96	93	61	11	35	1.2	71	7.940	0.173	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
S9	45	24	SP-SM	130	4275	2540	2358	0.9	1.3	M	4	1.00	S	21	1.30	1.00	7	12.5	0.99	32	27	6	6	1.0	29	0.303	0.161	0.000	1.99	No	Yes	SP-SM				Yes	No	1.99	-
S10	50	9	ML	120	4725	2671	2789	0.8	1.3	M	4	1.00	S	8	1.11	1.00	7	13.7	0.99	12	10	6	6	1.1	10	0.077	0.151	0.000	0.51	Yes	Yes	ML				Yes	YES	0.51	Liquefiable
S11	55	18	CL	110	5415	3156	3075	0.8	1.3	M	4	1.00	SCAL	14	1.22	0.85	7	15.5	0.99	16	13		35	1.3	16	0.112	0.139	0.553	0.80	Yes	Yes	CL				Yes	YES	0.80	Liquefiable
S12	60	92	ML	120	6915	3466	3363	0.8	1.3	M	4	1.00	SCAL	60	1.30	0.85	7	17.1	1.00	45	34		55	1.2	41	0.710	0.131	0.000	3.00	No	Yes	ML				Yes	No	3.00	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions*
2. URS Corporation 2006. *Guidance Document for Geotechnical Analyses, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2006.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), *(used only for guidance on M*

PROJECT NAME:	American River Common Features (ARC) Project
LEVEE SEGMENT:	Sacramento River East Levee North of American River (Natomas)
PROJECT NUMBER:	60148760 (43446)
Reach ID:	
Station:	CWR Station: 1501+00
Boring ID:	SRB-04
Boring Location (Used Levee Alignment Stationing and Offset or Boring Coordinates)	Coast Boring

Analysis By:	Alan P. Peri
Check By:	

Date:	10/13/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 21.4
Groundwater Elev. During Drilling (ft.) = 16.4
Analyzed Groundwater Elevation (ft.)= 16.5

Note: Depth at time of testing
Note: Below WSE 6 (MW-098)

Groundwater Depth Below GS During Drilling (ft.) = 25.0
Analyzed Groundwater Depth Below GS (ft.) = 25.6

Hammer Type = Automatic
Energy Ratio = 80
Confirm ER

Earthquake Information:
Return Period (years) = 200
ML = 7.0

PGA (g) = 0.26
Location = Cavi (Silver Creek, Lawtable, or Watsonville

Sample ID	Depth to Sample (ft.)	H_{soil}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ' (psf)	Effective Overburden Pressure During Earthquake, σ'_0 (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (L or SCAL, WORL)	N_1 for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Protrusion) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{FINES}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Sustance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS < 1.0 (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Moisture Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AN	Final Assessment (Yes/No) Based on Criteria in AC and AF	Factor of Safety, FS	Comment (Liquefiable For FS, <1 and Judgment Required for 1.0 <FS, < 1.3)
S1	2.5	19	ML	120	300	300	300	1.8	1.2	M	4	1.00	SCAL	21	1.25	0.95	7	2.9	0.75	8	14		35	1.3	17	0.236	0.134	0.000	1.76	No	No	ML	28	6		Yes	No	1.76	-
S2	5	39	CL	118	575	575	575	1.6	1.2	M	4	1.00	SCAL	59	1.30	0.85	7	3.4	0.75	23	37	42	35	1.2	44	1.526	0.132	0.000	3.00	No	No	CL				Yes	No	3.00	-
S3	7.5	59	CL	118	850	850	850	1.3	1.2	M	4	1.00	SCAL	35	1.30	0.85	7	4.1	0.73	16	24		25	1.2	29	0.434	0.130	0.000	3.00	No	No	CL				Yes	No	3.00	-
S4	10	87	CL	110	1125	1125	1125	1.3	1.2	M	4	1.00	SCAL	49	1.30	0.85	7	4.9	0.83	48	64		35	1.2	75	12.736	0.129	0.000	3.00	No	No	CL				Yes	No	3.00	-
S5	12.5	98	CL	118	1400	1400	1400	1.2	1.2	M	4	1.00	SCAL	37	1.30	0.85	7	5.6	0.87	36	43		35	1.2	51	1.949	0.126	0.000	3.00	No	No	CL				Yes	No	3.00	-
S6	15	120	CL	110	1675	1675	1675	1.1	1.2	M	4	1.00	SCAL	52	1.30	0.85	7	6.4	0.90	53	55		35	1.2	66	0.379	0.124	0.000	3.00	No	No	CL				Yes	No	3.00	-
S7	17.5	142	CL	110	1950	1950	1950	1.0	1.2	M	4	1.00	SCAL	13	1.10	0.95	7	7.2	0.92	19	19		35	1.3	14	0.109	0.122	0.202	0.89	Yes	No	CL				Yes	No	0.89	-
S8	20	161	CL	110	2225	2225	2225	0.9	1.2	M	4	1.00	SCAL	14	1.20	0.95	7	7.9	0.94	13	12		35	1.3	15	0.114	0.120	0.209	0.95	Yes	No	CL				Yes	No	0.95	-
S9	22.5	177	CL	110	2500	2500	2500	0.9	1.2	M	4	1.00	SCAL	33	1.30	0.85	7	9.7	0.95	39	27		25	1.2	33	0.426	0.119	0.000	3.00	No	No	CL				Yes	No	3.00	-
S10	25	195	ML	120	2900	2900	2900	0.8	1.2	M	4	1.00	SCAL	22	1.30	0.85	7	9.4	0.96	22	19		35	1.2	23	0.191	0.119	0.000	1.60	No	No	ML				Yes	No	1.60	-
S11	27.5	216	SW	135	3125	2969	3005	0.8	1.2	M	4	1.00	SCAL	71	1.30	0.85	7	10.2	0.97	72	58		5	1.0	61	3.282	0.119	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
S12	30	236	SW	130	3450	3139	3174	0.8	1.2	M	4	1.00	SCAL	29	1.30	0.85	7	11.0	0.98	39	24	4	5	1.0	34	0.210	0.119	0.000	1.77	No	Yes	SW				Yes	No	1.77	-
S13	32.5	257	SW	135	3769	3329	3395	0.8	1.2	M	4	1.00	SCAL	39	1.30	0.85	7	11.7	0.98	43	33		5	1.0	34	0.426	0.119	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
S14	35	277	SW	135	4113	3499	3634	0.8	1.2	M	4	1.00	SCAL	58	1.30	0.85	7	12.5	0.99	66	50		5	1.0	51	1.514	0.119	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
S15	37.5	297	SW	130	4439	3656	3837	0.7	1.2	M	4	1.00	SCAL	64	1.30	0.85	7	13.3	0.99	51	38		5	1.0	39	0.607	0.119	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
S16	40	318	SW	130	4763	3827	3982	0.7	1.2	M	4	1.00	SCAL	25	1.30	0.85	7	14.0	0.99	42	30	7	5	1.0	31	0.205	0.119	0.000	2.84	No	Yes	SW				Yes	No	2.84	-
S17	42.5	338	SW	130	5088	3995	4031	0.7	1.2	M	4	1.00	SCAL	17	1.25	0.85	7	14.8	0.99	21	16		5	1.0	15	0.099	0.118	0.403	0.85	Yes	Yes	SW				No	No	0.85	-
S18	45	358	CH	110	5363	4115	4150	0.7	1.2	M	4	1.00	SCAL	17	1.27	0.85	7	15.5	0.99	22	15		35	1.3	19	0.129	0.114	0.049	1.13	Yes	Yes	CH				No	No	1.13	-
S19	47.5	378	CH	110	5638	4234	4269	0.7	1.2	M	4	1.00	SCAL	18	1.28	0.95	7	16.3	1.00	29	14		35	1.3	17	0.114	0.113	0.125	1.01	Yes	Yes	CH				No	No	1.01	-
S20	50	0	CH	110	5913	4353	4388	0.7	1.2	M	4	1.00	SCAL	6	1.10	0.85	7	17.1	1.00	8	5		35	1.5	9	0.055	0.111	0.992	0.50	Yes	Yes	CH				No	No	0.50	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1312-1340. and Discussions and Closures (May, 2006)*
2. URS Corporation 2006, *Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2006.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.N.S. Queens Ferry, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME:	American River Common Features GRR Project
LEVEE SEGMENT:	Sacramento River East Levee North of American River (Natomas)
PROJECT NUMBER:	38319/160.65/02
Reach ID:	
Station:	DWR Station: 1378+00
Boring ID:	SPB-46
Boring Location (Cartesian coordinate/Stationing, and distance from Levee centerline/Waterside toe)	Levee Boring

Analysis By: Juan P. Perez
Check By:

Date: 10/1/2008
Date:

Data Input by Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 21.5
Groundwater Elev. During Drilling (ft.)= 4.8
Assigned Groundwater Elevation (ft.)= 15.5

Note: From Boring Log
Note: Below MSE Reinforced Zone

Groundwater Depth Below GS During Drilling (ft.) = 16.7
Assigned Groundwater Depth Below GS (ft.) = 6.0

Hammer Type = Automatic
Energy Ratio =75 Rotated Centline ER

Earthquake Information:
Return Period (years) = 500
M_w = 7.0

PGA (g) = 0.45
Location = Levee Levee Crest, Landside, or Waterside

Sample ID	Depth to Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Sampler Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (= IN SW, SCAL, MCAL)	N_1 for Sampler Correction Only (for SW Sampler Only	Sampler Correction for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick-Up (Protrusion) Rod Length Above Ground (Feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Corrective Factor for Fine Content, C_{Fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.0 [Yes/No] Column AB	Below Assigned Groundwater Level [Yes/No] Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (%)	Liquefaction Susceptibility Based on Soil Type [Yes/No] Column BD	Final Assessment [Yes/No] Based on Column AB, AF, and BD	Factor of Safety, FS	Comment (Liquefiable for FS,<1 and Judgment Required for 1.0 ≤FS, < 1.2)
S1	5	7	SP	100	500	500	500	1.5	1.3	M	4	1.00	SCAL	11	1.12	0.85	7	3.4	0.75	4	7		5	1.1	7	0.090	0.132	0.737	0.68	Yes	No	SP				Yes	No	9.58	-
S2	10	11	SP	105	1050	1050	1050	1.2	1.3	M	4	1.00	SCAL	14	1.16	0.85	7	8.9	0.93	7	9		5	1.0	10	0.099	0.128	0.765	0.70	Yes	No	SP				Yes	No	9.74	-
S3	15	14	SP	130	1950	1950	1950	1.0	1.3	M	4	1.00	SCAL	14	1.16	0.85	7	9.4	0.95	10	10		5	1.0	11	0.087	0.124	0.758	0.70	Yes	No	SP				Yes	No	9.74	-
S4	20	16	SP	130	2600	2600	2600	0.9	1.3	M	4	1.00	SCAL	9	1.11	0.85	7	7.9	0.94	8	7		5	1.1	7	0.061	0.120	0.590	0.51	Yes	No	SP				Yes	No	9.31	-
S5	25.5	14	SP	130	2925	2925	2925	0.8	1.3	M	4	1.00	SCAL	12	1.15	0.85	7	8.7	0.95	11	9		5	1.0	9	0.070	0.119	0.645	0.58	Yes	No	SP				Yes	No	9.55	-
S6	25	17	SP	130	3250	3250	3250	0.8	1.3	M	4	1.00	SCAL	16	1.14	0.85	7	9.4	0.96	15	8		5	1.1	9	0.063	0.119	0.563	0.53	Yes	No	SP				Yes	No	9.53	-
S7	31.5	11	SP-SM	135	3675	3675	3675	0.7	1.3	M	4	1.00	SCAL	11	1.16	0.85	7	10.2	0.97	12	9	21	18	1.1	10	0.068	0.119	0.569	0.57	Yes	Yes	SP-SM				Yes	YES	9.57	Liquefiable
S8	36	4	ML	120	3675	3675	3675	0.7	1.3	M	4	1.00	SCAL	3	1.16	0.85	7	11.0	0.98	3	2	87	35	1.9	4	0.045	0.119	1.000	0.38	Yes	Yes	ML				Yes	YES	9.38	Liquefiable
S9	40.5	5	CL	110	4150	4150	3739	0.7	1.3	M	4	1.00	SCAL	6	1.16	0.85	7	11.7	0.98	7	5		25	1.5	7	0.056	0.119	0.507	0.47	Yes	Yes	CL				Yes	YES	9.47	Liquefiable
S10	45	22	SP	130	4475	4319	3927	0.7	1.3	M	4	1.00	SCAL	15	1.21	0.85	7	12.5	0.99	18	12		5	1.0	12	0.081	0.119	0.627	0.68	Yes	Yes	SP				Yes	YES	9.68	Liquefiable
S11	47.5	18	SP	130	4900	4488	4076	0.7	1.3	M	4	1.00	SCAL	12	1.17	0.85	7	13.3	0.99	14	10		5	1.0	10	0.067	0.119	0.569	0.57	Yes	Yes	SP				Yes	YES	9.57	Liquefiable
S12	50	19	SP	130	5125	4657	4245	0.7	1.3	M	4	1.00	SCAL	12	1.17	0.85	7	14.0	0.99	15	10		5	1.0	10	0.068	0.119	0.562	0.56	Yes	Yes	SP				Yes	YES	9.56	Liquefiable
S13	52.5	13	SP	130	5450	4826	4414	0.6	1.3	M	4	1.00	SCAL	9	1.11	0.85	7	14.8	0.99	10	7		5	1.1	7	0.053	0.116	0.559	0.46	Yes	Yes	SP				Yes	YES	9.46	Liquefiable
S14	55	3	CL	110	5725	4945	4533	0.6	1.3	M	4	1.00	SCAL	3	1.16	0.85	7	15.5	0.99	4	3		25	1.9	5	0.043	0.119	1.000	0.38	Yes	Yes	CL				Yes	YES	9.38	Liquefiable
S15	57.5	10	SM	130	6050	5114	4702	0.6	1.3	M	4	1.00	SCAL	12	1.17	0.85	7	16.3	1.00	15	10		12	1.1	11	0.060	0.113	0.946	0.60	Yes	Yes	SM				Yes	YES	9.60	Liquefiable
S16	60	32	SP	130	6375	5282	4871	0.6	1.2	M	4	1.00	SCAL	38	1.38	0.85	7	17.1	1.00	50	31		5	1.0	32	0.126	0.111	0.000	2.93	No	Yes	SP				No	No	2.93	-
S17	62.5	47	SP	130	6700	5452	5040	0.6	1.3	M	4	1.00	SCAL	52	1.39	0.85	7	17.8	1.00	80	46	J	9	1.0	46	0.116	0.105	0.110	1.06	Yes	Yes	GW				Yes	YES	1.06	Judgment Required
S18	65	35	SP	130	7025	5621	5203	0.6	1.2	M	4	1.00	SCAL	33	1.38	0.85	7	18.6	1.00	51	30		5	1.0	31	0.123	0.098	0.058	1.14	Yes	Yes	SP				Yes	YES	1.14	Judgment Required
S19	67.5	34	SP	130	7350	5799	5378	0.6	1.2	M	4	1.00	SCAL	29	1.39	0.85	7	19.4	1.00	48	28		5	1.0	27	0.103	0.106	0.219	0.97	Yes	Yes	SP				Yes	YES	0.97	Liquefiable
S20	70	54	SP	130	7675	5958	5547	0.6	1.3	M	4	1.00	SCAL	31	1.38	0.85	7	20.1	1.00	44	25		5	1.0	26	0.206	0.104	0.000	1.87	No	Yes	SP				No	No	1.87	-
S21	72.5	24	SP	130	8025	6297	5885	0.5	1.3	M	4	1.00	SCAL	19	1.29	0.85	7	21.6	1.00	28	16		5	1.0	16	0.096	0.102	0.230	0.93	Yes	Yes	SP				Yes	YES	0.93	Liquefiable
S22	75	51	SP	130	8375	6635	6223	0.5	1.3	M	4	1.00	SCAL	32	1.39	0.85	7	23.2	1.00	45	25		5	1.0	25	0.197	0.100	0.000	1.87	No	Yes	SP				No	No	1.87	-
S23	77.5	37	SP	130	8625	6873	6561	0.5	1.3	M	4	1.00	SCAL	19	1.26	0.85	7	24.7	1.00	27	14	4	9	1.0	14	0.091	0.098	0.461	0.65	Yes	Yes	SP				Yes	YES	0.65	Liquefiable
S24	80	52	SP	130	10275	7311	6899	0.5	1.3	M	4	1.00	SCAL	27	1.39	0.85	7	26.2	1.00	42	22		6	1.0	23	0.151	0.099	0.001	1.59	No	Yes	SP				No	No	1.59	-

SACRAMENTO RIVER SOUTH

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions*
2. URS Corporation 2008. *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, M.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on M

PROJECT NAME:	American River Common Features (CSB Phase I)
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	26016760 45400
Report ID:	
Station:	Dutch Station 1085+82
Boring ID:	77-B-12
Boring Location (Enter Text Identifying Approximate and Relative Boring Location for Reference Use)	Toe Drains

Analyzed By:	Steven Orrell
Check By:	

Date:	9/23/2008
Date:	

Data Input By Hand
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 17.5
Groundwater Elev. During Drilling (ft.)= 4.5
Analyzed Groundwater Elevation (ft.)= 14.0

Note: Depth during drilling
Note: Estimate based on CGS/DWR

Groundwater Depth Below GS During Drilling (ft.) = 13.0
Analyzed Groundwater Depth Below GS (ft.) = 14.5

Hammer Type = Automatic
Energy Ratio = 70 Assumed

Earthquake Information:
Return Period (years) = 200
M_w = 6.8

PGA (g) = 0.14
Location = Latitude: 38.61, Longitude: -121.49

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.00 for Cal, 0.83 for SPT)	H_s for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Rod Length Correction Factor, C_R	Rod Length (ft)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, F_S	F_S > 1.2 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No)	Final Assessment (Yes/No) Based on Columns AE, AF, and AH	Factor of Safety, F_S	Comment (Liquefiable for F_S <1 and Judgment Required for 1.0 <F_S < 1.1)
																																	Liquefaction Susceptibility				
S1	1	20	ML	123	123	123	123	1.6	1.2	H	9	1.15	MCAL	20	1.00	0.93	7	2.1	0.75	15	36	81	85	1.2	31	0.660	0.121	0.000	2.85	No	No	ML	37	16	25	Yes	No	3.00	-
S2	4	15	ML	109	553	553	522	1.6	1.2	H	9	1.15	MCAL	34	1.00	0.99	7	3.4	0.75	12	19	75	85	1.2	24	0.531	0.179	0.000	2.79	No	Yes	ML			17	Yes	No	3.79	-
S3	10	16	SM	110	1162	1162	798	1.2	1.2	H	9	1.15	MCAL	22	1.00	0.99	7	4.5	0.85	16	19	35	35	1.2	22	0.271	0.172	0.000	2.28	No	Yes	SM			23	Yes	No	2.28	-
S4	15	14	SP	121	1797	1662	1052	1.1	1.2	H	9	1.15	MCAL	18	1.22	0.98	7	6.4	0.89	13	16		5	1.0	16	0.148	0.110	0.053	1.26	No	Yes	SP			33	Yes	No	1.26	-
S5	20	14	SP	125	2552	1918	1385	1.0	1.2	H	9	1.15	MCAL	14	1.21	0.99	7	7.9	0.94	14	14	5	5	1.0	15	0.132	0.118	0.139	1.10	Yes	Yes	SP			24	Yes	YES	1.10	Judgment Required
S6	25	24	SP	130	3004	2255	1725	0.9	1.2	H	9	1.15	MCAL	23	1.00	0.99	7	9.4	0.99	25	28		5	1.0	24	0.243	0.116	0.000	2.09	No	Yes	SP			23	Yes	No	2.09	-
S7	30	31	SP	130	3635	2593	2064	0.9	1.2	H	9	1.15	MCAL	31	1.00	0.99	7	11.0	0.99	32	36		5	1.0	37	0.345	0.113	0.000	3.05	No	Yes	SP				Yes	No	3.05	-
S8	35	30	SP	130	4390	2930	2404	0.8	1.2	H	9	1.15	MCAL	29	1.00	0.99	7	12.5	0.99	32	35	6	6	1.0	37	0.336	0.109	0.000	3.04	No	Yes	SP			24	Yes	No	3.04	-
S9	40	37	SP	122	4920	3336	2764	0.8	1.2	H	9	1.15	MCAL	31	1.00	0.99	7	14.0	0.99	39	39		5	1.0	23	0.203	0.106	0.000	1.91	No	Yes	SP			35	Yes	No	1.91	-
S10	45	54	SP	117	5405	3648	3077	0.8	1.2	H	9	1.15	MCAL	54	1.29	0.99	7	15.5	0.99	56	56		5	1.0	58	0.164	0.103	0.005	1.49	No	Yes	SP			17	Yes	No	1.49	-
S11	50	56	SP	126	6137	3828	3299	0.7	1.2	H	9	1.15	MCAL	29	1.30	0.99	7	17.1	1.00	56	56		5	1.0	57	0.255	0.101	0.000	2.53	No	Yes	SP			24	Yes	No	2.53	-
S12	55	57	SP	126	6769	4149	3618	0.7	1.2	H	9	1.15	MCAL	29	1.30	0.99	7	18.6	1.00	60	60	6	6	1.0	58	0.276	0.099	0.000	2.80	No	Yes	SP				Yes	No	2.80	-
S13	60	41	GW	134	7449	4509	3977	0.7	1.2	H	9	1.15	MCAL	27	1.30	0.99	7	20.1	1.00	44	59		5	1.0	59	0.304	0.096	0.000	3.09	No	Yes	GW			10	Yes	No	3.09	-
S14	65	58	SW	123	9126	4961	4331	0.6	1.2	H	9	1.15	MCAL	32	1.30	0.99	7	21.9	1.00	64	64		5	1.0	35	0.440	0.094	0.000	3.69	No	Yes	SW			11	Yes	No	3.69	-
S15	69	68	SP	135	9511	5219	4548	0.6	1.2	H	9	1.15	MCAL	36	1.30	0.99	7	22.9	1.00	80	80		5	1.0	61	0.982	0.092	0.000	3.82	No	Yes	SP				Yes	No	3.82	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev 0, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.B. Queens Wary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on M

PROJECT NAME:	American River Common Features (2006 Project
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	26016782.43400
Reach ID:	
Station:	Storm Station: 1099+00
Boring ID:	11-B-12
Boring Location (Enter Levee Alignment, and Waterside Riser, Land Side or Waterside)	Crest Boring

Analyst By:	Shawn Crall
Check By:	

Date:	9/25/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 20.0
Groundwater Elev. During Drilling (ft.)= 4.5
Analyzed Groundwater Elevation (ft.)= 15.0

Note: Depth during drilling
Note: Water under 5 feet (GW)

Groundwater Depth Below GS During Drilling (ft.) = 15.5
Analyzed Groundwater Depth Below GS (ft.) = 5.0

Hammer Type = Automatic
Energy Ratio = 70 Assumed

Earthquake Information
Return Period (years) = 200
M_w = 7.2

PGA (g) = 0.44
Location = Deep, Crest, Landside, or Waterside

Sample ID	Depth to Sample (ft.)	$N_{m,f}$	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (Inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SS, SCAL, SCAL)	H_s for Sampler Correction Only (for SW Sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Protrusion) Rod Length Above Ground (Feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	R_{d1}	R_{d2}	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.2 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (WC)	Liquefaction Susceptibility Based on Soil Type (Yes/Not Susceptible)	Final Assessment (Yes/No) Based on Column AG, and AH	Factor of Safety, FS	Comment (Liquefiable for FS, <1 and Judgment Required for 1.0 <FS, < 1.2)
S1	7	13	SM	128	256	256	256	1.6	1.2	H	8	1.15	MCAL	38	1.00	0.95	7	2.4	0.75	15	34		12	1.1	28	0.466	0.134	0.000	3.49	No	No	SM			13	Yes	No	3.00	-
S2	4	26	ML	122	749	749	749	1.4	1.2	H	8	1.15	MCAL	42	1.00	0.99	7	3.7	0.75	21	38		35	1.2	49	1.012	0.131	0.000	3.99	No	No	ML			23	Yes	No	3.00	-
S3	11	12	ML	103	1263	1263	1263	1.3	1.2	H	8	1.15	MCAL	35	1.00	0.99	7	5.5	0.85	11	14		35	1.3	17	0.161	0.127	0.010	1.27	No	No	ML			8	Yes	No	1.27	-
S4	15	19	ML	103	1675	1675	1675	1.1	1.2	H	8	1.15	MCAL	16	1.00	0.99	7	6.4	0.90	14	16		35	1.3	29	0.178	0.124	0.002	1.44	No	No	ML				Yes	No	1.44	-
S5	29	14	ML	109	2239	2239	2239	0.9	1.2	H	8	1.15	MCAL	33	1.19	0.99	7	7.8	0.94	14	13		35	1.3	17	0.134	0.120	0.057	1.12	Yes	No	ML			20	Yes	No	1.12	
S6	25	14	ML	116	2900	2900	2900	0.8	1.2	H	8	1.15	MCAL	12	1.17	0.99	7	9.4	0.96	14	12		35	1.3	16	0.113	0.119	0.214	0.95	Yes	Yes	ML			32	Yes	Yes	0.95	Liquefiable
S7	30	20	ML	119	3390	3390	3390	0.8	1.2	H	8	1.15	MCAL	19	1.33	0.99	7	11.0	0.99	21	16		35	1.2	29	0.194	0.119	0.014	1.30	No	Yes	ML			19	Yes	No	1.30	-
S8	35	12	SM	118	3980	3980	3980	0.7	1.2	H	8	1.15	MCAL	9	1.43	0.99	7	12.5	0.99	14	10		12	1.3	11	0.075	0.118	0.929	0.63	Yes	Yes	SM				Yes	Yes	0.63	Liquefiable
S9	40	62	SP	123	4935	4283	3659	0.7	1.2	H	8	1.15	MCAL	21	1.30	0.99	7	14.0	0.99	55	68	12	15	1.1	23	0.186	0.116	0.001	1.60	No	Yes	SP			24	Yes	No	1.60	-
S10	45	31	SP	124	6215	4591	3967	0.7	1.2	H	8	1.15	MCAL	28	1.30	0.99	7	15.5	0.99	33	22		5	1.0	33	0.172	0.114	0.000	1.50	No	Yes	SP			24	Yes	No	1.50	-
S11	50	65	SP	124	6835	4895	4275	0.6	1.2	H	8	1.15	MCAL	35	1.30	0.99	7	17.1	1.00	58	28		5	1.0	59	0.564	0.111	0.000	3.85	No	Yes	SP				Yes	No	3.00	-
S12	55	79	SP	119	6430	5182	4558	0.6	1.2	H	8	1.15	MCAL	19	1.30	0.99	7	18.8	1.00	35	19		5	1.0	36	0.197	0.108	0.021	1.27	No	Yes	SP			24	Yes	No	1.27	-
S13	60	51	SP	120	7030	5470	4846	0.6	1.2	H	8	1.15	MCAL	19	1.30	0.99	7	20.1	1.00	33	20		5	1.0	21	0.143	0.104	0.008	1.37	No	Yes	SP			25	Yes	No	1.37	-
S14	70	58	SP	126	8810	6126	5502	0.6	1.2	H	8	1.15	MCAL	29	1.30	0.99	7	23.2	1.00	54	31	11	11	1.1	33	0.334	0.100	0.000	3.00	No	Yes	SP			22	Yes	No	3.00	-
S15	80	87	SP	125	9580	6752	6128	0.5	1.2	H	8	1.15	MCAL	26	1.30	0.99	7	26.2	1.00	80	27		5	1.0	28	0.295	0.095	0.000	2.47	No	Yes	SP			24	Yes	No	2.47	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE:
1. Cetin, K.O., et. al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Nov 6, March 2008.
3. Seed, R.B., et. al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*. (used only for guidance on M

PROJECT NAME:	American River Corridor Feature GRR Project
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	26757/01.03.03
Reach ID:	
Station:	Depth Station: 1699+97
Boring ID:	T-R-12
Boring Location Sand Cone and Modified Ring Sampler Rock Core and Undisturbed Sampler	Toe Boring

Analysis By:	Shawn Orgill
Check By:	

Date:	8/31/2009
Date:	

Data Input By Hand
Results of Analysis
Calculated Values

Ground Elevation, ft (+): 17.5
Groundwater Elev. During Drilling (ft.) = 8.5
Analyzed Groundwater Elevation (ft.)= 7.5

Note: Depth during drilling
Note: Estimated WSE if not known

Groundwater Depth Below GS During Drilling (ft.) = 10.0
Analyzed Groundwater Depth Below GS (ft.) = 10.7

Hammer Type = Automatic
Energy Ratio = 1.0 (Assumed)

Earthquake Information:
Return Period (years) = 2475
M_w = 7.0

PGA (g) = 0.54
Location Type = Levee (Levee Crest, Landside, or Waterside)

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ'_v (psf)	Effective Overburden Pressure During Earthquake, σ'_v (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.00 for SCAL, SMCAL)	N_c for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Positioned Rod Length Above Ground (feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	K_σ	M_{cor}	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, <1.2 (Yes/No) Column AB	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AH	Final Assessment (Yes/No) Based on Columns AE, AF, and AH	Factor of Safety, FS	Comment (Liquefiable for FS, <1 and Analysis Required for 1.0 <FS, < 1.3)
																												Lab Test Results for CL, ML					Final Liquefaction Assessment		
S1	1	20	ML	123	123	123	123	1.6	1.2	H	8	1.15	MCAL	32	1.00	0.95	7	2.5	0.75	15	36	81	35	1.3	21	0.561	0.125	0.000	2.66	No	No	ML	37	16	25	Yes	No	3.00	-
S2	A	15	ML	106	553	553	553	1.6	1.2	H	8	1.15	MCAL	24	1.00	0.90	7	3.4	0.75	12	19	76	35	1.2	24	0.327	0.119	0.000	2.74	No	No	ML			17	Yes	No	2.74	-
S3	10	16	SM	110	1102	1102	1083	1.3	1.2	H	8	1.15	MCAL	23	1.00	0.90	7	4.5	0.83	14	18	28	25	1.2	23	0.245	0.119	0.000	2.66	No	Yes	SM			23	Yes	No	2.06	-
S4	15	14	SP	121	1707	1683	1376	1.1	1.2	H	8	1.15	MCAL	16	1.22	0.99	7	6.4	0.89	13	16		9	1.0	16	0.131	0.118	0.000	1.17	Yes	Yes	SP			33	Yes	YES	1.17	Judgment Required
S5	20	14	SP	129	2352	1915	1709	1.0	1.2	H	8	1.15	SCAL	14	1.21	0.99	7	7.3	0.94	14	14	5	9	1.0	15	0.123	0.116	0.139	1.04	Yes	Yes	SP			24	Yes	YES	1.04	Judgment Required
S6	25	24	SP	130	3094	2350	2049	0.9	1.2	H	8	1.15	MCAL	23	1.00	0.90	7	9.4	0.96	25	23		5	1.0	24	0.232	0.116	0.000	2.00	No	Yes	SP			23	Yes	No	2.00	-
S7	30	17	SP	130	3635	2560	2369	0.9	1.2	H	8	1.15	MCAL	27	1.00	0.95	7	11.0	0.99	32	29		5	1.0	29	0.291	0.113	0.000	2.94	No	Yes	SP				Yes	No	2.94	-
S8	35	39	SP	130	4288	2935	2729	0.8	1.2	H	8	1.10	SCAL	35	1.00	0.90	7	12.5	0.99	32	56	6	6	1.0	27	0.270	0.109	0.000	2.47	No	Yes	SP			24	Yes	No	2.47	-
S9	40	27	SP	130	4939	3235	3029	0.8	1.2	H	8	1.15	MCAL	31	1.00	0.90	7	14.0	0.99	29	28		6	1.0	23	0.197	0.106	0.000	1.86	No	Yes	SP			25	Yes	No	1.86	-
S10	45	24	SP	137	6669	3568	3462	0.8	1.2	H	8	1.15	MCAL	18	1.09	0.99	7	16.5	0.99	26	19		5	1.0	20	0.150	0.101	0.000	1.45	No	Yes	SP			17	Yes	No	1.45	-
S11	50	44	SP	126	6137	3828	3622	0.7	1.2	H	8	1.15	SMCAL	28	1.00	0.90	7	17.1	1.00	56	26		5	1.0	27	0.243	0.101	0.000	2.47	No	Yes	SP			24	Yes	No	2.47	-
S12	55	37	SP	126	6768	4148	3943	0.7	1.2	H	8	1.15	SMCAL	26	1.00	0.90	7	18.6	1.00	40	29	6	6	1.0	28	0.270	0.095	0.000	2.74	No	Yes	SP				Yes	No	2.74	-
S13	60	41	GW	134	7649	4599	4382	0.7	1.2	H	8	1.15	SMCAL	27	1.00	0.90	7	20.1	1.00	44	29		5	1.0	30	0.298	0.096	0.000	3.00	No	Yes	GW			10	Yes	No	3.00	-
S14	65	58	SW	133	8198	4961	4650	0.6	1.2	H	8	1.15	MCAL	22	1.00	0.90	7	21.5	1.00	64	34		5	1.0	35	0.431	0.094	0.000	3.00	No	Yes	SW			11	Yes	No	3.00	-
S15	69	60	GP	135	9511	5679	4873	0.6	1.5	H	8	1.15	MCAL	16	1.00	0.90	7	22.0	1.50	95	50		5	1.0	61	1.004	0.093	0.000	3.00	No	Yes	GP				Yes	No	3.00	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., *et al*, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential*, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1314-1340, and Discussions
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2008.
3. Seed, R.B., *et al*, 2003, *Recent Advances in Soil Liquefaction Engineering - A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.B. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on M

PROJECT NAME:	American River Common Features, 2006 Project
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	60149734.44400
Reach ID:	
Station:	Davis Station 1005+43
Boring ID:	11-R-12
Boring Location: (Enter Levee Alignment and distance from Levee Toe to Boring Location)	Land Boring

Analysis By:	Shawn Orgill
Check By:	

Date:	8/21/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 15.0
Groundwater Elev. During Drilling (ft.)= 1.0
Analyzed Groundwater Elevation (ft.)= 7.0

Note: Depth to first drilling
Note: Borehole WSE 5 (NAVD88)

Groundwater Depth Below GS During Drilling (ft.) = 14.0
Analyzed Groundwater Depth Below GS (ft.) = 8.0

Hammer Type = Automatic
Energy Ratio = 0.9 Assumed

Earthquake Information
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.18
Location = CNF (Cetin, Geist, Lukyanov, Moss and Wu 2004)

Sample ID	Depth to Sample (ft.)	$N_{m,f}$	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SH, SCNL, MCSL)	H_1 for Sampler Correction Only (for SW Sampler)	Sampler Correction for, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick-Up (Protrusion) Rod Length Above Ground (feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{FINES}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, F_S	F_S, < 1.3 (Yes/No) Return #6	Below Analyzed Groundwater Level (Yes/No) Column #7	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column #1	Final Assessment (Yes/No) Based on Columns #2 or #3 or #4	Factor of Safety, F_S	Comment (Liquefiable for F_S or Test Judgment, Required for F_S < 1.3)
S1	2	19	SM	126	259	259	259	1.6	1.2	H	8	1.15	MCAL	36	1.00	0.00	7	2.4	0.75	15	24		12	1.1	26	0.488	0.194	0.000	3.80	No	No	SM			12	Yes	No	3.80	-
S2	6	26	ML	123	749	749	749	1.4	1.2	H	8	1.15	MCAL	42	1.00	0.00	7	6.4	0.75	23	33		35	4.2	48	1.012	0.191	0.000	3.99	No	No	ML			23	Yes	No	3.99	-
S3	11	12	ML	103	1263	1263	1263	1.3	1.2	H	8	1.15	MCAL	35	1.00	0.00	7	9.9	0.85	11	14		35	1.3	17	0.151	0.127	0.013	1.27	No	No	ML			8	Yes	No	1.27	-
S4	15	15	ML	103	1670	1670	1670	1.1	1.2	H	8	1.15	MCAL	16	1.23	0.00	7	6.4	0.90	14	16		35	1.3	29	0.178	0.124	0.002	1.44	No	No	ML				Yes	No	1.44	-
S5	20	14	ML	109	2220	2220	2220	0.9	1.2	H	8	1.15	MCAL	13	1.19	0.00	7	7.8	0.94	14	13		35	1.3	17	0.134	0.120	0.057	1.12	Yes	No	ML			35	Yes	No	1.12	-
S6	25	14	ML	116	3000	3000	3000	0.8	1.2	H	8	1.15	MCAL	12	1.17	0.00	7	9.4	0.96	14	12		35	1.3	16	0.113	0.119	0.214	0.95	Yes	No	ML			32	Yes	No	0.95	-
S7	30	20	ML	119	3380	3380	3380	0.8	1.2	H	8	1.15	MCAL	16	1.09	0.00	7	11.0	0.98	21	19		35	1.2	23	0.156	0.119	0.014	1.25	No	No	ML			19	Yes	No	1.25	-
S8	35	13	SM	116	3990	3990	3990	0.7	1.2	H	8	1.15	MCAL	9	1.33	0.00	7	12.5	0.99	14	10		12	1.1	11	0.072	0.116	0.926	0.62	Yes	Yes	SM			0.62	Yes	Yes	Liquefiable	
S9	40	45	SP	123	4598	4598	3993	0.7	1.2	H	8	1.15	MCAL	31	1.00	0.00	7	14.0	0.99	33	33	12	12	1.1	23	0.186	0.116	0.001	1.67	No	Yes	SP			24	Yes	No	1.67	-
S10	45	34	SP	124	5216	4991	4291	0.7	1.2	H	8	1.15	MCAL	28	1.00	0.00	7	15.5	0.99	55	55		5	1.0	55	0.145	0.114	0.002	1.48	No	Yes	SP			24	Yes	No	1.48	-
S11	50	55	SP	124	5635	4888	4589	0.6	1.2	H	8	1.15	MCAL	36	1.00	0.00	7	17.1	1.00	58	58		5	1.0	58	0.552	0.111	0.000	3.00	No	Yes	SP				Yes	No	3.00	-
S12	55	58	SP	119	6030	5182	4882	0.6	1.2	H	8	1.15	MCAL	18	1.08	0.00	7	18.6	1.00	31	19		5	1.0	20	0.134	0.108	0.021	1.24	No	Yes	SP			24	Yes	No	1.24	-
S13	60	35	SP	120	7200	5479	5179	0.5	1.2	H	8	1.15	MCAL	19	1.20	0.00	7	20.1	1.00	53	30		5	1.0	31	0.140	0.104	0.000	1.34	No	Yes	SP			25	Yes	No	1.34	-
S14	75	58	SP	126	9310	6725	5625	0.5	1.2	H	8	1.15	MCAL	29	1.00	0.00	7	23.2	1.00	54	31	71	11	1.1	33	0.529	0.100	0.000	3.99	No	Yes	SP			22	Yes	No	3.99	-
S15	90	47	SP	126	9560	6757	6457	0.5	1.2	H	8	1.15	MCAL	24	1.30	0.00	7	26.2	1.00	50	27		5	1.0	29	0.251	0.095	0.000	3.43	No	Yes	SP			24	Yes	No	3.43	-

URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O. Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

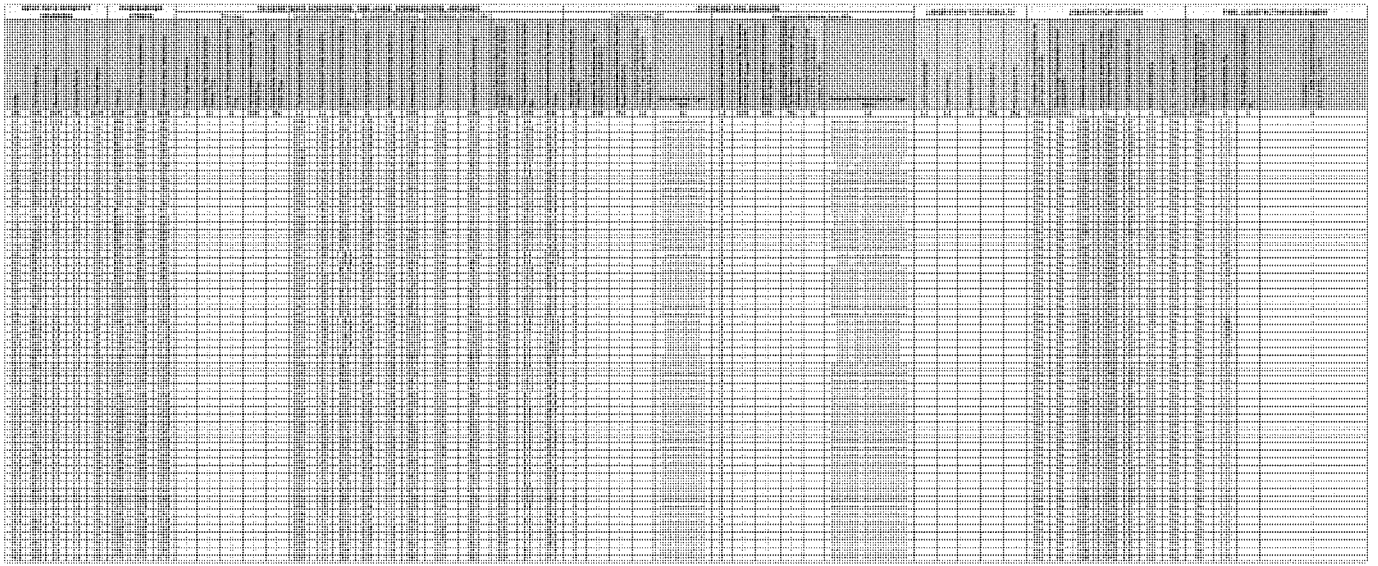
PROJECT NAME:	American River Common Features Geld Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	26420690
Reach ID:	NAR1 LR 134 - 145
Station:	1099+92
CPT ID:	RRECSAP_B40C
CPT Location:	Levee Crest

Analysis by:	S. Chan	Date:	10/1/2008
Checked by:	J. Perlt	Date:	10/1/2008

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and Distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	33.1	
Groundwater Elevation During Exploration (NAVD88) =	13.0	Note: Assumed
Design Groundwater Elevation (ft) =	13.0	Note: Typical Winter
Return Period (Years) =	200	
Peak Ground Acceleration (**PGA_g**) =	0.15	
Location (Crest/Landside/Waterside)	Crest	
Earthquake Magnitude (M_w) =	7.2	
Groundwater Depth bgs During Exploration (ft) =	20.1	
Groundwater Depth bgs During Earthquake(ft) =	20.1	
Total Number of Thin Layers (ft) =	0	



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
   Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O. Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering - A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features/GRR Project
LEVEE REACH/PUT:	Sacramento River East Levee (South)
PROJECT NUMBER:	26027620
Reach ID:	NAS/DI 134 1-4E
Station:	709+92
CPT ID:	KRE-CPT-108A
CPT Location:	Levee Crest

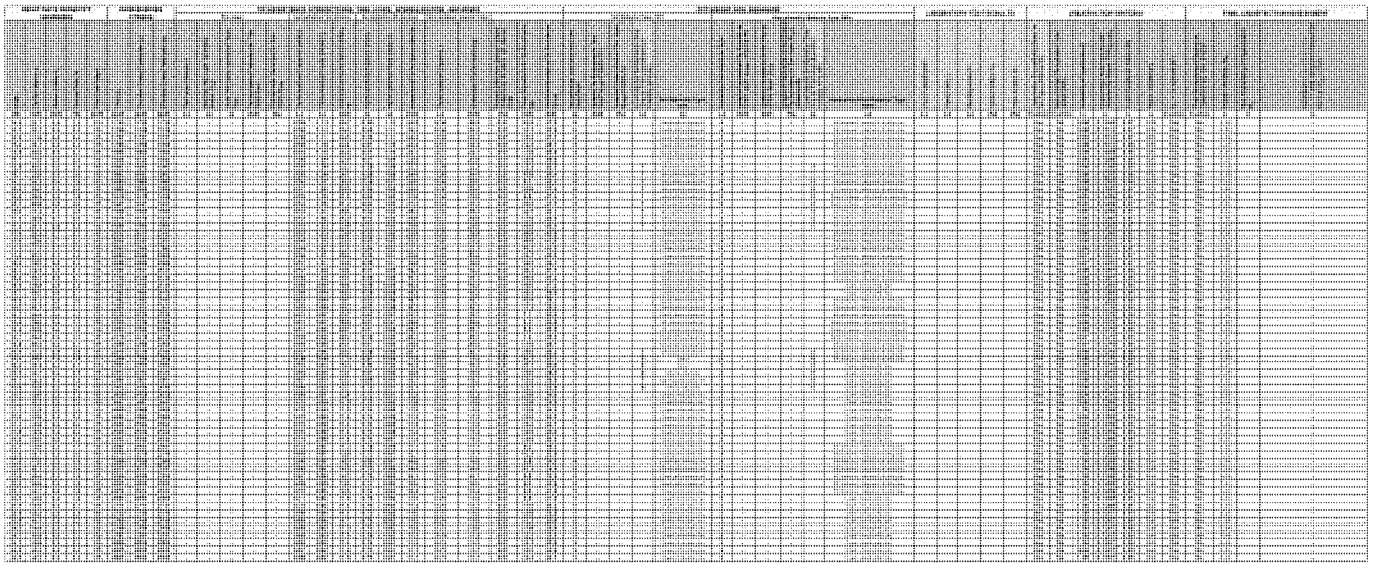
Analysis by:	S. Orgill
Reviewed by:	J. Reid
Date:	10/1/2008
Date:	10/3/2008

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	33.5
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	13.5
Return Period (Years) =	200
Peak Ground Acceleration (**PGA_g**) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	20.5
Groundwater Depth bgs During Earthquake (ft) =	20.0
Total Number of Thin Layers (N) =	9

Note: Assumed
Note: Typical Winter



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DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)). Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR Project
LEVEE SEGMENT:	Sacramento River East Levee (RiverW)
PROJECT NUMBER:	26827160
Reach ID:	NAW Crt Lg 1.46
Station:	1099+92
CPT ID:	NSECAP_0007
CPT Location:	Levee Crest

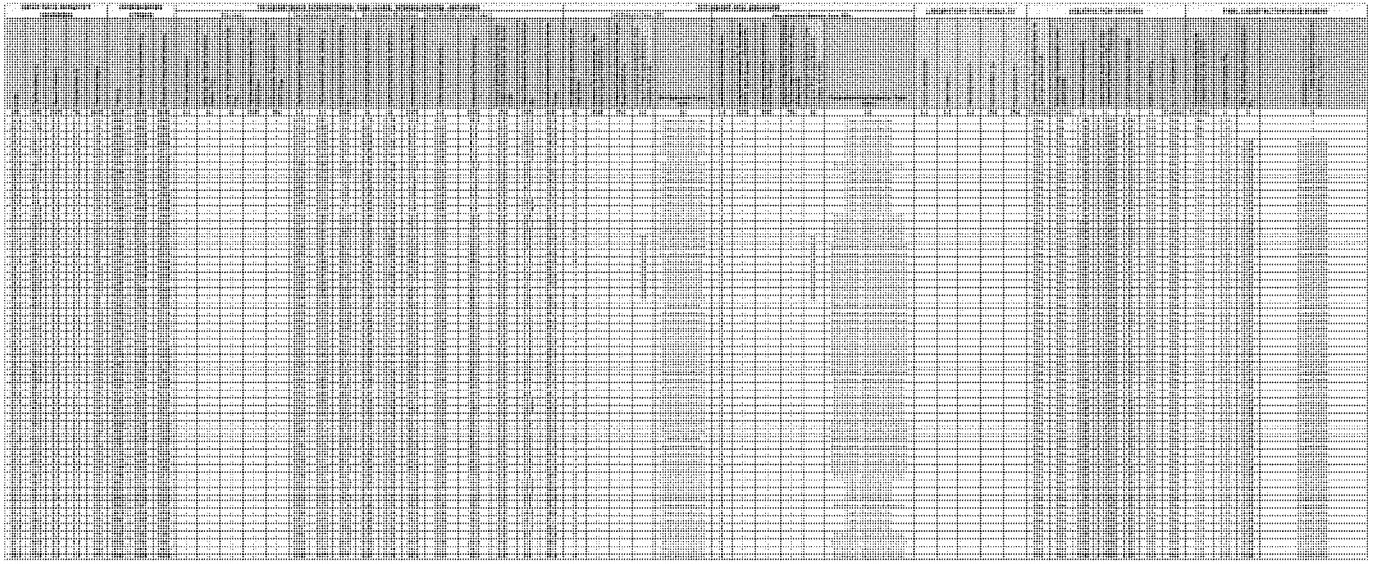
Analysis by:	S. Cyr
Checked by:	J. Fell
Date:	10/1/2008
Date:	10/1/2008

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	33.0
Groundwater Elevation During Exploration (NAVD88) =	19.0
Design Groundwater Elevation (ft) =	19.0
Return Period (Years) =	200
Peak Ground Acceleration (**PGA_g**) =	0.15
Location (Creek/Landside/Waterside)	Creek
Earthquake Magnitude (M_w) =	7.25
Groundwater Depth bgs During Exploration (ft) =	13.0
Groundwater Depth bgs During Earthquake (ft) =	29.0
Total Number of Thin Layers (#) =	8

Note: Assumed
Note: Typical Winter



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O. Moss, R. E.S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features GRR Project
LEVEE SEGMENT:	Sacramento Main East Levee (South)
PROJECT NUMBER:	36287(0)
Reach ID:	NLMR LT LM 1-48
Station:	1099+92
CPT ID:	W051SR_0047
CPT Location:	Levee Crest

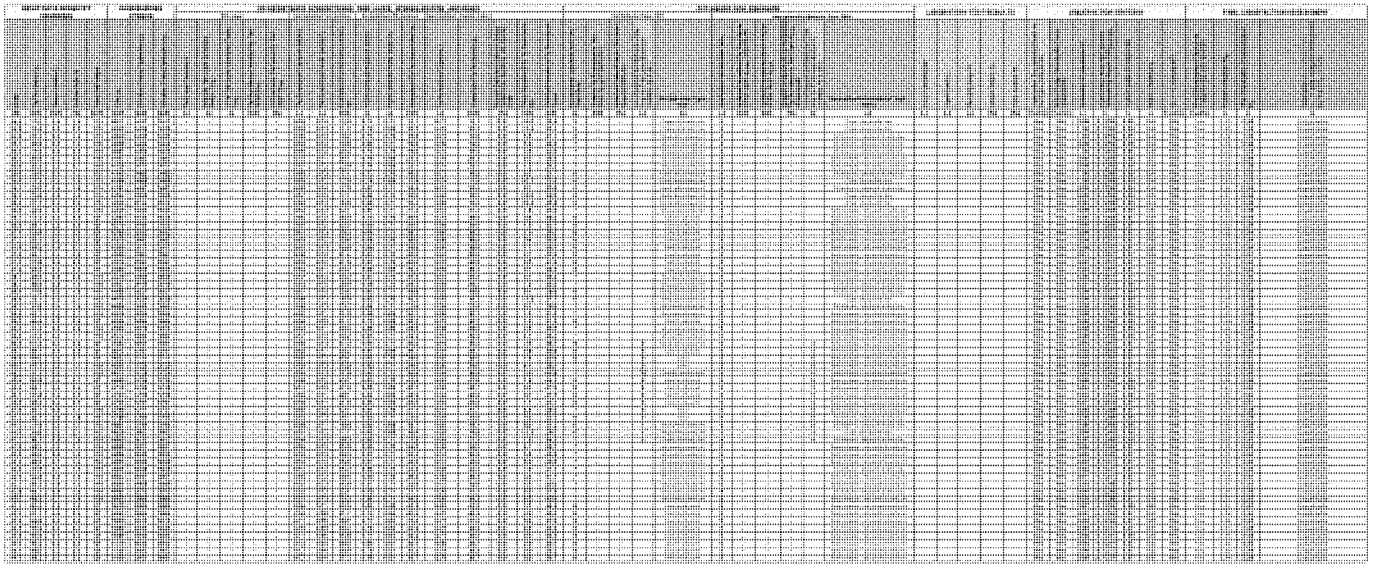
Analysis by:	S. Orgill
Checked by:	J. Perl
Date:	10/13/2008
Date:	10/13/2008

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	35.5 ft
Groundwater Elevation During Exploration (NAVD88) =	13.0 ft
Design Groundwater Elevation (fl) =	13.0 ft
Return Period (Years) =	200
Peak Ground Acceleration (**PGA_g**) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.2
Groundwater Depth bgs During Exploration (fl) =	22.5 ft
Groundwater Depth bgs During Earthquake(fl) =	22.5 ft
Total Number of Thin Layers (N) =	9

Note: Assumed
Note: Based Winter



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal. 35: pp. 442-459.

PROJECT NAME:	American River Common Features GRR Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	38287700
Reach ID:	NAR1 DV1 M 1.15
Station:	1559+00
CPT ID:	WSE5049_1559
CPT Location:	Levee Crest

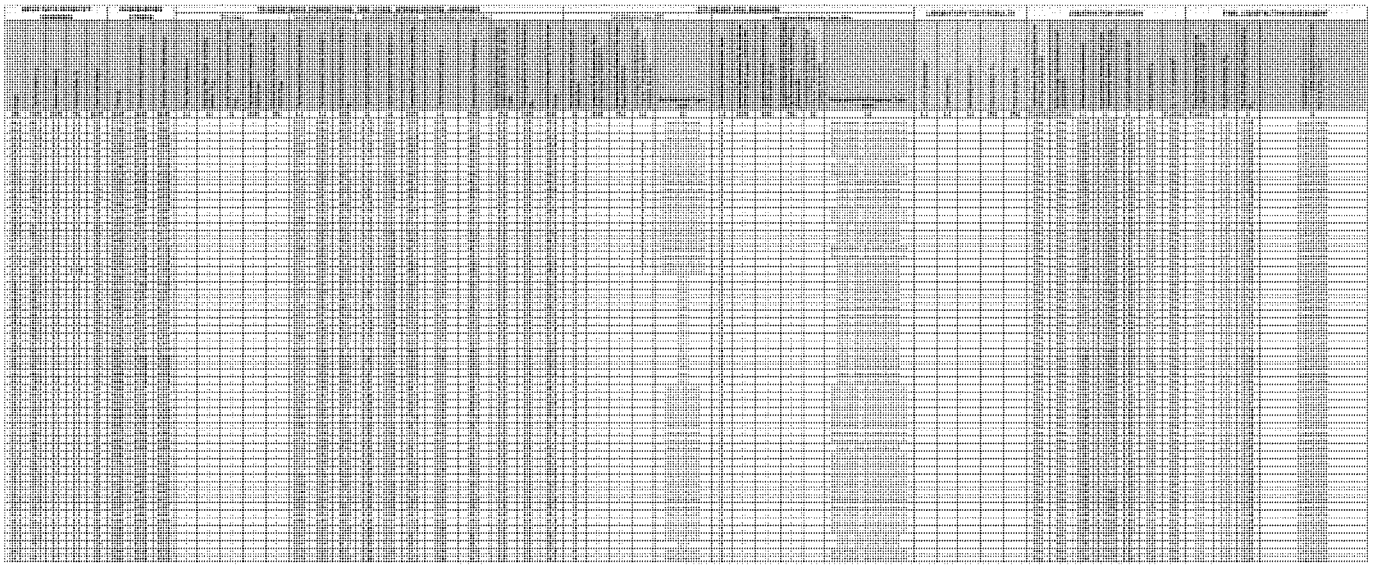
Analysis by:	S. Crigli
Checked by:	J. Perri
Date:	10/13/08
Date:	10/13/08

Data Input By Analyst
Results of Analysis
Calculated Value

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	33.7
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	18.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA_M g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.2
Groundwater Depth bgs During Exploration (ft) =	20.7
Groundwater Depth bgs During Earthquake (ft) =	15.7
Total Number of Thin Layers (N) =	81

Note: Assumed
Note: Typical Winter



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, May 2007, Page 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice, Blackie Academic & Professional, London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O. Moss, R.E.S., Kammerer, A.M., Wu, J., Pestana, J.M., Riemer, M.F., Sancio, R.B., Bray, J.D., Kayen, R.E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features/GRR Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	26538/60
Reach ID:	NASR1(0.1,M.1,R)
Station:	1099+92
CPT ID:	SRESAR_0940
CPT Location:	Levee Crest

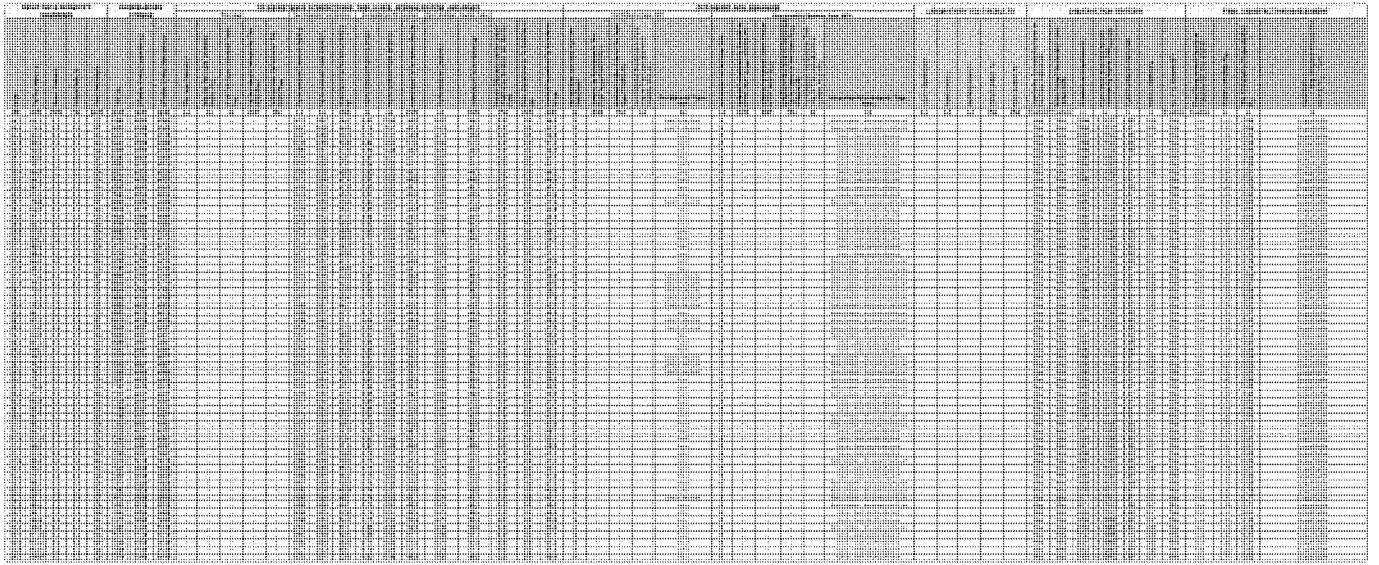
Analysis by:	S. Engr
Checked by:	S. Peer
Date:	10/1/2008
Date:	10/1/2008

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Check Levee Materials, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	34.0 ft
Groundwater Elevation (During Exploration (NAVD88)) =	13.0 ft
Design Groundwater Elevation (ft) =	19.0 ft
Return Period (Years) =	200
Peak Ground Acceleration (**PGA_g**) =	0.15 g
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	89.4 ft
Groundwater Depth bgs During Earthquake (ft) =	25.0 ft
Total Number of Thin Layers (N) =	8

Note: Assumed
Note: Typical Winter



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, r(doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	Ameriquest River Commons Features GRR Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	26027.01
Reach ID:	NAVD 88 (M) ? (ft)
Station:	1059+92
CPT ID:	ARSCPT_XXX
CPT Location:	Levee Crest

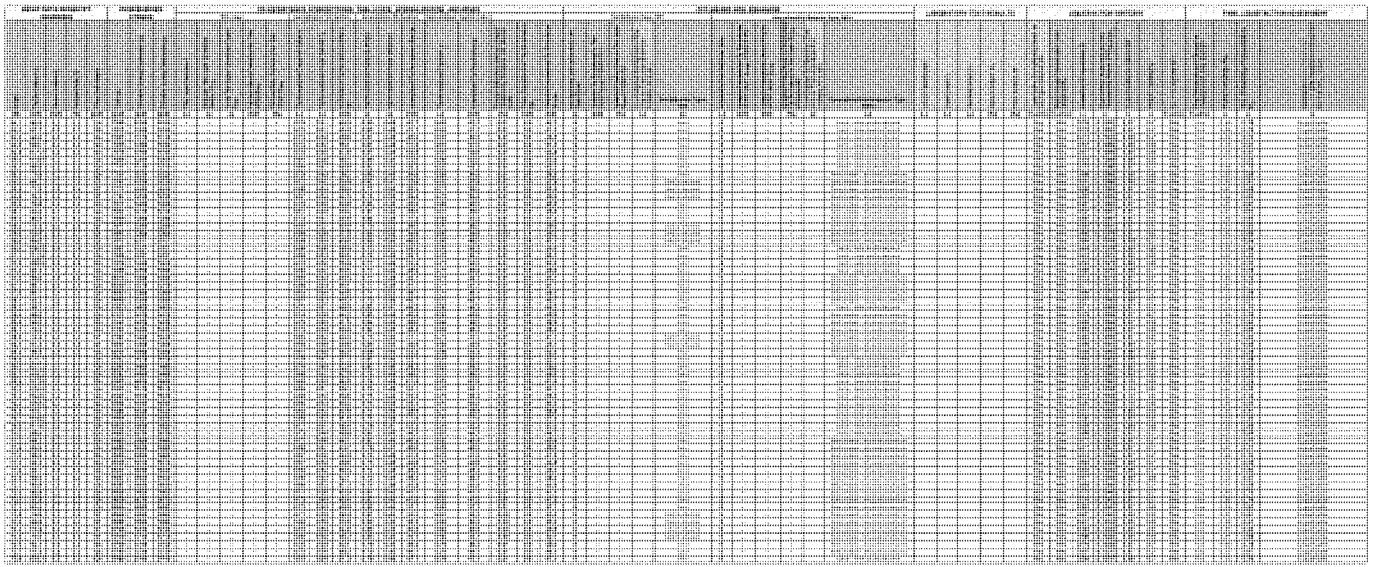
Note: Crest/Landside/Waterside, and distance from Crest/Lanpmse toe/Waterside toe

Analysis by:	Q. Crgt	Date:	10/1/2008
Checked by:	J. Perl	Date:	10/1/2008

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (NAVD88) =	33.0
Groundwater Elevation (During Exploration) (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	13.0
Return Period (Years) =	200
Peak Ground Acceleration (**PGA_g**) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	20.0
Groundwater Depth bgs During Earthquake(ft) =	20.0
Total Number of Thin Layers (N) =	8

Note: Assumed
Note: Typical Winter



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:

1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051. (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (9) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E.S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.J.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test". Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	Arcade River Corridor Features (SRS Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	3582/8700
Reach ID:	NAR1U1 [34.1-38
Station:	1099+92
CPT ID:	WSE5AR_SM4
CPT Location:	Lone Creek

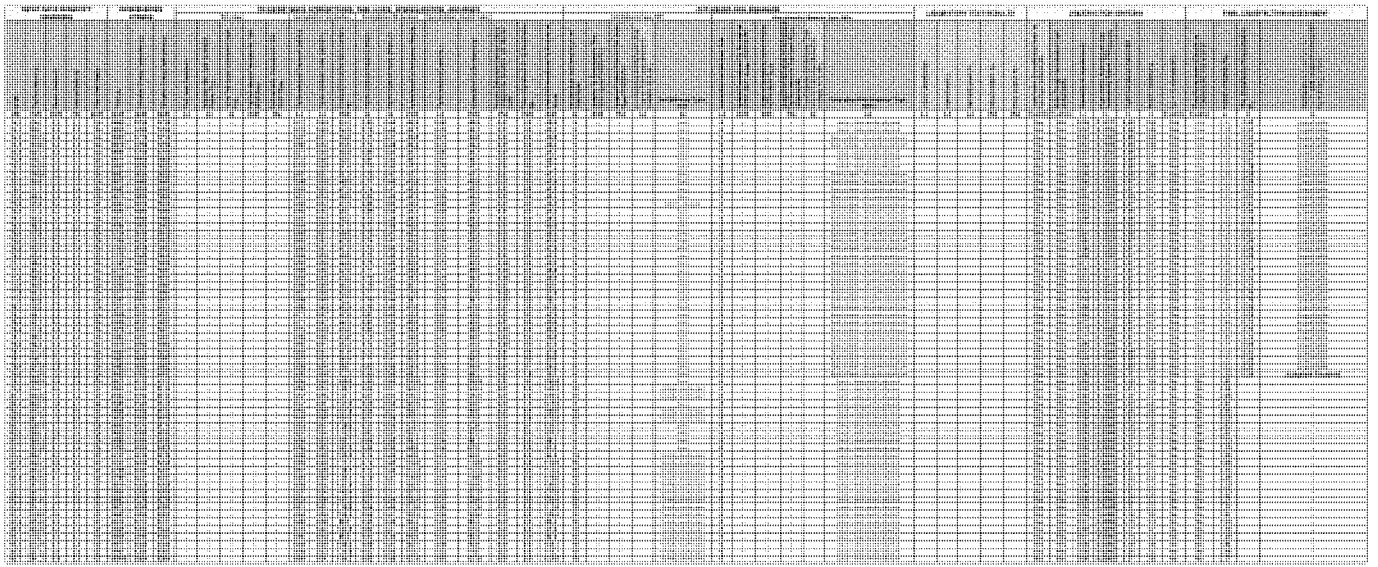
Analysis by:	S. Orgill
Checked by:	C. Neill
Date:	10/14/08
Date:	10/15/08

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	35.5
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	10.5
Return Period (Years) =	200
Peak Ground Acceleration (**PGA_g**) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	22.5
Groundwater Depth bgs During Earthquake (ft) =	25.0
Total Number of Thin Layers (N) =	0

Note: Assumed
Note: Typical Winter



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:

1. Moss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Pages 1177.
2. Lunne, T., Robertson, P.K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K.O. Moss, R. E.S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442–459.

PROJECT NAME:	American River Common Features GRR Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	26126759
Reach ID:	NR4 (LM 1.36)
Station:	1099+92
CPT ID:	DESCEAP_0007
CPT Location:	Levee Crest

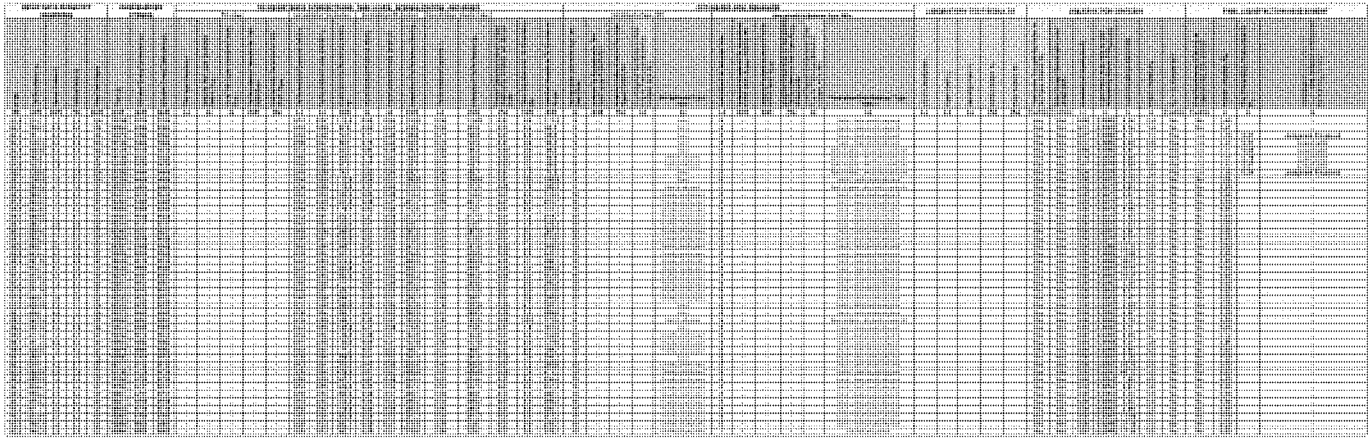
Analysis by:	S. Orgill	Date:	10/13/08
Checked by:	J. Perez	Date:	10/13/08

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	32.5	ft
Groundwater Elevation During Exploration (NAVD88) =	13.0	ft
Design Groundwater Elevation (ft) =	13.5	ft
Return Period (Years) =	200	
Peak Ground Acceleration (PGA_M) =	0.15	g
Location (Crest/Landside/Waterside)	Crest	
Earthquake Magnitude (M_w) =	7.0	
Groundwater Depth bgs During Exploration (ft) =	19.5	ft
Groundwater Depth bgs During Earthquake(ft) =	18.5	ft
Total Number of Thin Layers (N) =	8	

Note: Assumed
Note: Typical Winter



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:
1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2009, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (2NR Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	2406788
Reach ID:	NAR 01 LM 1.4R
Station:	Not Avail.
CPT ID:	WSE-SAR_06-RC
CPT Location:	Levee Crest

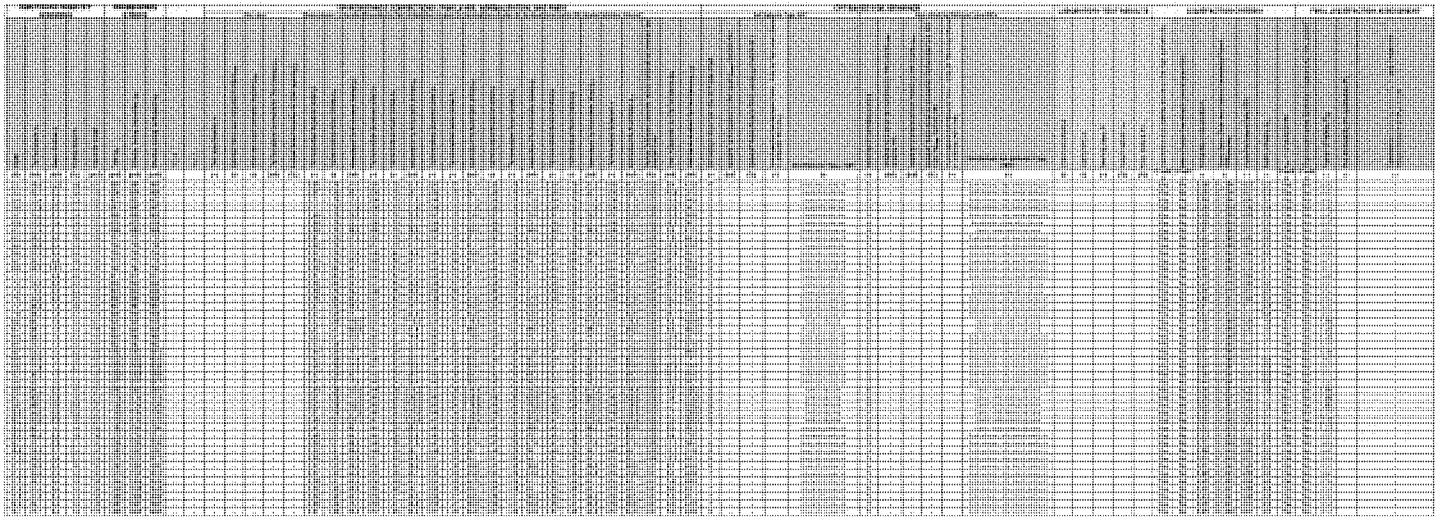
Analysis by:	S. Orgill
Checked by:	J. Perri
Date:	10/1/2009
Date:	10/5/2009

Data Input By Analyst
Results of Analysis
Calculated Value

Note: Crest/Landside/Waterside, and Distance from Crest/Landside/Waterside toe

Ground Elevation (NAVD88) =	38.5
Groundwater Elevation During Exploration (NAVD88) =	13.5
Design Groundwater Elevation (ft) =	7.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA_g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	6.0
Groundwater Depth bgs During Exploration (ft) =	25.1
Groundwater Depth bgs During Earthquake(ft) =	30.3
Total Number of Thin Layers (N) =	6

Note: Assumed
Note: Typical Summer



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 5, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (2autr Project)
LEVEE SEGMENT:	Sacramento River East Levee (Gravity)
PROJECT NUMBER:	26809760
Reach ID:	NAR.01.LM.1.49
Station	1060+00
CPT ID	WSESAR_504C
CPT Location:	Levee Crest

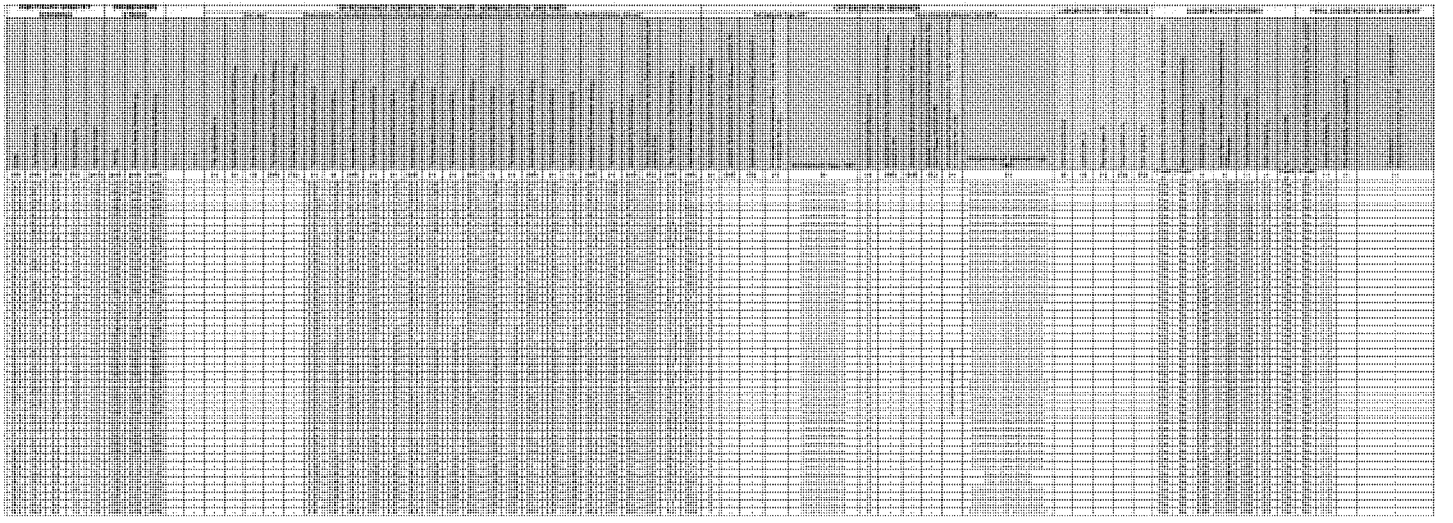
Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	38.1
Groundwater Elevation During Exploration (NAVD88) =	13.3
Design Groundwater Elevation (ft) =	7.8
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	24.8
Groundwater Depth bgs During Earthquake(ft) =	30.3
Total Number of Thin Layers (N) =	6

Note: Assumed
Note: Typical Summer

Analysis by:	S. Orgill	Date:	10/5/2008
Checked by:	J. Perri	Date:	10/15/2008

Data Input By Analyst
Results of Analysis
Calculated Values



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2000, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6. March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (2016) Project
LEVEE SEGMENT:	Sacramento River East Levee (SAM01)
PROJECT NUMBER:	29508760
Reach ID:	RA05 (0) M 1.49
Station	1803+50
CPT ID	RSE-EAR_0042
CPT Location	Levee Crest

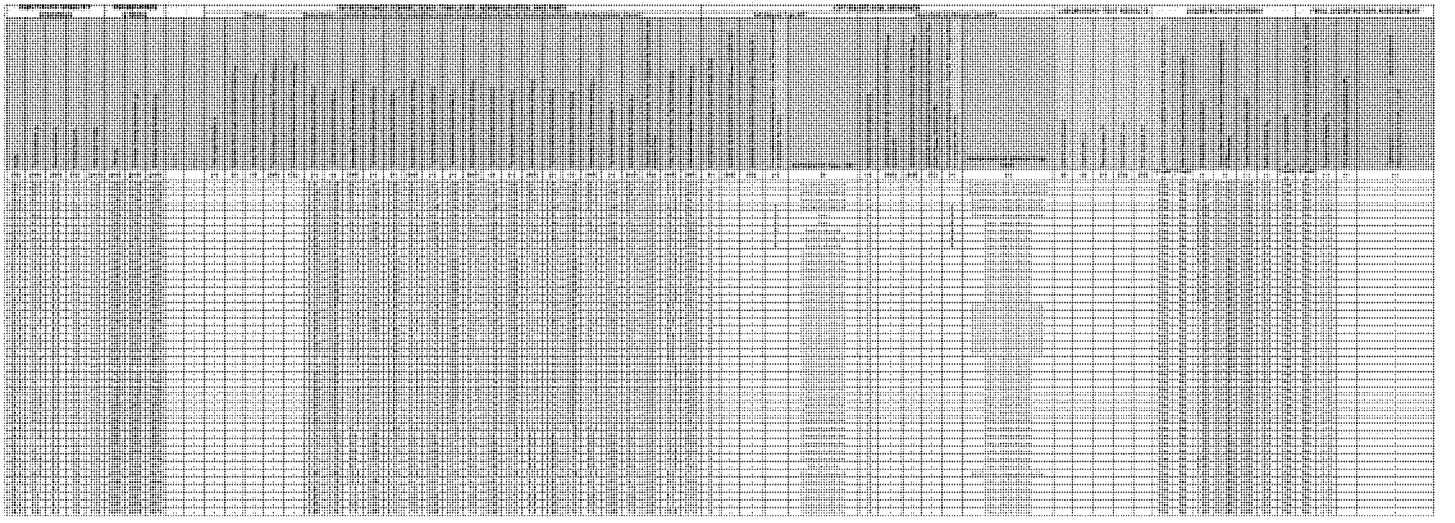
Analysis by:	S. Urgik
Checked by:	C. Perl
Date:	10/15/08
Date:	10/15/08

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (NAVD88) =	38.1
Groundwater Elevation During Exploration (NAVD88) =	10.1
Design Groundwater Elevation (ft) =	7.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	28.1
Groundwater Depth bgs During Earthquake(ft) =	30.6
Total Number of Thin Layers (N) =	6

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Note: Assumed
Note: Typical Summer



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:
1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006 "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (DWR Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	28387000
Reach ID:	NAR US 1&4 1.4b
Station:	1800+57
CPT ID:	WSESAR_004C
CPT Location:	Levee Crest

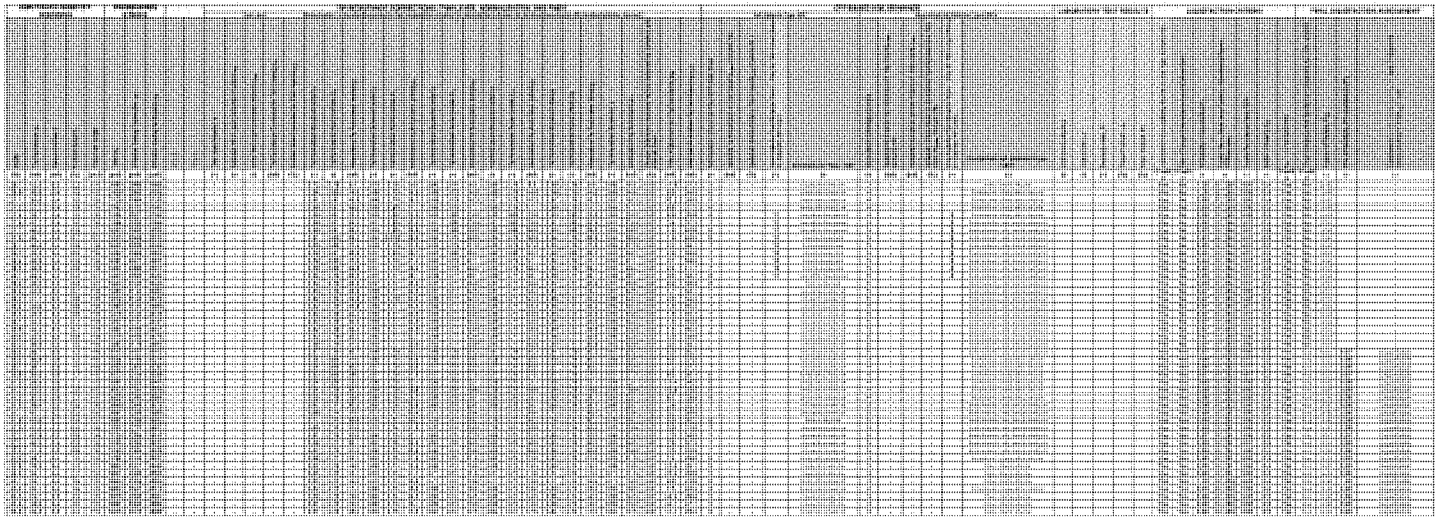
Analysis by:	S. Orgill
Checked by:	J. Perri
Date:	10/7/08
Date:	10/13/08

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside Toe/Waterside toe

Ground Elevation (NAVD88) =	38.1
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	7.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	25.1
Groundwater Depth bgs During Earthquake(ft) =	30.6
Total Number of Thin Layers (N) =	0

Note: Assumed
Note: Typical Summer



DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:
1. Idriss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J J M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2030. Guidance Document for Geotechnical Analysis. Urban Levee Geotechnical Evaluations Program. Rev. 6. March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wilde (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (SPK Project)
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	26929788
Reach ID:	RA85.0S1.LM1.sg
Station	1169+50
CPT ID	WSESAR_004C
CPT Location:	Levee Crest

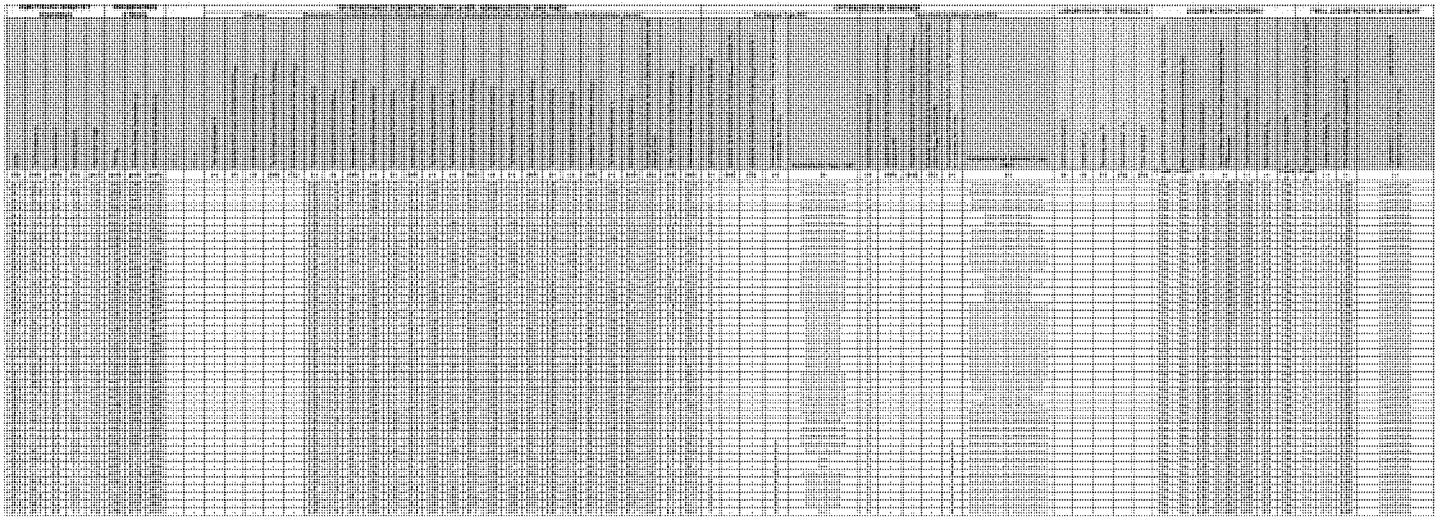
Analysis by:	S. Orgill
Checked by:	C. Perri
Date:	10/15/08
Date:	10/15/08

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	28.5
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	9.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.16
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	25.5
Groundwater Depth bgs During Earthquake(ft) =	30.5
Total Number of Thin Layers (N) =	0

Note: Assumed
Note: Typical Summer



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:
1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442–459.

PROJECT NAME:	Sacramento River Common Features (URS Project)
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	26924769
Reach ID:	NAR.US.LM.1.49
Station:	1165+92
CPT ID	WSESAR_P247
CPT Location:	Levee Crest

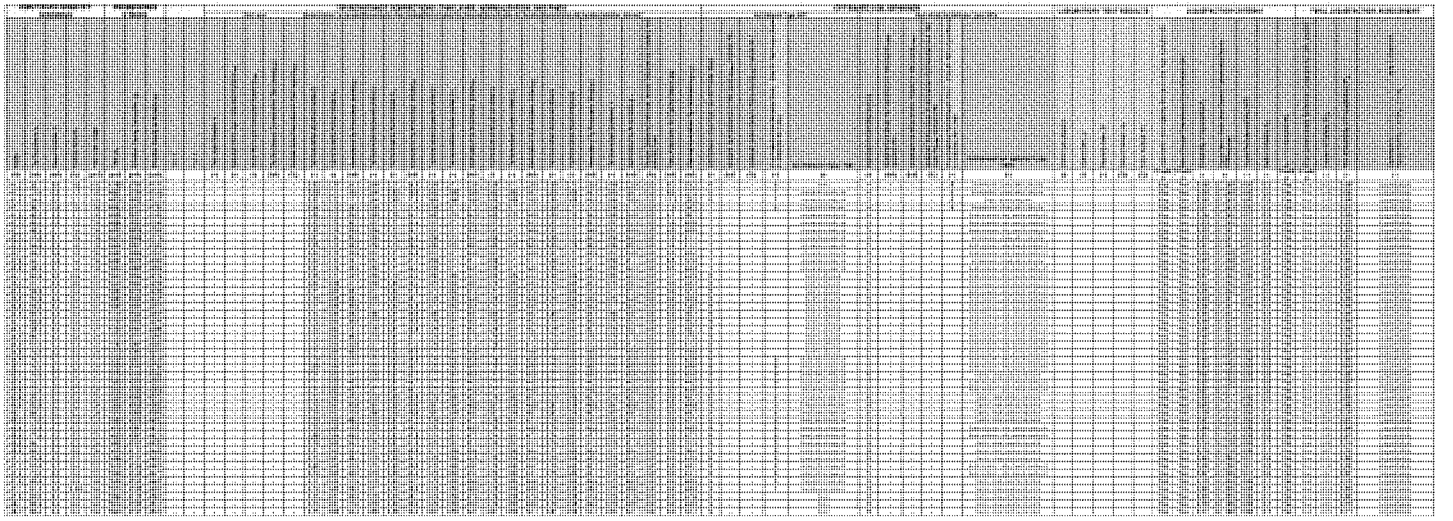
Analysis by:	S. Orgill
Checked by:	J. Perry
Date:	10/7/2008
Date:	10/7/2008

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and Distance from Crest/Landside/Waterside toe

Ground Elevation (NAVD88) =	38.5
Groundwater Elevation During Exploration (NAVD88) =	12.5
Design Groundwater Elevation (ft) =	7.5
Return Period (Years) =	100
Peak Ground Acceleration (PGA, g) =	0.19
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	26.1
Groundwater Depth bgs During Earthquake(ft) =	30.1
Total Number of Thin Layers (N) =	6

Note: Assumed
Note: Typical Summer



DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A, and Cetin, K.O., 2005. "CPT-Based Probabilistic and Deterministic Assessment of In Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi 10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal. 35, pp. 442-459.

PROJECT NAME:	American River Common Features (DRR Project)
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	2606720
Reach ID:	MA05.U1.M.1.up
Station	1[illegible]2
CPT ID	WSSAR_0047
CPT Location:	Levee Crest

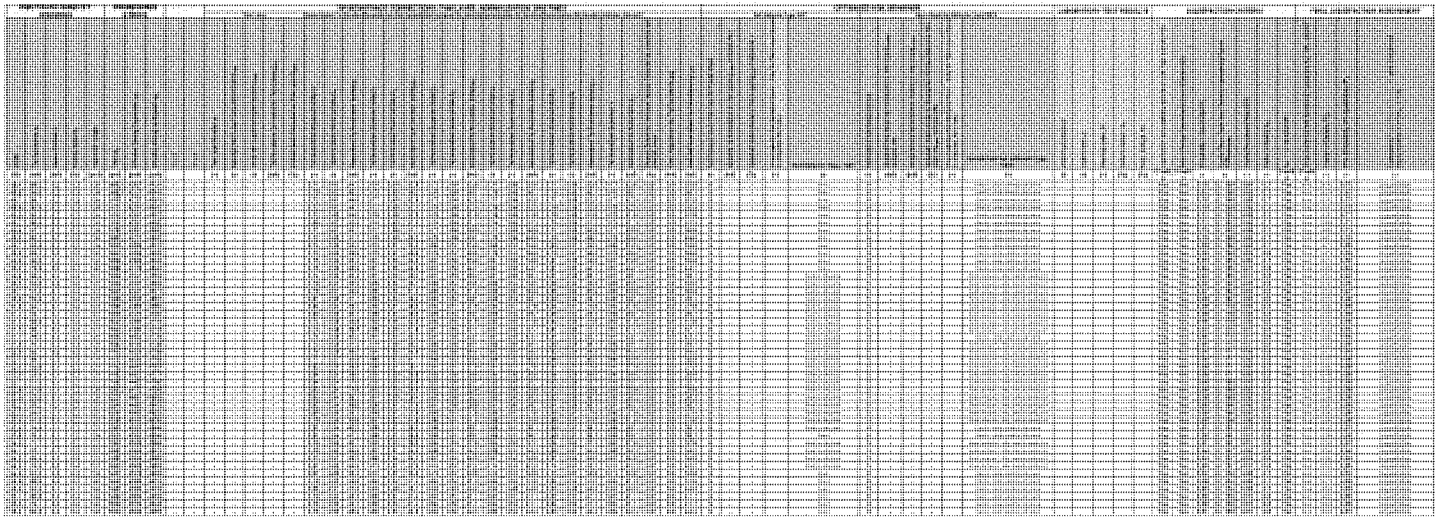
Ground Elevation (NAVD88) =	28.1
Groundwater Elevation During Exploration (NAVD88) =	13.8
Design Groundwater Elevation (ft) =	7.9
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	24.1
Groundwater Depth bgs During Earthquake(ft) =	20.5
Total Number of Thin Layers (N) =	60

Analysis by:	S. Urgo
Checked by:	J. Perry
Date:	10/7/2008
Date:	10/15/2008

Note: Crest/Landside/Waterside, and Seismic Data Crest/Landside/Waterside Use

Note: Assumed
Typical Summer

Data Input By Analyst
Results of Analysis
Calculated Values



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6. March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (2autn Project)
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	28278789
Reach ID:	NAR 01 LM 1 AS
Station:	(feet/m)?
CPT ID:	WSE6AR_0840
CPT Location:	Levee Crest

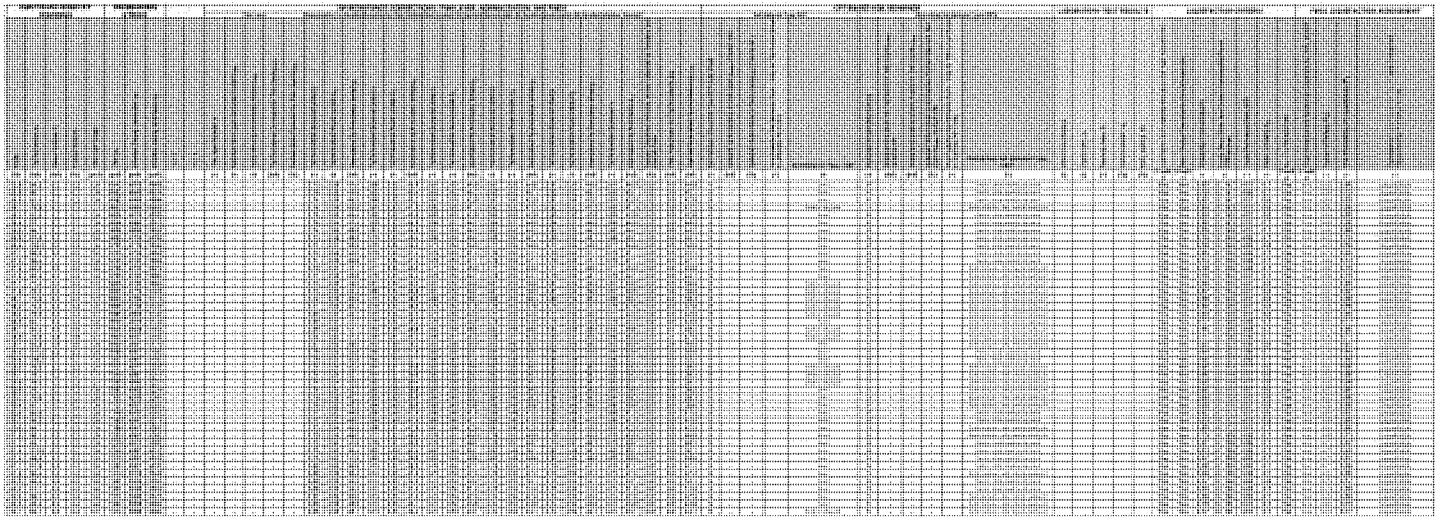
Ground Elevation (NAVD88) =	38.1
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	7.8
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	24.3
Groundwater Depth bgs During Earthquake(ft) =	30.3
Total Number of Thin Layers (N) =	0

Analysis by:	S. Orgill
Checked by:	C. Port
Date:	10/19/09
Date:	10/19/09

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Note: Assumed
Note: Typical Summer



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:
1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (5) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2009, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2009.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	Adeptcon River Common Features GRR Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	26958799
Reach ID:	RA5 R1 LM 1.49
Station	1+52+92
CPT ID	W95SAR_0042
CPT Location:	Levee Crest

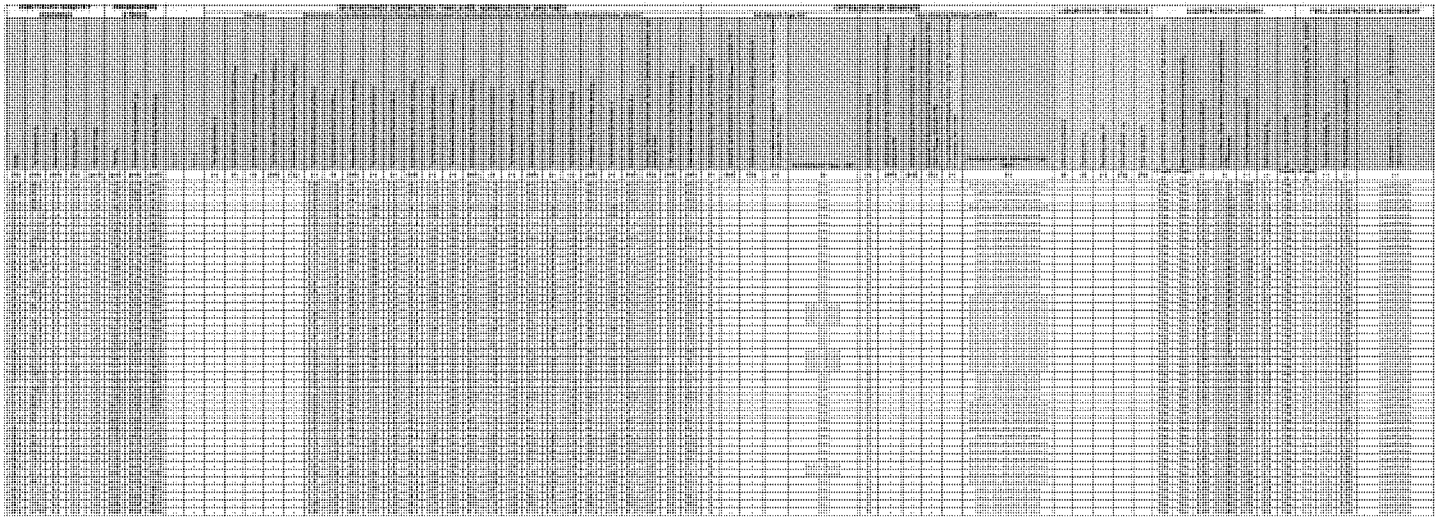
Analysis by:	S. Orgill
Checked by:	J. Perry
Date:	10/1/2009
Date:	10/15/2009

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	38.1
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	7.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA_M g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	25.1
Groundwater Depth bgs During Earthquake(ft) =	30.6
Total Number of Thin Layers (N) =	0

Note: Assumed
Note: Typical Summer



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)). Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2008. Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca.
5. Bray, J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering. Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (2016 Project)
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	24258701
Reach ID:	NAR5 U1 LM 1.4S
Station:	1560+00
CPT ID:	WSE SAR -004C
CPT Location:	Levee Crest

Ground Elevation (NAVD88) =	36.1
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	7.0
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	23.1
Groundwater Depth bgs During Earthquake(ft) =	30.0
Total Number of Thin Layers (N) =	0

Note: Crest/Landside/Waterside, and distance from Crest/Landside/Waterside toe

Note: Assumed

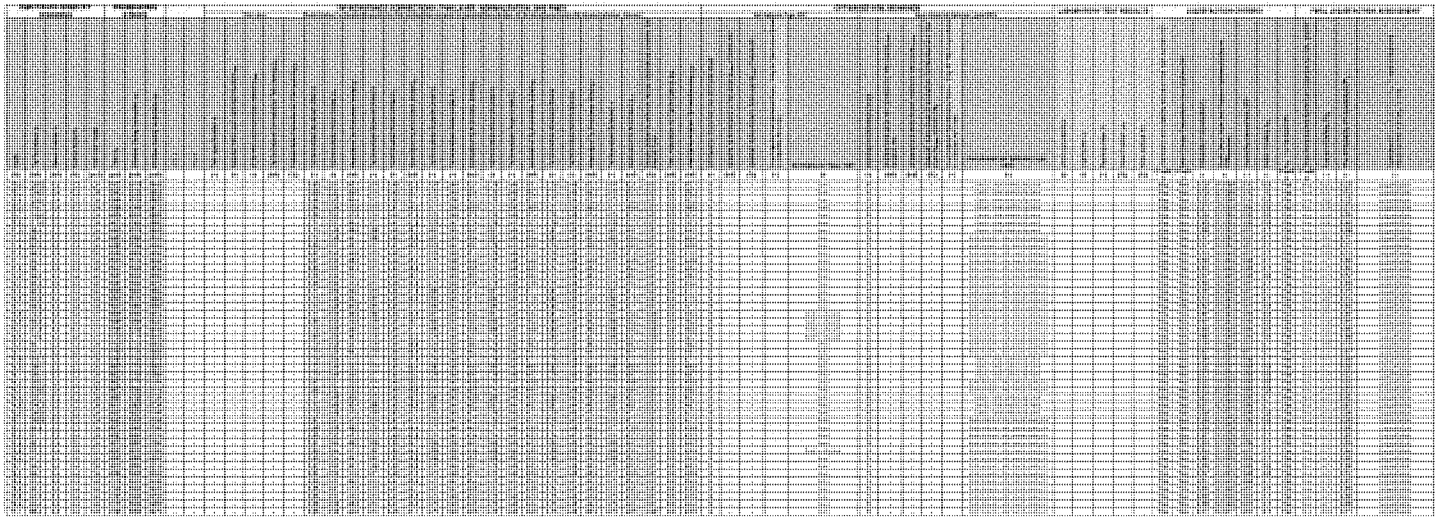
Note: Typical Scenario

Analysis by:	S. Orgill	Date:	10/7/2008
Checked by:	J. Fear	Date:	10/13/2008

Data Input By Analyst

Results of Analyses

Calculated Values



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES: 1. Moss, R.E.S., Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2006. "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997. Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2000, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 5, March 2008.
4. Seed, R.B., Cetin, K. O. Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003. "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework". 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca ,
5. Bray J.D., Sancio, R.B., 2006. "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils". Journal of Geotechnical and Geoenvironmental Engineering. Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998. "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal. 35, pp. 442-459.

PROJECT NAME:	American River Common Features (CVFR Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	28297760
Reach ID:	RA5.R1.LM.1.49
Station	1362+52
CPT ID	WSE-SAR_004C
CPT Location:	Levee Crest

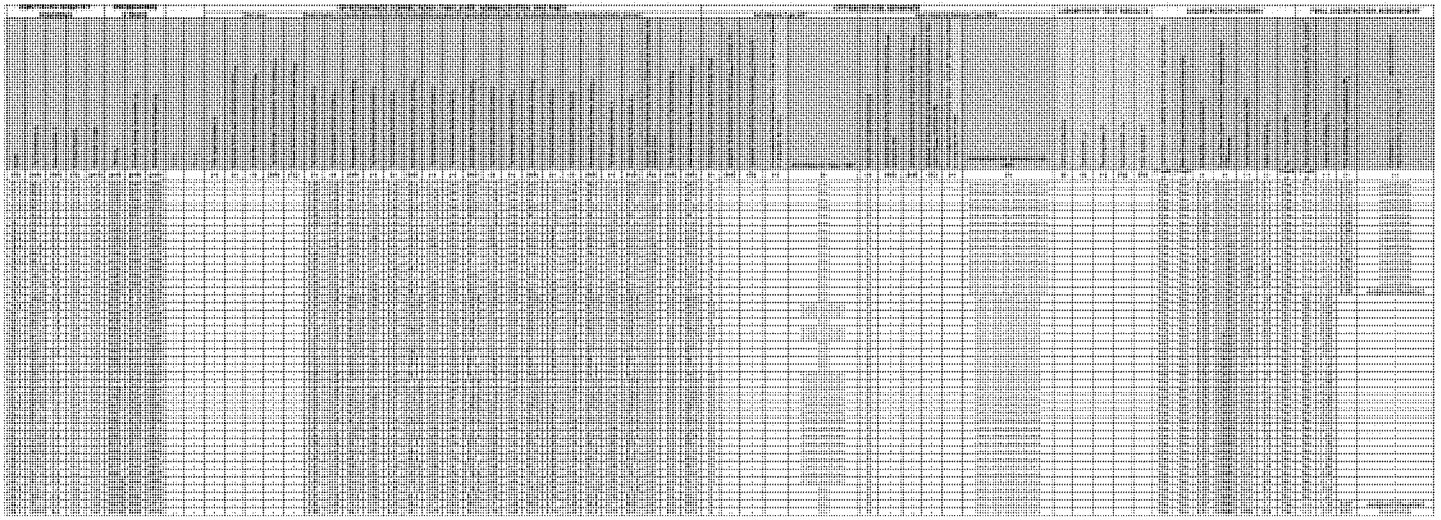
Analysis by:	S. Engle
Checked by:	C. Perri
Date:	10/1/2008
Date:	10/3/2008

Data Input By: Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside, and distance from Crest/Landside toe/Waterside toe

Ground Elevation (NAVD88) =	38.5
Groundwater Elevation During Exploration (NAVD88) =	13.0
Design Groundwater Elevation (ft) =	7.8
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	25.5
Groundwater Depth bgs During Earthquake(ft) =	30.5
Total Number of Thin Layers (N) =	6

Note: Assumed
Note: Typical Summer



URS

DWR Urban Levee Geotechnical Evaluations Program (ULGEP)
Task Area:
Table 1: CPT Based Liquefaction-Triggering Analysis for ULGEP

REFERENCES:
1. Moss, R.E.S. , Seed, R.B., Kayen, R.E., Stewart, J.P., Der Kiureghian, A. and Cetin, K.O., 2005, "CPT-Based Probabilistic and Deterministic Assessment of in Situ Seismic Soil Liquefaction Potential", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 8, August 2006, pp. 1032-1051, (doi:10.1061/(ASCE)1090-0241(2006)132:8(1032)).
Errata to Equation (8) were published the Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Sep 2007, Page 1177.
2. Lunne, T., Robertson, P. K. and Powell, J.J.M., 1997, Cone Penetration Testing in Geotechnical Practice. Blackie Academic & Professional. London.
3. URS Corporation 2006, Guidance Document for Geotechnical Analysis, Urban Levee Geotechnical Evaluations Program Rev. 6, March 2008.
4. Seed, R.B., Cetin, K. O, Moss, R. E. S., Kammerer, A. M., Wu, J., Pestana, J. M., Riemer, M. F., Sancio, R.B., Bray, J. D., Kayen, R. E., Faris, A., 2003, "Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework", 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
5. Bray, J.D., Sancio, R.B., 2006, "Assessment of the Liquefaction Susceptibility of Fine-Grained Soils", Journal of Geotechnical and Geoenvironmental Engineering, Vol. 132, No. 9, September 2006, pp. 1165-1177.
6. Robertson, P.K., and Wride (Fear), C.E., 1998, "Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test", Canadian Geotechnical Journal, 35, pp. 442-459.

PROJECT NAME:	American River Common Features (2autr Project
LEVEE SEGMENT:	Sacramento River East Levee (South)
PROJECT NUMBER:	26226769
Reach ID:	NAS US LM 1.46
Station:	1+60+00
CPT ID:	WSE-SAR_004C
CPT Location:	Levee Crest

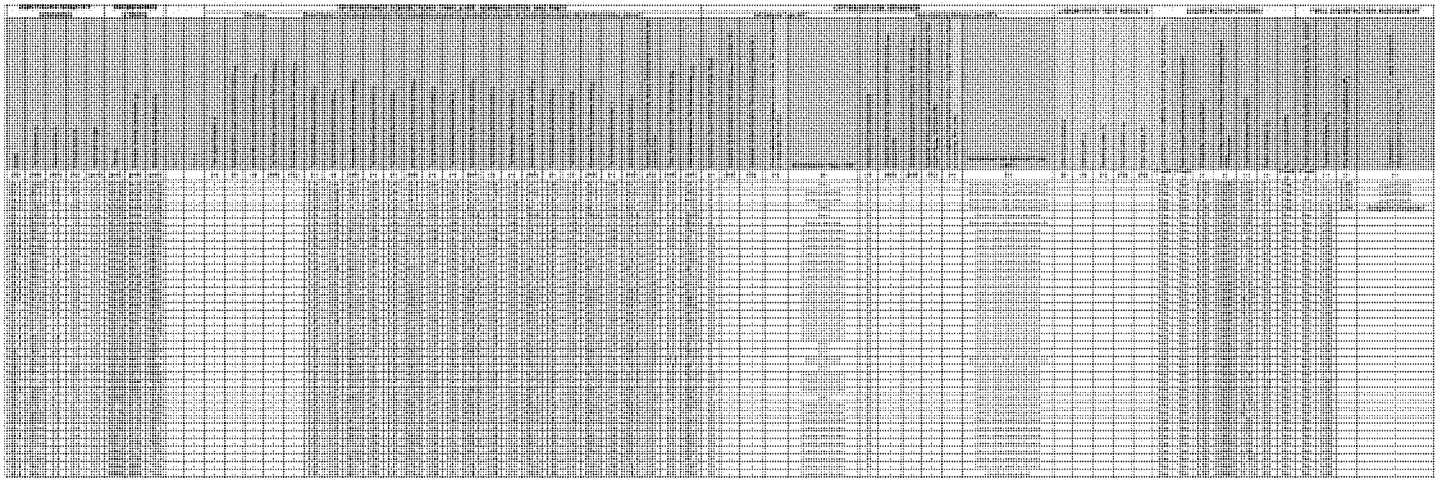
Analysis by:	S. Unger
Checked by:	J. Perl
Date:	10/13/05
Date:	10/13/05

Data Input By Analyst
Results of Analysis
Calculated Values

Note: Crest/Landside/Waterside and Stability Run Crest/Landside/Waterside Use

Ground Elevation (NAVD88) =	35.0
Groundwater Elevation During Exploration (NAVD88) =	12.0
Design Groundwater Elevation (ft) =	7.5
Return Period (Years) =	200
Peak Ground Acceleration (PGA, g) =	0.15
Location (Crest/Landside/Waterside)	Crest
Earthquake Magnitude (M_w) =	7.0
Groundwater Depth bgs During Exploration (ft) =	23.0
Groundwater Depth bgs During Earthquake(ft) =	30.0
Total Number of Thin Layers (N) =	0

Note: Assumed
Note: Typical Summer



URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 130, No. 12, 1313-1340, and Discussions
2. URS Corporation 2003, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2003.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on fi

PROJECT NAME	Assistance Near Common Features-URS Project
LEVEE SEGMENT	Sacramento River East Levee South of American River
PROJECT NUMBER	Station by Station
Power ID:	
Station	Depth Station = 34+00.0
Boring ID	SP-05-01.2
Boring Location (Check Landside/Waterside, and Berm or Free Field/Adjacent/Embankment)	Crest Boring

Analyzed By:	Shawn Dietz
Check By:	

Date:	6/6/2008
Date:	

Data Input By Hand
Results of Analysis
Calculated Values

Ground Elevation (ft.)=	15.5
Groundwater Elev. During Drilling (ft.)=	0.5
Analyzed Groundwater Elevation (ft.)=	0.5

Note: Depth during drilling
Note: Elevation WSE 5 (NAVD88)

Groundwater Depth Below GS During Drilling (ft.) = 20.0
Analyzed Groundwater Depth Below GS (ft.) = 29.0

Hammer Type = Automatic
Energy Ratio = 77 Assumed

Earthquake Information
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.15
Location = Deep, Crest Landside, or Waterside

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.0 for SPT, 1.2 for MOD. RING)	H_i for Sampler Correction Only (for SW Sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick-up (Push-tube) Rod Length Above Ground (feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	N_{60}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, if < 1.2 (Youd's), Otherwise AE	Below Analyzed Groundwater Level (Youd's) Otherwise AE	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (w%)	Liquefaction Susceptibility Based on Soil Type (Youd and Idriss A)	Final Assessment (Youd's) Based on Combined All Criteria	Factor of Safety, FS	Comment (Liquefiable for FS, if Less, Judgment Required for 1.0 <FS< 1.2)
S1	0.5	21	SM	130	65	65	65	1.6	1.3	H	8	1.15	0	34	1.20	1.20	7	2.5	0.75	23	37		35	1.2	44	2.739	0.143	0.000	3.80	No	No	SM					Yes	No	3.00	-
S2	3.5	21	SM	130	455	455	455	1.4	1.3	H	8	1.15	0	34	1.20	1.20	7	2.5	0.75	23	37		35	1.2	44	2.595	0.141	0.000	3.80	No	No	SM					Yes	No	3.00	-
S3	9.5	13	SP	130	1235	1235	1235	1.2	1.3	H	8	1.15	0	22	1.20	1.20	7	4.7	0.82	21	26		5	1.0	27	0.305	0.156	0.000	5.47	No	No	SP					Yes	No	5.47	-
S4	13.5	5	SP	130	1635	1635	1635	1.1	1.3	H	8	1.15	0	6	1.10	1.20	7	5.5	0.87	6	7	4	9	1.0	7	0.069	0.153	0.000	9.52	Yes	No	SP					Yes	Yes	9.52	-
S5	15.5	9	CL/ML	110	1955	1955	1955	1.0	1.3	H	8	1.15	0	9	1.13	1.20	7	6.5	0.90	12	12		35	1.3	16	0.124	0.151	0.215	0.85	Yes	No	CL/ML					No	No	0.85	-
S6	17.5	11	CL/ML	110	2175	2175	2175	1.0	1.3	H	8	1.15	0	11	1.16	1.20	7	7.5	0.92	15	14		35	1.3	18	0.146	0.150	0.051	1.13	Yes	No	CL/ML					No	No	1.13	-
S7	19.5	4	CL/ML	110	2385	2385	2385	0.9	1.3	H	8	1.15	0	4	1.10	1.20	7	7.5	0.92	5	5	10	35	1.3	7	0.064	0.127	0.091	0.59	Yes	No	CL/ML	25	7			No	No	0.59	-
S8	21.5	7	CL/ML	110	2815	2815	2815	0.9	1.3	H	8	1.15	0	8	1.10	1.20	7	9.4	0.95	10	9		35	1.3	11	0.094	0.127	0.034	0.66	Yes	No	CL/ML					No	No	0.66	-
S9	23.5	11	CL/ML	110	2935	2935	2935	0.8	1.3	H	8	1.15	0	9	1.14	1.20	7	9.5	0.96	15	12		35	1.3	17	0.121	0.127	0.207	0.95	Yes	No	CL/ML					No	No	0.95	-
S10	25.5	7	ML/CL	110	3025	3025	3025	0.8	1.3	H	8	1.15	0	6	1.10	1.20	7	9.5	0.96	10	8	19	35	1.4	11	0.077	0.127	0.019	0.61	Yes	No	ML/CL					Yes	No	0.61	-
S11	27.5	3	ML/CL	120	3315	3315	3315	0.8	1.3	H	8	1.15	0	2	1.10	1.20	7	10.2	0.97	4	3		35	1.7	5	0.045	0.126	1.000	0.49	Yes	No	ML/CL					Yes	No	0.49	-
S12	29.5	3	ML/CL	120	3555	3555	3555	0.8	1.3	H	8	1.15	0	2	1.10	1.20	7	10.8	0.97	4	3		35	1.7	5	0.045	0.126	1.000	0.39	Yes	Yes	ML/CL					Yes	YES	0.39	Liquefiable
S13	31.5	4	SM	130	3915	3721	3871	0.7	1.3	H	8	1.15	0	3	1.10	1.20	7	11.4	0.98	6	4		35	1.6	7	0.057	0.126	0.999	0.42	Yes	Yes	SM					Yes	YES	0.42	Liquefiable
S14	33.5	2	SM	130	4075	3887	3887	0.7	1.2	H	8	1.15	0	1	1.10	1.20	7	12.0	0.98	3	2	38	35	2.9	4	0.044	0.126	1.000	0.35	Yes	Yes	SM					Yes	YES	0.35	Liquefiable
S15	34.5	2	ML	120	4215	3973	3923	0.7	1.3	H	8	1.15	0	1	1.10	1.20	7	12.2	0.98	3	2		35	2.0	4	0.043	0.126	1.000	0.34	Yes	Yes	ML					Yes	YES	0.34	Liquefiable
S16	37.5	4	ML	120	4555	4067	4037	0.7	1.3	H	8	1.15	0	3	1.10	1.20	7	13.0	0.99	6	4		35	1.6	6	0.051	0.126	1.000	0.41	Yes	Yes	ML					Yes	YES	0.41	Liquefiable
S17	39.5	13	SM	130	4815	4223	4173	0.7	1.3	H	8	1.15	0	9	1.14	1.20	7	13.3	0.99	19	13		35	1.3	17	0.105	0.126	0.366	0.87	Yes	Yes	SM					Yes	YES	0.87	Liquefiable
S18	41.5	9	SM	130	5075	4327	4307	0.7	1.3	H	8	1.15	0	6	1.10	1.20	7	14.5	0.99	13	9		35	1.3	12	0.076	0.124	0.021	0.61	Yes	Yes	SM					Yes	YES	0.61	Liquefiable
S19	43.5	5	SM	130	5395	4483	4443	0.7	1.3	H	8	1.15	0	3	1.10	1.20	7	15.1	0.99	7	5		35	1.3	7	0.055	0.123	0.525	0.41	Yes	Yes	SM					Yes	YES	0.41	Liquefiable
S20	45.5	2	SM	130	5595	4639	4579	0.7	1.2	H	8	1.15	0	1	1.10	1.20	7	15.7	0.99	3	2		35	2.0	4	0.041	0.122	1.000	0.34	Yes	Yes	SM					Yes	YES	0.34	Liquefiable
S21	48.5	2	SM	130	5865	4831	4751	0.6	1.2	H	8	1.15	0	1	1.10	1.20	7	16.8	1.00	3	2	36	35	2.3	4	0.040	0.120	1.000	0.33	Yes	Yes	SM					Yes	YES	0.33	Liquefiable
S22	51.5	1	SM	130	6075	5003	4963	0.6	1.3	H	8	1.15	0	1	1.10	1.20	7	17.5	1.00	1	1		35	3.0	3	0.037	0.117	1.000	0.32	Yes	Yes	SM					Yes	YES	0.32	Liquefiable
S23	54.5	4	SM	130	6705	5295	5195	0.6	1.3	H	8	1.15	0	3	1.10	1.20	7	18.4	1.00	5	4		35	1.6	5	0.046	0.115	1.000	0.40	Yes	Yes	SM					Yes	YES	0.40	Liquefiable
S24	57.5	3	SM	130	7155	5435	5385	0.6	1.3	H	8	1.15	0	1	1.10	1.20	7	19.1	1.00	3	2	45	35	2.3	5	0.039	0.113	1.000	0.34	Yes	Yes	SM					Yes	YES	0.34	Liquefiable
S25	60.5	1	SM	130	7545	5642	5592	0.6	1.3	H	8	1.15	0	1	1.10	1.20	7	20.1	1.00	1	1		35	3.1	3	0.036	0.111	1.000	0.30	Yes	Yes	SM					Yes	YES	0.30	Liquefiable
S26	63.5	6	SM	130	7935	5848	5798	0.6	1.3	H	8	1.15	0	4	1.10	1.20	7	21.2	1.00	5	5		35	1.6	6	0.051	0.108	0.997	0.47	Yes	Yes	SM					Yes	YES	0.47	Liquefiable
S27	64.5	13	CL/ML	110	8265	5957	5907	0.6	1.3	H	8	1.15	0	7	1.11	1.20	7	22.1	1.00	19	10		5	1.0	11	0.063	0.106	0.945	0.58	Yes	Yes	CL/ML					Yes	YES	0.58	Liquefiable
S28	66.5	10	CL/ML	110	8595	6120	6089	0.6	1.3	H	8	1.15	0	6	1.10	1.20	7	23.0	1.00	15	8		5	1.0	8	0.055	0.106	0.997	0.52	Yes	Yes	CL/ML					Yes	YES	0.52	Liquefiable
S29	72.5	9	CL/ML	110	9825	6273	6223	0.6	1.2	H	8	1.15	0	6	1.10	1.20	7	24.5	1.00	13	7		5	1.1	9	0.051	0.104	0.994	0.49	Yes	Yes	CL/ML					Yes	YES	0.49	Liquefiable
S30	78.5	11	ML	120	9645	6616	6569	0.5	1.3	H	8	1.15	0	6	1.10	1.20	7	25.9	1.00	16	9	53	35	1.3	12	0.066	0.101	0.829	0.67	Yes	Yes	ML					Yes	YES	0.67	Liquefiable
S31	81.5	34	SM	130	10595	6781	6741	0.5	1.3	H	8	1.15	0	15	1.22	1.20	7	26.7	1.00	45	19		35	1.2	24	0.163	0.099	0.000	3.80	No	Yes	ML					Yes	No	1.63	-
S32	84.5	58	SP-SM	130	10995	6984	6944	0.5	1.3	H	8	1.15	0	27	1.30	1.20	7	27.5	1.00	74	38		12	1.1	42	0.654	0.098	0.000	3.80	No	Yes	SP-SM					Yes	No	3.00	-
S33	87.5	58	SP-SM	130	10795	7197	7147	0.5	1.3	H	8	1.15	MCAL	26	1.30	0.93	7	28.5	1.00	59	31	12	12	1.1	33	0.328	0.096	0.000	3.80	No	Yes	SP-SM					Yes	No	3.00	-
S34	90.5	58	SP-SM	130	11175	7400	7350	0.5	1.3	H	8	1.15	MCAL	26	1.30	0.93	7	29.4	1.00	59	31		12	1.1	33	0.312	0.095	0.000	3.80	No	Yes	SP-SM					Yes	No	3.00	-
S35	93.5	59	GW	140	11595	7603	7563	0.5	1.3	H	8	1.15	MCAL	25	1.30	0.92	7	30.3	1.00	59	30		3	1.9	41	0.273	0.093	0.000	3.80	No	Yes	GW					Yes	No	3.00	-
S36	96.5	59	GW	140	12015	7805	7815	0.5	1.2	H	8	1.15	MCAL	25	1.30	0.92	7	31.2	1.00	59	30	14	14	1.1	32	0.234	0.092	0.000	3.80	No	Yes	GW					Yes	No	3.00	-
S37	99.5	49	SM	130	12465	8068	8018	0.5	1.2	H	8	1.15	MCAL	24	1.30	0.89	7	32.2	1.00	50	29		16	1.1	31	0.274	0.090	0.000	3.80	No	Yes	SM					Yes	No	3.00	-
S38	102	59	GW	140	13755	8352	8312	0.5	1.3	H	8	1.15	MCAL	25	1.30	0.92	7	32.9	1.00	59	29		5	1.9	29	0.244	0.090	0.000	2.73	No	Yes	GW					Yes	No	3.73	-
S39	105.5	66	SM	130	14238	8499	8449	0.5	1.3	H	8	1.15	MCAL	32	1.30	0.95	7	34.0	1.00	72	37		30	1.2	43	0.695	0.089	0.000	3.80	No	Yes	SM					Yes	No	3.00	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions
2. URS Corporation 2008. *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2008.
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*. (used only for guidance on M

PROJECT NAME:	American River Common Features GRR Project
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	26916/Task 45400
Reach ID:	
Station:	Right Station 1181+50
Boring ID:	GS-R2-3
Boring Location (Enter North and Westerly, and Meters from Levee Centerline/Waterside toe)	Landside Field Boring
Ground Elevation (ft.)=	23.5
Groundwater Elev. During Drilling (ft.)=	7.5
Analyzed Groundwater Elevation (ft.)=	11.6

Note: Rotary Wash Drilling; Assume Typical Summer
Note: Under Water Boring (USA)

Analyst By:	Shawn Graff
Check By:	
Date:	8/31/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Groundwater Depth Below GS During Drilling (ft.) = 14.3
Analyzed Groundwater Depth Below GS (ft.) = 9.7

Hammer Type = Automatic
Energy Ratio = 79 Adds=+4

Earthquake Information
Return Period (years) = 200
M_w = 6.27

PGA (g) = 0.12
Location = Landside (Either, Crest, Landside, or Waterside

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.0 for SCAL, 1.1 for SSAL, 1.2 for SPT)	H_1 for Sampler Correction Only (for SW Sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Penetrated) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, α_{fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, FS	P_L < 1.2 (Yes/No) Column AG	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AI	Final Assessment (Yes/No) based on Columns AG, AH, AI	Factor of Safety, FS	Comment (Liquefiable for FS <1 and Judgment Required for 1.0 <FS < 1.3)
1	2	4	ML	111	222	222	222	1.5	1.2	M	4	1.00	MCAL	0	1.10	0.99	7	2.4	0.75	3	4	93	35	1.5	7	0.118	0.241	0.993	0.49	Yes	No	ML			25	Yes	No	0.49	-
2	4	5	ML	111	444	444	444	1.5	1.2	M	4	1.00	S	5	1.10	1.00	7	3.8	0.75	3	4		35	1.5	7	0.095	0.239	1.000	0.40	Yes	No	ML				Yes	No	0.40	-
3	6	3	ML	116	676	676	676	1.5	1.2	M	4	1.00	MCAL	3	1.10	0.98	7	5.7	0.75	1	2	95	35	1.9	4	0.072	0.234	1.000	0.31	Yes	No	ML			23	Yes	No	0.31	-
4	8	1	ML	116	909	909	909	1.5	1.2	M	4	1.00	S	1	1.10	1.00	7	4.3	0.80	1	1		35	2.4	3	0.061	0.230	1.000	0.26	Yes	No	ML				Yes	No	0.26	-
5	10	1	ML	116	1143	1143	1121	1.2	1.2	M	4	1.00	MCAL	1	1.10	0.99	7	4.9	0.83	1	1	98	35	2.8	3	0.056	0.227	1.000	0.25	Yes	Yes	ML			22	Yes	Yes	0.25	Liquefiable
6	12	1	ML	116	1372	1372	1298	1.2	1.2	M	4	1.00	S	1	1.10	1.00	7	5.5	0.85	1	1		35	2.8	3	0.056	0.223	1.000	0.25	Yes	Yes	ML				Yes	Yes	0.25	Liquefiable
7	14	1	ML	117	1640	1734	1447	1.1	1.2	M	4	1.00	MCAL	1	1.10	0.99	7	6.2	0.91	1	1	99	35	3.3	3	0.052	0.215	1.000	0.24	Yes	Yes	ML			24	Yes	Yes	0.24	Liquefiable
8	16	1	ML	117	2074	1943	1596	1.0	1.2	M	4	1.00	S	1	1.10	1.00	7	7.3	0.92	1	1		35	2.7	3	0.052	0.212	1.000	0.24	Yes	Yes	ML				Yes	Yes	0.24	Liquefiable
9	20	1	ML	116	2306	1960	1663	1.0	1.2	M	4	1.00	MCAL	1	1.10	0.99	7	7.5	0.94	1	1	84	35	3.3	3	0.052	0.206	1.000	0.24	Yes	Yes	ML			27	Yes	Yes	0.24	Liquefiable
10	22	1	SM	117	2540	2060	1772	1.0	1.2	M	4	1.00	MCAL	1	1.10	0.98	7	8.5	0.96	1	1	38	35	3.1	4	0.049	0.199	1.000	0.24	Yes	Yes	SM			38	Yes	Yes	0.24	Liquefiable
11	25	1	ML	117	2891	2203	1936	0.9	1.2	M	4	1.00	S	1	1.10	1.00	7	9.4	0.98	1	1		35	2.8	3	0.048	0.195	1.000	0.25	Yes	Yes	ML				Yes	Yes	0.25	Liquefiable
12	28	11	SM	122	3257	2462	2115	0.8	1.2	M	4	1.00	SCAL	10	1.13	0.89	7	10.4	0.97	10	9	25	25	1.3	11	0.088	0.180	0.999	0.47	Yes	Yes	SM			25	Yes	Yes	0.47	Liquefiable
13	31	10	SM	122	3633	2681	2294	0.8	1.2	M	4	1.00	S	9	1.11	1.00	7	11.3	0.98	11	10		12	1.1	11	0.095	0.180	0.997	0.47	Yes	Yes	SM				Yes	Yes	0.47	Liquefiable
14	35	39	SP-SM	130	4143	2851	2544	0.8	1.2	M	4	1.00	MCAL	24	1.00	0.69	7	12.5	0.99	27	22	8	8	1.0	23	0.209	0.170	0.528	1.23	No	Yes	SP-SM				Yes	No	1.23	-
15	40	15	SP	130	4750	3189	2982	0.8	1.2	M	4	1.00	S	12	1.15	1.00	7	14.9	0.99	17	14		5	1.0	14	0.101	0.167	0.896	0.65	Yes	Yes	SP				Yes	Yes	0.65	Liquefiable
16	45	21	SP-SM	130	5443	3527	3349	0.8	1.2	M	4	1.00	MCAL	16	1.21	0.90	7	16.3	0.99	19	15	7	7	1.1	15	0.107	0.147	0.744	0.73	Yes	Yes	SP-SM				Yes	Yes	0.73	Liquefiable
17	50	14	SP-SM	130	6030	3866	3578	0.7	1.2	M	4	1.00	S	19	1.13	1.00	7	17.1	1.00	16	12		8	1.1	12	0.093	0.136	0.961	0.60	Yes	Yes	SP-SM				Yes	Yes	0.60	Liquefiable

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1314-1340. and Discussions*
2. URS Corporation 2008. *Guidance Document for Geotechnical Analysis, Urban Lenses Geotechnical Evaluations Program Rev. 0, March 2008.*
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.B. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999).* (used only for guidance on M

PROJECT NAME:	Aberdeen Road Concept Feasibility Study
LEVEE SEGMENT:	Sacramento River East Levee South of Arboga Road
PROJECT NUMBER:	26837/06.0A02
Reaches:	
Station:	DWR Station: 1393+65
Boring ID	B3-FS-1
Boring Location (Email Jennifer.Hitchcock, Jennifer.Hitchcock@urs.com)	Cross Sloughs
Ground Elevation (ft.)=	24.0
Groundwater Elev. During Drilling (ft.) =	4.0
Analyzed Groundwater Elevation (ft.)=	11.0

Note: Per GW measurement, Assume Typical Summer Water (GSE-8 (NAVD88))

Analysis By: Steven Orgill
Check By:

Date: 9/9/2008
Date:

Data Input By: Amber Reuters or Antonio Valera

Groundwater Depth Below GS During Drilling (ft.) = 28.0
Analyzed Groundwater Depth Below GS (ft.) = 24.0

Hammer Type = Automatic
Energy Ratio = 76 Assumed

Earthquake Information
Return Period (years) = 200
M_w = 6.0

PGA (g) = 0.19
Location = Chart From: Cram, Londrella, or Wentville

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SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al., 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering*, ASCE, Vol. 130, No. 12, 1273-1345, and Discussions
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2008.
3. Seed, R.B., et al. 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.G. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on R

PROJECT NAME	American River Common Features (SRR Project)
LEVEE SEGMENT	Sacramento River East Levee (SAFCA/American River
PROJECT No./JOB No.	29876/Task 45430
Reach ID	
Station	Right Station: 1+00+00
Boring ID	SS-42-1
Boring Location (Use Coord. Info/Methods, and Datum) (Use Coord. Info/Methods, and Datum)	Cmd Boring

Analyst's By	Steven Gratt
Check By	

Date	9/23/2009
Date	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)=	35.0
Groundwater Elev. During Drilling (ft.)=	7.5
Analyzed Groundwater Elevation (ft.)=	7.5

Note: Rotary Wash Drilling; Sonoma Typical Summer
Note: Summer water in riverchannel

Groundwater Depth Below GS During Drilling (ft.) = 27.5
Analyzed Groundwater Depth Below GS (ft.) = 28.5

Hammer Type = Automatic
Energy Ratio = 1.0 Adjusted

Earthquake Information:
Return Period (years) = 200
M_w = 7.0
PGA (g) = 0.15
Location = Cmd (Cmd, Sheet, Lat/Deg, Lt/Min/Sec)

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URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE 1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340, and Discussions*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2008.
3. Boulanger, R.W., et al, 2007, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, M.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on M

PROJECT NAME:	American River Common Features 2008 Project
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	26991782.06400
Sheet ID:	
Station:	Depth Station: 1551+00
Boring ID:	SP-08-05-ZA
Boring Location (River Centerline Reference and Distance from Centerline)	Toe (Boring) – 1 Ref from Landside Toe

Analyst By:	Shawn Dyer
Check By:	

Date:	9/25/2009
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 23.5
Groundwater Elev. During Drilling (ft.)= 7.5
Analyzed Groundwater Elevation (ft.)= 7.5

Note: Depth during drilling
Note: Saturday WSE (5 hours/gw)

Groundwater Depth Below GS During Drilling (ft.) = 16.0
Analyzed Groundwater Depth Below GS (ft.) = 16.0

Hammer Type = Automatic
Energy Ratio = 77 Classified

Earthquake Information
Return Period (years) = 200
ML = 6.0

PGA (g) = 0.16
Location = Landside (Enter Cell Location, or Proximity)

Sample ID	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S: std, SCAL: SCAL)	H_s for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S, for SW Sampler Only	Sampler Correction for Analysis, C_S	Back-Up (Protrusion) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, $C_{N_{FC}}$	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, +1.2 (Studies) Uncerta Adj	Ratio= Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AH	First Assessment (Yes/No) Based on Column AE, AF, and AG	Factor of Safety, FS	Comment (Liquefiable for FS, +1 and Judgment Required for 1.0 <FS, < 1.3)
S1	0.5	12	ML	120	60	60	60	1.6	1.3	H	8	1.15	S	15	1.20	1.00	7	2.0	0.75	13	21		35	1.2	26	0.710	0.244	0.000	2.90	No	No	ML				Yes	No	2.90	-
S2	2.5	16	ML	120	300	300	300	1.4	1.3	H	8	1.15	S	24	1.00	1.00	7	2.5	0.75	18	28		35	1.2	34	0.935	0.242	0.000	3.99	No	No	ML				Yes	No	3.99	-
S3	4.5	9	ML	120	540	540	540	1.6	1.3	H	8	1.15	S	34	1.00	1.00	7	3.0	0.75	10	16	58	35	1.2	20	0.247	0.237	0.109	1.84	Yes	No	ML				Yes	No	1.84	-
S4	6.5	8	ML/CL	120	780	780	780	1.6	1.3	H	8	1.15	S	13	1.15	1.20	7	3.8	0.76	9	14		9	1.9	15	0.154	0.233	0.847	0.65	Yes	No	ML/CL				Yes	No	0.65	-
S5	8.5	6	ML	120	1020	1020	1020	1.4	1.3	H	8	1.15	S	8	1.11	1.20	7	4.4	0.81	7	10		35	1.2	13	0.124	0.228	0.977	0.54	Yes	No	ML				Yes	No	0.54	-
S6	10.5	4	ML	120	1260	1260	1260	1.2	1.3	H	8	1.15	S	5	1.10	1.20	7	5.0	0.84	5	5		35	1.4	9	0.094	0.226	1.000	0.38	Yes	No	ML				Yes	No	0.38	-
S7	12.5	5	SM	130	1630	1630	1630	1.2	1.3	H	8	1.15	S	6	1.10	1.20	7	5.5	0.87	6	6		35	1.4	11	0.092	0.222	0.999	0.43	Yes	No	SM				Yes	No	0.43	-
S8	14.5	2	ML	120	1740	1740	1740	1.2	1.3	H	8	1.15	S	2	1.10	1.20	7	6.2	0.89	3	3		35	1.7	5	0.059	0.213	1.000	0.27	Yes	No	ML				Yes	No	0.27	-
S9	16.5	2	SM	130	2020	1614	2000	1.1	1.3	H	8	1.15	S	2	1.10	1.20	7	6.8	0.91	3	3	37	35	1.7	5	0.057	0.205	1.000	0.27	Yes	Yes	SM				Yes	YES	0.27	Liquefiable
S10	18.5	2	SM	130	2280	1760	2143	1.1	1.3	H	8	1.15	S	2	1.10	1.20	7	7.5	0.93	3	3		35	1.5	4	0.053	0.211	1.000	0.25	Yes	Yes	SM				Yes	YES	0.25	Liquefiable
S11	20.5	6	SM	130	2540	1885	2278	1.0	1.3	H	8	1.15	S	6	1.10	1.20	7	8.1	0.94	5	5		25	1.2	11	0.083	0.207	0.999	0.40	Yes	Yes	SM				Yes	YES	0.40	Liquefiable
S12	22.5	6	SM	130	2800	2020	2413	1.0	1.3	H	8	1.15	S	6	1.10	1.20	7	8.7	0.95	5	5	28	34	1.2	10	0.078	0.202	1.000	0.39	Yes	Yes	SM				Yes	YES	0.39	Liquefiable
S13	24.5	6	SM	130	3060	2155	2549	1.0	1.3	H	8	1.15	S	6	1.10	1.20	7	9.3	0.96	7	7		24	1.3	9	0.069	0.197	1.000	0.35	Yes	Yes	SM				Yes	YES	0.35	Liquefiable
S14	26.5	4	SM	130	3320	2290	2684	0.9	1.3	H	8	1.15	S	4	1.10	1.20	7	9.9	0.97	6	5		20	1.3	7	0.059	0.192	1.000	0.31	Yes	Yes	SM				Yes	YES	0.31	Liquefiable
S15	28.5	2	SP-SM	130	3580	2425	2819	0.9	1.3	H	8	1.15	S	2	1.10	1.20	7	10.5	0.97	3	3		8	1.2	3	0.044	0.186	1.000	0.24	Yes	Yes	SP-SM				Yes	YES	0.24	Liquefiable
S16	30.5	1	SM	130	3840	2561	2954	0.9	1.3	H	8	1.15	S	1	1.10	1.20	7	11.1	0.98	1	1		20	1.9	2	0.041	0.181	1.000	0.23	Yes	Yes	SM				Yes	YES	0.23	Liquefiable
S17	32.5	2	SP-SM	130	4100	2696	3089	0.9	1.3	H	8	1.15	S	2	1.10	1.20	7	11.7	0.98	3	2		9	1.2	3	0.043	0.176	1.000	0.24	Yes	Yes	SP-SM				Yes	YES	0.24	Liquefiable
S18	34.5	3	SP-SM	130	4360	2831	3224	0.8	1.3	H	8	1.15	S	3	1.10	1.20	7	12.3	0.98	4	4		9	1.1	4	0.046	0.171	1.000	0.27	Yes	Yes	SP-SM				Yes	YES	0.27	Liquefiable
S19	36.5	4	SM	130	4620	2966	3360	0.8	1.3	H	8	1.15	S	3	1.10	1.20	7	13.0	0.99	5	5		35	1.5	7	0.057	0.166	1.000	0.34	Yes	Yes	SM				Yes	YES	0.34	Liquefiable
S20	38.5	9	SM	130	4880	3102	3495	0.8	1.3	H	8	1.15	S	7	1.12	1.20	7	13.6	0.99	13	11	66	35	1.3	14	0.093	0.160	0.934	0.58	Yes	Yes	SM				Yes	YES	0.58	Liquefiable
S21	40.5	12	SM	120	5140	3237	3630	0.8	1.3	H	8	1.15	S	8	1.16	1.20	7	14.2	0.99	16	14		35	1.3	17	0.121	0.156	0.513	0.76	Yes	Yes	SM				Yes	YES	0.76	Liquefiable
S22	42.5	9	SM	130	5400	3373	3765	0.8	1.3	H	8	1.15	S	7	1.11	1.20	7	14.9	0.99	13	10		35	1.3	13	0.095	0.152	0.838	0.59	Yes	Yes	SM				Yes	YES	0.59	Liquefiable
S23	44.5	11	SP-SM	130	5660	3507	3900	0.8	1.3	H	8	1.15	S	9	1.13	1.20	7	15.4	0.99	16	12		8	1.1	10	0.085	0.149	0.944	0.57	Yes	Yes	SP-SM				Yes	YES	0.57	Liquefiable
S24	47.5	11	ML	120	6020	3680	4073	0.7	1.3	H	8	1.15	S	8	1.13	1.20	7	16.3	1.00	16	12		35	1.3	15	0.100	0.143	0.729	0.70	Yes	Yes	ML				Yes	YES	0.70	Liquefiable
S25	50.5	11	ML	120	6380	3853	4246	0.7	1.3	H	8	1.15	S	8	1.13	1.20	7	17.2	1.00	16	12	71	35	1.3	15	0.094	0.137	0.717	0.70	Yes	Yes	ML				Yes	YES	0.70	Liquefiable
S26	53.5	15	SM	130	6770	4056	4449	0.7	1.3	H	8	1.15	S	7	1.11	1.20	7	18.1	1.00	15	10		12	1.3	11	0.073	0.132	0.862	0.55	Yes	Yes	SM				Yes	YES	0.55	Liquefiable
S27	56.5	34	SP-SM	130	7180	4259	4652	0.7	1.3	H	8	1.15	S	16	1.29	1.00	7	19.1	1.00	35	24		8	1.0	25	0.205	0.126	0.000	1.63	No	Yes	SP-SM				Yes	No	1.63	-
S28	59.5	15	SM	130	7590	4461	4854	0.7	1.3	H	8	1.15	S	12	1.20	1.00	7	20.0	1.00	27	18		20	1.3	23	0.137	0.121	0.033	1.13	Yes	Yes	SM				Yes	YES	1.13	Judgment Required
S29	62.5	13	SM	130	7940	4664	5057	0.7	1.3	H	8	1.15	S	9	1.14	1.20	7	20.9	1.00	19	13		35	1.3	16	0.093	0.119	0.396	0.84	Yes	Yes	SM				Yes	YES	0.84	Liquefiable
S30	65.5	15	SM	130	8330	4867	5260	0.6	1.3	H	8	1.15	S	10	1.16	1.20	7	21.9	1.00	22	14		20	1.3	18	0.100	0.117	0.354	0.96	Yes	Yes	SM				Yes	YES	0.96	Liquefiable
S31	68.5	16	SW-SM	130	8720	5070	5463	0.6	1.3	H	8	1.15	S	11	1.17	1.20	7	22.7	1.00	24	15		8	1.0	40	1.094	0.115	0.000	3.00	No	Yes	SW-SM				Yes	No	3.00	-
S32	71.5	35	SM	130	9110	5277	5666	0.5	1.3	H	8	1.15	SCAL	22	1.30	0.89	7	23.5	1.00	41	25		20	1.1	28	0.244	0.113	0.003	2.15	No	Yes	SM				Yes	No	2.15	-
S33	74.5	50	GW	140	9530	5585	5999	0.5	1.3	H	8	1.15	SCAL	32	1.30	0.89	7	24.5	1.00	59	36		5	1.0	37	0.442	0.112	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
S34	77.5	68	GW	140	9950	5736	6131	0.5	1.3	H	8	1.15	SCAL	39	1.30	0.89	7	25.5	1.00	80	46		5	1.0	50	0.613	0.110	0.000	3.00	No	Yes	GW				Yes	No	3.00	-
S35	80.5	50	GW	140	10370	5977	6364	0.5	1.3	H	8	1.15	SCAL	29	1.30	0.89	7	26.4	1.00	59	34		5	1.0	35	0.389	0.109	0.000	2.89	No	Yes	GW				Yes	No	2.89	-
S36	83.5	59	SP-SM	130	10785	6174	6567	0.5	1.3	H	8	1.15	SCAL	28	1.30	0.89	7	27.3	1.00	69	36		8	1.0	35	0.364	0.105	0.000	3.00	No	Yes	SP-SM				Yes	No	3.00	-
S37	86.5	99	SP-SM	130	11199	6376	6770	0.5	1.3	H	8	1.15	SCAL	55	1.30	0.89	7	28.2	1.00	117	65		9	1.0	60	1.436	0.107	0.000	3.00	No	Yes	SP-SM				Yes	No	3.00	-
S38	89.5	69	GW	140	11579	6609	7003	0.5	1.3	H	8	1.15	SCAL	39	1.30	0.89	7	29.1	1.00	69	32		5	1.0	33	0.332	0.104	0.000	3.00	No	Yes	GW				Yes	No	3.00	-

Liq. Test Results for CL, ML

Post-Liquefaction Assessment

T:\Projects\Levee Eval\Shawn Dyer\Reference\SPT_Excel Liquefaction_SDR\[SDR 08-05-ZA Liquefaction]
11/3/2009

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SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340, and Discussions*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Union Levee Geotechnical Evaluations Program Rev 0, March 2008,
3. Seed, R.B., et al, 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.B. Queens Mary, Long Beach, Ca ,
4. Southern California Earthquake Center, *University of Southern California, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on R

PROJECT NAME:	American River Common Features GRR Project
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	60216782.6400
Event ID:	1
Station:	Clark Station: 1343+00
Boring ID:	SP-05-09-24
Boring Location (Enter Levee Station/Offset, and Distance from Levee Centerline and Waterside Toe)	Toe Boring – 5 feet from Landside Toe
Ground Elevation (ft.)=	25.0
Groundwater Elev. During Drilling (ft.)=	13.0
Analyzed Groundwater Elevation (ft.)=	11.0

Analysis By: Steven Orgill
Check By:

Date: 8/25/2008
Date:

Data Used By Shaw:
Results of Analysis
Calculated Values

Note: Depth during drilling
Note: Winter GWE 6 (NAVD88)

Groundwater Depth Below GS During Drilling (ft.) = 10.0
Analyzed Groundwater Depth Below GS (ft.) = 11.7

Hammer Type = Automatic
Energy Ratio = 77 Automatic

Earthquake Information:
Return Period (years) = 200
M_w = 6.5

PGA (g) = 0.15
Location = Eastern Sacramento Valley, Sand Transition, or Waterside

Sample ID	Depth to Sample (ft.)	$N_{m,c}$	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ'_v (psf)	Effective Overburden Pressure During Earthquake, σ'_v (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S-SS; R-RC; SCAL-SCAL)	H_s for Sampler Correction Only (for SM Sampler)	Sampler Correction, C_S, for SM Sampler Only	Sampler Correction for Analysis, C_S	Rod Stick Up (Penetrated) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	M_{cor}	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, $C_{N_{cor}}$	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Seismic Guidance Document, CSR	Thin Probability of Liquefaction, P_L	Factor of Safety, FS	FS, = 1.3 (Yes/No) Seismic ME	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AT	Final Assessment (Yes/No) Based on Column AU, and AV	Factor of Safety, FS_L	Comment (Liquefiable for FS, =1 and Judgment Required for 1.1< FS_L < 1.3)
S1	0.5	12	ML	120	60	60	60	1.4	1.3	H	8	1.15	S	13	1.20	1.20	7	2.0	0.75	13	21		35	1.2	26	0.715	0.244	0.000	2.93	No	No	ML					Yes	No	2.93	-
S2	2.5	16	ML	120	300	300	300	1.6	1.3	H	8	1.15	S	24	1.20	1.20	7	3.5	0.75	19	28		35	1.2	34	0.635	0.242	0.000	2.60	No	No	ML					Yes	No	2.60	-
S3	4.5	9	ML	120	540	540	540	1.5	1.3	H	8	1.15	S	14	1.19	1.20	7	5.2	0.75	10	16	58	25	1.2	20	0.347	0.237	0.108	1.84	Yes	No	ML					Yes	No	1.84	-
S4	6.5	8	ML/CL	120	780	780	780	1.4	1.3	H	8	1.15	S	13	1.16	1.20	7	6.8	0.75	9	14		9	1.0	15	0.154	0.233	0.847	0.66	Yes	No	ML/CL					Yes	No	0.66	-
S5	8.5	6	ML	120	1020	1020	1020	1.4	1.3	H	8	1.15	S	9	1.11	1.20	7	4.4	0.91	7	10		35	1.3	13	0.124	0.229	0.977	0.54	Yes	No	ML					Yes	No	0.54	-
S6	10.5	4	ML	120	1260	1229	1260	1.3	1.3	H	8	1.15	S	5	1.10	1.20	7	5.6	0.94	5	8		35	1.4	9	0.086	0.226	1.000	0.38	Yes	No	ML					Yes	No	0.38	-
S7	12.5	6	SM	130	1630	1464	1630	1.2	1.3	H	8	1.15	S	8	1.10	1.20	7	6.5	0.87	6	9		35	1.4	11	0.091	0.222	0.999	0.42	Yes	Yes	SM					Yes	Yes	0.42	Liquefiable
S8	14.5	2	ML	120	1740	1478	1589	1.3	1.3	H	8	1.15	S	2	1.10	1.20	7	6.2	0.89	3	3		35	1.7	5	0.061	0.219	1.000	0.28	Yes	Yes	ML					Yes	YES	0.28	Liquefiable
S9	16.3	2	SM	130	2020	1614	1739	1.1	1.3	H	8	1.15	S	2	1.10	1.20	7	6.9	0.91	3	3	37	35	1.7	5	0.065	0.216	1.000	0.27	Yes	Yes	SM					Yes	YES	0.27	Liquefiable
S10	14.5	2	SM	130	2210	1760	1956	1.1	1.3	H	8	1.15	S	2	1.10	1.20	7	7.5	0.93	3	3		35	1.5	4	0.055	0.211	1.000	0.26	Yes	Yes	SM					Yes	YES	0.26	Liquefiable
S11	20.5	6	SM	130	2540	1985	1991	1.0	1.3	H	8	1.15	S	6	1.10	1.20	7	8.1	0.84	8	9		25	1.2	11	0.088	0.207	0.999	0.42	Yes	Yes	SM					Yes	YES	0.42	Liquefiable
S12	22.5	8	SM	130	2930	2220	2126	1.0	1.3	H	8	1.15	S	8	1.10	1.20	7	8.7	0.86	8	9	26	24	1.2	10	0.082	0.202	1.000	0.41	Yes	Yes	SM					Yes	YES	0.41	Liquefiable
S13	24.5	5	SM	130	3060	2155	2261	1.0	1.3	H	8	1.15	S	5	1.10	1.20	7	9.3	0.96	7	7		24	1.2	9	0.071	0.197	1.000	0.36	Yes	Yes	SM					Yes	YES	0.36	Liquefiable
S14	26.5	4	SM	130	3220	2290	2396	0.9	1.3	H	8	1.15	S	4	1.10	1.20	7	9.5	0.97	6	5		20	1.3	7	0.051	0.192	1.000	0.32	Yes	Yes	SM					Yes	YES	0.32	Liquefiable
S15	28.5	2	SP-SM	130	3580	2535	2532	0.9	1.3	H	8	1.15	S	2	1.10	1.20	7	10.5	0.97	3	3		8	1.2	3	0.045	0.186	1.000	0.24	Yes	Yes	SP-SM					Yes	YES	0.24	Liquefiable
S16	30.5	1	SM	130	3940	2561	2667	0.9	1.3	H	8	1.15	S	1	1.10	1.20	7	11.3	0.98	3	3		20	1.9	2	0.042	0.181	1.000	0.23	Yes	Yes	SM					Yes	YES	0.23	Liquefiable
S17	32.5	2	SP-SM	130	4160	2695	2802	0.9	1.3	H	8	1.15	S	2	1.10	1.20	7	11.7	0.98	3	3		8	1.2	3	0.044	0.176	1.000	0.25	Yes	Yes	SP-SM					Yes	YES	0.25	Liquefiable
S18	34.5	3	SP-SM	130	4340	2831	2937	0.9	1.3	H	8	1.15	S	3	1.10	1.20	7	12.2	0.98	4	4		8	1.1	4	0.047	0.171	1.000	0.28	Yes	Yes	SP-SM					Yes	YES	0.28	Liquefiable
S19	36.5	4	SM	130	4520	2965	3072	0.9	1.3	H	8	1.15	S	3	1.10	1.20	7	13.0	0.99	5	5		35	1.5	7	0.066	0.166	1.000	0.36	Yes	Yes	SM					Yes	YES	0.36	Liquefiable
S20	38.5	9	SM	130	4680	3102	3208	0.9	1.3	H	8	1.15	S	7	1.12	1.20	7	13.6	0.99	10	11	46	35	1.3	14	0.095	0.160	0.994	0.59	Yes	Yes	SM					Yes	YES	0.59	Liquefiable
S21	40.5	12	SM	130	5140	3237	3343	0.8	1.3	H	8	1.15	S	9	1.16	1.20	7	14.2	0.99	16	14		35	1.3	11	0.124	0.156	0.513	0.80	Yes	Yes	SM					Yes	YES	0.80	Liquefiable
S22	42.5	9	SM	130	5400	3373	3478	0.8	1.3	H	8	1.15	S	7	1.11	1.20	7	14.9	0.99	13	10		35	1.3	13	0.096	0.152	0.838	0.59	Yes	Yes	SM					Yes	YES	0.59	Liquefiable
S23	44.5	11	SP-SM	130	5660	3507	3613	0.8	1.3	H	8	1.15	S	9	1.15	1.20	7	15.4	0.99	16	12		9	1.1	10	0.095	0.148	0.544	0.66	Yes	Yes	SP-SM					Yes	YES	0.66	Liquefiable
S24	47.5	13	ML	120	6020	3680	3786	0.7	1.3	H	8	1.15	S	9	1.19	1.20	7	16.3	1.00	16	12		35	1.3	15	0.102	0.143	0.726	0.71	Yes	Yes	ML					Yes	YES	0.71	Liquefiable
S25	48.5	11	ML	120	6260	3853	3959	0.7	1.3	H	8	1.15	S	8	1.19	1.20	7	17.2	1.00	15	12	71	35	1.3	15	0.096	0.137	0.717	0.71	Yes	Yes	ML					Yes	YES	0.71	Liquefiable
S26	50.5	15	SM	130	6770	4056	4162	0.7	1.3	H	8	1.15	S	7	1.11	1.20	7	18.1	1.00	15	10		12	1.3	11	0.074	0.132	0.562	0.56	Yes	Yes	SM					Yes	YES	0.56	Liquefiable
S27	52.5	34	SP-SM	130	7160	4259	4364	0.7	1.3	H	8	1.15	S	18	1.29	1.20	7	19.1	1.00	35	24		8	1.0	25	0.203	0.128	0.000	1.65	No	Yes	SP-SM					Yes	No	1.65	-
S28	54.5	15	SM	130	7550	4461	4567	0.7	1.3	H	8	1.15	S	12	1.20	1.20	7	20.0	1.00	27	18		20	1.3	20	0.130	0.121	0.033	1.15	Yes	Yes	SM					Yes	YES	1.15	Judgment Required
S29	62.5	13	SM	130	7940	4664	4770	0.7	1.3	H	8	1.15	S	9	1.14	1.20	7	20.9	1.00	19	13		35	1.3	16	0.101	0.113	0.356	0.85	Yes	Yes	SM					Yes	YES	0.85	Liquefiable
S30	66.5	15	SM	130	8330	4867	4973	0.6	1.3	H	8	1.15	S	10	1.16	1.20	7	21.9	1.00	22	14		20	1.3	16	0.102	0.117	0.264	0.87	Yes	Yes	SM					Yes	YES	0.87	Liquefiable
S31	68.5	10	SW-SM	130	8720	5070	5176	0.6	1.3	H	8	1.15	S	7	1.11	1.20	7	22.7	1.00	14	9		8	1.3	9	0.061	0.113	0.000	2.00	No	Yes	SW-SM					Yes	No	2.00	-
S32	71.5	16	SM	130	9110	5272	5378	0.6	1.3	H	8	1.15	SCAL	22	1.20	0.93	7	23.8	1.00	41	25		20	1.3	28	0.246	0.113	0.000	2.19	No	Yes	SM					Yes	No	2.19	-
S33	74.5	59	GW	140	9530	5505	5611	0.6	1.3	H	8	1.15	SCAL	38	1.20	0.93	7	24.5	1.00	59	36		5	1.0	57	0.449	0.112	0.000	3.00	No	Yes	GW					Yes	No	3.00	-
S34	77.5	66	GW	140	9950	5736	5844	0.6	1.3	H	8	1.15	SCAL	38	1.20	0.93	7	25.5	1.00	68	36		5	1.0	66	0.415	0.110	0.000	3.00	No	Yes	GW					Yes	No	3.00	-
S35	80.5	58	GW	140	10370	5971	6077	0.6	1.3	H	8	1.15	SCAL	29	1.20	0.99	7	26.4	1.00	53	28		5	1.0	25	0.282	0.108	0.000	3.00	No	Yes	GW					Yes	No	3.00	-
S36	83.5	59	SP-SM	130	10783	6174	6280	0.5	1.3	H	8	1.15	SCAL	29	1.20	0.99	7	27.3	1.00	59	34		8	1.0	25	0.369	0.105	0.000	3.00	No	Yes	SP-SM					Yes	No	3.00	-
S37	86.5	99	SP-SM	130	11199	6376	6982	0.5	1.2	H	8	1.15	SCAL	35	1.20	0.93	7	29.2	1.00	117	65		8	1.0	69	4.562	0.107	0.000	9.56	No	Yes	SP-SM					Yes	No	9.56	-
S38	88.5	59	GW	140	11579	6620	6715	0.5	1.3	H	8	1.15	SCAL	29	1.20	0.99	7	29.1	1.00	59	32		5	1.0	23	0.535	0.104	0.000	3.00	No	Yes	GW					Yes	No	3.00	-

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SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions*
2. URS Corporation 2008. *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev 0, March 2008.
3. Seed, R.B., et al, 2003. *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar: Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California* (1999), (used only for guidance on M

PROJECT NAME:	American River Common Features (ARCF Phase
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	1610-7654.45455
Report ID:	
Station:	RMW Station: 1191+00
Boring ID:	B-RD-2
Boring Location (Enter Coordinates/Stations, and distance from Centerline/Levee/Waterside toe	Landside Field Boring

Analyzed By:	Shawn Orgill
Check By:	

Date:	9/24/2009
Date:	

Data Input By Hand
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 21.5
Groundwater Elev. During Drilling (ft.) = 7.0
Analyzed Groundwater Elevation (ft.)= 7.0

Note: Rotary Wash Drilling, Adjusted Transit Borehole Elevation WGS 84 (NAVD88)
Note:

Groundwater Depth Below GS During Drilling (ft.) = 14.5
Analyzed Groundwater Depth Below GS (ft.) = 14.5

Hammer Type = Automatic
Energy Ratio = 72 Assumed

Earthquake Information
Return Period (years) = 475
M_w = 6.6

PGA (g) = 0.19
Location = Lat/Lon

Enter, Check, Landcalc, or Worksheet

Sample ID	Depth to Sample (ft)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ'_o (psf)	Effective Overburden Pressure During Earthquake, σ'_o (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, or C, SOIL, MCAL)	R_L for Sampler Correction Only (for SW sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Pressured) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	R_{fc}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1(60)cs}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, FS_L	$FS_L < 1.2$ (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AI	Final Assessment (Yes/No) Based on Columns AE, AF, and AH	Factor of Safety, FS_L	Comment (Liquefiable for FS_L < and Judgment Required for 1.0 <FS_L < 1.2)
1	2	4	ML	111	222	222	222	1.5	1.2	M	4	1.00	MCAL	0	1.10	0.99	7	2.4	0.75	3	6	83	35	1.0	7	0.116	0.241	0.993	0.49	Yes	No	ML			22	Yes	No	0.49	-
2	4	3	ML	111	444	444	444	1.5	1.2	M	4	1.00	S	0	1.10	1.00	7	3.6	0.75	3	4		35	1.6	7	0.095	0.236	1.000	0.40	Yes	No	ML				Yes	No	0.56	-
3	6	2	ML	116	676	676	676	1.5	1.2	M	4	1.00	MCAL	3	1.10	0.99	7	5.7	0.75	1	2	93	35	1.9	4	0.072	0.234	1.000	0.31	Yes	No	ML			23	Yes	No	0.31	-
4	9	1	ML	116	999	906	906	1.5	1.2	M	4	1.00	S	1	1.10	1.00	7	4.2	0.80	1	1		35	2.4	3	0.061	0.230	1.000	0.26	Yes	No	ML				Yes	No	0.26	-
5	10	1	ML	116	1160	1160	1160	1.2	1.2	M	4	1.00	MCAL	1	1.10	0.99	7	4.9	0.83	1	1	58	35	2.8	3	0.058	0.227	1.000	0.25	Yes	No	ML			22	Yes	No	0.23	-
6	12	1	ML	116	1272	1272	1272	1.2	1.2	M	4	1.00	S	1	1.10	1.00	7	5.5	0.86	1	1		35	2.6	3	0.054	0.223	1.000	0.24	Yes	No	ML				Yes	No	0.24	-
7	15	1	ML	117	1640	1734	1734	1.1	1.2	M	4	1.00	SMCAL	1	1.10	0.99	7	6.7	0.91	1	1	59	35	3.1	3	0.045	0.216	1.000	0.23	Yes	Yes	ML			34	Yes	YES	0.45	Liquefiable
8	19	1	ML	117	2074	1943	1943	1.0	1.2	M	4	1.00	S	1	1.10	1.00	7	7.3	0.92	1	1		35	2.7	3	0.043	0.213	1.000	0.23	Yes	Yes	ML				Yes	YES	0.23	Liquefiable
9	20	1	ML	116	2366	1959	1959	1.0	1.2	M	4	1.00	MCAL	1	1.10	0.99	7	7.5	0.94	1	1	84	35	3.1	3	0.048	0.209	1.000	0.23	Yes	Yes	ML			37	Yes	YES	0.23	Liquefiable
10	22	1	SM	117	2640	2560	2560	1.0	1.2	M	4	1.00	MCAL	1	1.10	0.98	7	8.6	0.95	1	1	36	36	3.1	3	0.047	0.203	1.000	0.23	Yes	Yes	SM			36	Yes	YES	0.23	Liquefiable
11	25	1	ML	117	2931	2225	2225	0.9	1.2	M	4	1.00	S	1	1.10	1.00	7	9.4	0.96	1	1		35	2.6	3	0.047	0.195	1.000	0.24	Yes	Yes	ML				Yes	YES	0.24	Liquefiable
12	28	11	SM	122	3357	2492	2492	0.8	1.2	M	4	1.00	SMCAL	10	1.13	0.89	7	10.4	0.97	10	9	25	25	1.2	11	0.085	0.186	0.998	0.45	Yes	Yes	SM			25	Yes	YES	0.45	Liquefiable
13	31	10	SM	122	3623	2581	2581	0.8	1.2	M	4	1.00	S	9	1.11	1.00	7	11.2	0.98	11	10		12	1.3	11	0.083	0.180	0.997	0.46	Yes	Yes	SM				Yes	YES	0.46	Liquefiable
14	35	26	SP-SM	130	4143	2851	2851	0.8	1.2	M	4	1.00	MCAL	24	1.30	0.99	7	12.3	0.99	27	22	9	8	1.9	23	0.233	0.170	0.529	1.26	Yes	Yes	SP-SM				Yes	YES	1.26	Judgment Required
15	40	15	SP	130	4790	3189	3189	0.8	1.2	M	4	1.00	S	12	1.16	1.00	7	14.0	0.99	17	14		5	1.0	14	0.096	0.157	0.894	0.63	Yes	Yes	SP				Yes	YES	0.63	Liquefiable
16	45	21	SP-SM	130	5445	3527	3527	0.8	1.2	M	4	1.00	MCAL	16	1.21	0.99	7	15.5	0.99	19	15	7	7	1.1	15	0.105	0.147	0.744	0.71	Yes	Yes	SP-SM				Yes	YES	0.71	Liquefiable
17	50	14	SP-SM	130	6030	3860	3860	0.7	1.2	M	4	1.00	S	10	1.18	1.00	7	17.1	1.00	16	12		9	1.3	12	0.092	0.136	0.561	0.69	Yes	Yes	SP-SM				Yes	YES	0.69	Liquefiable

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SPT BASED LIQUEFACTION ANALYSIS

REFERENCE 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1213-1240, and Discussions*

2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev. 0, March 2008.

3. Seed, R.B., et. al, 2003, *Recent Advances in Soil Liquefaction Engineering : A Unified and Consistent Framework*, 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, M.M.S. Queens Mary, Long Beach, Ca .

4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction* in California (1999), (used only for guidance on M

PROJECT NAME:	Sevenmile River Corridor Features (SRK Project)
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	18481782.68400
Reach ID:	
Station:	Station: 1514+00
Boring ID:	R-06-09-SA
Boring Location (Enter Levee Centerline and distance from Levee Centerline on Waterside toe)	Toe Boring – 5 feet from Landside Toe

Analyzed By:	Shawn Dodt
Check By:	

Date:	3/26/2009
Date:	

Data Input By Hand
Results of Analysis
Calculated Values

Ground Elevation (ft.)=	15.5
Groundwater Elev. During Drilling (ft.) =	12.5
Analyzed Groundwater Elevation (ft.)=	N.A.

Note: Depth during drilling
Note: Summer WSE 5 (NAVD88)

Groundwater Depth Below GS During Drilling (ft.) = 2.9
Analyzed Groundwater Depth Below GS (ft.) = 12.9

Hammer Type = Automatic
Energy Ratio = 77 Assumed

Earthquake Information:
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.25
Location = Sacramento *(Enter Citrus Heights, CA or Willowside)*

Remarks	Depth to Sample (ft.)	N_{blows}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (Inch)	Correction for Borehole Diameter, C_B	Sampler Code (1.00 FOR STANDARD)	H_s for Sampler Correction Only (for SW Sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick up (Pushcase), Rod Length Above Ground (feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	N_{60}	$N_{1(60)}$	Fines Content for Analysis (%)	Fines Content for Fine Content, C_{fines}	Correction Factor for Fine Content, C_{fines}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	Pre Probability of Liquefaction, PL	Factor of Safety, FS	FS, < 1.2 (Yes/No) Column AE	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (w%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AI	Fines Adjustments (Yes/No) Based on Idriss/Boulanger Method	Factor of Safety, FS	Comment (Liquefiable for FS, <1 and Judgment Required for 1.0 <FS, < 1.3)
S1	1.5	4	CL	110	165	165	165	1.4	1.2	H	8	1.15	5	6	1.10	1.20	7	2.3	0.75	4	7		35	1.4	10	0.161	0.242	0.839	0.67	Yes	No	CL				No	No	0.67	-
S2	3.5	5	CL	110	385	385	385	1.6	1.2	H	8	1.15	5	6	1.10	1.20	7	4.8	0.75	4	9		35	1.2	12	0.161	0.230	0.907	0.70	Yes	No	CL				No	No	0.70	-
S3	5.5	3	CL	110	605	605	605	1.5	1.2	H	8	1.15	5	6	1.10	1.20	7	6.5	0.75	3	5	69	35	1.5	9	0.096	0.205	1.000	0.41	Yes	No	CL	38	13		No	No	0.41	-
S4	7.5	2	CL	110	825	825	825	1.6	1.2	H	8	1.15	5	6	1.10	1.20	7	8.1	0.79	2	4		35	1.6	6	0.076	0.231	1.000	0.31	Yes	No	CL				No	No	0.31	-
S5	9.5	12	ML	120	1205	1204	1205	1.4	1.2	H	8	1.15	5	17	1.24	1.20	7	9.7	0.82	15	20		35	1.2	25	0.236	0.220	0.000	1.20	No	No	ML				Yes	No	1.20	-
S6	11.5	3	ML	120	1565	1149	1565	1.3	1.2	H	8	1.15	5	4	1.10	1.20	7	11.3	0.85	4	5		35	1.3	7	0.076	0.224	1.000	0.34	Yes	No	ML				Yes	No	0.34	-
S7	13.5	2	SM	130	1955	1298	1527	1.2	1.2	H	8	1.15	5	2	1.10	1.20	7	13.0	0.88	2	3	43	35	1.7	5	0.062	0.200	1.000	0.28	Yes	Yes	SM				Yes	YES	0.28	Liquefiable
S8	15.5	1	SM	130	1820	1418	1962	1.2	1.2	H	8	1.15	5	1	1.10	1.20	7	14.6	0.90	1	2		35	2.2	4	0.051	0.217	1.000	0.24	Yes	Yes	SM				Yes	YES	0.24	Liquefiable
S9	17.5	4	SM	130	2535	1655	1797	1.1	1.2	H	8	1.15	5	5	1.10	1.20	7	16.2	0.93	5	6		30	1.4	9	0.074	0.213	1.000	0.25	Yes	Yes	SM				Yes	YES	0.25	Liquefiable
S10	19.5	6	SM	130	3045	1892	1953	1.1	1.2	H	8	1.15	5	7	1.10	1.20	7	17.8	0.93	6	9		30	1.3	12	0.095	0.210	0.998	0.44	Yes	Yes	SM				Yes	YES	0.44	Liquefiable
S11	21.5	4	CL-ML	110	3585	1765	2026	1.1	1.3	H	8	1.15	5	4	1.10	1.20	7	19.4	0.95	5	6	66	35	1.4	8	0.072	0.205	1.000	0.35	Yes	Yes	CL-ML	26	5		Yes	YES	0.35	Liquefiable
S12	23.5	3	CL-ML	110	3795	1880	2123	1.0	1.3	H	8	1.15	5	3	1.10	1.20	7	20.9	0.96	4	4		35	1.5	7	0.063	0.198	1.000	0.32	Yes	Yes	CL-ML				Yes	YES	0.32	Liquefiable
S13	25.5	1	SM	130	3045	2015	2259	1.0	1.3	H	8	1.15	5	1	1.10	1.20	7	22.5	0.96	1	1		12	1.5	2	0.043	0.194	1.000	0.22	Yes	Yes	SM				Yes	YES	0.22	Liquefiable
S14	27.5	1	SM	130	3305	2151	2393	1.0	1.3	H	8	1.15	5	1	1.10	1.20	7	24.2	0.97	1	1	44	35	2.4	3	0.047	0.193	1.000	0.25	Yes	Yes	SM				Yes	YES	0.25	Liquefiable
S15	29.5	1	SM	130	3565	2286	2529	0.9	1.3	H	8	1.15	5	1	1.10	1.20	7	25.9	0.97	1	1		35	2.4	3	0.047	0.194	1.000	0.25	Yes	Yes	SM				Yes	YES	0.25	Liquefiable
S16	31.5	4	SM	130	3825	2421	2664	0.9	1.3	H	8	1.15	5	4	1.10	1.20	7	27.4	0.98	4	5		35	1.5	9	0.067	0.179	1.000	0.26	Yes	Yes	SM				Yes	YES	0.26	Liquefiable
S17	33.5	3	SM	130	4085	2556	2799	0.9	1.3	H	8	1.15	5	3	1.10	1.20	7	29.0	0.98	3	4	43	35	1.6	6	0.055	0.173	1.000	0.22	Yes	Yes	SM				Yes	YES	0.22	Liquefiable
S18	35.5	3	SM	130	4345	2691	2934	0.8	1.3	H	8	1.15	5	3	1.10	1.20	7	30.6	0.99	4	5		35	1.6	6	0.054	0.166	1.000	0.22	Yes	Yes	SM				Yes	YES	0.22	Liquefiable
S19	37.5	8	SM	130	4605	2827	3069	0.8	1.3	H	8	1.15	5	7	1.11	1.20	7	32.3	0.99	12	10		35	1.3	13	0.092	0.162	0.962	0.55	Yes	Yes	SM				Yes	YES	0.55	Liquefiable
S20	39.5	13	SP-SM	130	4865	2962	3205	0.8	1.3	H	8	1.15	5	10	1.20	1.20	7	33.9	0.99	22	18		8	1.1	19	0.140	0.158	0.296	0.89	Yes	Yes	SP-SM				Yes	YES	0.89	Liquefiable
S21	41.5	19	SP-SM	120	5125	3097	3349	0.8	1.3	H	8	1.15	5	15	1.26	1.20	7	34.5	0.99	29	22		9	1.0	23	0.194	0.154	0.011	1.26	No	Yes	SP-SM				Yes	No	1.26	-
S22	43.5	13	SW-SM	120	5385	3233	3470	0.8	1.3	H	8	1.15	5	10	1.17	1.20	7	36.1	0.99	19	15		8	1.1	16	0.103	0.150	0.673	0.73	Yes	Yes	SW-SM				Yes	YES	0.73	Liquefiable
S23	45.5	12	SP	130	5645	3367	3616	0.8	1.3	H	8	1.15	5	9	1.14	1.20	7	35.7	0.99	16	12	3	5	1.8	12	0.063	0.146	0.952	0.57	Yes	Yes	SP				Yes	YES	0.57	Liquefiable
S24	47.5	17	SP	130	5905	3570	3843	0.7	1.3	H	8	1.15	5	13	1.21	1.20	7	36.4	1.00	25	18		5	1.9	19	0.137	0.141	0.163	0.97	Yes	Yes	SP				Yes	YES	0.97	Liquefiable
S25	51.5	18	SP	130	6425	3773	4068	0.7	1.3	H	8	1.15	5	12	1.19	1.20	7	37.5	1.00	24	17		5	1.9	18	0.126	0.136	0.301	0.89	Yes	Yes	SP				Yes	YES	0.89	Liquefiable
S26	54.8	18	SP	130	6815	3976	4293	0.7	1.3	H	8	1.15	5	11	1.17	1.20	7	38.4	1.00	22	16		5	1.9	16	0.106	0.130	0.466	0.82	Yes	Yes	SP				Yes	YES	0.82	Liquefiable
S27	57.5	19	SP-SM	130	7285	4179	4521	0.7	1.3	H	8	1.15	5	13	1.22	1.20	7	39.4	1.00	28	19	7	7	1.9	29	0.141	0.125	0.043	1.13	Yes	Yes	SP-SM				Yes	YES	1.13	Judgment Required
S28	60.5	15	SP-SM	130	7685	4381	4629	0.7	1.3	H	8	1.15	5	10	1.16	1.20	7	40.3	1.00	22	15		9	1.1	16	0.105	0.120	0.415	0.84	Yes	Yes	SP-SM				Yes	YES	0.84	Liquefiable
S29	63.5	13	SP-SM	130	7965	4584	4827	0.7	1.3	H	8	1.15	5	9	1.14	1.20	7	41.3	1.00	19	13		9	1.1	13	0.091	0.116	0.745	0.79	Yes	Yes	SP-SM				Yes	YES	0.79	Liquefiable
S30	66.5	24	SP-SM	130	8375	4787	5030	0.6	1.3	H	8	1.15	9	16	1.26	1.20	7	42.2	1.00	35	23		6	1.6	36	0.180	0.116	0.001	1.55	No	Yes	SP-SM				Yes	No	1.55	-
S31	69.5	26	SP-SM	130	8795	4989	5233	0.6	1.3	H	8	1.15	9	16	1.28	1.20	7	43.3	1.00	38	24		9	1.0	25	0.178	0.115	0.000	1.74	No	Yes	SP-SM				Yes	No	1.74	-
S32	72.5	32	SP-SM	130	9155	5193	5435	0.6	1.3	H	8	1.15	SHOL	20	1.30	0.90	7	43.9	1.00	50	29		9	1.0	35	0.184	0.113	0.000	1.63	No	Yes	SP-SM				Yes	No	1.63	-
S33	75.5	44	SP-SM	130	9545	5398	5639	0.6	1.3	H	8	1.15	SHOL	27	1.00	0.90	7	44.6	1.00	62	32		9	1.0	33	0.544	0.111	0.000	3.00	No	Yes	SP-SM				Yes	No	3.00	-
S34	78.5	77	SP-SM	130	9935	5598	5841	0.6	1.3	H	8	1.15	SHOL	45	1.00	0.90	7	45.2	1.00	91	54		8	1.0	56	1.970	0.109	0.000	3.00	No	Yes	SP-SM				Yes	No	3.00	-
S35	81.5	59	SW	130	10325	5801	6044	0.6	1.3	H	8	1.15	SHOL	32	1.00	0.90	7	45.7	1.00	65	38		5	1.9	29	0.534	0.108	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
S36	84.5	45	GP	140	10795	6034	6277	0.6	1.3	H	8	1.15	SHOL	26	1.00	0.90	7	47.0	1.00	54	31		5	1.9	52	0.512	0.107	0.000	2.96	No	Yes	GP				Yes	No	2.96	-
S37	87.5	76	SW	130	11125	6237	6479	0.6	1.3	H	8	1.15	SHOL	43	1.00	0.90	7	48.0	1.00	90	53		5	1.9	52	1.503	0.107	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
S38	90.5	45	GP	140	11555	6440	6712	0.6	1.3	H	8	1.15	SHOL	21	1.00	0.90	7	49.0	1.00	45	25		5	1.9	26	0.199	0.106	0.000	1.78	No	Yes	GP				Yes	No	1.78	-
S39	93.5	49	GW	140	11975	6700	6949	0.5	1.3	H	8	1.15	SHOL	25	1.00	0.90	7	50.3	1.00	57	31		5	1.9	32	0.297	0.105	0.000	2.83	No	Yes	GW				Yes	No	2.83	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K.O., et al, 2004, *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340, and Discussions and Closures (May, 2006)*
2. URS Corporation 2008, *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev 0, March 2008.
3. Youd, B.R., et al, 2001, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.B. Queens Mary, Long Beach, Ca .
4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*, (used only for guidance on MCAL and SCAL sampler correction)

PROJECT NAME	American River Common Features (SPK Project)
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	26516760.45000
Reach ID:	
Station	Cycle Stations: 1515+00
Boring ID	SP-06-02-2
Boring Location (Enter Lat/Lon in decimals, and delete Rev. Grid/Lat/Lon/Stn/Offset)	Fixed Spring
Ground Elevation (ft.)=	33.0
Groundwater Elev. During Drilling (ft.) =	11.2
Analyzed Groundwater Elevation (ft.)=	10.9
Note:	Depth during drilling
Note:	Water depth (elevation)

Analysis By:	Shawn Duff
Check By:	
Date:	9/25/2008
Date:	

Data Input By Analyst
Results of Analysis
Calculated Values

Groundwater Depth Below GS During Drilling (ft.) = 23.3
Analyzed Groundwater Depth Below GS (ft.) = 24.1

Hammer Type = Automatic
Energy Ratio = 77 Assumed

Earthquake Information
Return Period (years) = 200
M_w = 7.0

PGA (g) = 0.16
Location = Other *(Enter Exact Location, or Waterside)*

Sample ID	Depth to Sample (ft.)	N_{SPT}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_v (psf)	Effective Overburden Pressure During Drilling, σ'_v (psf)	Effective Overburden Pressure During Earthquake, σ'_v (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SS, MCAL, SCAL)	H_s for Sampler Correction Only (for SM Sampler)	Sampler Correction, C_S, for SM Sampler Only	Sampler Correction for Analysis, C_S	Stick Up (Penetration) Rod Length Above Ground (feet)	Rod Length (ft)	Rod Length Correction Factor, C_R	N_{60}	$N_{1(60)}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{Fines}	$N_{1(60)CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, PL	Factor of Safety, FS	FS, = 1.2 (Youd'01 Guidance)	Below Analyzed Groundwater Level (Yes/No) Column AE	USCS Classification	Liquid Limit, LL	Plasticity Index, PI	Water Content, (W%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Based on Column AD, AH, and AI	Final Assessment (Yes/No) Based on Column AJ, AK, and AL	Factor of Safety, FS	Comment (Liquefiable for FS, =1 and Judgment Required for 1.0 <FS, < 1.2)
S1	0.5	18	ML	120	60	60	60	1.6	1.3	H	8	1.15	S	26	1.20	1.20	7	2.5	0.75	18	28		35	1.2	34	1.312	0.143	0.000	2.85	No	No	ML					No	3.00	
S2	3.5	8	ML	120	420	420	420	1.5	1.3	H	8	1.15	S	10	1.16	1.20	7	2.5	0.75	9	14		35	1.2	16	0.237	0.141	0.000	1.61	No	No	ML					No	1.61	
S3	5.5	11	ML	120	780	780	780	1.4	1.3	H	8	1.15	S	18	1.23	1.20	7	3.5	0.75	12	20		35	1.2	24	0.311	0.138	0.000	2.25	No	No	ML					No	2.25	
S4	9.5	9	SM	120	1170	1170	1170	1.3	1.3	H	8	1.15	S	32	1.16	1.20	7	4.7	0.82	11	14		20	1.2	19	0.186	0.136	0.021	1.25	No	No	SM					Yes	No	1.22	-
S5	12.5	6	CL	110	1500	1500	1500	1.2	1.3	H	8	1.15	S	7	1.10	1.20	7	5.5	0.87	9	9		35	1.3	12	0.101	0.133	0.020	0.76	Yes	No	CL					No	No	0.75	-
S6	15.5	6	CL	110	1830	1830	1830	1.2	1.3	H	8	1.15	S	8	1.12	1.20	7	6.5	0.90	11	11		35	1.3	14	0.114	0.131	0.021	0.89	Yes	No	CL					No	No	0.88	-
S7	17.5	7	CL	110	2050	2050	2050	1.2	1.3	H	8	1.15	S	7	1.10	1.20	7	7.5	0.92	9	9		35	1.3	12	0.097	0.129	0.043	0.75	Yes	No	CL					No	No	0.73	-
S8	19.5	5	CL	110	2270	2270	2270	1.1	1.3	H	8	1.15	S	9	1.10	1.20	7	7.5	0.93	7	5		35	1.4	9	0.074	0.127	0.063	0.58	Yes	No	CL					No	No	0.56	-
S9	21.5	5	CL	110	2490	2490	2490	0.9	1.3	H	8	1.15	S	4	1.10	1.20	7	9.4	0.95	7	5		35	1.4	9	0.070	0.127	0.063	0.55	Yes	No	CL					No	No	0.54	-
S10	23.5	3	ML/CL	120	2710	2710	2710	0.9	1.3	H	8	1.15	S	5	1.10	1.20	7	9.4	0.95	4	4	YR	55	1.6	6	0.065	0.127	0.093	0.43	Yes	No	ML/CL					Yes	No	0.42	-
S11	25.5	4	ML/CL	120	2970	2970	2970	0.8	1.3	H	8	1.15	S	3	1.10	1.20	7	9.4	0.95	5	5		35	1.5	7	0.095	0.127	0.056	0.67	Yes	Yes	ML/CL					Yes	YES	0.67	Liquefiable
S12	27.5	4	ML/CL	120	3210	2970	2997	0.8	1.3	H	8	1.15	S	3	1.10	1.20	7	10.2	0.97	5	5		35	1.5	7	0.095	0.126	0.067	0.67	Yes	Yes	ML/CL					Yes	YES	0.67	Liquefiable
S13	29.5	6	ML	120	3450	3060	3112	0.8	1.3	H	8	1.15	S	4	1.10	1.20	7	10.9	0.97	7	5		35	1.4	9	0.064	0.126	0.090	0.51	Yes	Yes	ML					Yes	YES	0.51	Liquefiable
S14	31.5	7	ML	120	3690	3240	3227	0.8	1.3	H	8	1.15	S	2	1.10	1.20	7	11.4	0.98	9	6	56	35	1.9	4	0.047	0.126	1.000	0.37	Yes	Yes	ML					Yes	YES	0.37	Liquefiable
S15	33.5	3	ML	120	3930	3240	3342	0.8	1.3	H	8	1.15	S	2	1.10	1.20	7	12.3	0.98	4	3		35	1.7	5	0.051	0.126	1.000	0.40	Yes	Yes	ML					Yes	YES	0.39	Liquefiable
S16	35.5	4	SM	120	4170	3454	3477	0.8	1.3	H	8	1.15	S	3	1.10	1.20	7	12.6	0.99	5	4		25	1.5	7	0.055	0.126	0.999	0.44	Yes	Yes	SM					Yes	YES	0.44	Liquefiable
S17	37.5	4	SM	130	4460	3689	3613	0.7	1.3	H	8	1.15	S	3	1.10	1.20	7	13.3	0.99	5	4		25	1.5	7	0.054	0.126	0.999	0.43	Yes	Yes	SM					Yes	YES	0.43	Liquefiable
S18	39.5	6	ML	120	4690	3704	3729	0.7	1.3	H	8	1.15	S	4	1.10	1.20	7	13.8	0.99	7	5		35	1.5	9	0.059	0.126	0.997	0.48	Yes	Yes	ML					Yes	YES	0.48	Liquefiable
S19	41.5	3	ML	120	4930	3819	3843	0.7	1.3	H	8	1.15	S	2	1.10	1.20	7	14.5	0.99	4	3	55	35	1.7	5	0.046	0.126	1.000	0.38	Yes	Yes	ML					Yes	YES	0.39	Liquefiable
S20	43.5	4	ML	120	5170	3934	3958	0.7	1.3	H	8	1.15	S	3	1.10	1.20	7	15.1	0.99	5	4		35	1.6	7	0.052	0.123	0.999	0.42	Yes	Yes	ML					Yes	YES	0.42	Liquefiable
S21	45.5	2	CL/ML	110	5390	4050	4053	0.7	1.3	H	8	1.15	S	1	1.10	1.20	7	15.7	0.99	3	2		35	2.0	4	0.042	0.122	1.000	0.35	Yes	Yes	CL/ML					No	No	0.35	-
S22	47.5	4	CL/ML	110	5720	4173	4196	0.7	1.3	H	8	1.15	S	3	1.10	1.20	7	16.6	1.00	4	4		35	1.8	6	0.051	0.120	0.999	0.43	Yes	Yes	CL/ML					No	No	0.43	-
S23	49.5	4	CL/ML	110	5950	4333	4339	0.7	1.3	H	8	1.15	S	3	1.10	1.20	7	17.5	1.00	4	4		35	1.8	6	0.050	0.117	0.999	0.43	Yes	Yes	CL/ML					No	No	0.43	-
S24	54.5	5	SM	130	6448	4519	4542	0.7	1.3	H	8	1.15	S	4	1.10	1.20	7	18.4	1.00	5	5		25	1.8	8	0.056	0.115	0.999	0.50	Yes	Yes	SM					Yes	YES	0.50	Liquefiable
S25	57.5	15	SM	130	6930	4731	4765	0.7	1.3	H	8	1.15	S	10	1.17	1.20	7	19.6	1.00	14	15	14	14	1.1	17	0.108	0.113	0.215	0.96	Yes	Yes	SM					Yes	YES	0.96	Liquefiable
S26	59.5	12	SM	130	7220	4924	4947	0.6	1.3	H	8	1.15	S	8	1.12	1.20	7	20.3	1.00	10	11		14	1.3	13	0.077	0.111	0.730	0.69	Yes	Yes	SM					Yes	YES	0.69	Liquefiable
S27	61.5	13	SM	130	7510	5126	5150	0.6	1.3	H	8	1.15	S	9	1.13	1.20	7	21.2	1.00	13	12		25	1.3	15	0.094	0.109	0.386	0.86	Yes	Yes	SM					Yes	YES	0.85	Liquefiable
S28	64.5	1	SM	130	8000	5329	5353	0.6	1.3	H	8	1.15	S	4	1.10	1.20	7	22.1	1.00	10	5		25	1.4	9	0.057	0.106	0.961	0.53	Yes	Yes	SM					Yes	YES	0.53	Liquefiable
S29	68.5	19	SM	130	8890	5933	5956	0.6	1.3	H	8	1.15	S	11	1.19	1.20	7	23.9	1.00	19	17		25	1.2	20	0.129	0.106	0.025	1.21	No	Yes	SM					No	No	1.21	-
S30	72.5	16	SM	130	9790	6338	6759	0.6	1.3	H	8	1.15	S	9	1.13	1.20	7	23.9	1.00	21	12		25	1.2	15	0.096	0.104	0.461	0.92	Yes	Yes	SM					Yes	YES	0.91	Liquefiable
S31	79.5	19	SM	130	9170	5939	5963	0.6	1.3	H	8	1.15	S	13	1.27	1.20	7	24.8	1.00	27	18		25	1.2	19	0.111	0.102	0.075	1.09	Yes	Yes	SM					Yes	YES	1.09	Judgment Required
S32	78.5	20	SM	130	9660	6140	6164	0.6	1.3	H	8	1.15	S	16	1.27	1.20	7	25.8	1.00	41	24		20	1.1	26	0.205	0.101	0.000	2.03	No	Yes	SM					No	No	2.03	-
S33	81.5	29	SW-SM	130	9950	6340	6367	0.6	1.3	H	8	1.15	S	34	1.24	1.20	7	26.7	1.00	57	31	6	6	1.9	22	0.140	0.099	0.003	1.41	No	Yes	SW-SM					Yes	No	1.41	-
S34	86.5	21	SM	130	10340	6546	6570	0.6	1.3	H	8	1.15	S	12	1.19	1.20	7	27.6	1.00	31	17		12	1.1	19	0.111	0.096	0.047	1.16	Yes	Yes	SM					Yes	YES	1.16	Judgment Required
S35	87.5	38	SM	130	18745	6749	6773	0.5	1.2	H	8	1.15	MCAL	11	1.18	0.92	7	29.5	1.00	28	13		12	1.1	14	0.073	0.096	0.492	0.82	Yes	Yes	SM					Yes	YES	0.82	Liquefiable
S36	89.5	20	SM	130	11120	6950	6975	0.5	1.3	H	8	1.19	MCAL	11	1.18	0.99	7	29.4	1.00	24	15	13	14	1.1	14	0.076	0.095	0.445	0.82	Yes	Yes	SM					Yes	YES	0.82	Liquefiable
S37	90.5	30	SM	130	11519	7154	7178	0.5	1.3	H	8	1.15	MCAL	16	1.27	0.99	7	30.3	1.00	35	19		12	1.1	20	0.122	0.093	0.000	1.32	No	Yes	SM					Yes	No	1.32	-
S38	95.5	52	SM	130	11908	7357	7381	0.5	1.3	H	8	1.15	MCAL	17	1.29	0.99	7	31.2	1.00	38	20		12	1.1	21	0.132	0.090	0.000	1.44	No	Yes	SM					Yes	No	1.44	-
S39	98.5	52	SM	130	12285	7560	7584	0.5	1.3	H	8	1.15	MCAL	27	1.35	0.99	7	32.2	1.00	51	25		12	1.1	28	0.203	0.090	0.000	2.00	No	Yes	SM					Yes	No	2.00	-
S40	100.5	59	SM	130	12660	7761	7787	0.5	1.3	H	8	1.15	MCAL	29	1.36	0.99	7	33.1	1.00	68	35		12	1.1	37	0.434	0.090	0.000	3.99	No	Yes	SM					Yes	No	3.00	-
S41	103	56	SM	130	13005	7932	7956	0.5	1.3	H	8	1.15	MCAL	29	1.36	0.99	7	33.8	1.00	59	30		12	1.1	32	0.282	0.089	0.000	3.50	No	Yes	SM					Yes	No	3.00	-

URS

SPT BASED LIQUEFACTION ANALYSIS

REFERENCE: 1. Cetin, K. O., et al, 2004. *Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 130, No. 12, 1313-1340. and Discussions*

2. URS Corporation 2008. *Guidance Document for Geotechnical Analysis*, Urban Levee Geotechnical Evaluations Program Rev 0, March 2008.

3. Seed, R.B., et. al. 2003, *Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework*. 26th Annual ASCE Los Angeles Geotechnical Spring Seminar, Keynote Presentation, H.M.S. Queens Mary, Long Beach, Ca .

4. Southern California Earthquake Center, University of Southern California, *Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California (1999)*. (used only for guidance on M

PROJECT NAME:	American River Common Features (ARCF) Project
LEVEE SEGMENT:	Sacramento River East Levee South of American River
PROJECT NUMBER:	38697/02.48432
Drawn ID:	
Station:	Depth Station: 16+13+00
Boring ID:	EP-06-05-28
Boring Location:	Toe Survey -) feet from Landside Toe
Enter Levee Centerline Coordinates and Reverse Point Direction at http://gmt.soest.hawaii.edu/geoware.html	

Analyzed By: Shawn Orgill
Check By:

Date: 5/26/2009
Date:

Data Input By Analyst
Results of Analysis
Calculated Values

Ground Elevation (ft.)= 19.5
Groundwater Elev. During Drilling (ft.) = 12.0
Analyzed Groundwater Elevation (ft.)= 12.0

Note: Depth during drilling
Note: WSEL at EOD (12/4/08)

Groundwater Depth Below SS During Drilling (ft.) = 7.5
Analyzed Groundwater Depth Below SS (ft.) = 7.5

Hammer Type = Automatic
Energy Ratio = 77 Adjusted

Earthquake Information:
Return Period (years) = 200
M_w = 7.0

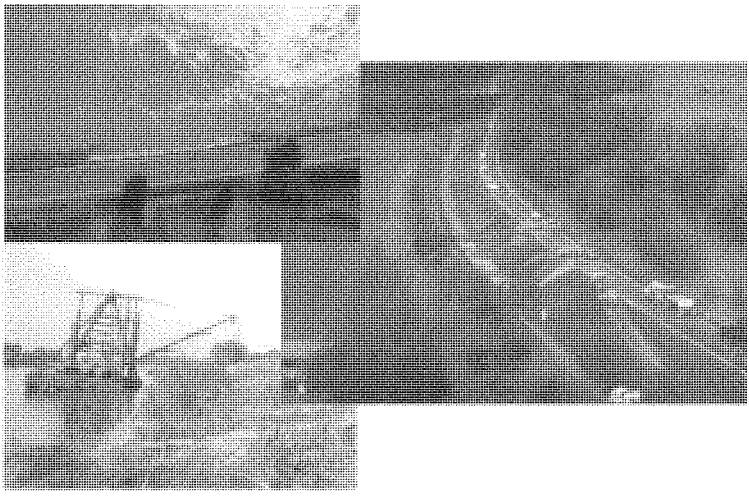
PGA (g) = 0.15
Location = Central Valley, Great Valley, or Foothills

Sample ID	Depth to Sample (ft.)	N_{blow}	USCS Classification	Unit Weight (pcf)	Overburden Pressure, σ_o (psf)	Effective Overburden Pressure During Drilling, σ_o' (psf)	Effective Overburden Pressure During Earthquake, σ_o' (psf)	Overburden Correction Factor, C_N	Correction for Hammer Energy Efficiency, C_E	Drilling Method	Borehole Diameter (inch)	Correction for Borehole Diameter, C_B	Sampler Code (S, SS, SC, PCA, HCA)	H_s for Sampler Correction Only (for SW Sampler)	Sampler Correction, C_S for SW Sampler Only	Sampler Correction for Analysis, C_S	Stick up (Protrusion) Rod Length Above Ground (feet)	Rod Length (m)	Rod Length Correction Factor, C_R	N_{60}	$N_{1,60,CS}$	Fines Content (%)	Fines Content for Analysis (%)	Correction Factor for Fine Content, C_{fines}	$N_{1,60,CS}$	Cyclic Resistance Ratio, CRR	Cyclic Stress Ratio from Guidance Document, CSR	The Probability of Liquefaction, P_L	Factor of Safety, F_S	P_L < 1.2 (Yes/No) Column AG	Below Analyzed Groundwater Level (Yes/No) Column AF	USCS Classification	Liquid Limit, LL	Plastic Ity Index, PI	Water Content (W%)	Liquefaction Susceptibility Based on Soil Type (Yes/No) Column AI	Final Assessment (Yes/No) Based on Columns AE or AH, AG	Factor of Safety, F_S	Comment (Liquefiable for F_S<1 and Judgment Required for 1 < F_S < 1.3)
S1	1.5	4	CL	110	165	165	165	1.6	1.3	H	8	1.15	S	6	1.10	1.20	7	2.3	0.75	4	7		35	1.4	10	0.181	0.242	0.839	0.87	Yes	No	CL				No	No	0.87	-
S2	3.5	5	CL	110	385	385	385	1.5	1.3	H	8	1.15	S	8	1.10	1.20	7	2.8	0.75	5	9		35	1.3	12	0.149	0.238	0.907	0.62	Yes	No	CL				No	No	0.91	-
S3	5.5	3	CL	110	605	605	605	1.5	1.3	H	8	1.15	S	6	1.10	1.20	7	3.5	0.75	3	5	93	35	1.5	8	0.094	0.235	1.000	0.41	Yes	No	CL	36	13		No	No	0.61	-
S4	7.5	5	CL	110	825	825	825	1.5	1.3	H	8	1.15	S	8	1.10	1.20	7	4.1	0.79	3	4		35	1.6	6	0.076	0.231	1.000	0.33	Yes	No	CL				No	No	0.53	-
S5	9.5	12	ML	120	1065	1024	1069	1.4	1.3	H	8	1.15	S	12	1.24	1.20	7	4.7	0.82	10	20		35	1.2	25	0.301	0.226	0.000	1.32	No	Yes	ML				Yes	No	1.32	-
S6	11.5	3	ML	120	1305	1143	1154	1.3	1.3	H	8	1.15	S	4	1.30	1.20	7	5.3	0.85	4	5		35	1.5	7	0.079	0.224	1.000	0.35	Yes	Yes	ML				Yes	Yes	0.35	Liquefiable
S7	13.5	2	SM	130	1625	1264	1309	1.2	1.2	H	8	1.15	S	2	1.30	1.20	7	5.9	0.88	2	3	43	35	1.7	5	0.066	0.220	1.000	0.30	Yes	Yes	SM				Yes	Yes	0.29	Liquefiable
S8	15.5	1	SM	130	1625	1419	1396	1.2	1.2	H	8	1.15	S	1	1.30	1.20	7	6.4	0.90	1	2		35	2.2	4	0.055	0.217	1.000	0.25	Yes	Yes	SM				Yes	Yes	0.23	Liquefiable
S9	17.5	4	SM	130	2665	1656	1639	1.1	1.2	H	8	1.15	S	5	1.10	1.20	7	7.0	0.92	5	5		35	1.4	9	0.070	0.213	1.000	0.27	Yes	Yes	SM				Yes	Yes	0.27	Liquefiable
S10	19.5	4	SM	130	2345	1890	1868	1.1	1.2	H	8	1.15	S	7	1.10	1.20	7	7.6	0.93	4	5		35	1.3	10	0.096	0.210	0.996	0.44	Yes	Yes	SM				Yes	Yes	0.44	Liquefiable
S11	21.5	4	CL-ML	115	2565	1765	1760	1.1	1.2	H	8	1.15	S	4	1.30	1.20	7	8.4	0.95	5	5	85	55	1.4	8	0.075	0.205	1.000	0.37	Yes	Yes	CL-ML	26	8		Yes	Yes	0.37	Liquefiable
S12	23.5	3	CL-ML	115	2705	1800	1855	1.0	1.2	H	8	1.15	S	3	1.10	1.20	7	9.0	0.96	4	4		55	1.5	7	0.065	0.199	1.000	0.33	Yes	Yes	CL-ML				Yes	Yes	0.33	Liquefiable
S13	25.5	1	SM	130	3045	2015	1999	1.0	1.2	H	8	1.15	S	1	1.10	1.20	7	9.6	0.96	1	1		12	1.5	1	0.046	0.194	1.000	0.23	Yes	Yes	SM				Yes	Yes	0.23	Liquefiable
S14	27.5	1	SM	130	3255	2151	2129	1.0	1.2	H	8	1.15	S	1	1.10	1.20	7	10.2	0.97	1	1	44	35	2.4	3	0.046	0.189	1.000	0.25	Yes	Yes	SM				Yes	Yes	0.25	Liquefiable
S15	29.5	1	SM	130	3585	2286	2261	0.9	1.3	H	8	1.15	S	1	1.10	1.20	7	10.8	0.97	1	1		35	2.4	3	0.046	0.184	1.000	0.26	Yes	Yes	SM				Yes	Yes	0.25	Liquefiable
S16	31.5	4	SM	130	3825	2421	2395	0.9	1.3	H	8	1.15	S	4	1.10	1.20	7	11.4	0.98	6	5		35	1.5	9	0.085	0.175	1.000	0.26	Yes	Yes	SM				Yes	Yes	0.26	Liquefiable
S17	33.5	3	SM	130	4095	2556	2531	0.9	1.3	H	8	1.15	S	3	1.10	1.20	7	12.0	0.98	4	3	43	35	1.6	6	0.057	0.173	1.000	0.33	Yes	Yes	SM				Yes	Yes	0.32	Liquefiable
S18	35.5	3	SM	130	4345	2691	2666	0.9	1.3	H	8	1.15	S	3	1.10	1.20	7	12.6	0.99	4	3		35	1.6	6	0.056	0.168	1.000	0.33	Yes	Yes	SM				Yes	Yes	0.33	Liquefiable
S19	37.5	6	SM	130	4655	2827	2802	0.8	1.3	H	8	1.15	S	7	1.11	1.20	7	13.3	0.99	12	10		35	1.3	13	0.093	0.163	0.962	0.56	Yes	Yes	SM				Yes	Yes	0.54	Liquefiable
S20	39.5	15	SP-SM	130	4965	2962	2937	0.8	1.3	H	8	1.15	S	15	1.20	1.20	7	13.9	0.99	22	18		8	1.1	19	0.144	0.158	0.256	0.91	Yes	Yes	SP-SM				Yes	Yes	0.91	Liquefiable
S21	41.5	19	SP-SM	130	5125	3097	3072	0.8	1.3	H	8	1.15	S	19	1.26	1.20	7	14.5	0.99	28	22		8	1.0	23	0.199	0.154	0.011	1.29	No	Yes	SP-SM				Yes	No	1.29	-
S22	43.5	13	GW-SM	130	5385	3232	3207	0.8	1.3	H	8	1.15	S	13	1.17	1.20	7	15.1	0.99	19	16		8	1.3	16	0.111	0.150	0.679	0.74	Yes	Yes	SW-SM				Yes	Yes	0.74	Liquefiable
S23	45.5	11	SP	130	5645	3367	3342	0.8	1.3	H	8	1.15	S	11	1.16	1.20	7	15.7	0.99	15	12	3	8	1.0	12	0.064	0.146	0.952	0.58	Yes	Yes	SP				Yes	Yes	0.58	Liquefiable
S24	47.5	17	SP	130	5835	3570	3545	0.7	1.3	H	8	1.15	S	13	1.21	1.20	7	16.2	1.00	25	19		5	1.0	19	0.140	0.141	0.163	0.99	Yes	Yes	SP				Yes	Yes	0.99	Liquefiable
S25	51.5	16	SP	130	6425	3773	3749	0.7	1.3	H	8	1.15	S	12	1.19	1.20	7	17.5	1.00	24	17		5	1.0	18	0.122	0.134	0.363	0.92	Yes	Yes	SP				Yes	Yes	0.92	Liquefiable
S26	54.5	15	SP	130	6815	3976	3951	0.7	1.3	H	8	1.15	S	11	1.17	1.20	7	18.4	1.00	22	16		5	1.0	16	0.105	0.130	0.464	0.83	Yes	Yes	SP				Yes	Yes	0.83	Liquefiable
S27	57.5	19	SP-SM	130	7205	4179	4154	0.7	1.3	H	8	1.15	S	13	1.22	1.20	7	19.4	1.00	28	19	7	7	1.0	20	0.144	0.125	0.043	1.16	Yes	Yes	SP-SM				Yes	Yes	1.16	Judgment Required
S28	60.5	15	SP-SM	130	7595	4381	4356	0.7	1.3	H	8	1.15	S	10	1.16	1.20	7	20.3	1.00	22	15		5	1.0	15	0.101	0.120	0.476	0.84	Yes	Yes	SP-SM				Yes	Yes	0.84	Liquefiable
S29	63.5	13	SP-SM	130	7985	4584	4559	0.7	1.3	H	8	1.15	S	9	1.14	1.20	7	21.2	1.00	19	13		8	1.1	13	0.084	0.116	0.741	0.71	Yes	Yes	SP-SM				Yes	Yes	0.71	Liquefiable
S30	66.5	24	SP-SM	130	8375	4787	4762	0.6	1.3	H	8	1.15	S	16	1.26	1.20	7	22.1	1.00	35	23		8	1.0	24	0.182	0.116	0.001	1.57	No	Yes	SP-SM				Yes	No	1.57	-
S31	69.5	26	SP-SM	130	8765	4990	4965	0.6	1.3	H	8	1.15	S	16	1.26	1.20	7	23.0	1.00	38	24		8	1.0	25	0.202	0.115	0.000	1.76	No	Yes	SP-SM				Yes	No	1.76	-
S32	72.5	32	SP-SM	130	9155	5193	5168	0.6	1.3	H	8	1.15	MCAL	20	1.30	0.89	7	23.9	1.00	38	23		8	1.0	25	0.187	0.113	0.000	1.66	No	Yes	SP-SM				Yes	No	1.66	-
S33	75.5	44	SP-SM	130	9545	5395	5370	0.6	1.3	H	8	1.15	MCAL	27	1.30	0.93	7	24.8	1.00	52	32		8	1.0	33	0.249	0.111	0.000	3.09	No	Yes	SP-SM				Yes	No	3.09	-
S34	78.5	77	SP-SM	130	9935	5596	5573	0.6	1.3	H	8	1.15	MCAL	46	1.30	0.93	7	25.8	1.00	91	54		8	1.0	56	2.005	0.109	0.000	3.50	No	Yes	SP-SM				Yes	No	3.00	-
S35	81.5	59	SW	130	10325	5801	5776	0.6	1.3	H	8	1.15	MCAL	35	1.30	0.99	7	26.7	1.00	65	38		5	1.0	39	0.540	0.106	0.000	3.00	No	Yes	SW				Yes	No	3.00	-
S36	84.5	45	GP	140	10765	6024	6999	0.6	1.3	H	8	1.15	MCAL	29	1.30	0.99	7	27.6	1.00	54	31		5	1.0	32	0.316	0.107	0.000	2.94	No	Yes	GP				Yes	No	2.94	-
S37	87.5	78	SW	130	11135	6207	6252	0.6	1.3	H	8	1.15	MCAL	43	1.30	0.99	7	29.0	1.00	90	51		5	1.0	53	1.595	0.107	0.000	3.66	No	Yes	SW				Yes	No	3.66	-
S38	90.5	35	GP	140	11555	6466	6444	0.6	1.3	H	8	1.15	MCAL	21	1.30	0.99	7	29.4	1.00	45	25		5	1.0	26	0.191	0.104	0.000	1.82	No	Yes	GP				Yes	No	1.99	-
S39	93.5	48	SW	140	11975	6782	6877	0.6	1.3	H	8	1.15	MCAL	26	1.30	0.99	7	30.3	1.00	57	31		5	1.0	32	0.320	0.105	0.000	2.94	No	Yes	SW				Yes	No	2.94	-

Post-Authorization Change Report
And Interim General Reevaluation Report

American River Watershed

Common Features Project
Natomas Basin
Sacramento and Sutter Counties, California



SAFCA
Sacramento Area Flood Control Agency

US Army Corps of Engineers ®
Sacramento District

Appendix G – Cost

October 2010

APPENDIX G
COST ENGINEERING

1. BASIS OF DESIGN

This estimate is based on the draft report:
American River Common Features Project,
Natomas Post Authorization Change Report and Interim General Reevaluation Report

The type of solicitation is expected to be unrestricted IFB.

Civil Design quantities are per three AE's (HDR, Wood Rodgers and Mead & Hunt) with spot checking by SPK. HDR also provided "bare cost" estimates for Pumping Plant modifications, Riverside Canal and well relocations.

2. PROJECT SCOPE/DESCRIPTION

The project area is comprised of nine reaches, designated A through I for economic evaluation and construction sequencing purposes. Costs for both the NED and locally preferred plan (LPP) have been developed. The Sacramento Area Flood Control Agency (SAFCA) has completed construction, or is in the process of doing so, much of the work in Reaches B, C & D (sans Pumping Station Modifications). These costs are shown as either sunk (omitted) for contracted work expected to be completed before 10/2010 or as Section 104 work for ongoing projects SAFCA is providing for.

The description of each reach, and typical work involved, is as follows:

- Reach A: SREL from Interstate Highway 5 north to San Juan Road. (Adjacent levee, cutoff wall, Irrigation Canal, Pumping Plant Relocations (3) and Private Irrigation Facilities (1))
- Reach B: SREL from San Juan Road north to Elverta Road. (Adjacent levee, cutoff wall, seepage berm, Irrigation/Drainage Canals (2), Pumping Plant Relocations (4))
- Reach C: SREL from Elverta Road north to Sankey Road at the west end of the south levee of the NCC. (Adjacent levee, cutoff wall, seepage berm, Irrigation/Drainage Canals (2), Pumping Plant Relocations (2), Private Irrigation Facility)
- Reach D: NCC south levee from Sankey Road north to Howsley Road. (Cutoff wall, Pumping Plant Relocations (3))
- Reach E: PGCC west levee from Howsley Road north to Sankey Road. (Cutoff wall, Vinyl Sheet Pile, Private Irrigation Facilities (4))
- Reach F: NEMDC west levee from Sankey Road south to Elverta Road. (Cutoff wall, Drained stability berm, flattened landside levee slope, Private Irrigation Facilities (5))

- Reach G: NEMDC west levee from Elverta Road south to the pumping station just upstream of Dry Creek. (Cutoff wall, Pumping Plant Relocations, Private Irrigation Facilities (4))
- Reach H: NEMDC west levee from the pumping station just upstream of Dry Creek south to Northgate Boulevard. (Cutoff wall, Jet Grouting, Pumping Plant Relocations (2))
- Reach I: ARNL from Northgate Boulevard south to Interstate Highway 5. (Cutoff wall, Pumping Plant Relocations)

3. TOTAL PROJECT COSTS (SEE ATTACHED)

The costs shown in the attached Total Project Cost (TPC) summary sheets are developed from two sources (1) bid data from various projects put forth by SAFCA for the Natomas Levee Improvement Project (Reaches B, C and D) and (2) feasibility level plans and associated quantities developed by three AE firms, HDR, Wood Rodgers, and Mead & Hunt (Reaches A, E, F, G, H and I plus work remaining in Reaches B, C and D). Costs were developed primarily through the use of MII and the local 'database' of construction methods (labor, equipment, and materials cost data, construction crews and anticipated production rate, anticipated borrow and disposal sites, etc). These are relatively up-to-date (June 2010 Davis-Bacon rates, recent quotes for bulk materials, but only 2007 MII equipment rates). First Costs are based on 1 Oct 2010 price levels. Fully funded costs are first costs escalated to the midpoint of design or construction (as per the anticipated construction schedule).

4. MII COST ESTIMATE (SEE ATTACHED) - NOTES & ASSUMPTIONS

OVERTIME
Overtime is included in this estimate. Assumption is 10 hr days, 6 days/week.

ACQUISITION PLAN
Construction Contracts are assumed to be design-bid-build, lowest competitive price.

CONTRACTING PLAN
The prime contractor is expected to be an earthwork contractor responsible for the general site work, borrow site excavation, levee degrading and rebuilding to the restored or new levee height.
Subcontractors are provided for two categories, miscellaneous/general and trucking:
Miscellaneous/General Subcontractors are expected to be utilized for cutoff wall placement, pumping plant relocations, bridge relocations, jet grouting, sheet pile work, paving and hydroseeding.

PROJECT CONSTRUCTION
The project consists of 9 reaches (A-I) with multiple utility relocations for penetrations through the levees (primarily pumping plants and private irrigation

facilities). Should the LPP ultimately be constructed, several bridges will also be raised.

SITE ACCESS
The project sites encompass the perimeter of the Natomas Basin in the Sacramento, CA area and are accessible by paved local roads. Certain reaches (B, C, D & E) are of close enough proximity to borrow areas that scrapers are a viable option for degrading of levees and levee restoration.

BORROW \ DISPOSAL AREAS
Many potential borrow areas have been identified in or very near to (such as the "Triangle") the Natomas basin and these are expected to provide the borrow required. Disposal of Debris is normal.

CONSTRUCTION METHODOLOGY
The construction methodologies are considered standard, except for deep (greater than 85 ft) cutoff wall excavation & placement. Below this depth a conventional long reach hydraulic excavator cannot be used. The method provided in the cost estimate opts for the contractor to utilize a hydraulic clamshell in excavating to the lower depths of the wall (the lower 18.5 ft for the extreme depth walls, 103.5 ft deep). The estimator realizes that production by the clamshell is much slower than that of the excavator but the extra depth is approximately 20% of that for the excavator and it is believed the 18.5 ft done by the clamshell will allow it to roughly keep up with the 85 ft done by the excavator. Other methods such as deep-soil-mixing are expected to be a contractor option. Deep soil mixing was examined but is expected to be slightly less cost effective than excavator/clamshell at this depth.

UNUSUAL CONDITIONS
No unusual conditions.

UNIQUE TECHNIQUES OF CONSTRUCTION
Proximity of existing bridge abutments or retaining walls requires that jet grouting be performed in lieu of placing slurry cutoff walls in two short lengths of Reach H.

EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED
In an urban area such as Sacramento, equipment and labor is readily available within a 100 mile radius of the site.

ENVIRONMENTAL CONCERNS
Environmental protection requires consideration of air, water, and land, and involves noise, solid-waste management and management of other pollutants. In order to prevent or provide for abatement and control of any environmental pollution arising from the work activities, the Contractor and his subcontractors in the performance of this contract, shall comply with all applicable Federal, State, and local laws, and regulations concerning environmental pollution control and

abatement. The Contractor shall use best management practices at all times to minimize the potential for environmental impacts. A running 2% markup on construction equipment is provided to account for air quality considerations.

LABOR RATES, EQUIPMENT RATES, MATERIAL COSTS & SALES TAX
This estimate meets Davis Bacon wage rates for Davis Bacon wage determinations for the state of California, General Decision Numbers: CA 20100003 03/12/2010, CA 20100006 03/12/2010, CA 20100009 03/12/2010 and CA 20100026 03/12/2010.

Equipment unit costs were obtained from Quotes or verbal/telephone conversations with Contractors performing like or similar work and the MCACES Equipment Library.

Material prices were obtained from Quotes, supply catalogs, previous similar estimates, and the MCACES Cost Book.

Sales tax is applied at 8.75%.

PRODUCTION RATES
Productivity/Task Durations are based on production for 50 minutes/hr for meetings/breaks, accessing the working area/office trailer to get supplies.

BRIDGE RAISING COSTS
These were provided by Wood Rodgers an AE firm who provided the civil design for Reaches D-H. The costs are within reason when compared to "Comparative Bridge Costs" (January 2010) as set forth by Caltrans.

Note: Gasoline and diesel fuel costs used in the estimate are the average costs in the Sacramento area as of July 2010. Off-road diesel costs are assumed at 90% of on-road.

5. CONTRACTOR MARKUPS

Profit is included for the prime contractor (8.48% based on PWG). Home Office Overhead is considered to be 7% for these relatively large projects. Job/Field Office Overhead (JOOH) is set at 10% for all reaches except Reach I, where it is set at 23%. Small Tool Markup is set at a running 2% of Labor costs. Bond is set at 0.7%.

Initially, JOOH was calculated independently for each reach (based on the developed construction schedule) with Small Tools set at 2% of Prime Contractor Labor. It is considered very likely however, that the contractors will be given the full construction season to complete the work (2 seasons in the case of Reach A). Reaches A-H typically showed a JOOH in the 8-11% range, with an average of about 9.5%. 10% was therefore chosen to be used uniformly in those reaches.

Reach I has a somewhat higher JOOH due to a shorter calculated construction duration extended to allow the full construction season.
Likewise, bond was initially calculated based on Bond Class B. A weighted average was used for conformity of costs between like work in the NED vs the LPP.

Miscellaneous/General Subcontractors have profit set at of 10% , Home Office Overhead at 12% and Job Office Overhead at 15% (performs the majority of the cutoff wall/jet grouting/sheet pile/pumping plant/bridge work). Bond is set at 0.8%.

The Trucking/Hauling Subcontractors have profit set at of 10%, Home Office Overhead at 10% and Job Office Overhead at 5%. Bond again is set at 1.0%.

6. CONSTRUCTION SCHEDULE (SEE ATTACHED)

Total Project Schedules including design, pre-construction, construction and post construction were developed using MS Project with construction durations based on those developed in MII. These were used to insure the project reaches could be completed within the construction windows and with the anticipated crews. It was determined that Reaches A, B, E, F, G & H will require two crews for slurry wall construction, excavation at the borrow areas and levee restoration. It was determined that Reach A would also require two construction seasons due to the long construction period for the deep slurry walls.

CONSTRUCTION WINDOWS
The estimate considers the construction work window for major construction activities to be May-Oct, April and November are available for mobilization and demobilization of equipment and non-flood protection items such as hydroseeding that do not change the effectiveness of flood control and drainage system.

7. COST RISK ANALYSIS (SEE ATTACHED)

The scope of the risk analysis was to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The study does not include consideration for operation and maintenance or life cycle costs.

NOTE: Also attached are summary sheets of Annual Costs and a Summary Project Costs.

****TOTAL PROJECT COST SUMMARY**** 8/26/2010

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE POST AUTHORIZATION CHANGE REPORT, NED PLAN
PROJECT: NATOMAS PACR — U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
LOCATION: CALIFORNIA — P.O.C.: JOE W. YEE, CHIEF, COST ENGINEERING SECTION

Current MCACES Estimate Prepared: 16-Aug-2010
Effective Price Level (EPL): 1-Oct-2010

ACCOUNT NO.	FEATURE DESCRIPTION		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 COST ($K)	CNTG ($K)	TOTAL ($K)	SUNK COST ($K)	OMB MIDPT(%)	FULLY FUNDED...FULLY FUNDED ESTIMATE... (3... COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.															
			Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2010				
Total															
	FEDERAL COSTS														
6	FISH & WILDLIFE FACILITIES		15,175	3,694		18,869		15,175	3,694	18,869	1,865		15,996	3,945	19,941
	Reach B		1,862	15	1	1,877		1,862	15	1,877	164		1,922	15	1,937
	Reach C		1,926	0		1,926		1,926	0	1,926	1,701		1,926	0	1,926
	Reach E		4,907	1,810	37	6,717		4,907	1,810	6,717	0		5,283	1,950	7,233
	Reach H		6,480	1,869	29	8,349		6,480	1,869	8,349	0		6,865	1,980	8,846
11	LEVEES & FLOODWALLS		313,225	74,858		388,083		313,225	74,858	388,083	79,451		326,017	78,805	403,822
	Reach A	11	55,084	17,509	32	72,593		55,084	17,509	72,593	0		56,858	18,072	74,930
	Reach B		63,286	9,998	25	73,284		63,286	9,998	73,284	23,163		64,320	10,248	74,568
	Reach C		21,972	257	39	22,229		21,972	257	22,229	21,321		22,034	281	22,315
	Reach D		37,232	989	44	38,221		37,232	989	38,221	34,967		37,449	1,083	38,532
	Reach E		30,569	11,738	38	42,307		30,569	11,738	42,307	0		32,916	12,640	45,556
	Reach F		35,245	11,261	32	46,506		35,245	11,261	46,506	0		37,296	11,916	49,212
	Reach G		25,543	9,472	37	35,015		25,543	9,472	35,015	0		27,485	10,191	37,676
	Reach H		30,435	9,966	33	40,401		30,435	9,966	40,401	0		32,242	10,558	42,800
	Reach I		13,859	3,668	26	17,527		13,859	3,668	17,527	0		14,417	3,816	18,233
13	PUMPING PLANT		42,044	14,091		56,135		42,044	14,091	56,135	0		44,793	15,117	59,910
	Reach A	13	4,818	1,185	25	6,003		4,818	1,185	6,003	0		4,973	1,223	6,196
	Reach B		13,840	3,375	24	17,215		13,840	3,375	17,215	0		14,400	3,512	17,912
	Reach C		15,056	6,430	43	21,486		15,056	6,430	21,486	0		16,493	7,039	23,532
	Reach D		2,820	1,387	49	4,207		2,820	1,387	4,207	0		3,089	1,520	4,609
	Reach G		2,078	745	36	2,823		2,078	745	2,823	0		2,236	802	3,038
	Reach H		2,227	654	29	2,881		2,227	654	2,881	0		2,359	693	3,052
	Reach I		1,195	315	26	1,510		1,195	315	1,510	0		1,243	328	1,571
18	CULT. RESRC. PRESERV.	(1	5,660	918	16	6,578		5,660	918	6,578	0		5,885	954	6,839
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		376,104	93,561		469,665		376,104	93,561	469,665	81,316		391,691	98,821	490,512
1	LANDS & DAMAGES, Admin	(2	3,590	537		4,127		3,590	537	4,127	0		3,993	597	4,590
	Reach A	A	666	99	15	765		666	99	765	0		692	103	795
	Reach B		821	124	15	945		821	124	945	0		884	133	1,017
	Reach C		256	39	15	295		256	39	295	0		314	47	361
	Reach D		85	13	15	98		85	13	98	0		104	16	120
	Reach E		346	51	15	397		346	51	397	0		405	60	465
	Reach F		279	42	15	321		279	42	321	0		314	47	361
	Reach G		210	31	15	241		210	31	241	0		246	37	283
	Reach H		785	117	15	902		785	117	902	0		882	131	1,013
	Reach I		142	21	15	163		142	21	163	0		152	23	175
1	LANDS & DAMAGES, Real Estate		10,301	4,064		14,365		10,301	4,064	14,365	0		10,769	4,267	15,036
	Reach A	C	1,792	520	29	2,312		1,792	520	2,312	0		1,819	528	2,347
	Reach B		4,147	1,701	41	5,848		4,147	1,701	5,848	0		4,278	1,755	6,033
	Reach C		709	318	45	1,027		709	318	1,027	0		769	345	1,114
	Reach D		1,580	932	59	2,512		1,580	932	2,512	0		1,714	1,012	2,726
	Reach E		790	284	36	1,074		790	284	1,074	0		843	303	1,146
	Reach H		1,283	309	24	1,592		1,283	309	1,592	0		1,346	324	1,670
30	PLAN/ENGINEERING/DESIGN		123,807	5,290		129,097		123,807	5,290	129,097	84,588		127,870	5,867	133,737
	Reach A	A	12,946	1,217	14	14,163		12,946	1,217	14,163	3,961		13,536	1,297	14,833
	Reach B		43,088	915	10	44,003		43,088	915	44,003	34,283		43,538	959	44,497
	Reach C		26,040	327	14	26,367		26,040	327	26,367	23,692		26,540	396	26,936
	Reach D		10,705	141	14	10,846		10,705	141	10,846	9,688		10,923	172	11,095
	Reach E		8,239	810	19	9,049		8,239	810	9,049	3,982		8,928	942	9,870
	Reach F		6,969	577	14	7,546		6,969	577	7,546	2,740		7,440	642	8,082
	Reach G		3,065	428	14	3,493		3,065	428	3,493	0		3,555	496	4,051
	Reach H		8,845	637	14	9,482		8,845	637	9,482	4,148		9,384	710	10,094
	Reach I		3,910	238	13	4,148		3,910	238	4,148	2,104		4,026	253	4,279
31	CONSTRUCTION MANAGEMT		143,678	7,355		151,033		143,678	7,355	151,033	120,851		146,740	8,406	155,146
	Reach A	A	4,792	1,496	31	6,288		4,792	1,496	6,288	0		5,163	1,612	6,775
	Reach B		41,108	1,074	25	42,182		41,108	1,074	42,182	36,773		41,394	1,142	42,536
	Reach C		37,618	535	43	38,353		37,618	535	38,353	36,561		38,135	670	38,805
	Reach D		47,924	190	47	48,114		47,924	190	48,114	47,517		48,028	238	48,266
	Reach E		2,838	1,084	38	3,922		2,838	1,084	3,922	0		3,407	1,301	4,708
	Reach F		2,820	901	32	3,721		2,820	901	3,721	0		3,338	1,034	4,272
	Reach G		2,043	756	37	2,799		2,043	756	2,799	0		2,448	906	3,354
	Reach H		3,131	1,000	32	4,131		3,131	1,000	4,131	0		3,604	1,152	4,756
	Reach I		1,204	319	26	1,523		1,204	319	1,523	0		1,323	351	1,674
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		657,480	110,807		768,287		657,480	110,807	768,287	286,755		681,063	117,958	799,021
	NON-FEDERAL CONTRIBUTION (-)		45,741	9,537		55,278		45,741	9,537	55,278	3,077		47,521	10,097	57,618
	SECTION 104 (-)		45,741	9,508		55,249		45,741	9,508	55,249	253,974		47,521	10,082	57,603
	TOTAL FEDERAL COSTS		**$565,998**	**$91,762**		**$657,760**		**$565,998**	**$91,762**	**$657,760**	**$29,704**		**$586,021**	**$97,779**	**$683,800**
	NON-FEDERAL COSTS														
1	LANDS AND DAMAGES		155,431	49,907		205,338		155,431	49,907	205,338	7,772		162,311	52,331	214,642
	Reach A	C	23,347	5,612	24	28,959		23,347	5,612	28,959	417		23,693	5,696	29,389
	Reach B		40,931	14,146	35	55,077		40,931	14,146	55,077	3,503		42,114	14,592	56,706
	Reach C		11,207	3,974	43	15,181		11,207	3,974	15,181	1,998		11,991	4,312	16,303
	Reach D		3,633	1,532	59	5,165		3,633	1,532	5,165	1,021		3,856	1,662	5,518

****CONTRACT COST SUMMARY(CONT'D)****

Current MCACES Estimate Prepared: 16-Aug-2010
Effective Price Level (EPL): 1-Oct-2010

ACCOUNT NO.	FEATURE DESCRIPTION		Contingency Applied To Remaining Cost Only: COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED ESTIMATE... SUNK COST ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
	Index Codes: 0 - no esc. applied; A - Administration; C - Combined indexes; All other codes used coincides with the Code of Accounts.										Sunk Cost Price Level (EPL): 1-Oct-2010				
	Reach E		25,076	8,175	33	33,251		25,076	8,175	33,251	378		26,730	8,722	35,452
	Reach F		9,220	4,547	50	13,767		9,220	4,547	13,767	99		9,667	4,771	14,438
	Reach G		13,118	5,222	40	18,340		13,118	5,222	18,340	0		13,998	5,572	19,569
	Reach H		26,642	5,363	20	32,005		26,642	5,363	32,005	215		27,940	5,626	33,566
	Reach I		2,257	1,336	63	3,593		2,257	1,336	3,593	141		2,324	1,378	3,702
2	RELOCATIONS		85,183	25,583		110,766		85,183	25,583	110,766	9,066		89,786	27,260	117,046
	Reach A		10,851	2,757	25	13,608		10,851	2,757	13,608	0		11,200	2,846	14,046
	Reach B		19,164	3,745	24	22,909		19,164	3,745	22,909	3,577		19,795	3,897	23,692
	Reach C		9,625	2,565	47	12,190		9,625	2,565	12,190	4,132		10,145	2,808	12,953
	Reach D		8,903	3,420	45	12,323		8,903	3,420	12,323	1,357		9,624	3,748	13,372
	Reach E		7,801	3,150	40	10,951		7,801	3,150	10,951	0		8,400	3,392	11,792
	Reach F		9,006	2,939	33	11,945		9,006	2,939	11,945	0		9,530	3,110	12,640
	Reach G		7,795	2,881	37	10,676		7,795	2,881	10,676	0		8,387	3,100	11,487
	Reach H		9,537	3,459	36	12,996		9,537	3,459	12,996	0		10,103	3,665	13,768
	Reach I		2,501	667	27	3,168		2,501	667	3,168	0		2,602	694	3,296
	SECTION 104		305,202	5,867		311,069		305,202	5,867	311,069	281,665		305,391	5,914	311,305
	Reach A	C	3,349	0		3,349		3,349	0	3,349	3,349		3,349	0	3,349
	Reach B		116,390	5,867	25	122,257		116,390	5,867	122,257	92,853		116,579	5,914	122,493
	Reach C		82,460	0		82,460		82,460	0	82,460	82,460		82,460	0	82,460
	Reach D		91,286	0		91,286		91,286	0	91,286	91,286		91,286	0	91,286
	Reach E		3,450	0		3,450		3,450	0	3,450	3,450		3,450	0	3,450
	Reach F		2,740	0		2,740		2,740	0	2,740	2,740		2,740	0	2,740
	Reach H		3,423	0		3,423		3,423	0	3,423	3,423		3,423	0	3,423
	Reach I		2,104	0		2,104		2,104	0	2,104	2,104		2,104	0	2,104
30	PLAN/ENGINEERING/DESIGN		16,670	2,944		19,614		16,670	2,944	19,614	8,280		17,088	3,099	20,187
	Reach A	2	1,631	414	25	2,045		1,631	414	2,045	3		1,677	425	2,102
	Reach B		4,521	104	24	4,625		4,521	104	4,625	4,090		4,534	106	4,640
	Reach C		4,555	308	47	4,863		4,555	308	4,863	3,895		4,608	333	4,941
	Reach D		1,080	366	45	1,446		1,080	366	1,446	272		1,130	389	1,519
	Reach E		1,170	473	40	1,643		1,170	473	1,643	0		1,244	503	1,747
	Reach F		1,081	352	33	1,433		1,081	352	1,433	0		1,129	368	1,497
	Reach G		1,177	432	37	1,609		1,177	432	1,609	8		1,250	459	1,709
	Reach H		1,149	415	36	1,564		1,149	415	1,564	5		1,202	434	1,636
	Reach I		306	80	27	386		306	80	386	6		314	82	396
31	CONSTRUCTION MANAGE'MT		5,723	1,832		7,555		5,723	1,832	7,555	560		6,050	1,954	8,004
	Reach A	2	868	221	25	1,089		868	221	1,089	0		896	228	1,124
	Reach B		760	56	24	816		760	56	816	530		762	56	818
	Reach C		470	205	47	675		470	205	675	30		512	224	736
	Reach D		538	244	45	782		538	244	782	0		590	267	857
	Reach E		624	252	40	876		624	252	876	0		672	271	943
	Reach F		721	235	33	956		721	235	956	0		764	248	1,012
	Reach G		779	289	37	1,068		779	289	1,068	0		838	311	1,149
	Reach H		763	277	36	1,040		763	277	1,040	0		809	293	1,102
	Reach I		200	53	27	253		200	53	253	0		207	56	263
	SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)		568,209	86,133		654,342		568,209	86,133	654,342	307,343		580,626	90,558	671,184
	NON-FEDERAL CONTRIBUTION (+)		45,741	9,537		55,278		45,741	9,537	55,278	3,077		47,521	10,097	57,618
	SECTION 104 (-) Remaining Allowable		259,461	(3,641)		255,820		259,461	(3,641)	255,820	27,691		257,870	(4,168)	253,702
	TOTAL NON-FEDERAL COSTS		**$354,489**	**$99,311**		**$453,800**		**$354,489**	**$99,311**	**$453,800**	**$282,729**		**$370,277**	**$104,823**	**$475,100**
	TOTAL FEDERAL AND NON-FEDERAL COSTS, Total		**$920,487**	**$191,073**		**$1,111,560**		**$920,487**	**$191,073**	**$1,111,560**	**$312,433**		**$856,298**	**$202,602**	**$1,159,900**
	Reach A														
	FEDERAL COSTS														
11	LEVEES & FLOODWALLS		55,084	17,509	32	72,593	0.00	55,084	17,509	72,593	0	3.2	56,868	18,072	74,930
13	PUMPING PLANT		4,818	1,185	25	6,003	0.00	4,818	1,185	6,003	0	3.2	4,973	1,223	6,196
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		59,902	18,694		78,596		59,902	18,694	78,596	0		61,831	19,295	81,126
1	LANDS & DAMAGES, Admin. (1		666	99	15	765	0.00	666	99	765	0	3.9	692	103	795
1	LANDS & DAMAGES, Real Estate		1,792	520	29	2,312	0.00	1,792	520	2,312	0	1.5	1,819	528	2,347
30	PLAN/ENGINEERING/DESIGN		12,946	1,217		14,163		12,946	1,217	14,163	3,961		13,536	1,297	14,833
	FEDERAL	A	9,597	1,217	14	10,814	0.00	9,597	1,217	10,814	612	5.2	10,187	1,297	11,484
	NON-FEDERAL - Section 104	A	3,349	0		3,349	0.00	3,349	0	3,349	3,349	0	3,349	0	3,349
31	CONSTRUCTION MANAGE'MT		4,792	1,496	31	6,288	0.00	4,792	1,496	6,288	0	7.7	5,163	1,612	6,775
	TOTAL FEDERAL COSTS		**$80,099**	**$22,026**		**$102,124**		**$80,099**	**$22,026**	**$102,124**	**$3,961**		**$83,041**	**$22,835**	**$105,876**
	NON-FEDERAL COSTS														
1	LANDS AND DAMAGES		23,347	5,612	24	28,959	0.00	23,347	5,612	28,959	417	1.5	23,693	5,696	29,389
2	RELOCATIONS		10,851	2,757	25	13,608	0.00	10,851	2,757	13,608	0	3.2	11,200	2,846	14,046
	SECTION 104		3,349	0		3,349		3,349	0	3,349	3,349		3,349	0	3,349
	30 PED Section 104	C	3,349	0		3,349		3,349	0	3,349	3,349	0	3,349	0	3,349
30	PLAN/ENGINEERING/DESIGN		1,631	414	25	2,045	0.00	1,631	414	2,045	3	2.8	1,677	425	2,102
31	CONSTRUCTION MANAGE'MT		868	221	25	1,089	0.00	868	221	1,089	0	3.2	896	228	1,124

****CONTRACT COST SUMMARY(CONT'D)****

Current MCACES Estimate Prepared: 16-Aug-2010
Effective Price Level (EPL): 1-Oct-2010

ACCOUNT NO.	FEATURE DESCRIPTION		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED ESTIMATE... SUNK COST ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.															
			Contingency Applied To Remaining Cost Only										Sunk Cost Price Level (EPL): 1-Oct-2010		
TOTAL NON-FEDERAL COSTS			$40,046	$9,004		$49,050		$40,046	$9,004	$49,050	$3,769		$40,815	$9,195	$50,010
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach A			$116,795	$31,030		$147,825		$116,795	$31,030	$147,825	$4,381		$120,507	$32,030	$152,537
Reach B															
FEDERAL COSTS															
6 FISH & WILDLIFE FACILITIES			1,862	15		1,877		1,862	15	1,877	164		1,922	15	1,937
FEDERAL	6		1,635	0		1,635	0.00	1,635	0	1,635	0	3.6	1,694	0	1,694
NON-FEDERAL - Section 104	6		227	15	24	242	0.00	227	15	242	164	0.4	228	15	243
11 LEVEES & FLOODWALLS			63,286	9,998		73,284		63,286	9,998	73,284	23,163		64,320	10,248	74,568
FEDERAL	11		20,245	4,832	24	25,077	0.00	20,245	4,832	25,077	0	4.3	21,115	5,040	26,155
NON-FEDERAL - Section 104	11		43,041	5,166	26	48,207	0.00	43,041	5,166	48,207	23,163	0.4	43,205	5,208	48,413
13 PUMPING PLANT			13,840	3,375	24	17,215	0.00	13,840	3,375	17,215	0	4	14,400	3,512	17,912
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS			78,988	13,388		92,376		78,988	13,388	92,376	23,327		80,642	13,775	94,417
1 LANDS & DAMAGES, Admin.	(1		821	124	15	945	0.00	821	124	945	0	7.6	884	133	1,017
1 LANDS & DAMAGES, Real Estate			4,147	1,701	41	5,848	0.00	4,147	1,701	5,848	0	3.2	4,278	1,755	6,033
30 PLAN/ENGINEERING/DESIGN			43,088	915		44,003		43,088	915	44,003	34,283		43,538	958	44,497
FEDERAL	A		8,347	647	9	8,994	0.00	8,347	647	8,994	1,530	6.5	8,787	689	9,476
NON-FEDERAL - Section 104	A		34,741	268	13	35,009	0.00	34,741	268	35,009	32,753	0	34,751	270	35,021
31 CONSTRUCTION MANAGEMT			41,108	1,074		42,182		41,108	1,074	42,182	36,773		41,394	1,142	42,536
FEDERAL	A		2,727	656	24	3,383	0.00	2,727	656	3,383	0	10	2,999	721	3,720
NON-FEDERAL - Section 104	A		38,381	418	26	38,799	0.00	38,381	418	38,799	36,773	0	38,395	421	38,816
TOTAL FEDERAL COSTS			$168,152	$17,202		$185,354		$168,152	$17,202	$185,354	$84,383		$170,736	$17,764	$188,500
NON-FEDERAL COSTS															
1 LANDS AND DAMAGES			40,931	14,146	38	55,077	0.00	40,931	14,146	55,077	3,503	3	42,114	14,592	56,706
2 RELOCATIONS			19,164	3,745	24	22,909	0.00	19,164	3,745	22,909	3,577	3.4	19,795	3,897	23,692
SECTION 104			116,390	5,867		122,257		116,390	5,867	122,257	92,853		116,579	5,914	122,493
06 Fish and Wild Life	C		227	15	24	242		227	15	242	164	0.4	228	15	243
11 Levee and Floodwall	C		43,041	5,166	26	48,207		43,041	5,166	48,207	23,163	0.4	43,205	5,208	48,413
30 PED			34,741	268	13	35,009		34,741	268	35,009	32,753		34,751	270	35,021
31 CM			38,381	418	26	38,799		38,381	418	38,799	36,773		38,395	421	38,816
30 PLAN/ENGINEERING/DESIGN			4,521	104	24	4,625	0.00	4,521	104	4,625	4,090	0.3	4,634	105	4,740
31 CONSTRUCTION MANAGEMT			760	56	24	816	0.00	760	56	816	530	0.2	762	56	818
TOTAL NON-FEDERAL COSTS			$181,766	$23,918		$205,684		$181,766	$23,918	$205,684	$104,553		$183,784	$24,565	$208,349
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach B			$233,528	$35,253		$268,781		$233,528	$35,253	$268,781	$106,083		$237,941	$36,415	$274,356
Reach C															
FEDERAL COSTS															
6 FISH & WILDLIFE FACILITIES			1,926	0		1,926		1,926	0	1,926	1,701		1,926	0	1,926
FEDERAL	6		225	0	0	225	0.00	225	0	225	0	0	225	0	225
NON-FEDERAL - Section 104	6		1,701	0		1,701	0.00	1,701	0	1,701	1,701	0	1,701	0	1,701
11 LEVEES & FLOODWALLS			21,972	257		22,229		21,972	257	22,229	21,321		22,034	281	22,315
FEDERAL	11		651	257	39	908	0.00	651	257	908	0	9.5	713	281	994
NON-FEDERAL - Section 104	11		21,321	0		21,321	0.00	21,321	0	21,321	21,321	0	21,321	0	21,321
13 PUMPING PLANT			15,066	6,430	43	21,496	0.00	15,066	6,430	21,496	0	9.5	16,493	7,039	23,532
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS			38,964	6,687		45,651		38,964	6,687	45,651	23,022		40,453	7,320	47,773
1 LANDS & DAMAGES, Admin.	(1		256	39	15	295	0.00	256	39	295	0	22	314	47	361
1 LANDS & DAMAGES, Real Estate			709	318	45	1,027	0.00	709	318	1,027	0	8.5	769	345	1,114
30 PLAN/ENGINEERING/DESIGN			26,040	327		26,367		26,040	327	26,367	23,682		26,540	396	26,936
FEDERAL	A		3,163	327	14	3,490	0.00	3,163	327	3,490	805	16	3,663	396	4,059
NON FEDERAL - Section 104	A		22,877	0		22,877	0.00	22,877	0	22,877	22,877	0	22,877	0	22,877
31 CONSTRUCTION MANAGEMT			37,818	535		38,353		37,818	535	38,353	36,561		38,135	670	38,805
FEDERAL	A		1,257	535	43	1,792	0.00	1,257	535	1,792	0	25	1,574	670	2,244
NON FEDERAL - Section 104	A		36,561	0		36,561	0.00	36,561	0	36,561	36,561	0	36,561	0	36,561
TOTAL FEDERAL COSTS			$103,787	$7,906		$111,693		$103,787	$7,906	$111,693	$83,265		$106,211	$8,778	$114,989
NON-FEDERAL COSTS															
1 LANDS AND DAMAGES			11,207	3,974	43	15,181	0.00	11,207	3,974	15,181	1,998	7.4	11,991	4,312	16,303
2 RELOCATIONS			9,625	2,565	47	12,190	0.00	9,625	2,565	12,190	4,132	6.3	10,145	2,808	12,953
SECTION 104			82,460	0		82,460		82,460	0	82,460	82,460		82,460	0	82,460

****CONTRACT COST SUMMARY(CONT'D)****															
Current MCACES Estimate Prepared: 16-Aug-2010						AUTHORIZE/BUDGET				.....FULLY FUNDED ESTIMATE... (3.....					
Effective Price Level (EPL): 1-Oct-2010						PRICE LEVEL: 1-Oct-2010				SUNK					FULLY
ACCOUNT NO. FEATURE DESCRIPTION		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)		FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.															
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2010					
06 Fish and Wild Life	C	1,701	0		1,701		1,701	0	1,701	1,701	0	1,701	0		1,701
11 Levee and Floodwall		21,321	0		21,321		21,321	0	21,321	21,321		21,321	0		21,321
30 PED		22,877	0		22,877		22,877	0	22,877	22,877		22,877	0		22,877
31 CM		36,561	0		36,561		36,561	0	36,561	36,561		36,561	0		36,561
30 PLAN/ENGINEERING/DESIGN		4,555	308	47	4,863	0.00	4,555	308	4,863	3,896	1.6	4,608	333		4,941
31 CONSTRUCTION MANAGEMT		470	205	47	675	0.00	470	205	675	30	9	512	224		736
TOTAL NON-FEDERAL COSTS		$108,317	$7,052		$115,369		$108,317	$7,052	$115,369	$92,516		$109,716	$7,677		$117,393
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach C		$129,644	$14,958		$144,602		$129,644	$14,958	$144,602	$93,321		$133,467	$15,455		$148,922
Reach D															
FEDERAL COSTS															
11 LEVEES & FLOODWALLS		37,232	989		38,221		37,232	989	38,221	34,967		37,449	1,083		38,532
FEDERAL	11	2,265	989	44	3,254	0.00	2,265	989	3,254	0	9.6	2,482	1,083		3,565
NON FEDERAL - Section 104	11	34,967	0		34,967	0.00	34,967	0	34,967	34,967	0	34,967	0		34,967
13 PUMPING PLANT		2,820	1,387	49	4,207	0.00	2,820	1,387	4,207	0	9.6	3,089	1,520		4,609
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		40,052	2,376		42,428		40,052	2,376	42,428	34,967		40,538	2,603		43,141
1 LANDS & DAMAGES, Admin. (1		85	13	15	98	0.00	85	13	98	0	22	104	16		120
1 LANDS & DAMAGES, Real Estate		1,580	932	59	2,512	0.00	1,580	932	2,512	0	8.5	1,714	1,012		2,726
30 PLAN/ENGINEERING/DESIGN		10,705	141		10,846		10,705	141	10,846	9,638		10,923	172		11,095
FEDERAL	A	1,903	141	14	2,044	0.00	1,903	141	2,044	836	12	2,121	172		2,293
NON FEDERAL - Section 104	A	8,802	0		8,802	0.00	8,802	0	8,802	8,802	0	8,802	0		8,802
31 CONSTRUCTION MANAGEMT		47,924	190		48,114		47,924	190	48,114	47,517		48,028	238		48,266
FEDERAL	A	407	190	47	597	0.00	407	190	597	0	25	511	238		749
NON FEDERAL - Section 104	A	47,517	0		47,517	0.00	47,517	0	47,517	47,517	0	47,517	0		47,517
TOTAL FEDERAL COSTS		$100,346	$3,652		$103,998		$100,346	$3,652	$103,998	$92,172		$101,307	$4,041		$105,348
NON-FEDERAL COSTS															
1 LANDS AND DAMAGES		3,633	1,532	59	5,165	0.00	3,633	1,532	5,165	1,021	6.8	3,856	1,662		5,518
2 RELOCATIONS		8,903	3,420	45	12,323	0.00	8,903	3,420	12,323	1,357	8.5	9,624	3,748		13,372
SECTION 104		91,286	0		91,286		91,286	0	91,286	91,286		91,286	0		91,286
11 Levee and Floodwall	C	34,967	0		34,967		34,967	0	34,967	34,967	0	34,967	0		34,967
30 PED		8,802	0		8,802		8,802	0	8,802	8,802		8,802	0		8,802
31 CM		47,517	0		47,517		47,517	0	47,517	47,517		47,517	0		47,517
30 PLAN/ENGINEERING/DESIGN		1,080	366	45	1,446	0.00	1,080	366	1,446	272	5	1,130	389		1,519
31 CONSTRUCTION MANAGEMT		538	244	45	782	0.00	538	244	782	0	9.6	590	267		857
TOTAL NON-FEDERAL COSTS		$105,440	$5,562		$111,002		$105,440	$5,562	$111,002	$93,936		$106,486	$6,066		$112,552
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach D		$114,500	$9,214		$123,714		$114,500	$9,214	$123,714	$94,822		$116,507	$10,107		$126,614
Reach E															
FEDERAL COSTS															
6 FISH & WILDLIFE FACILITIES		4,907	1,810	37	6,717	0.00	4,907	1,810	6,717	0	7.7	5,283	1,950		7,233
11 LEVEES & FLOODWALLS		30,569	11,738	38	42,307	0.00	30,569	11,738	42,307	0	7.7	32,916	12,640		45,556
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		35,476	13,548		49,024		35,476	13,548	49,024	0		38,199	14,590		52,789
1 LANDS & DAMAGES, Admin. (1		346	51	15	397	0.00	346	51	397	0	17	405	60		465
1 LANDS & DAMAGES, Real Estate		790	284	36	1,074	0.00	790	284	1,074	0	6.7	843	303		1,146
30 PLAN/ENGINEERING/DESIGN		8,239	810		9,049		8,239	810	9,049	3,982		8,928	942		9,870
FEDERAL	A	4,789	810	19	5,599	0.00	4,789	810	5,599	532	15	6,478	942		6,420
NON-FEDERAL - Section 104	A	3,450	0		3,450	0.00	3,450	0	3,450	3,450	0	3,450	0		3,450
31 CONSTRUCTION MANAGEMT		2,838	1,084	38	3,922	0.00	2,838	1,084	3,922	0	20	3,407	1,301		4,708
TOTAL FEDERAL COSTS		$47,689	$15,777		$63,466		$47,689	$15,777	$63,466	$3,982		$51,782	$17,196		$68,979
NON-FEDERAL COSTS															
1 LANDS AND DAMAGES		25,076	8,175	33	33,251	0.00	25,076	8,175	33,251	378	6.6	26,730	8,722		35,452
2 RELOCATIONS		7,801	3,150	40	10,951	0.00	7,801	3,150	10,951	0	7.7	8,400	3,392		11,792
SECTION 104		3,450	0		3,450		3,450	0	3,450	3,450		3,450	0		3,450
30 PED	C	3,450	0		3,450		3,450	0	3,450	3,450	0	3,450	0		3,450
30 PLAN/ENGINEERING/DESIGN		1,170	473	40	1,643	0.00	1,170	473	1,643	0	6.3	1,244	503		1,747

******CONTRACT COST SUMMARY(CONT'D)******

Current MCACES Estimate Prepared: 16-Aug-2010 Effective Price Level (EPL): 1-Oct-2010 ACCOUNT NO. FEATURE DESCRIPTION		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED ESTIMATE... SUNK COST ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.														
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2010				
31 CONSTRUCTION MANAGE'MT		624	252	40	876	0.00	624	252	876	0	7.6	672	271	943
TOTAL NON-FEDERAL COSTS		$38,121	$12,050		$50,171		$38,121	$12,050	$50,171	$3,828		$40,496	$12,888	$53,384
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach E		$82,360	$27,827		$110,187		$82,360	$27,827	$110,187	$4,360		$88,828	$30,084	$118,912
Reach F														
FEDERAL COSTS														
11 LEVEES & FLOODWALLS		35,245	11,261	32	46,506	0.00	35,245	11,261	46,506	0	5.8	37,296	11,916	49,212
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		35,245	11,261		46,506		35,245	11,261	46,506	0		37,296	11,916	49,212
1 LANDS & DAMAGES, Admin. (1		279	42	15	321	0.00	279	42	321	0	12	314	47	361
30 PLAN/ENGINEERING/DESIGN		6,969	577		7,546		6,969	577	7,546	2,740		7,440	642	8,082
FEDERAL	A	4,229	577	14	4,806	0.00	4,229	577	4,806	0	11	4,700	642	5,342
NON-FEDERAL - Section 104	A	2,740	0		2,740	0.00	2,740	0	2,740	2,740	0	2,740	0	2,740
31 CONSTRUCTION MANAGE'MT		2,820	901	32	3,721	0.00	2,820	901	3,721	0	15	3,238	1,034	4,272
TOTAL FEDERAL COSTS		$45,313	$12,781		$58,094		$45,313	$12,781	$58,094	$2,740		$48,288	$13,639	$61,927
NON-FEDERAL COSTS														
1 LANDS AND DAMAGES		9,220	4,547	50	13,767	0.00	9,220	4,547	13,767	99	4.9	9,667	4,771	14,438
2 RELOCATIONS		9,006	2,939	33	11,945	0.00	9,006	2,939	11,945	0	5.8	9,530	3,110	12,640
SECTION 104		2,740	0		2,740		2,740	0	2,740	2,740		2,740	0	2,740
30 PED	C	2,740	0		2,740		2,740	0	2,740	2,740	0	2,740	0	2,740
30 PLAN/ENGINEERING/DESIGN		1,081	352	33	1,433	0.00	1,081	352	1,433	0	4.5	1,129	368	1,497
31 CONSTRUCTION MANAGE'MT		721	235	33	956	0.00	721	235	956	0	5.9	764	248	1,012
TOTAL NON-FEDERAL COSTS		$22,768	$8,073		$30,841		$22,768	$8,073	$30,841	$2,839		$23,830	$8,497	$32,327
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach F		$65,341	$20,854		$86,195		$65,341	$20,854	$86,195	$2,839		$59,378	$22,136	$81,514
Reach G														
FEDERAL COSTS														
11 LEVEES & FLOODWALLS		25,543	9,472	37	35,015	0.00	25,543	9,472	35,015	0	7.6	27,485	10,191	37,676
13 PUMPING PLANT		2,078	745	36	2,823	0.00	2,078	745	2,823	0	7.6	2,236	802	3,038
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		27,621	10,217		37,838		27,621	10,217	37,838	0		29,721	10,993	40,714
1 LANDS & DAMAGES, Admin. (1		210	31	15	241	0.00	210	31	241	0	17	246	37	283
30 PLAN/ENGINEERING/DESIGN		3,065	428	14	3,493	0.00	3,065	428	3,493	0	16	3,555	496	4,051
31 CONSTRUCTION MANAGE'MT		2,043	756	37	2,799	0.00	2,043	756	2,799	0	20	2,448	906	3,354
TOTAL FEDERAL COSTS		$32,939	$11,432		$44,371		$32,939	$11,432	$44,371	$0		$35,970	$12,432	$48,402
NON-FEDERAL COSTS														
1 LANDS AND DAMAGES		13,118	5,222	40	18,340	0.00	13,118	5,222	18,340	0	5.7	13,996	5,572	19,568
2 RELOCATIONS		7,795	2,881	37	10,676	0.00	7,795	2,881	10,676	0	7.6	8,387	3,100	11,487
30 PLAN/ENGINEERING/DESIGN		1,177	432	37	1,609	0.00	1,177	432	1,609	8	6.2	1,250	459	1,709
31 CONSTRUCTION MANAGE'MT		779	289	37	1,068	0.00	779	289	1,068	0	7.6	838	311	1,149
TOTAL NON-FEDERAL COSTS		$22,869	$8,824		$31,693		$22,869	$8,824	$31,693	$8		$24,471	$9,442	$33,913
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach G		$55,808	$20,256		$76,064		$55,808	$20,256	$76,064	$8		$60,441	$21,874	$82,315
Reach H														
FEDERAL COSTS														
6 FISH & WILDLIFE FACILITIES		6,480	1,869	29	8,349	0.00	6,480	1,869	8,349	0	5.9	6,865	1,980	8,845
11 LEVEES & FLOODWALLS		30,435	9,966	33	40,401	0.00	30,435	9,966	40,401	0	5.9	32,242	10,558	42,800
13 PUMPING PLANT		2,227	654	29	2,881	0.00	2,227	654	2,881	0	5.9	2,359	693	3,052
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		39,142	12,489		51,631		39,142	12,489	51,631	0		41,466	13,231	54,697
1 LANDS & DAMAGES, Admin. (1		785	117	15	902	0.00	785	117	902	0	12	882	131	1,013
1 LANDS & DAMAGES, Real Estate		1,283	309	24	1,592	0.00	1,283	309	1,592	0	4.9	1,346	324	1,670

****CONTRACT COST SUMMARY(CONT'D)****

Current MCACES Estimate Prepared: 16-Aug-2010 Effective Price Level (EPL): 1-Oct-2010 ACCOUNT NO. FEATURE DESCRIPTION		AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	....FULLY FUNDED ESTIMATE.... (3 SUNK COST ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.														
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2010				
30 PLAN/ENGINEERING/DESIGN		8,845	637		9,482		8,845	637	9,482	4,148		9,384	710	10,094
FEDERAL	A	5,422	637	14	6,059	0.00	5,422	637	6,059	725	10	5,961	710	6,671
NON-FEDERAL - Section 104	A	3,423	0		3,423	0.00	3,423	0	3,423	3,423	0	3,423	0	3,423
31 CONSTRUCTION MANAGEMT		3,131	1,000	32	4,131	0.00	3,131	1,000	4,131	0	15	3,604	1,152	4,756
TOTAL FEDERAL COSTS		$53,186	$14,552		$67,738		$53,186	$14,552	$67,738	$4,148		$56,682	$15,548	$72,230
NON-FEDERAL COSTS														
1 LANDS AND DAMAGES		26,842	5,363	20	32,005	0.00	26,842	5,363	32,005	215	4.9	27,940	5,626	33,566
2 RELOCATIONS		9,537	3,459	36	12,996	0.00	9,537	3,459	12,996	0	5.9	10,103	3,665	13,768
SECTION 104		3,423	0		3,423		3,423	0	3,423	3,423		3,423	0	3,423
30 PED	C	3,423	0		3,423		3,423	0	3,423	3,423	0	3,423	0	3,423
30 PLAN/ENGINEERING/DESIGN		1,149	415	36	1,564	0.00	1,149	415	1,564	5	4.6	1,202	434	1,636
31 CONSTRUCTION MANAGEMT		763	277	36	1,040	0.00	763	277	1,040	0	6	809	293	1,102
TOTAL NON-FEDERAL COSTS		$41,514	$9,514		$51,028		$41,514	$9,514	$51,028	$3,643		$43,477	$10,018	$53,495
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach H		$91,277	$24,066		$115,343		$91,277	$24,066	$115,343	$4,366		$98,736	$25,566	$122,302
Reach I														
FEDERAL COSTS														
11 LEVEES & FLOODWALLS		13,859	3,668	26	17,527	0.00	13,859	3,668	17,527	0	4	14,417	3,816	18,233
13 PUMPING PLANT		1,195	315	26	1,510	0.00	1,195	315	1,510	0	4	1,243	328	1,571
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		15,054	3,983		19,037		15,054	3,983	19,037	0		15,660	4,144	19,804
1 LANDS & DAMAGES, Admin. (1		142	21	15	163	0.00	142	21	163	0	7.4	152	23	175
30 PLAN/ENGINEERING/DESIGN		3,910	238		4,148		3,910	238	4,148	2,104		4,026	253	4,279
FEDERAL	A	1,806	238	13	2,044	0.00	1,806	238	2,044	0	6.4	1,922	253	2,175
NON-FEDERAL - Section 104	A	2,104	0		2,104	0.00	2,104	0	2,104	2,104	0	2,104	0	2,104
31 CONSTRUCTION MANAGEMT		1,204	319	26	1,523	0.00	1,204	319	1,523	0	9.8	1,323	351	1,674
TOTAL FEDERAL COSTS		$20,310	$4,561		$24,871		$20,310	$4,561	$24,871	$2,104		$21,181	$4,771	$25,932
NON-FEDERAL COSTS														
1 LANDS AND DAMAGES		2,257	1,336	83	3,593	0.00	2,257	1,336	3,593	141	3	2,324	1,378	3,702
2 RELOCATIONS		2,501	667	27	3,168	0.00	2,501	667	3,168	0	4	2,602	694	3,296
SECTION 104		2,104	0		2,104		2,104	0	2,104	2,104		2,104	0	2,104
30 PED	C	2,104	0		2,104		2,104	0	2,104	2,104	0	2,104	0	2,104
30 PLAN/ENGINEERING/DESIGN		306	80	27	386	0.00	306	80	386	8	2.6	314	82	396
31 CONSTRUCTION MANAGEMT		200	53	27	253	0.00	200	53	253	0	4	207	56	263
TOTAL NON-FEDERAL COSTS		$7,368	$2,136		$9,504		$7,368	$2,136	$9,504	$2,251		$7,551	$2,210	$9,761
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach I		$25,574	$6,697		$32,271		$25,574	$6,697	$32,271	$2,251		$28,608	$6,981	$33,589

GENERAL NOTES

(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.
(2 Federal administrative costs for non-Federal land acquisition.
(3 The Fully Funded cost estimate was prepared in compliance with OMB INDEXES EC-11-2-199, published on MAR. 31, 2010.
(4 01 Account for Land and Damages cost are from Real Estates.
(5 Fully Funded Estimate was supported using Project Cost Estimate (PCE) spreadsheet.
(6 30 Account Planning, Engineering and Design and 31 Account Construction Management cost was provided by its respective organizations.
(7 Federal 30 Account Planning, Engineering sunk cost to date is $5,090,000.
(8 Section 104 Sunk cost to date is $307,343,000.
(9 Tota Sunk Cost to date is $312,433,000

CONTINGENCY RATIONALE

(A CONTINGENCIES USED WAS DERIVED BY THE COST RISK ANALYSIS PROCESS AND IS BASED ON A 80% CONFIDENCE LEVEL.
NED RISK DATA WAS ABSTRACTED FROM THE LPP RISK MODEL. IT WAS ASSUMED THAT THE ANY RISK ASSOCIATED WITH THE LPP PLAN WOULD BE SIMILAIR TO THE NED PLAN.

CHIEF, COST ENGINEERING

PROJECT MANAGER

CHIEF, REAL ESTATE

The estimate was prepared in accordance with current guidance. The estimate has undergone an independent technical review, and that all issues that may have been identified in the independent technical review have been resolved.

****TOTAL PROJECT COST SUMMARY**** 8/26/2010

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE POST AUTHORIZATION CHANGE REPORT, LPP PLAN
PROJECT: NATOMAS PACR — U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
LOCATION: CALIFORNIA — P.O.C.: JOE W. YEE, CHIEF, COST ENGINEERING SECTION

Current MCACES Estimate Prepared: 16-Aug-2010
Effective Price Level (EPL): 1-Oct-2010

ACCOUNT NO.	FEATURE DESCRIPTION		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 COST ($K)	CNTG ($K)	TOTAL ($K)	SUNK COST ($K)	OMB MIDPT(%)	FULLY FUNDED ESTIMATE... (3..... COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.															
			Contingency Applied To Remaining Cost Only										Sunk Cost Price Level (EPL): 1-Oct-2010		
Total															
	FEDERAL COSTS														
6	FISH & WILDLIFE FACILITIES		15,175	3,694		18,869		15,175	3,694	18,869	1,865		15,996	3,945	19,941
	Reach B		1,862	15	1	1,877		1,862	15	1,877	164		1,922	15	1,937
	Reach C		1,926	0	0	1,926		1,926	0	1,926	1,701		1,926	0	1,926
	Reach E		4,907	1,810	37	6,717		4,907	1,810	6,717	0		5,283	1,950	7,233
	Reach H		6,480	1,869	29	8,349		6,480	1,869	8,349	0		6,865	1,980	8,845
11	LEVEES & FLOODWALLS		338,254	79,096		417,350		338,254	79,096	417,350	90,921		350,477	83,211	433,688
	Reach A	11	55,084	17,509	32	72,593		55,084	17,509	72,593	0		56,858	18,072	74,930
	Reach B		74,105	11,997	25	86,102		74,105	11,997	86,102	26,288		75,147	12,250	87,397
	Reach C		25,943	257	39	26,200		25,943	257	26,200	25,292		26,005	281	26,286
	Reach D		41,814	1,080	44	42,894		41,814	1,080	42,894	39,341		42,050	1,184	43,234
	Reach E		33,402	12,879	39	46,281		33,402	12,879	46,281	0		35,967	13,868	49,835
	Reach F		36,823	11,766	32	48,589		36,823	11,766	48,589	0		38,966	12,450	51,416
	Reach G		26,789	9,974	37	36,763		26,789	9,974	36,763	0		28,825	10,732	39,557
	Reach H		30,435	9,966	33	40,401		30,435	9,966	40,401	0		32,242	10,558	42,800
	Reach I		13,859	3,668	26	17,527		13,859	3,668	17,527	0		14,417	3,816	18,233
13	PUMPING PLANT		42,044	14,091		56,135		42,044	14,091	56,135	0		44,793	15,117	59,910
	Reach A	13	4,818	1,185	25	6,003		4,818	1,185	6,003	0		4,973	1,223	6,196
	Reach B		13,840	3,375	24	17,215		13,840	3,375	17,215	0		14,400	3,512	17,912
	Reach C		15,066	6,430	43	21,496		15,066	6,430	21,496	0		16,493	7,039	23,532
	Reach D		2,820	1,387	49	4,207		2,820	1,387	4,207	0		3,089	1,520	4,609
	Reach G		2,078	745	36	2,823		2,078	745	2,823	0		2,236	802	3,038
	Reach H		2,227	654	29	2,881		2,227	654	2,881	0		2,359	693	3,052
	Reach I		1,195	315	26	1,510		1,195	315	1,510	0		1,243	328	1,571
18	CULT. RESRC. PRESERV. (1		5,660	918		6,578		5,660	918	6,578			5,885	954	6,839
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		401,133	97,799		498,932		401,133	97,799	498,932	92,786		417,151	103,227	520,378
1	LANDS & DAMAGES, Admin (2		3,590	537		4,127		3,590	537	4,127	0		3,993	597	4,590
	Reach A	A	666	99	15	765		666	99	765	0		692	103	795
	Reach B		821	124	15	945		821	124	945	0		884	133	1,017
	Reach C		256	39	15	295		256	39	295	0		314	47	361
	Reach D		85	13	15	98		85	13	98	0		104	16	120
	Reach E		346	51	15	397		346	51	397	0		405	60	465
	Reach F		279	42	15	321		279	42	321	0		314	47	361
	Reach G		210	31	15	241		210	31	241	0		246	37	283
	Reach H		785	117	15	902		785	117	902	0		882	131	1,013
	Reach I		142	21	15	163		142	21	163	0		152	23	175
1	LANDS & DAMAGES, Real Estate		10,301	4,064		14,365		10,301	4,064	14,365	0		10,769	4,267	15,036
	Reach A	C	1,792	520	29	2,312		1,792	520	2,312	0		1,819	528	2,347
	Reach B		4,147	1,701	41	5,848		4,147	1,701	5,848	0		4,278	1,755	6,033
	Reach C		709	318	45	1,027		709	318	1,027	0		769	345	1,114
	Reach D		1,580	932	59	2,512		1,580	932	2,512	0		1,714	1,012	2,726
	Reach E		790	284	36	1,074		790	284	1,074	0		843	303	1,146
	Reach H		1,283	309	24	1,592		1,283	309	1,592	0		1,346	324	1,670
30	PLAN/ENGINEERING/DESIGN		125,320	5,514		130,834		125,320	5,514	130,834	84,588		129,501	6,106	135,607
	Reach A	A	12,946	1,217	14	14,163		12,946	1,217	14,163	3,961		13,536	1,297	14,833
	Reach B		43,880	1,022	11	44,902		43,880	1,022	44,902	34,283		44,335	1,066	45,401
	Reach C		26,040	327	14	26,367		26,040	327	26,367	23,682		26,540	396	26,936
	Reach D		10,746	148	14	10,894		10,746	148	10,894	9,688		10,973	180	11,153
	Reach E		8,579	874	19	9,453		8,579	874	9,453	3,982		9,325	1,015	10,340
	Reach F		7,159	602	14	7,761		7,159	602	7,761	2,740		7,652	669	8,321
	Reach G		3,215	449	14	3,664		3,215	449	3,664	0		3,730	520	4,250
	Reach H		8,845	637	14	9,482		8,845	637	9,482	4,148		9,384	710	10,094
	Reach I		3,910	238	13	4,148		3,910	238	4,148	2,104		4,026	253	4,279
31	CONSTRUCTION MANAGE'MT		144,745	7,689		152,434		144,745	7,689	152,434	120,851		147,897	8,778	156,675
	Reach A	A	4,792	1,496	31	6,288		4,792	1,496	6,288	0		5,163	1,612	6,775
	Reach B		41,706	1,229	25	42,935		41,706	1,229	42,935	36,773		41,996	1,299	43,295
	Reach C		37,818	535	43	38,353		37,818	535	38,353	36,561		38,135	670	38,805
	Reach D		47,940	198	47	48,138		47,940	198	48,138	47,517		48,047	249	48,296
	Reach E		3,065	1,175	38	4,240		3,065	1,175	4,240	0		3,680	1,410	5,090
	Reach F		2,946	941	32	3,887		2,946	941	3,887	0		3,382	1,081	4,463
	Reach G		2,143	796	37	2,939		2,143	796	2,939	0		2,567	954	3,521
	Reach H		3,131	1,000	32	4,131		3,131	1,000	4,131	0		3,604	1,152	4,756
	Reach I		1,204	319	26	1,523		1,204	319	1,523	0		1,323	351	1,674
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		685,089	115,603		800,692		685,089	115,603	800,692	298,225		709,311	122,975	832,286
	NON-FEDERAL CONTRIBUTION(-)		73,350	14,333		87,683		73,350	14,333	87,683	14,547		75,769	15,114	90,883
	SECTION 104 (-) - NED		45,741	9,508		55,249		45,741	9,508	55,249	253,974		47,521	10,082	57,603
	TOTAL FEDERAL NED COSTS		**$565,998**	**$91,762**		**$657,760**		**$565,998**	**$91,762**	**$657,760**	**$29,704**		**$586,021**	**$97,779**	**$683,800**
	NON-FEDERAL COSTS														
1	LANDS AND DAMAGES		155,431	49,907		205,338		155,431	49,907	205,338	7,772		162,311	52,331	214,642
	Reach A	C	23,347	5,612	24	28,959		23,347	5,612	28,959	417		23,693	5,696	29,389
	Reach B		40,931	14,146	35	55,077		40,931	14,146	55,077	3,503		42,114	14,592	56,706
	Reach C		11,207	3,974	43	15,181		11,207	3,974	15,181	1,998		11,991	4,312	16,303
	Reach D		3,633	1,532	59	5,165		3,633	1,532	5,165	1,021		3,856	1,662	5,518

****CONTRACT COST SUMMARY(CONT'D)****

Current MCACES Estimate Prepared: 16-Aug-2010 Effective Price Level (EPL): 1-Oct-2010 ACCOUNT NO. FEATURE DESCRIPTION		Contingency Applied To Remaining Cost Only COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE... (3..... SUNK COST ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.										Sunk Cost Price Level (EPL): 1-Oct-2010				
Reach E		25,076	8,175	33	33,251		25,076	8,175	33,251	378		26,730	8,722	35,452
Reach F		9,220	4,547	50	13,767		9,220	4,547	13,767	99		9,667	4,771	14,438
Reach G		13,118	5,222	40	18,340		13,118	5,222	18,340	0		13,996	5,572	19,568
Reach H		26,642	5,363	20	32,005		26,642	5,363	32,005	215		27,940	5,626	33,566
Reach I		2,257	1,336	63	3,593		2,257	1,336	3,593	141		2,324	1,378	3,702
2 RELOCATIONS		98,315	29,385		127,700		98,315	29,385	127,700	11,724		103,589	31,316	134,905
Reach A	2	10,851	2,757	25	13,608		10,851	2,757	13,608	0		11,200	2,846	14,046
Reach B		21,796	4,322	24	26,118		21,796	4,322	26,118	3,809		22,525	4,497	27,022
Reach C		10,585	2,566	47	13,151		10,585	2,566	13,151	5,092		11,105	2,809	13,914
Reach D		10,369	3,531	47	13,900		10,369	3,531	13,900	2,823		11,091	3,869	14,960
Reach E		11,433	4,617	40	16,050		11,433	4,617	16,050	0		12,312	4,971	17,283
Reach F		11,584	3,835	33	15,419		11,584	3,835	15,419	0		12,256	4,058	16,316
Reach G		9,659	3,631	38	13,290		9,659	3,631	13,290	0		10,393	3,907	14,300
Reach H		9,537	3,459	36	12,996		9,537	3,459	12,996	0		10,103	3,665	13,768
Reach I		2,501	667	27	3,168		2,501	667	3,168	0		2,602	694	3,296
SECTION 104 - NED		305,202	5,867		311,069		305,202	5,867	311,069	281,665		305,391	5,914	311,305
30 PLAN/ENGINEERING/DESIGN		18,152	3,478		21,630		18,152	3,478	21,630	8,280		18,545	3,662	22,307
Reach A	2	1,631	414	25	2,045		1,631	414	2,045	3		1,677	425	2,102
Reach B		4,869	187	24	5,056		4,869	187	5,056	4,090		4,890	192	5,082
Reach C		4,555	308	47	4,863		4,555	308	4,863	3,896		4,608	333	4,941
Reach D		1,080	377	47	1,457		1,080	377	1,457	272		1,130	401	1,531
Reach E		1,715	693	40	2,408		1,715	693	2,408	0		1,824	736	2,560
Reach F		1,390	460	33	1,850		1,390	460	1,850	0		1,452	481	1,933
Reach G		1,457	544	38	2,001		1,457	544	2,001	8		1,548	578	2,126
Reach H		1,149	415	36	1,564		1,149	415	1,564	5		1,202	434	1,635
Reach I		306	80	27	386		306	80	386	6		314	82	396
31 CONSTRUCTION MANAGE'MT		6,593	2,147		8,740		6,593	2,147	8,740	560		6,968	2,292	9,260
Reach A	2	868	221	25	1,089		868	221	1,089	0		896	228	1,124
Reach B		946	100	24	1,046		946	100	1,046	530		949	101	1,050
Reach C		470	205	47	675		470	205	675	30		511	225	736
Reach D		538	252	47	790		538	252	790	0		590	276	866
Reach E		915	369	40	1,284		915	369	1,284	0		986	397	1,383
Reach F		927	307	33	1,234		927	307	1,234	0		981	325	1,306
Reach G		966	363	38	1,329		966	363	1,329	0		1,039	391	1,430
Reach H		763	277	36	1,040		763	277	1,040	0		809	293	1,102
Reach I		200	53	27	253		200	53	253	0		207	56	263
SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)		583,693	90,784		674,477		583,693	90,784	674,477	310,001		596,904	95,515	692,419
NON-FEDERAL CONTRIBUTION (+)		73,350	14,333		87,683		73,350	14,333	87,683	14,547		76,769	15,114	90,883
Non-Federal Contribution - NED		45,741	9,537		55,278		45,741	9,537	55,278	3,077		47,521	10,097	57,618
Additional Cost Above NED		27,609	4,796		32,405		27,609	4,796	32,405	11,470		28,248	5,017	33,265
SECTION 104 (-) - NED		259,461	(3,641)		255,820		259,461	(3,641)	255,820	27,691		257,870	(4,168)	253,702
TOTAL NON-FEDERAL COSTS		**$397,582**	**$108,758**		**$506,340**		**$397,582**	**$108,758**	**$506,340**	**$296,857**		**$414,803**	**$114,797**	**$529,600**
TOTAL FEDERAL AND NON-FEDERAL COSTS, Total		**$963,580**	**$200,520**		**$1,164,100**		**$963,580**	**$200,520**	**$1,164,100**	**$326,561**		**$1,000,824**	**$212,576**	**$1,213,400**
Reach A														
FEDERAL COSTS														
11 LEVEES & FLOODWALLS		55,084	17,509	32	72,593	0.00	55,084	17,509	72,593	0	3.2	56,858	18,072	74,930
13 PUMPING PLANT		4,818	1,185	25	6,003	0.00	4,818	1,185	6,003	0	3.2	4,973	1,223	6,196
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		59,902	18,694		78,596		59,902	18,694	78,596	0		61,831	19,295	81,126
1 LANDS & DAMAGES, Admin. (1		666	99	15	765	0.00	666	99	765	0	3.9	692	103	795
1 LANDS & DAMAGES, Real Estate		1,792	520	29	2,312	0.00	1,792	520	2,312	0	1.5	1,819	528	2,347
30 PLAN/ENGINEERING/DESIGN		12,946	1,217		14,163	0.00	12,946	1,217	14,163	3,961		13,536	1,297	14,833
FEDERAL	A	9,597	1,217	14	10,814	0.00	9,597	1,217	10,814	612	5.2	10,187	1,297	11,484
NON FEDERAL - Section 104	A	3,349	0		3,349	0.00	3,349	0	3,349	3,349	0	3,349	0	3,349
31 CONSTRUCTION MANAGE'MT		4,792	1,496	31	6,288	0.00	4,792	1,496	6,288	0	7.7	5,163	1,612	6,775
TOTAL FEDERAL NED COSTS		**$80,098**	**$22,026**		**$102,124**		**$80,098**	**$22,026**	**$102,124**	**$3,961**		**$83,041**	**$22,835**	**$105,876**
NON-FEDERAL COSTS														
1 LANDS AND DAMAGES		23,347	5,612	24	28,959	0.00	23,347	5,612	28,959	417	1.5	23,693	5,696	29,389
2 RELOCATIONS		10,851	2,757	25	13,608	0.00	10,851	2,757	13,608	0	3.2	11,200	2,846	14,046
SECTION 104 - NED		3,349	0		3,349		3,349	0	3,349	3,349		3,349	0	3,349
30 PLAN/ENGINEERING/DESIGN		1,631	414	25	2,045	0.00	1,631	414	2,045	3	2.8	1,677	425	2,102
31 CONSTRUCTION MANAGE'MT		868	221	25	1,089	0.00	868	221	1,089	0	3.2	896	228	1,124
TOTAL NON-FEDERAL COSTS		**$40,046**	**$9,004**		**$49,050**		**$40,046**	**$9,004**	**$49,050**	**$3,769**		**$40,815**	**$9,195**	**$50,010**
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach A		**$116,795**	**$31,030**		**$147,825**		**$116,795**	**$31,030**	**$147,825**	**$4,381**		**$120,507**	**$32,030**	**$152,537**

****CONTRACT COST SUMMARY(CONT'D)****

Current MCACES Estimate Prepared: 16-Aug-2010
Effective Price Level (EPL): 1-Oct-2010

ACCOUNT NO.	FEATURE DESCRIPTION		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED ESTIMATE... SUNK ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.															
			Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2010				
Reach B															
	FEDERAL COSTS														
6	FISH & WILDLIFE FACILITIES		1,862	15		1,877		1,862	15	1,877	164		1,922	15	1,937
	FEDERAL	6	1,635	0	0	1,635	0.00	1,635	0	1,635	0	3.6	1,694	0	1,694
	NON FEDERAL - Section 104	6	227	15	24	242	0.00	227	15	242	164	0.4	228	15	243
11	LEVEES & FLOODWALLS		74,105	11,997		86,102		74,105	11,997	86,102	26,288		76,147	12,250	87,397
	FEDERAL	11	20,245	4,832	24	25,077	0.00	20,245	4,832	25,077	0	4	21,060	5,026	26,086
	NON FEDERAL - Section 104	11	53,860	7,165	26	61,025	0.00	53,860	7,165	61,025	26,288	0.5	54,087	7,224	61,311
13	PUMPING PLANT		13,840	3,375	24	17,215	0.00	13,840	3,375	17,215	0	4	14,400	3,512	17,912
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		89,807	15,387		105,194		89,807	15,387	105,194	26,452		91,469	15,777	107,246
1	LANDS & DAMAGES, Admin. (1		821	124	15	945	0.00	821	124	945	0	7.6	884	133	1,017
1	LANDS & DAMAGES, Real Estate		4,147	1,701	41	5,848	0.00	4,147	1,701	5,848	0	3.2	4,278	1,755	6,033
30	PLAN/ENGINEERING/DESIGN		43,880	1,022		44,902		43,880	1,022	44,902	34,283		44,335	1,066	45,401
	FEDERAL	A	8,347	647	9	8,994	0.00	8,347	647	8,994	1,530	5.4	8,787	689	9,476
	NON FEDERAL - Section 104	A	35,533	375	13	35,908	0.00	35,533	375	35,908	32,753	0	35,548	377	35,925
31	CONSTRUCTION MANAGEMT		41,706	1,229		42,935		41,706	1,229	42,935	36,773		41,996	1,299	43,295
	FEDERAL	A	2,727	656	24	3,383	0.00	2,727	656	3,383	0	10	2,999	721	3,720
	NON FEDERAL - Section 104	A	38,979	573	26	39,552	0.00	38,979	573	39,552	36,773	0.1	38,997	578	39,575
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		180,361	19,463		199,824		180,361	19,463	199,824	97,508		182,962	20,030	202,992
	NON-FEDERAL CONTRIBUTION(-)		12,209	2,261		14,470		12,209	2,261	14,470	3,125		12,226	2,266	14,492
	TOTAL FEDERAL NED COSTS		**$168,152**	**$17,202**		**$185,354**		**$168,152**	**$17,202**	**$185,354**	**$94,383**		**$170,736**	**$17,764**	**$188,500**
	NON-FEDERAL COSTS														
1	LANDS AND DAMAGES		40,931	14,146	38	55,077	0.00	40,931	14,146	55,077	3,503	3	42,114	14,592	56,706
2	RELOCATIONS		21,796	4,322	24	26,118	0.00	21,796	4,322	26,118	3,809	3.5	22,525	4,497	27,022
	SECTION 104 - NED		116,390	5,867		122,257		116,390	5,867	122,257	92,853		116,579	5,914	122,493
30	PLAN/ENGINEERING/DESIGN		4,869	187	24	5,056	0.00	4,869	187	5,056	4,090	0.5	4,890	192	5,082
31	CONSTRUCTION MANAGEMT		946	100	24	1,046	0.00	946	100	1,046	530	0.4	949	101	1,050
	SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)		184,932	24,622		209,554		184,932	24,822	209,554	104,785		187,057	25,296	212,353
	NON-FEDERAL CONTRIBUTION (+)		12,209	2,261		14,470		12,209	2,261	14,470	3,125		12,226	2,266	14,492
	Additional Cost Above NED		12,209	2,261		14,470		12,209	2,261	14,470	3,125		12,226	2,266	14,492
	TOTAL NON-FEDERAL COSTS		**$197,141**	**$26,883**		**$224,024**		**$197,141**	**$26,883**	**$224,024**	**$107,910**		**$199,283**	**$27,562**	**$226,845**
	TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach B		**$248,903**	**$38,218**		**$287,121**		**$248,903**	**$39,218**	**$287,121**	**$109,440**		**$253,440**	**$39,412**	**$292,852**
Reach C															
	FEDERAL COSTS														
6	FISH & WILDLIFE FACILITIES		1,926	0		1,926		1,926	0	1,926	1,701		1,926	0	1,926
	FEDERAL	6	225	0	0	225	0.00	225	0	225	0	0	225	0	225
	NON FEDERAL - Section 104	6	1,701	0		1,701	0.00	1,701	0	1,701	1,701	0	1,701	0	1,701
11	LEVEES & FLOODWALLS		25,943	257		26,200		25,943	257	26,200	25,292		26,005	281	26,286
	FEDERAL	11	651	257	39	908	0.00	651	257	908	0	9.5	713	281	994
	NON FEDERAL - Section 104	11	25,292	0		25,292	0.00	25,292	0	25,292	25,292	0	25,292	0	25,292
13	PUMPING PLANT		15,066	6,430	43	21,496	0.00	15,066	6,430	21,496	0	9.5	16,493	7,039	23,532
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		42,935	6,687		49,622		42,935	6,687	49,622	26,993		44,424	7,320	51,744
1	LANDS & DAMAGES, Admin. (1		256	39	15	295	0.00	256	39	295	0	22	314	47	361
1	LANDS & DAMAGES, Real Estate		709	318	45	1,027	0.00	709	318	1,027	0	8.5	769	345	1,114
30	PLAN/ENGINEERING/DESIGN		26,040	327		26,367		26,040	327	26,367	23,682		26,540	396	26,936
	FEDERAL	A	3,163	327	14	3,490	0.00	3,163	327	3,490	805	16	3,563	396	4,059
	NON FEDERAL - Section 104	A	22,877	0		22,877	0.00	22,877	0	22,877	22,877	0	22,877	0	22,877
31	CONSTRUCTION MANAGEMT		37,818	535		38,353		37,818	535	38,353	36,561		38,135	670	38,805
	FEDERAL	A	1,257	535	43	1,792	0.00	1,257	535	1,792	0	25	1,574	670	2,244
	NON FEDERAL - Section 104	A	36,561	0		36,561	0.00	36,561	0	36,561	36,561	0	36,561	0	36,561
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		107,758	7,906		115,664		107,758	7,906	115,664	97,236		110,182	8,778	118,960
	NON-FEDERAL CONTRIBUTION(-)		3,971	0		3,971		3,971	0	3,971	3,971		3,971	0	3,971
	TOTAL FEDERAL NED COSTS		**$103,787**	**$7,906**		**$111,693**		**$103,787**	**$7,906**	**$111,693**	**$93,265**		**$106,211**	**$8,778**	**$114,989**

****CONTRACT COST SUMMARY(CONT'D)****															
Current MCACES Estimate Prepared: 16-Aug-2010 Effective Price Level (EPL): 1-Oct-2010						AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010				.....FULLY FUNDED ESTIMATE... (3.....					
ACCOUNT NO. FEATURE DESCRIPTION		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	SUNK COST ($K)	OMB MIDPT(%)		COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.															
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2010					
NON-FEDERAL COSTS															
1 LANDS AND DAMAGES		11,207	3,974	43	15,181	0.00	11,207	3,974	15,181	1,998	7.4		11,991	4,312	16,303
2 RELOCATIONS		10,585	2,566	47	13,151	0.00	10,585	2,566	13,151	5,092	5.8		11,105	2,809	13,914
SECTION 104 - NED		82,460	0		82,460		82,460	0	82,460	82,460			82,460	0	82,460
30 PLAN/ENGINEERING/DESIGN		4,555	308	47	4,863	0.00	4,555	308	4,863	3,898	1.6		4,608	333	4,941
31 CONSTRUCTION MANAGE'MT		470	205	47	675	0.00	470	205	675	30	9		511	225	736
SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)		109,277	7,053		116,330		109,277	7,053	116,330	93,478			110,675	7,679	118,354
NON-FEDERAL CONTRIBUTION (+) Additional Cost Above NED		3,971 3,971	0 0		3,971 3,971		3,971 3,971	0 0	3,971 3,971	3,971 3,971			3,971 3,971	0 0	3,971 3,971
TOTAL NON-FEDERAL COSTS		**$113,248**	**$7,053**		**$120,301**		**$113,248**	**$7,053**	**$120,301**	**$97,447**			**$114,646**	**$7,679**	**$122,325**
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach C		**$134,575**	**$14,959**		**$149,534**		**$134,575**	**$14,959**	**$149,534**	**$98,252**			**$138,397**	**$16,457**	**$154,854**
Reach D															
FEDERAL COSTS															
11 LEVEES & FLOODWALLS		41,814	1,080		42,894		41,814	1,080	42,894	39,341			42,050	1,184	43,234
FEDERAL	11	2,473	1,080	44	3,553	0.00	2,473	1,080	3,553	0	9.6		2,709	1,184	3,893
NON FEDERAL - Section 104	11	39,341	0		39,341	0.00	39,341	0	39,341	39,341	0		39,341	0	39,341
13 PUMPING PLANT		2,820	1,387	49	4,207	0.00	2,820	1,387	4,207	0	9.6		3,089	1,520	4,609
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		44,634	2,467		47,101		44,634	2,467	47,101	39,341			45,139	2,704	47,843
1 LANDS & DAMAGES, Admin. (1		85	13	15	98	0.00	85	13	98	0	22		104	16	120
1 LANDS & DAMAGES, Real Estate		1,580	932	59	2,512	0.00	1,580	932	2,512	0	8.5		1,714	1,012	2,726
30 PLAN/ENGINEERING/DESIGN		10,746	148		10,894		10,746	148	10,894	9,688			10,973	180	11,153
FEDERAL	A	1,944	148	14	2,092	0.00	1,944	148	2,092	886	12		2,171	180	2,351
NON FEDERAL - Section 104	A	8,802	0		8,802	0.00	8,802	0	8,802	8,802	0		8,802	0	8,802
31 CONSTRUCTION MANAGE'MT		47,940	198		48,138		47,940	198	48,138	47,517			48,047	249	48,296
FEDERAL	A	423	198	47	621	0.00	423	198	621	0	25		530	249	779
NON FEDERAL - Section 104	A	47,517	0		47,517	0.00	47,517	0	47,517	47,517	0		47,517	0	47,517
SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		104,985	3,758		108,743		104,985	3,758	108,743	96,546			105,977	4,161	110,138
NON-FEDERAL CONTRIBUTION(-)		4,639	106		4,745		4,639	106	4,745	4,374			4,670	120	4,790
TOTAL FEDERAL NED COSTS		**$100,346**	**$3,652**		**$103,998**		**$100,346**	**$3,652**	**$103,998**	**$92,172**			**$101,307**	**$4,041**	**$105,348**
NON-FEDERAL COSTS															
1 LANDS AND DAMAGES		3,633	1,532	59	5,165	0.00	3,633	1,532	5,165	1,021	5.8		3,856	1,662	5,518
2 RELOCATIONS		10,369	3,531	47	13,900	0.00	10,369	3,531	13,900	2,823	7.6		11,091	3,869	14,960
SECTION 104 - NED		91,286	0		91,286		91,286	0	91,286	91,286			91,286	0	91,286
30 PLAN/ENGINEERING/DESIGN		1,080	377	47	1,457	0.00	1,080	377	1,457	272	5.1		1,130	401	1,531
31 CONSTRUCTION MANAGE'MT		538	252	47	790	0.00	538	252	790	0	9.6		590	276	866
SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)		106,906	5,692		112,598		106,906	5,692	112,598	95,402			107,953	6,208	114,161
NON-FEDERAL CONTRIBUTION (+) Additional Cost Above NED		4,639 4,639	106 106		4,745 4,745		4,639 4,639	106 106	4,745 4,745	4,374 4,374			4,670 4,670	120 120	4,790 4,790
TOTAL NON-FEDERAL COSTS		**$111,545**	**$5,798**		**$117,343**		**$111,545**	**$5,798**	**$117,343**	**$99,776**			**$112,623**	**$6,328**	**$118,951**
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach D		**$120,605**	**$9,450**		**$130,055**		**$120,605**	**$9,450**	**$130,055**	**$100,662**			**$122,844**	**$10,369**	**$133,013**
Reach E															
FEDERAL COSTS															
6 FISH & WILDLIFE FACILITIES		4,907	1,810	37	6,717	0.00	4,907	1,810	6,717	0	7.7		5283	1950	7233
11 LEVEES & FLOODWALLS		33,402	12,879	39	46,281	0.00	33,402	12,879	46,281	0	7.7		35967	13868	49835
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		38,309	14,689		52,998		38,309	14,689	52,998	0			41250	15818	57068
1 LANDS & DAMAGES, Admin. (1		346	51	15	397	0.00	346	51	397	0	17		405	60	465
1 LANDS & DAMAGES, Real Estate		790	284	36	1,074	0.00	790	284	1,074	0	6.7		843	303	1146
30 PLAN/ENGINEERING/DESIGN		8,579	874		9,453		8,579	874	9,453	3,982			9325	1015	10340
FEDERAL	A	5,129	874	19	6,003	0.00	5,129	874	6,003	532	15		5875	1015	6890
NON FEDERAL - Section 104	A	3,450	0		3,450	0.00	3,450	0	3,450	3,450	0		3450	0	3450

****CONTRACT COST SUMMARY(CONT'D)****

Current MCACES Estimate Prepared: 16-Aug-2010
Effective Price Level (EPL): 1-Oct-2010

ACCOUNT NO.	FEATURE DESCRIPTION		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED ESTIMATE... SUNK COST ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined Indexes; All other codes used coincides with the Code of Accounts.															
			Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2010				
31	CONSTRUCTION MANAGE'MT		3,065	1,175	38	4,240	0.00	3,065	1,175	4,240	0	20	3680	1410	5090
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		51,089	17,073		68,162		51,089	17,073	68,162	3,982		55503	18606	74109
	NON-FEDERAL CONTRIBUTION(-)		3,400	1,296		4,696		3,400	1,296	4,696	0		3721	1410	5131
	TOTAL FEDERAL NED COSTS		**$47,689**	**$15,777**		**$63,466**		**$47,689**	**$15,777**	**$63,466**	**$3,982**		**$51,782**	**$17,196**	**$68,978**
	NON-FEDERAL COSTS														
1	LANDS AND DAMAGES		25,076	8,175	33	33,251	0.00	25,076	8,175	33,251	378	6.6	26,730	8,722	35,452
2	RELOCATIONS		11,433	4,617	40	16,050	0.00	11,433	4,617	16,050	0	7.7	12,312	4,971	17,283
	SECTION 104 - NED		3,450	0		3,450		3,450	0	3,450	3,450		3,450	0	3,450
30	PLAN/ENGINEERING/DESIGN		1,715	693	40	2,408	0.00	1,715	693	2,408	0	6.3	1,824	736	2,560
31	CONSTRUCTION MANAGE'MT		915	369	40	1,284	0.00	915	369	1,284	0	7.7	986	397	1,383
	SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)		42,589	13,854		56,443		42,589	13,854	56,443	3,828		45,302	14,826	60,128
	NON-FEDERAL CONTRIBUTION (+)		3,400	1,296		4,696		3,400	1,296	4,696	0		3,721	1,410	5,131
	Additional Cost Above NED		3,400	1,296		4,696		3,400	1,296	4,696	0		3,721	1,410	5,131
	TOTAL NON-FEDERAL COSTS		**$45,989**	**$15,150**		**$61,139**		**$45,989**	**$15,150**	**$61,139**	**$3,828**		**$49,023**	**$16,236**	**$65,259**
	TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach E		**$90,228**	**$30,927**		**$121,155**		**$90,228**	**$30,927**	**$121,155**	**$4,360**		**$97,355**	**$33,432**	**$130,787**
	Reach F														
	FEDERAL COSTS														
11	LEVEES & FLOODWALLS		36,823	11,766	32	48,589	0.00	36,823	11,766	48,589	0	5.8	38,966	12,450	51,416
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		36,823	11,766		48,589		36,823	11,766	48,589	0		38,966	12,450	51,416
1	LANDS & DAMAGES, Admin. (1		279	42	15	321	0.00	279	42	321	0	12	314	47	361
30	PLAN/ENGINEERING/DESIGN		7,159	602		7,761		7,159	602	7,761	2,740		7,652	669	8,321
	FEDERAL	A	4,419	602	14	5,021	0.00	4,419	602	5,021	0	11	4,912	669	5,581
	NON FEDERAL - Section 104	A	2,740	0		2,740	0.00	2,740	0	2,740	2,740	0	2,740	0	2,740
31	CONSTRUCTION MANAGE'MT		2,946	941	32	3,887	0.00	2,946	941	3,887	0	15	3,382	1,081	4,463
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		47,207	13,351		60,558		47,207	13,351	60,558	2,740		50,314	14,247	64,561
	NON-FEDERAL CONTRIBUTION(-)		1,894	570		2,464		1,894	570	2,464	0		2,026	608	2,634
	TOTAL FEDERAL NED COSTS		**$45,313**	**$12,781**		**$58,094**		**$45,313**	**$12,781**	**$58,094**	**$2,740**		**$48,288**	**$13,639**	**$61,927**
	NON-FEDERAL COSTS														
1	LANDS AND DAMAGES		9,220	4,547	50	13,767	0.00	9,220	4,547	13,767	99	4.9	9,667	4,771	14,438
2	RELOCATIONS		11,584	3,835	33	15,419	0.00	11,584	3,835	15,419	0	5.8	12,258	4,058	16,316
	SECTION 104 - NED		2,740	0		2,740		2,740	0	2,740	2,740		2,740	0	2,740
30	PLAN/ENGINEERING/DESIGN		1,390	460	33	1,850	0.00	1,390	460	1,850	0	4.5	1,452	481	1,933
31	CONSTRUCTION MANAGE'MT		927	307	33	1,234	0.00	927	307	1,234	0	5.8	981	325	1,306
	SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)		25,861	9,149		35,010		25,861	9,149	35,010	2,839		27,098	9,635	36,733
	NON-FEDERAL CONTRIBUTION (+)		1,894	570		2,464		1,894	570	2,464	0		2,026	608	2,634
	Additional Cost Above NED		1,894	570		2,464		1,894	570	2,464	0		2,026	608	2,634
	TOTAL NON-FEDERAL COSTS		**$27,755**	**$9,719**		**$37,474**		**$27,755**	**$9,719**	**$37,474**	**$2,839**		**$29,124**	**$10,243**	**$39,367**
	TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach F		**$70,328**	**$22,500**		**$92,828**		**$70,328**	**$22,500**	**$92,828**	**$2,839**		**$74,672**	**$23,882**	**$98,554**
	Reach G														
	FEDERAL COSTS														
11	LEVEES & FLOODWALLS		26,789	9,974	37	36,763	0.00	26,789	9,974	36,763	0	7.6	28,825	10,732	39,557
13	PUMPING PLANT		2,078	745	36	2,823	0.00	2,078	745	2,823	0	7.6	2,236	802	3,038
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		28,867	10,719		39,586		28,867	10,719	39,586	0		31,061	11,534	42,595
1	LANDS & DAMAGES, Admin. (1		210	31	15	241	0.00	210	31	241	0	17	246	37	283
30	PLAN/ENGINEERING/DESIGN		3,215	449	14	3,664	0.00	3,215	449	3,664	0	16	3,730	520	4,250

****CONTRACT COST SUMMARY(CONT'D)****

Current MCACES Estimate Prepared: 16-Aug-2010 Effective Price Level (EPL): 1-Oct-2010 ACCOUNT NO. FEATURE DESCRIPTION		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	....FULLY FUNDED ESTIMATE... (3.... SUNK COST ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined indexes; All other codes used coincides with the Code of Accounts.														
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2010				
31 CONSTRUCTION MANAGE'MT		2,143	796	37	2,939	0.00	2,143	796	2,939	0	20	2,567	954	3,521
SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION		34,435	11,995		46,430		34,435	11,995	46,430	0		37,604	13,045	50,649
NON-FEDERAL CONTRIBUTION(-)		1,496	563		2,059		1,496	563	2,059	0		1,634	613	2,247
TOTAL FEDERAL NED COSTS		**$32,939**	**$11,432**		**$44,371**		**$32,939**	**$11,432**	**$44,371**	**$0**		**$35,970**	**$12,432**	**$48,402**
NON-FEDERAL COSTS														
1 LANDS AND DAMAGES		13,118	5,222	40	18,340	0.00	13,118	5,222	18,340	0	5.7	13,996	5,572	19,568
2 RELOCATIONS		9,659	3,631	38	13,290	0.00	9,659	3,631	13,290	0	7.6	10,393	3,907	14,300
30 PLAN/ENGINEERING/DESIGN		1,457	544	38	2,001	0.00	1,457	544	2,001	8	8.2	1,548	578	2,126
31 CONSTRUCTION MANAGE'MT		966	363	38	1,329	0.00	966	363	1,329	0	7.6	1,039	391	1,430
SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)		25,200	9,760		34,960		25,200	9,760	34,960	8		26,976	10,448	37,424
NON-FEDERAL CONTRIBUTION (+)		1,496	563		2,059		1,496	563	2,059	0		1,634	613	2,247
Additional Cost Above NED		1,496	563		2,059		1,496	563	2,059	0		1,634	613	2,247
TOTAL NON-FEDERAL COSTS		**$26,696**	**$10,323**		**$37,019**		**$26,696**	**$10,323**	**$37,019**	**$8**		**$28,610**	**$11,061**	**$39,671**
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach G		**$59,635**	**$21,755**		**$81,390**		**$59,635**	**$21,755**	**$81,390**	**$8**		**$64,580**	**$23,493**	**$88,073**
Reach H														
FEDERAL COSTS														
6 FISH & WILDLIFE FACILITIES		6,480	1,869	29	8,349	0.00	6,480	1,869	8,349	0	5.9	6,865	1,980	8,845
11 LEVEES & FLOODWALLS		30,435	9,966	33	40,401	0.00	30,435	9,966	40,401	0	5.9	32,242	10,558	42,800
13 PUMPING PLANT		2,227	654	29	2,881	0.00	2,227	654	2,881	0	5.9	2,359	693	3,052
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		39,142	12,489		51,631		39,142	12,489	51,631	0		41,466	13,231	54,697
1 LANDS & DAMAGES, Admin. (1		785	117	15	902	0.00	785	117	902	0	12	882	131	1,013
1 LANDS & DAMAGES, Real Estate		1,283	309	24	1,592	0.00	1,283	309	1,592	0	4.9	1,346	324	1,670
30 PLAN/ENGINEERING/DESIGN		8,845	637		9,482		8,845	637	9,482	4,148		9,384	710	10,094
FEDERAL	A	5,422	637	14	6,059	0.00	5,422	637	6,059	725	10	5,961	710	6,671
NON FEDERAL - Section 104	A	3,423	0		3,423	0.00	3,423	0	3,423	3,423	0	3,423	0	3,423
31 CONSTRUCTION MANAGE'MT		3,131	1,000	32	4,131	0.00	3,131	1,000	4,131	0	15	3,604	1,152	4,756
TOTAL FEDERAL NED COSTS		**$53,186**	**$14,552**		**$67,738**		**$53,186**	**$14,552**	**$67,738**	**$4,148**		**$56,682**	**$15,548**	**$72,230**
NON-FEDERAL COSTS														
1 LANDS AND DAMAGES		26,642	5,363	20	32,005	0.00	26,642	5,363	32,005	215	4.9	27,940	5,626	33,566
2 RELOCATIONS		9,537	3,459	36	12,996	0.00	9,537	3,459	12,996	0	5.9	10,103	3,665	13,768
SECTION 104 - NED		3,423	0		3,423		3,423	0	3,423	3,423		3,423	0	3,423
30 PLAN/ENGINEERING/DESIGN		1,149	415	36	1,564	0.00	1,149	415	1,564	5	4.6	1,202	434	1,636
31 CONSTRUCTION MANAGE'MT		763	277	36	1,040	0.00	763	277	1,040	0	6	809	293	1,102
TOTAL NON-FEDERAL COSTS		**$41,514**	**$9,514**		**$51,028**		**$41,514**	**$9,514**	**$51,028**	**$3,643**		**$43,477**	**$10,018**	**$53,495**
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach H		**$91,277**	**$24,066**		**$115,343**		**$91,277**	**$24,066**	**$115,343**	**$4,368**		**$96,736**	**$25,566**	**$122,302**
Reach I														
FEDERAL COSTS														
11 LEVEES & FLOODWALLS		13,859	3,668	26	17,527	0.00	13,859	3,668	17,527	0	4	14,417	3,816	18,233
13 PUMPING PLANT		1,195	315	26	1,510	0.00	1,195	315	1,510	0	4	1,243	328	1,571
SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS		15,054	3,983		19,037		15,054	3,983	19,037	0		15,660	4,144	19,804
1 LANDS & DAMAGES, Admin. (1		142	21	15	163	0.00	142	21	163	0	7.4	152	23	175
30 PLAN/ENGINEERING/DESIGN		3,910	238		4,148		3,910	238	4,148	2,104		4,028	253	4,279
FEDERAL	A	1,806	238	13	2,044	0.00	1,806	238	2,044	0	8.4	1,922	253	2,175
NON FEDERAL - Section 104	A	2,104	0		2,104	0.00	2,104	0	2,104	2,104	0	2,104	0	2,104
31 CONSTRUCTION MANAGE'MT		1,204	319	26	1,523	0.00	1,204	319	1,523	0	9.9	1,323	351	1,674
TOTAL FEDERAL NED COSTS		**$20,310**	**$4,561**		**$24,871**		**$20,310**	**$4,561**	**$24,871**	**$2,104**		**$21,161**	**$4,771**	**$25,932**
NON-FEDERAL COSTS														

****CONTRACT COST SUMMARY(CONT'D)****

Current MCACES Estimate Prepared: 16-Aug-2010 Effective Price Level (EPL): 1-Oct-2010 ACCOUNT NO. FEATURE DESCRIPTION	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	AUTHORIZE/BUDGET PRICE LEVEL: 1-Oct-2010 OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	.....FULLY FUNDED ESTIMATE... (3..... SUNK COST ($K)	OMB MIDPT(%)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
Index Codes: 0 - no esc. applied; A - Administration; C - Combined indexes; All other codes used coincides with the Code of Accounts.													
	Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2010				
1 LANDS AND DAMAGES	2,257	1,336	63	3,593	0.00	2,257	1,336	3,593	141	3	2,324	1,378	3,702
2 RELOCATIONS	2,501	667	27	3,168	0.00	2,501	667	3,168	0	4	2,602	694	3,296
SECTION 104 - NED	2,104	0		2,104		2,104	0	2,104	2,104		2,104	0	2,104
30 PLAN/ENGINEERING/DESIGN	306	80	27	386	0.00	306	80	386	8	2.6	314	82	396
31 CONSTRUCTION MANAGE'MT	200	53	27	253	0.00	200	53	253	0	4	207	56	263
TOTAL NON-FEDERAL COSTS	$7,368	$2,136		$9,504		$7,368	$2,136	$9,504	$2,251		$7,551	$2,210	$9,761
TOTAL FEDERAL AND NON-FEDERAL COSTS, Reach I	$25,574	$6,697		$32,271		$25,574	$6,697	$32,271	$2,251		$26,608	$6,981	$33,589

The project area is comprisad of nine reaches, designated A through I for economic evaluation and construction sequencing purposes. Costs for both the NED and locally preferred plan (LPP) have been developed. The Sacramento Area Flood Control Agency (SAFCA) has completed construction, or is in the process of doing so, much of the levee work in Reaches B, C & D (sans Pumping Station Modifications). These costs are shown as Section 104 work and include sunk costs for contracted work expected to be completed before 10/2010 and remaining work for ongoing projects SAFCA is providing for.

For the Locally Preferred Plan (LPP) or Early Implementation Plan (EIP), levees are raised to the 200 year water surface plus 3 ft (as determined by SAFCA) in areas where they are not already of sufficient height.

The National Economic Plan (NED), or Reduced Early Implementation Plan (REIP), does not involve raising the levees but does fix them in place and provide seepage control.

Work primarily involves increasing levee stability by increasing levee width and controlling seepage thru use of soil-bentonite slurry walls and in some cases, a seepage berm. A great deal of work is also required for many Pumping Stations/Plants and Private Irrigation Facilities where piping previously penetrated through the levee will now be relocated to pass above the nominal levee crown or 200 year water surface. Where this occurs, new pumps & motors must be provided. Where possible, a positve closure structures is placed in the levee instead of raising the pipes. In this case, the pumps do not need to be replaced. Many additional utility crossings (water, gas, electrical) of the levee also require relocating pipes/conduits.

Estimated by CESPK-ED-SC

Designed by HDR & USACE (Sacramento District)

Prepared by Robert Vrchoticky

Preparation Date 8/16/2010

Effective Date of Pricing 8/16/2010

Estimated Construction Time Days

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Project Notes vii

NED 1

R-A-NED Reach A - NED 1

11 Levees and Floodwalls 1

13 Pumping Plants 1

02 Relocations 1

R-B-NED Reach B - NED 1

06 Fish & Wildlife Facilities 1

06-104 Fish & Wildlife Facilities - Section 104 1

11 Levees & Floodwalls 1

11-104 Levees & Floodwalls - Section 104 1

13 Pumping Plants 1

02 Relocations 1

R-C-NED Reach C - NED 1

06 Fish & Wildlife Facilities 1

06-104 Fish & Wildlife Facilities - Section 104 1

11 Levees & Floodwalls 1

11-104 Levees & Floodwalls - Section 104 1

13 Pumping Plants 1

02 Relocations 1

R-D-NED Reach D - NED 2

11 Levees & Floodwalls 2

11-104 Levees & Floodwalls - Section 104 2

13 Pumping Plants 2

02 Relocations 2

R-E-NED Reach E - NED 2

06 Fish & Wildlife 2

11 Levees & Floodwalls 2

02 Relocations 2

R-F-NED Reach F - NED 2

11 Levees and Floodwalls 2

02 Relocations 2

R-G-NED Reach G - NED 2

11 Levees and Floodwalls 2

13 Pumping Plants 2

02 Relocations 2

R-H-NED Reach H - NED 2
06 Fish and Wildlife Facilities 2
11 Levees and Floodwalls 2
13 Pumping Plants 2
02 Relocations 2
R-I-NED Reach I - NED 3
11 Levees and Floodwalls 3
13 Pumping Plants 3
02 Relocations 3
LPP 4
R-A-LPP Reach A - LPP 4
11 Levees and Floodwalls 4
13 Pumping Plants 4
02 Relocations 4
R-B-LPP Reach B - LPP 4
06 Fish & Wildlife Facilities 4
06-104 Fish & Wildlife Facilities - Section 104 4
11 Levees & Floodwalls 4

11-104 Levees & Floodwalls - Section 104 4

13 Pumping Plants 4

02 Relocations 4

R-C-LPP Reach C - LPP 4

06 Fish & Wildlife Facilities 4

06-104 Fish & Wildlife Facilities - Section 104 4

11 Levees & Floodwalls 4

11-104 Levees & Floodwalls - Section 104 4

13 Pumping Plants 4

02 Relocations 4

R-D-LPP Reach D - LPP 5

11 Levees & Floodwalls 5

11-104 Levees & Floodwalls - Section 104 5

13 Pumping Plants 5

02 Relocations 5

R-E-LPP Reach E - LPP 5

06 Fish & Wildlife 5

11 Levees & Floodwalls 5

02 Relocations 5

R-F-LPP Reach F - LPP 5

11 Levees and Floodwalls 5

02 Relocations 5

R-G-LPP Reach G - LPP 5

11 Levees and Floodwalls 5

13 Pumping Plants 5

02 Relocations 5

R-H-LPP Reach H - LPP 5

06 Fish and Wildlife Facilities 5

11 Levees and Floodwalls 5

13 Pumping Plants 5

02 Relocations 5

R-I-LPP Reach I - LPP 6

11 Levees and Floodwalls 6

13 Pumping Plants 6

02 Relocations 6

Date	Author	Note

8/3/2010 Vrchoticky

File Location: CostEng on "Dolomite/Engineering/EDPublic"
F:\CivWorks\Projects\AmRiver - CommFeat_CWE&IGE-NatomasPACR
File Name: CWE-Natomas (6x10wk) "date of latest revision".mlp

BASIS OF DESIGN
This estimate is based on the draft report:
American River Common Features Project,
Natomas Post Authorization Change Report and Interim General Reevaluation Report
The type of solicitation is expected to be unrestricted IFB.

Note: Civil Design quantities are per three AE's (HDR, Wood Rodgers and Mead & Hunt) with spot checking by SPK. HDR also provided "bare cost" estimates for Pumping Plant modifications, Riverside Canal and well relocations.

PROJECT SCOPE/DESCRIPTION
The project area is comprised of nine reaches, designated A through I for economic evaluation and construction sequencing purposes. Costs for both the NED and locally preferred plan (LPP) have been developed. The Sacramento Area Flood Control Agency (SAFCA) has completed construction, or is in the process of doing so, much of the work in Reaches B, C & D (sans Pumping Station Modifications). These costs are shown as either sunk (omitted) for contracted work expected to be completed before 10/2010 or as Section 104 work for ongoing projects SAFCA is providing for.

The description of each reach, and typical work involved for each, is as follows:
Reach A: SREL from Interstate Highway 5 north to San Juan Road. (Adjacent levee, cutoff wall, Irrigation Canal, Pumping Plant Relocations (3) and Private Irrigation Facilities (1))
Reach B: SREL from San Juan Road north to Elverta Road. (Adjacent levee, cutoff wall, seepage berm, Irrigation/Drainage Canals (2), Pumping Plant Relocations (4))
Reach C: SREL from Elverta Road north to Sankey Road at the west end of the south levee of the NCC. (Adjacent levee, cutoff wall, seepage berm, Irrigation/Drainage Canals (2), Pumping Plant Relocations (2), Private Irrigation Facility)
Reach D: NCC south levee from Sankey Road north to Howsley Road. (Cutoff wall, Pumping Plant Relocations (3))
Reach E: PGCC west levee from Howsley Road north to Sankey Road. (Cutoff wall, Vinyl Sheet Pile, Private Irrigation Facilities (4))
Reach F: NEMDC west levee from Sankey Road south to Elverta Road. (Cutoff wall, Drained stability berm, flattened

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landside levee slope, Private Irrigation Facilities (5))
Reach G: NEMDC west levee from Elverta Road south to the pumping station just upstream of Dry Creek. (Cutoff wall, Pumping Plant Relocations, Private Irrigation Facilities (4))
Reach H: NEMDC west levee from the pumping station just upstream of Dry Creek south to Northgate Boulevard. (Cutoff wall, Jet Grouting, Pumping Plant Relocations (2))
Reach I: ARNL from Northgate Boulevard south to Interstate Highway 5. (Cutoff wall, Pumping Plant Relocations)

In addition, bridge work (removal & raise/replacement) is required for bridges in Reaches E-H

CONSTRUCTION SCHEDULE
Total Project Schedules including design, pre-construction, construction and post construction were developed using MS Project with construction durations based on those developed in MII. These were used to insure the project reaches could be completed within the construction windows and with the anticipated crews. It was determined that Reaches A, B, E, F, G & H will require two crews for slurry wall construction, excavation at the borrow areas and levee restoration. It was determined that Reach A would also require two construction seasons due to the long construction period for the deep slurry walls.

CONSTRUCTION WINDOWS
This estimate considers the construction work window for major construction activities to be May-Oct, April and November are available for mobilization and demobilization of equipment and non-flood protection items such as hydroseeding that do not change the effectiveness of flood control and drainage system.

OVERTIME
Overtime is included in this estimate. Assumption is 10 hr days, 6 days/week.

ACQUISITION PLAN
Construction Contracts are assumed to be design-bid-build, lowest competetive price.

CONTRACTING PLAN
The prime contractor is expected to be an earthwork contractor responsible for the general site work, borrow site excavation, levee degrading and rebuilding to the restored or new levee height.
Subcontractors are provided for two categories, miscellaneous/general and trucking:

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Miscellaneous/General Subcontractors are expected to be utilized for cutoff wall placement, pumping plant relocations, bridge relocations, jet grouting, sheet pile work, paving and hydroseeding.

PROJECT CONSTRUCTION
The project consists of 9 reaches (A-I) with multiple utility relocations for penetrations through the levees (primarily pumping plants and private irrigation facilities). Should the LPP ultimately be constructed, several bridges will also be raised.

SITE ACCESS
The project sites encompass the perimeter of the Natomas Basin in the Sacramento, CA area and are accessible by paved local roads. Certain reaches (B, C, D & E) are of close enough proximity to borrow areas that scrapers are a viable option for degrading of levees and levee restoration.

BORROW \ DISPOSAL AREAS
Many potential borrow areas have been identified in or very near to (such as the "Triangle") the Natomas basin and these are expected to provide the borrow required. Disposal of Debris is normal.

CONSTRUCTION METHODOLOGY
The construction methodologies are considered standard, except for deep (greater than 85 ft) cutoff wall excavation & placement. Below this depth a conventional long reach hydraulic excavator cannot be used. The method provided in the cost estimate opts for the contractor to utilize a hydraulic clamshell in excavating to the lower depths of the wall (the lower 18.5 ft for the extreme depth walls, 103.5 ft deep). The estimator realizes that production by the clamshell is much slower than that of the excavator but the extra depth is approximately 20% of that for the excavator and it is believed the 18.5 ft done by the clamshell will allow it to roughly keep up with the 85 ft done by the excavator. Other methods such as deep-soil-mixing are expected to be a contractor option. Deep soil mixing was examined but is expected to be slightly less cost effective than excavator/clamshell at this depth.

UNUSUAL CONDITIONS
No unusual conditions.

UNIQUE TECHNIQUES OF CONSTRUCTION
Proximity of existing bridge abutments or retaining walls require that jet grouting be performed in lieu of placing slurry

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cutoff walls in two short lengths of Reach H.

EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED
In an urban area such as Sacramento, equipment and labor is readily available within a 100 mile radius of the site.

ENVIRONMENTAL CONCERNS
Environment protection requires consideration of air, water, and land, and involves noise, solid-waste management and management of other pollutants. In order to prevent or provide for abatement and control of any environmental pollution arising from the work activities, the Contractor and his subcontractors in the performance of this contract, shall comply with all applicable Federal, State, and local laws, and regulations concerning environmental pollution control and abatement. The Contractor shall use best management practices at all times to minimize the potential for environmental impacts. A running 2% markup on construction equipment is provided to account for air quality considerations.

LABOR RATES, EQUIPMENT RATES, MATERIAL COSTS & SALES TAX
This estimate meets Davis Bacon wage rates for Davis Bacon wage determinations for the state of California, General Decision Numbers: CA 20100003 03/12/2010, CA 20100006 03/12/2010, CA 20100009 03/12/2010 and CA 20100026 03/12/2010.

Equipment unit costs were obtained from Quotes or verbal/telephone conversations with Contractors performing like or similar work and the MCACES Equipment Library.

Material prices were obtained from Quotes, supply catalogs, previous similar estimates, and the MCACES Cost Book.

Sales tax is applied at 8.75%.

CONTRACTOR MARKUPS
Profit is included for the prime contractor (8.48% based on PWG). Home Office Overhead is considered to be 7% for these relatively large projects. Job/Field Office Overhead (JOOH) is set at 10% for all reaches except Reach I, where it is set at 23%. Small Tool Markup is set at a running 2% of Labor costs. Bond is set at 0.7%.

Initially, JOOH was calculated independently for each reach (based on the developed construction schedule) with Small Tools set at 2% of Prime Contractor Labor. It is considered very likely however, that the contractors will be given the full

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construction season to complete the work (2 seasons in the case of Reach A). Reaches A-H typically showed a JOOH in the 8-11% range, with an average of about 9.5%. 10% was therefore chosen to be used uniformly in those reaches. Reach I has a somewhat higher JOOH due to a shorter calculated construction duration extended to allow the full construction season.
Likewise, bond was initially calculated based on Bond Class B. A weighted average was used for conformity of costs between like work in the NED vs the LPP.

Miscellaneous/General Subcontractors have profit set at of 10% , Home Office Overhead at 12% and Job Office Overhead at 15% (performs the majority of the cutoff wall/jet grouting/sheet pile/pumping plant/bridge work). Bond is set at 0.8%.

The Trucking/Hauling Subcontractors have profit set at of 10%, Home Office Overhead at 10% and Job Office Overhead at 5%. Bond again is set at 1.0%.

Productivity/Task Durations are based on production for 50 minutes/hr for meetings/breaks, accessing the working area/office trailer to get supplies.

Note: Gasoline and diesel fuel costs used in the estimate are the average costs in the Sacramento area as of July 2010. Off-road diesel costs are assumed at 90% of on-road.

BRIDGE RAISING COSTS
These were provided by Wood Rodgers an AE firm who provided the civil design for Reaches D-H. The costs are within reason when compared to "Comparative Bridge Costs" (January 2010) as set forth by Caltrans.

Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
NED	1.00	EA	363,735,688	26,413,228	19,227,092	24,922,705	2,231,758	455,633,744
R-A-NED Reach A - NED	1.00	EA	54,782,444	5,378,244	4,141,248	5,368,004	480,690	70,745,360
11 Levees and Floodwalls	1.00	EA	42,836,965	4,283,697	3,298,446	4,275,540	382,863	55,077,511
13 Pumping Plants	1.00	EA	3,747,294	374,729	288,542	374,016	33,492	4,818,074
02 Relocations	1.00	EA	8,198,184	719,818	554,260	718,448	64,335	10,849,776
R-B-NED Reach B - NED	1.00	EA	79,114,346	3,519,066	2,709,681	3,512,366	314,522	98,144,479
06 Fish & Wildlife Facilities	1.00	EA	0	0	0	0	0	1,635,000
06-104 Fish & Wildlife Facilities - Section 104	1.00	EA	57,771	0	0	0	0	227,262
11 Levees & Floodwalls	1.00	EA	15,746,711	1,574,671	1,212,497	1,571,673	140,739	20,246,290
11-104 Levees & Floodwalls - Section 104	1.00	EA	36,951,576	0	0	0	0	43,030,812
13 Pumping Plants	1.00	EA	10,764,869	1,076,487	828,895	1,074,437	96,213	13,840,901
02 Relocations	1.00	EA	15,593,420	867,908	668,289	866,256	77,571	19,164,215
R-C-NED Reach C - NED	1.00	EA	39,719,073	1,557,551	1,199,314	1,554,585	139,209	48,587,363
06 Fish & Wildlife Facilities	1.00	EA	0	0	0	0	0	225,000
06-104 Fish & Wildlife Facilities - Section 104	1.00	EA	58,620	0	0	0	0	1,700,802
11 Levees & Floodwalls	1.00	EA	505,949	50,595	38,958	50,499	4,522	650,522
11-104 Levees & Floodwalls - Section 104	1.00	EA	19,382,393	0	0	0	0	21,320,632
13 Pumping Plants	1.00	EA	11,717,469	1,171,747	902,245	1,169,516	104,727	15,065,703
02 Relocations	1.00	EA	8,054,643	335,209	258,111	334,571	29,960	9,624,704

Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
R-D-NED Reach D - NED	1.00	EA	42,845,481	982,419	756,462	980,548	87,805	48,954,845
11 Levees & Floodwalls	1.00	EA	1,761,281	176,128	135,619	175,793	15,742	2,264,562
11-104 Levees & Floodwalls - Section 104	1.00	EA	31,787,966	0	0	0	0	34,966,763
13 Pumping Plants	1.00	EA	2,193,513	219,351	168,901	218,934	19,605	2,820,304
02 Relocations	1.00	EA	7,102,721	586,939	451,943	585,822	52,459	8,903,217
R-E-NED Reach E - NED	1.00	EA	33,788,351	3,158,425	2,431,987	3,152,412	282,290	43,276,990
06 Fish & Wildlife	1.00	LS	3,867,988	201,389	155,069	201,005	17,999	4,906,977
11 Levees & Floodwalls	1.00	LS	23,774,870	2,377,487	1,830,665	2,372,960	212,492	30,568,474
02 Relocations	1.00	LS	6,145,493	579,549	446,253	578,446	51,798	7,801,539
R-F-NED Reach F - NED	1.00	EA	34,567,721	3,388,772	2,609,355	3,382,320	302,877	44,251,045
11 Levees and Floodwalls	1.00	EA	27,411,734	2,741,173	2,110,704	2,735,954	244,997	35,244,562
02 Relocations	1.00	LS	7,155,987	647,599	498,651	646,366	57,880	9,006,483
R-G-NED Reach G - NED	1.00	EA	27,661,797	2,715,180	2,090,688	2,710,010	242,674	35,420,349
11 Levees and Floodwalls	1.00	EA	19,870,168	1,987,017	1,530,003	1,983,233	177,593	25,548,014
13 Pumping Plants	1.00	EA	1,616,350	161,635	124,459	161,327	14,446	2,078,217
02 Relocations	1.00	LS	6,175,280	566,528	436,227	565,449	50,634	7,794,118
R-H-NED Reach H - NED	1.00	EA	39,046,654	2,905,311	2,237,090	2,899,780	259,667	48,699,264
06 Fish and Wildlife Facilities	1.00	LS	6,465,180	0	0	0	0	6,480,180
11 Levees and Floodwalls	1.00	EA	23,687,698	2,368,770	1,823,953	2,364,260	211,713	30,456,393
13 Pumping Plants	1.00	EA	1,732,066	173,207	133,369	172,877	15,481	2,227,000
02 Relocations	1.00	LS	7,161,710	363,335	279,768	362,643	32,474	9,535,692

Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
R-I-NED Reach I - NED	1.00	EA	12,209,820	2,808,259	1,051,266	1,362,680	122,024	17,554,049
11 Levees and Floodwalls	1.00	EA	9,639,973	2,217,194	830,002	1,075,872	96,341	13,859,381
13 Pumping Plants	1.00	EA	831,248	191,187	71,570	92,772	8,307	1,195,085
02 Relocations	1.00	LS	1,738,599	399,878	149,693	194,037	17,375	2,499,583

Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
LPP	1.00	EA	394,836,881	26,914,655	19,613,191	25,423,178	2,276,574	493,796,239
R-A-LPP Reach A - LPP	1.00	EA	54,782,444	5,378,244	4,141,248	5,368,004	480,690	70,745,360
11 Levees and Floodwalls	1.00	EA	42,836,965	4,283,697	3,298,446	4,275,540	382,863	55,077,511
13 Pumping Plants	1.00	EA	3,747,294	374,729	288,542	374,016	33,492	4,818,074
02 Relocations	1.00	EA	8,198,184	719,818	554,260	718,448	64,335	10,849,776
R-B-LPP Reach B - LPP	1.00	EA	90,241,870	3,519,066	2,709,681	3,512,366	314,522	111,596,269
06 Fish & Wildlife Facilities	1.00	EA	0	0	0	0	0	1,635,000
06-104 Fish & Wildlife Facilities - Section 104	1.00	EA	57,771	0	0	0	0	227,262
11 Levees & Floodwalls	1.00	EA	15,746,711	1,574,671	1,212,497	1,571,673	140,739	20,246,290
11-104 Levees & Floodwalls - Section 104	1.00	EA	45,948,278	0	0	0	0	53,850,689
13 Pumping Plants	1.00	EA	10,764,869	1,076,487	828,895	1,074,437	96,213	13,840,901
02 Relocations	1.00	EA	17,724,241	867,908	668,289	866,256	77,571	21,796,128
R-C-LPP Reach C - LPP	1.00	EA	44,202,371	1,557,551	1,199,314	1,554,585	139,209	53,518,991
06 Fish & Wildlife Facilities	1.00	EA	0	0	0	0	0	225,000
06-104 Fish & Wildlife Facilities - Section 104	1.00	EA	58,620	0	0	0	0	1,700,802
11 Levees & Floodwalls	1.00	EA	505,949	50,595	38,958	50,499	4,522	650,522
11-104 Levees & Floodwalls - Section 104	1.00	EA	22,992,454	0	0	0	0	25,291,699
13 Pumping Plants	1.00	EA	11,717,469	1,171,747	902,245	1,169,516	104,727	15,065,703
02 Relocations	1.00	EA	8,927,880	335,209	258,111	334,571	29,960	10,585,264

Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
R-D-LPP Reach D - LPP	1.00	EA	48,317,112	998,624	768,940	996,723	89,254	55,003,740
11 Levees & Floodwalls	1.00	EA	1,923,334	192,333	148,097	191,967	17,190	2,472,921
11-104 Levees & Floodwalls - Section 104	1.00	EA	35,764,544	0	0	0	0	39,340,998
13 Pumping Plants	1.00	EA	2,193,513	219,351	168,901	218,934	19,605	2,820,304
02 Relocations	1.00	EA	8,435,721	586,939	451,943	585,822	52,459	10,369,517
R-E-LPP Reach E - LPP	1.00	EA	38,552,931	3,428,031	2,639,584	3,421,504	306,386	49,742,795
06 Fish & Wildlife	1.00	LS	3,867,988	201,389	155,069	201,005	17,999	4,906,977
11 Levees & Floodwalls	1.00	EA	25,978,727	2,597,873	2,000,362	2,592,926	232,189	33,402,077
02 Relocations	1.00	LS	8,706,215	628,769	484,152	627,572	56,197	11,433,741
R-F-LPP Reach F - LPP	1.00	EA	37,569,397	3,506,996	2,700,387	3,500,318	313,444	48,409,289
11 Levees and Floodwalls	1.00	EA	28,641,933	2,864,193	2,205,429	2,858,740	255,992	36,826,287
02 Relocations	1.00	LS	8,927,463	642,802	494,958	641,579	57,452	11,583,001
R-G-LPP Reach G - LPP	1.00	EA	29,914,283	2,812,573	2,165,681	2,807,218	251,378	38,526,483
11 Levees and Floodwalls	1.00	EA	20,836,074	2,083,607	1,604,378	2,079,640	186,226	26,789,925
13 Pumping Plants	1.00	EA	1,616,350	161,635	124,459	161,327	14,446	2,078,217
02 Relocations	1.00	LS	7,461,860	567,330	436,844	566,250	50,706	9,658,341
R-H-LPP Reach H - LPP	1.00	EA	39,046,654	2,905,311	2,237,090	2,899,780	259,667	48,699,264
06 Fish and Wildlife Facilities	1.00	LS	6,465,180	0	0	0	0	6,480,180
11 Levees and Floodwalls	1.00	EA	23,687,698	2,368,770	1,823,953	2,364,280	211,713	30,456,393
13 Pumping Plants	1.00	EA	1,732,066	173,207	133,369	172,877	15,481	2,227,000
02 Relocations	1.00	LS	7,161,710	363,335	279,768	362,643	32,474	9,535,692

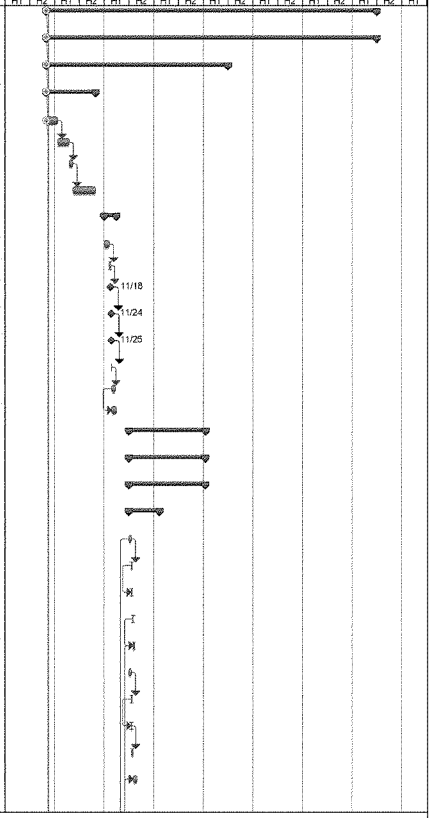
Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
R-I-LPP Reach I - LPP	1.00	EA	12,209,820	2,808,259	1,051,266	1,362,680	122,024	17,554,049
11 Levees and Floodwalls	1.00	EA	9,639,973	2,217,194	830,002	1,075,872	96,341	13,859,381
13 Pumping Plants	1.00	EA	831,248	191,187	71,570	92,772	8,307	1,195,085
02 Relocations	1.00	LS	1,738,599	399,878	149,693	194,037	17,375	2,499,583

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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
1	**Natomas PACR (NED)**	**2608.75 days**	**Mon 8/2/10**	**Sat 4/1/17**			
2	**Construction of Reaches A, B (remaining), H, I, E, F, G, and B,C,D (utility relocations)**	**2608.75 days**	**Mon 8/2/10**	**Sat 4/1/17**			
3	**Construction Contract 1 - Reach A**	**1433.75 days**	**Mon 8/2/10**	**Tue 4/1/14**			SREL Sta 742+60 to Sta 956+83 and Sta 0+00 to 20+50. Work involves levee improvements and/or
4	**Design**	**390 days**	**Mon 8/2/10**	**Mon 8/1/11**			
5	Collect field explorations	90 days	Mon 8/2/10	Mon 10/25/10		6	
6	Conduct geotechnical evaluation	90 days	Mon 10/25/10	Mon 1/17/11	5	7	
7	Develop Basis of Design Report	30 days	Mon 1/17/11	Mon 2/14/11	6	8	
8	Develop Plans & Specifications	180 days	Mon 2/14/11	Mon 8/1/11	7		
9	**Pre-Construction**	**96.25 days**	**Mon 10/3/11**	**Sat 12/31/11**			
10	Project Bid	41.25 days	Mon 10/3/11	Thu 11/10/11		11	
11	Award Task Order	8.75 days	Thu 11/10/11	Fri 11/18/11	10	12	
12	Construction Contract Awarded	0 days	Fri 11/18/11	Fri 11/18/11	11	13FS+6.25 days	
13	Issue NTP	0 days	Thu 11/24/11	Thu 11/24/11	12FS+6.25 days	14FS+1.25 days	
14	NTP Acknowledged	0 days	Fri 11/25/11	Fri 11/25/11	13FS+1.25 days	15	
15	Pre-Con Meeting	1.25 days	Fri 11/25/11	Sat 11/26/11	14	16	
16	Prepare Pre-Construction Submittals	28.75 days	Sat 11/26/11	Fri 12/23/11	15	17SS	
17	Corps Approve Pre-Constructon Submittals	37.5 days	Sat 11/26/11	Sat 12/31/11	16SS		
18	**Construction**	**605.69 days**	**Mon 4/2/12**	**Fri 10/18/13**			
19	Levees & Floodwalls	603.5 days	Mon 4/2/12	Wed 10/16/13			
20	Levees	603.5 days	Mon 4/2/12	Wed 10/16/13			
21	Season 1	241.25 days	Mon 4/2/12	Tue 11/13/12			
22	Site Mobilization - Levees	18 days	Mon 4/2/12	Wed 4/18/12		23,74SS,127SS	
23	Haul Roads & Drainage	6 days	Wed 4/18/12	Tue 4/24/12	22	24SS	
24	SWPP Installation - Levees	5 days	Wed 4/18/12	Mon 4/23/12	23SS		full duration of levee constr
25	Clearing & Grubbing	3 days	Tue 5/1/12	Thu 5/3/12		26SS+2 days	
26	Levee Stripping	12 days	Wed 5/2/12	Mon 5/14/12	25SS+2 days	35SS+2 days	
27	Site Mobilization - Borrow Areas	18 days	Mon 4/2/12	Wed 4/18/12		28	
28	Haul Roads & Drainage - Borrow Areas	6 days	Wed 4/18/12	Tue 4/24/12	27	29SS	
29	SWPP Installation - Borrow Areas	2 days	Wed 4/18/12	Fri 4/20/12	28SS	30	full duration of borrow area use
30	Borrow Areas - Surface Layer Removal & Stockpile	13 days	Fri 4/20/12	Wed 5/2/12	29		
31	Borrow Areas - Excavation & Hauling (to replace std depth CO Wall Waste)	28 days	Fri 5/4/12	Wed 5/30/12	35SS		assumes 2 crews used

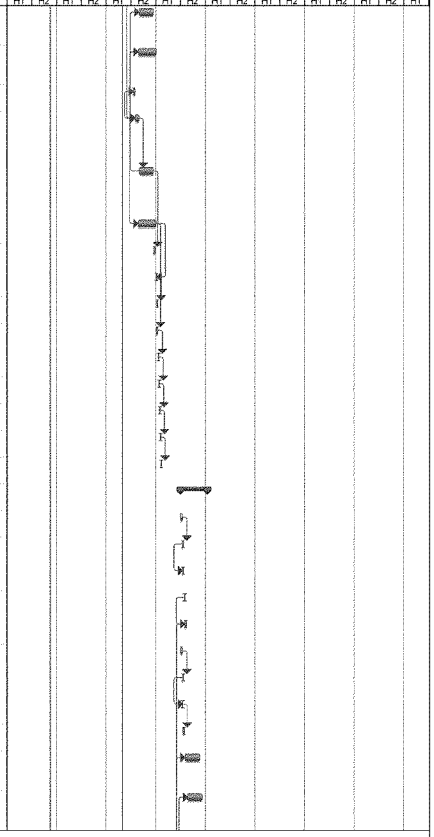


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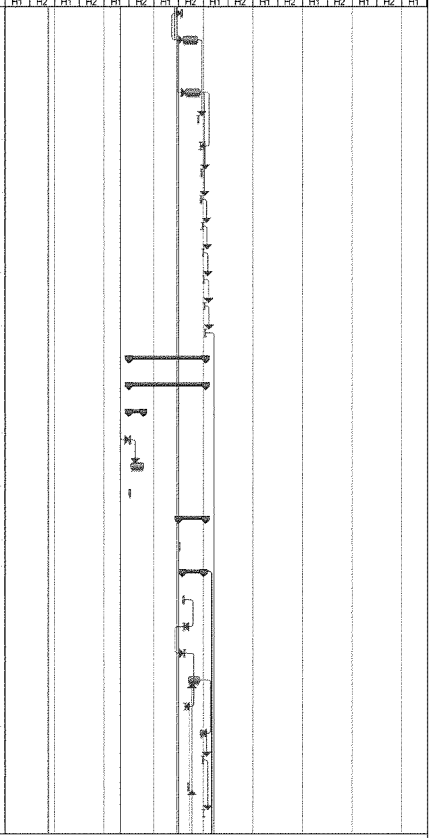
AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

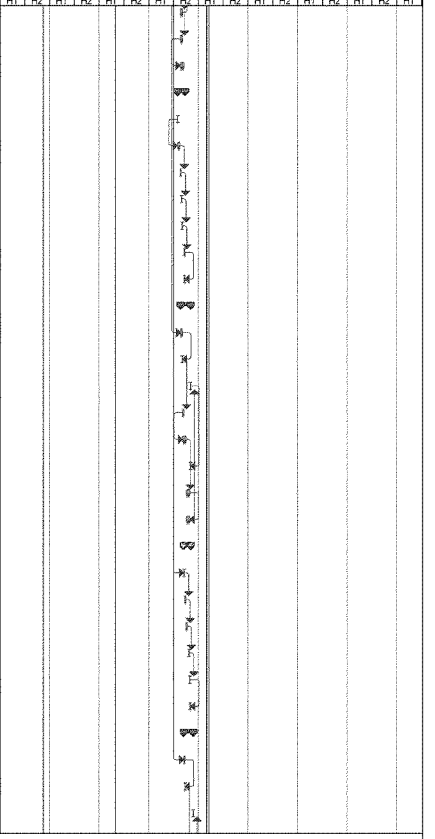
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
32	Borrow Areas - Excavation & Hauling (to replace deep CO Wall Waste)	115 days	Wed 5/30/12	Fri 9/14/12	36SS		assumes 2 crews used
33	Borrow Areas - Excavation & Hauling	143 days	Thu 5/24/12	Thu 10/4/12	37SS		assumes 2 crews used
34	Site Mobilization - Slurry Wall	15 days	Tue 4/17/12	Tue 5/1/12	35SS-18 days		
35	Slurry Wall Construction (depth less than 75')	28 days	Fri 5/4/12	Wed 5/30/12	26SS+2 days	36,31SS,37SS+2 days,34SS-18 days	
36	Slurry Wall Construction (depth 75' or more)	115 days	Wed 5/30/12	Fri 9/14/12	35	38,32SS	Assumes 2 crews used
37	Select/Levee Fill & Random Fill	143 days	Thu 5/24/12	Thu 10/4/12	35SS+21 days	33SS,41,39FF+2 days	asssumes 2 crews used
38	Demob - Slurry Wall	12 days	Fri 9/14/12	Wed 9/26/12	36		
39	Maintenance Road - ABC	3 days	Sat 10/6/12	Tue 10/9/12	37FF+5 days	40	
40	Revegetation/Hydroseed	10 days	Tue 10/9/12	Thu 10/18/12	39		
41	Surface Layer Restoration - Borrow Areas	15 days	Thu 10/4/12	Thu 10/18/12	37	42	
42	Demob - Borrow Areas	6 days	Thu 10/18/12	Wed 10/24/12	41	43	
43	Site Cleanup/Finish Work - Borrow Areas	5 days	Wed 10/24/12	Mon 10/29/12	42	44	
44	Weather Delays	6 days	Mon 10/29/12	Sat 11/3/12	43	45	
45	Demob - Levee Areas	5 days	Sat 11/3/12	Thu 11/8/12	44	46	
46	Site Cleanup/Finish Work - Levee Areas	5 days	Thu 11/8/12	Tue 11/13/12	45		
47	Season 2	213.5 days	Mon 4/1/13	Wed 10/16/13			
48	Site Mobilization - Levees - Season 1	18 days	Mon 4/1/13	Wed 4/17/13		49	
49	Haul Roads & Drainage	6 days	Wed 4/17/13	Tue 4/23/13	48	50SS	
50	SWPP Installation - Levees	5 days	Wed 4/17/13	Mon 4/22/13	49SS		full duration of levee constr
51	Clearing & Grubbing	3 days	Wed 5/1/13	Fri 5/3/13		52SS+2 days	
52	Levee Stripping	12 days	Thu 5/2/13	Tue 5/14/13	51SS+2 days	53SS+2 days	
53	Site Mobilization - Borrow Areas	18 days	Mon 4/1/13	Wed 4/17/13		54	
54	Haul Roads & Drainage - Borrow Areas	6 days	Wed 4/17/13	Tue 4/23/13	53	55SS	
55	SWPP Installation - Borrow Areas	2 days	Wed 4/17/13	Fri 4/19/13	54SS	56	full duration of borrow area use
56	Borrow Areas - Surface Layer Removal & Stockpile	13 days	Fri 4/19/13	Wed 5/1/13	55		
57	Borrow Areas - Excavation & Hauling (to replace deep CO Wall Waste)	115 days	Sat 5/4/13	Tue 8/20/13	60SS		assumes 2 crews used
58	Borrow Areas - Excavation & Hauling	115 days	Fri 5/24/13	Mon 9/9/13	61SS		assumes 2 crews used



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
59	Site Mobilization - Slurry Wall	15 days	Wed 4/17/13	Wed 5/1/13	60SS-18 days		
60	Slurry Wall Construction (depth 75' or more)	115 days	Sat 5/4/13	Tue 8/20/13	52SS+2 days	57SS,62,61SS+ days,59SS-18 days,101SS+20 days,110SS+45	Assumes 2 crews used
61	Select/Levee Fill & Random Fill	115 days	Fri 5/24/13	Mon 9/9/13	60SS+21 days	58SS,65,63FF+ days	assumes 2 crews used
62	Demob - Slurry Wall	12 days	Tue 8/20/13	Fri 8/30/13	60		
63	Maintenance Road - ABC	3 days	Tue 9/10/13	Fri 9/13/13	61FF+5 days	64	
64	Revegetation/Hydroseed	10 days	Fri 9/13/13	Mon 9/23/13	63		
65	Surface Layer Restoration - Borrow Areas	15 days	Mon 9/9/13	Mon 9/23/13	61	66	
66	Demob - Borrow Areas	5 days	Mon 9/23/13	Fri 9/27/13	65	67	
67	Site Cleanup/Finish Work - Borrow Areas	5 days	Fri 9/27/13	Wed 10/2/13	66	68	
68	Weather Delays	6 days	Wed 10/2/13	Mon 10/7/13	67	69	
69	Demob - Levee Areas	5 days	Mon 10/7/13	Fri 10/11/13	68	70	
70	Site Cleanup/Finish Work - Levee Areas	5 days	Fri 10/11/13	Wed 10/16/13	69	127FF,128FF	
71	Relocations	605.69 days	Mon 4/2/12	Fri 10/18/13			
72	Utilities	605.69 days	Mon 4/2/12	Fri 10/18/13			
73	Season 1	115.19 days	Mon 4/2/12	Wed 7/18/12			
74	Site Mobilization - for Util Relocations	15 days	Mon 4/2/12	Mon 4/16/12	22SS	75	
75	Utility Poles	100 days	Mon 4/16/12	Wed 7/18/12	74		1/day
76	Site Demob - for Util Relocations	15 days	Mon 4/2/12	Sat 4/14/12			
77	Season 2	215.5 days	Mon 4/1/13	Fri 10/18/13			
78	Site Mobilization - for Util Relocations	15 days	Mon 4/1/13	Mon 4/15/13			
79	Riverside Canal, SREL 3B	168 days	Wed 5/1/13	Fri 10/4/13		124	
80	Demo	16 days	Wed 5/1/13	Wed 5/15/13		81FF	
81	Clear & Grub	8 days	Wed 5/8/13	Wed 5/15/13	80FF	82SS+2 days	
82	Stripping	11 days	Fri 5/10/13	Mon 5/20/13	81SS+2 days	84FF+1 day	
83	Compacted Embankment	89 days	Thu 6/13/13	Wed 9/4/13	89FS+5 days	85FF+20 days	
84	Excavation to Stockpile	3 days	Sat 5/18/13	Tue 5/21/13	82FF+1 day	89,90	
85	Concrete Canal Lining	14 days	Tue 9/10/13	Mon 9/23/13	83FF+20 days	86	
86	ABC	9 days	Mon 9/23/13	Wed 10/2/13	85	88	
87	Field Irrigation Turnouts	10 days	Sat 6/8/13	Tue 6/18/13	89		
88	Erosion Control Seeding	3 days	Wed 10/2/13	Fri 10/4/13	86		



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
89	30-IN Solid Wall HDPE Pipeline	20 days	Tue 5/21/13	Sat 6/8/13	84	83FS+5 days,87	
90	Pumping Plant Outfall	20 days	Tue 5/21/13	Sat 6/8/13	84	91SS	
91	Water Control Facilities	30 days	Tue 5/21/13	Tue 6/18/13	90SS		
92	Private Irrigation Facility Relocation (Tennet-Labvitch)	60 days	Wed 5/1/13	Wed 6/26/13			Sta ~853+00
93	Demo	2 days	Wed 5/1/13	Thu 5/2/13		94SS	
94	Earthwork	20 days	Wed 5/1/13	Mon 5/20/13	93SS	95	
95	Well Drilling	10 days	Mon 5/20/13	Wed 5/29/13	94	96	
96	Well Development	5 days	Wed 5/29/13	Mon 6/3/13	95	97	
97	Concrete Pad	5 days	Mon 6/3/13	Fri 6/7/13	96	98FS+10 days	
98	Pump & Discharge Pipe	10 days	Mon 6/17/13	Wed 6/26/13	97FS+10 days	99FF	
99	Electrical Service	10 days	Mon 6/17/13	Wed 6/26/13	98FF		
100	Pumping Plant - Sump 160	80 days	Thu 5/23/13	Tue 8/6/13			Sta ~900+00
101	Demo	16 days	Thu 5/23/13	Fri 6/7/13	60SS+20 days	102FF	expected to commence about 20 days before levee construction reaches this point
102	Earthwork	4 days	Mon 6/3/13	Fri 6/7/13	101FF	104	
103	Roads	4 days	Fri 8/2/13	Tue 8/6/13	108	106FF	
104	Pipes	12 days	Fri 6/7/13	Tue 6/18/13	102	105SS	
105	Positive Closure Vault	30 days	Fri 6/7/13	Fri 7/5/13	104SS	107	
106	Security Fence	2 days	Sat 8/3/13	Tue 8/6/13	103FF		
107	Pumps & Motors	30 days	Fri 7/5/13	Fri 8/2/13	105	108FF	
108	Power & Controls	30 days	Fri 7/5/13	Fri 8/2/13	107FF	103	
109	RD 1000, PP No 1A	56 days	Sat 6/15/13	Wed 8/7/13			Sta ~924+50
110	Demo	6 days	Sat 6/15/13	Fri 6/21/13	60SS+45 days	111	expected to commence about 20 days before levee construction reaches this point
111	Site Work	12 days	Fri 6/21/13	Tue 7/2/13	110	112	
112	Construct Chamber for Sluice Gates & Flap Gates	10 days	Tue 7/2/13	Thu 7/11/13	111	113FS+10 days	
113	New Slide/Sluice Gates	8 days	Sat 7/20/13	Mon 7/29/13	112FS+10 days	114	
114	New Flap Gates & Power Winch for Opening	5 days	Mon 7/29/13	Fri 8/2/13	113	115FF+5 days	
115	Powr & Controls for Gate Facilities	10 days	Mon 7/29/13	Wed 8/7/13	114FF+5 days		
116	RD 1000, PP No 1B	78 days	Sat 6/15/13	Tue 8/27/13			Sta ~924+50
117	Demo	13 days	Sat 6/15/13	Thu 6/27/13	60SS+45 days	118FF	expected to commence about 20 days before levee construction reaches this point
118	Earthwork	3 days	Tue 6/25/13	Thu 6/27/13	117FF	120	
119	Roads	5 days	Thu 8/22/13	Tue 8/27/13	123		

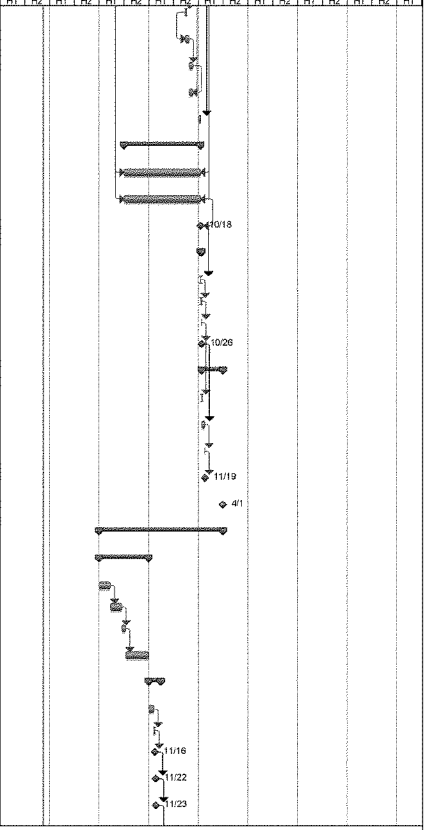


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
120	Pipes	10 days	Thu 6/27/13	Sat 7/6/13	118	121SS	
121	Positive Closure Vault	30 days	Thu 6/27/13	Thu 7/25/13	120SS	122	
122	Pumps & Motors	30 days	Thu 7/25/13	Thu 8/22/13	121	123FF	
123	Power & Controls	30 days	Thu 7/25/13	Thu 8/22/13	122FF	119	
124	Site Demob - for Util Relocations	15 days	Fri 10/4/13	Fri 10/18/13	79		
125	Engineering during Construction, S&A and Construction Completion	605 days	Mon 4/2/12	Fri 10/18/13			
126	Engineering During Construction	605 days	Mon 4/2/12	Fri 10/18/13	22SS,70FF		
127	Supervision and Administration	605 days	Mon 4/2/12	Fri 10/18/13	22SS,70FF	128FF	
128	Construction Completion	0 days	Fri 10/18/13	Fri 10/18/13	127FF	130	
129	**Inspection and Construction per Punch List**	**9 days**	**Fri 10/18/13**	**Sat 10/26/13**			
130	PreFinal Inspection	2 days	Fri 10/18/13	Sat 10/19/13	128	131	
131	Contractor Implement Punch List Items	6 days	Sat 10/19/13	Fri 10/25/13	130	132	
132	Final Inspection	1 day	Fri 10/25/13	Sat 10/26/13	131	133,135	
133	Construction Physical Completion	0 days	Sat 10/26/13	Sat 10/26/13	132	136	
134	**Project Closeout**	**167.25 days**	**Sat 10/26/13**	**Tue 4/1/14**			
135	Construction Prepares Project Completion Letter	6 days	Sat 10/26/13	Fri 11/1/13	132		
136	Contractors Complete As-Builts	24 days	Sat 10/26/13	Mon 11/18/13	133	137	
137	Submit As-Builts	1 day	Mon 11/18/13	Tue 11/19/13	136	138	
138	Notice of Completion/Assumption of OMRR&R	0 days	Tue 11/19/13	Tue 11/19/13	137		
139	Project Fiscally Complete	0 days	Tue 4/1/14	Tue 4/1/14			
140	**Construction Contract 2 - Reach B (remaining work)**	**977.5 days**	**Sat 10/1/11**	**Tue 4/1/14**			SREL Sta 635+00 to 742+60 - Work involves changes to several pumping plants and canal...
141	**Design**	**390 days**	**Sat 10/1/11**	**Sat 9/29/12**			
142	Collect field explorations	90 days	Sat 10/1/11	Sat 12/24/11		143	
143	Conduct geotechnical evaluation	90 days	Sat 12/24/11	Sat 3/17/12	142	144	
144	Develop Basis of Design Report	30 days	Sat 3/17/12	Sat 4/14/12	143	145	
145	Develop Plans & Specifications	180 days	Sat 4/14/12	Sat 9/29/12	144		
146	**Pre-Construction**	**96.25 days**	**Mon 10/1/12**	**Sat 12/29/12**			
147	Project Bid	41.25 days	Mon 10/1/12	Thu 11/8/12		148	
148	Award Task Order	8.75 days	Thu 11/8/12	Fri 11/16/12	147	149	
149	Construction Contract Awarded	0 days	Fri 11/16/12	Fri 11/16/12	148	150FS+6.25 days	
150	Issue NTP	0 days	Thu 11/22/12	Thu 11/22/12	149FS+6.25 days	151FS+1.25 days	
151	NTP Acknowledged	0 days	Fri 11/23/12	Fri 11/23/12	150FS+1.25 days	152	



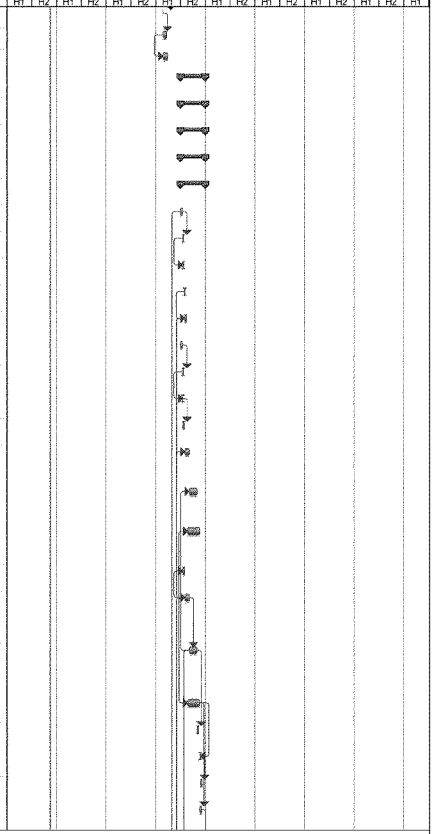
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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

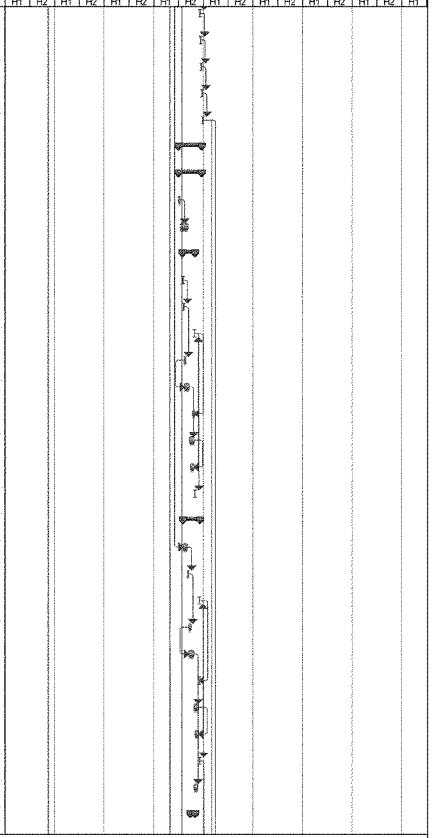
Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
152	Pre-Con Meeting	1.25 days	Fri 11/23/12	Sat 11/24/12	151	153	
153	Prepare Pre-Construction Submittals	28.75 days	Sat 11/24/12	Fri 12/21/12	152	154SS	
154	Corps Approve Pre-Construcion Submittals	37.5 days	Sat 11/24/12	Sat 12/29/12	153SS		
155	**Construction**	**196.5 days**	**Mon 4/1/13**	**Tue 10/1/13**			
156	Levees & Floodwalls	196.5 days	Mon 4/1/13	Tue 10/1/13			
157	Levees	196.5 days	Mon 4/1/13	Tue 10/1/13			
158	General Construction Schedule	196.5 days	Mon 4/1/13	Tue 10/1/13			
159	Season 1	196.5 days	Mon 4/1/13	Tue 10/1/13			
160	Site Mobilization - Levees	18 days	Mon 4/1/13	Wed 4/17/13		161,218SS,219	
161	Haul Roads & Drainage	6 days	Wed 4/17/13	Tue 4/23/13	160	162SS	
162	SWPP Installation - Levees	8 days	Wed 4/17/13	Wed 4/24/13	161SS		full duration of levee constr
163	Clearing & Grubbing	3 days	Wed 5/1/13	Fri 5/3/13		164SS+2 days	
164	Levee Stripping	12 days	Thu 5/2/13	Tue 5/14/13	163SS+2 days	173SS+2 days	
165	Site Mobilization - Borrow Areas	18 days	Mon 4/1/13	Wed 4/17/13		166	
166	Haul Roads & Drainage - Borrow Areas	6 days	Wed 4/17/13	Tue 4/23/13	165	167SS	
167	SWPP Installation - Borrow Areas	2 days	Wed 4/17/13	Fri 4/19/13	166SS	168	full duration of borrow area use
168	Borrow Areas - Surface Layer Removal & Stockpile	10 days	Fri 4/19/13	Mon 4/29/13	167		
169	Borrow Areas - Excavation & Hauling (to replace std depth CO Wall Waste)	34 days	Sat 5/4/13	Wed 6/5/13	173SS		
170	Borrow Areas - Excavation & Hauling (to replace deep CO Wall Waste)	62 days	Wed 6/5/13	Fri 8/2/13	174SS		
171	Borrow Areas - Excavation & Hauling	96 days	Fri 5/24/13	Wed 8/21/13	175SS		assumes 2 crews used
172	Site Mobilization - Slurry Wall	15 days	Wed 4/17/13	Wed 5/1/13	173SS-18 days		
173	Slurry Wall Construction (depth 75' or more)	34 days	Sat 5/4/13	Wed 6/5/13	164SS+2 days	169SS,172SS-1 days,174,175SS days,200SS	
174	Slurry Wall Construction (depth less than 75')	62 days	Wed 6/5/13	Fri 8/2/13	173	170SS,176,211 days	asssumes 2 crews used
175	Select/Levee Fill & Random Fill	96 days	Fri 5/24/13	Wed 8/21/13	173SS+21 days	171SS,179,177 days	asssumes 2 crews used
176	Demob - Slurry Wall	12 days	Fri 8/2/13	Tue 8/13/13	174		
177	Maintenance Road - ABC	4 days	Thu 8/22/13	Mon 8/26/13	175FF+5 days	178	
178	Revegetation/Hydroseed	16 days	Mon 8/26/13	Tue 9/10/13	177		
179	Surface Layer Restoration - Borrow Areas	15 days	Wed 8/21/13	Wed 9/4/13	175	180	



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ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
180	Demob - Borrow Areas	5 days	Wed 9/4/13	Mon 9/9/13	179	181	
181	Site Cleanup/Finish Work - Borrow Areas	5 days	Mon 9/9/13	Fri 9/13/13	180	182	
182	Weather Delays	6 days	Fri 9/13/13	Thu 9/19/13	181	183	
183	Demob - Levee Areas	6 days	Thu 9/19/13	Wed 9/25/13	182	184	
184	Site Cleanup/Finish Work - Levee Areas	6 days	Wed 9/25/13	Tue 10/1/13	183	218FF,219FF,2	
185	Relocations	185.5 days	Mon 4/1/13	Fri 9/20/13			
186	Utilities	185.5 days	Mon 4/1/13	Fri 9/20/13			
187	Site Mobilization - for Util Relocations	15 days	Mon 4/1/13	Mon 4/15/13		188	
188	Utility Poles	60 days	Mon 4/15/13	Mon 6/10/13	187		1/day
189	Elkhorn PP, Phase 2	100 days	Wed 5/1/13	Fri 8/2/13			
190	Demo	5 days	Wed 5/1/13	Mon 5/6/13		191	
191	Earthwork	8 days	Mon 5/6/13	Mon 5/13/13	190	193	
192	Roads	4 days	Fri 7/26/13	Tue 7/30/13	197	195FF,198	
193	Pipes	14 days	Mon 5/13/13	Sat 5/25/13	191	194SS	
194	Positive Closure Vault	40 days	Mon 5/13/13	Wed 6/19/13	193SS	196	
195	Pump Platform Rehab	20 days	Thu 7/11/13	Tue 7/30/13	192FF		
196	Pumps & Motors	40 days	Wed 6/19/13	Fri 7/26/13	194	197FF	
197	Power & Controls	30 days	Fri 6/28/13	Fri 7/26/13	196FF	192	
198	Bank Stabilization	3 days	Tue 7/30/13	Fri 8/2/13	192		
199	RD 1000, PP No 3	134 days	Sat 5/4/13	Fri 9/6/13			Sta ~676+00
200	Demo	35 days	Sat 5/4/13	Thu 6/6/13	173SS	201	expected to commence about 35 days before levee construction
201	Earthwork	10 days	Thu 6/6/13	Sat 6/15/13	200	203	
202	Roads	4 days	Thu 8/29/13	Mon 9/2/13	207	205FF,206	
203	Pipes	20 days	Sat 6/15/13	Thu 7/4/13	201	204SS	
204	Positive Closure & Flow Meter Vaults	40 days	Sat 6/15/13	Tue 7/23/13	203SS	206,209	
205	Security Fence	2 days	Fri 8/30/13	Mon 9/2/13	202FF		
206	Pumps & Motors	40 days	Tue 7/23/13	Thu 8/29/13	204	207FF	
207	Power & Controls	30 days	Thu 8/1/13	Thu 8/29/13	206FF	202	
208	Flap Gates	5 days	Mon 9/2/13	Fri 9/6/13	202	216	
209	C-I-P Concrete Baffles	30 days	Tue 7/23/13	Tue 8/20/13	204		
210	Riverside PP, Phase 1	37 days	Fri 6/28/13	Fri 8/2/13			Sta ~707+50

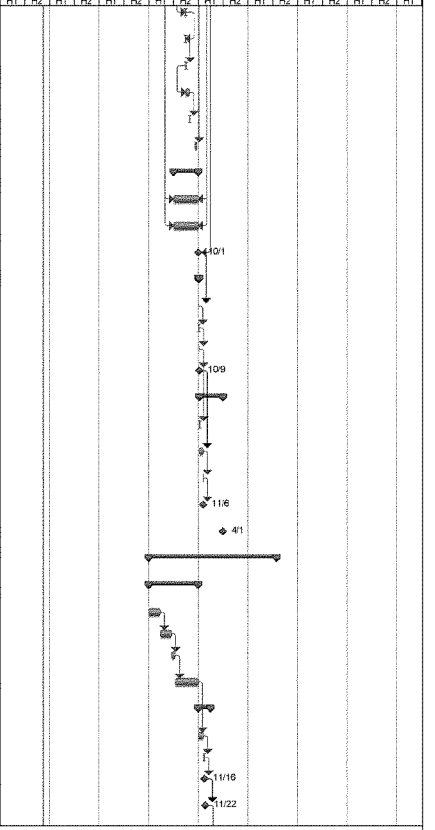


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
211	Demo	2 days	Fri 6/28/13	Mon 7/1/13	174SS+25 days	212FF	expected to commence about 5 days before levee construction reaches this point
212	Earthwork	2 days	Fri 6/28/13	Mon 7/1/13	211FF	213	
213	Pipes	5 days	Mon 7/1/13	Fri 7/5/13	212	214SS	
214	Flow Meter Vault	30 days	Mon 7/1/13	Mon 7/29/13	213SS	215	
215	Bollards	5 days	Mon 7/29/13	Fri 8/2/13	214		
216	Site Demobilization - for Util Relocations	15 days	Fri 9/6/13	Fri 9/20/13	208		
217	Engineering during Construction, S&A and Construction Completion	195 days	Tue 4/2/13	Tue 10/1/13			
218	Engineering During Construction	195 days	Tue 4/2/13	Tue 10/1/13	160SS,184FF		
219	Supervision and Administration	195 days	Tue 4/2/13	Tue 10/1/13	160SS,184FF		
220	Construction Completion	0 days	Tue 10/1/13	Tue 10/1/13	184FF	222	
221	**Inspection and Construction per Punch List**	**8.75 days**	**Tue 10/1/13**	**Wed 10/9/13**			
222	PreFinal Inspection	1.25 days	Tue 10/1/13	Wed 10/2/13	220	223	
223	Contractor Implement Punch List Items	6.25 days	Wed 10/2/13	Tue 10/8/13	222	224	
224	Final Inspection	1.25 days	Tue 10/8/13	Wed 10/9/13	223	225,227	
225	Construction Physical Completion	0 days	Wed 10/9/13	Wed 10/9/13	224	228	
226	**Project Closeout**	**186 days**	**Wed 10/9/13**	**Tue 4/1/14**			
227	Construction Prepares Project Completion Letter	6.25 days	Wed 10/9/13	Tue 10/15/13	224		
228	Contractors Complete As-Builts	28.75 days	Wed 10/9/13	Tue 11/5/13	225	229	
229	Submit As-Builts	1.25 days	Tue 11/5/13	Wed 11/6/13	228	230	
230	Notice of Completion/Assumption of OMRR&R	0 days	Wed 11/6/13	Wed 11/6/13	229		
231	Project Fiscally Complete	0 days	Tue 4/1/14	Tue 4/1/14			
232	**Construction Contract 3 - Reach H**	**1010 days**	**Mon 10/1/12**	**Fri 5/1/15**			Sta 0+00 to 237+00 - Work involves levee improvements and/or [illegible]
233	**Design**	**390 days**	**Mon 10/1/12**	**Mon 9/30/13**			
234	Collect field explorations	90 days	Mon 10/1/12	Mon 12/24/12		235	
235	Conduct geotechnical evaluation	90 days	Mon 12/24/12	Mon 3/18/13	234	236	
236	Develop Basis of Design Report	30 days	Mon 3/18/13	Mon 4/15/13	235	237	
237	Develop Plans & Specifications	180 days	Mon 4/15/13	Mon 9/30/13	236	239	
238	**Pre-Construction**	**96.25 days**	**Tue 10/1/13**	**Mon 12/30/13**			
239	Project Bid	41.25 days	Tue 10/1/13	Fri 11/8/13	237	240	
240	Award Task Order	8.75 days	Fri 11/8/13	Sat 11/16/13	239	241	
241	Construction Contract Awarded	0 days	Sat 11/16/13	Sat 11/16/13	240	242FS+6.25 days	
242	Issue NTP	0 days	Fri 11/22/13	Fri 11/22/13	241FS+6.25 days	243FS+1.25 days	

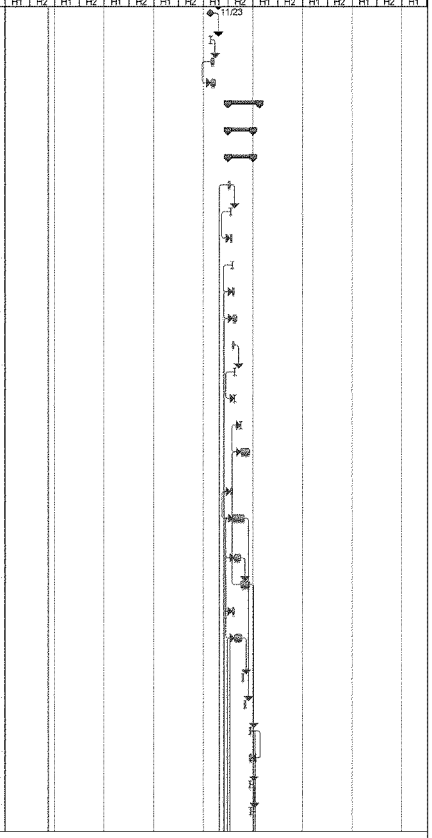


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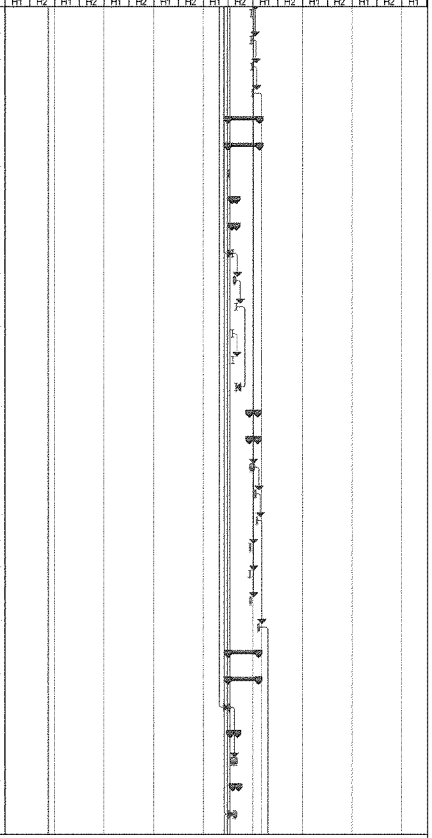
AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
243	NTP Acknowledged	0 days	Sat 11/23/13	Sat 11/23/13	242FS+1.25 days	244	
244	Pre-Con Meeting	1.25 days	Sat 11/23/13	Mon 11/25/13	243	245	
245	Prepare Pre-Construction Submittals	28.75 days	Mon 11/25/13	Sat 12/21/13	244	246SS	
246	Corps Approve Pre-Constructon Submittals	37.5 days	Mon 11/25/13	Mon 12/30/13	245SS		
247	**Construction**	**249.5 days**	**Tue 4/1/14**	**Wed 11/19/14**			
248	Levees & Floodwalls	198.75 days	Tue 4/1/14	Fri 10/3/14			
249	Levees	198.75 days	Tue 4/1/14	Fri 10/3/14			
250	Site Mobilization - Levees	18 days	Tue 4/1/14	Thu 4/17/14		251,299SS	
251	Haul Roads & Drainage	6 days	Thu 4/17/14	Wed 4/23/14	250	252SS	maintain for full duration of levee constr
252	SWPP Installation - Levees	13 days	Thu 4/17/14	Tue 4/29/14	251SS		full duration of levee constr
253	Clearing & Grubbing	5 days	Thu 5/1/14	Tue 5/6/14		254SS+2 days,282SS	
254	Levee Stripping	16 days	Fri 5/2/14	Sat 5/17/14	253SS+2 days	255SS+2 days	2 crews
255	Levee Degrading	31 days	Mon 5/5/14	Tue 6/3/14	254SS+2 days	262SS+2 days	2 crews
256	Site Mobilization - Borrow Areas	18 days	Thu 5/1/14	Sat 5/17/14		257	
257	Haul Roads & Drainage - Borrow Areas	5 days	Sat 5/17/14	Thu 5/22/14	256	258SS	full duration of borrow area use
258	SWPP Installation - Borrow Areas	2 days	Sat 5/17/14	Tue 5/20/14	257SS		full duration of borrow area use
259	Surface Layer Removal & Stockpile - Borrow Areas	5 days	Tue 7/1/14	Sat 7/5/14	260SS-2 days		0.66 AC/hr, 4 scrapers
260	Excavation & Hauling - Borrow Areas	70 days	Thu 7/3/14	Sat 9/6/14	264SS	259SS-2 days	
261	Site Mobilization - Slurry Wall	18 days	Sat 4/19/14	Tue 5/6/14	262SS-18 days	265SS+12 days	
262	Slurry Wall Construction	90 days	Tue 5/6/14	Tue 7/29/14	255SS+2 days	261SS-18 days,303SS,26 days,263SS+12	2 rigs/crews
263	Embankment Fill, from Levee Degrading	50 days	Sat 5/17/14	Thu 7/3/14	262SS+12 days	264	2 crews
264	Emankment Fill, from Borrow	70 days	Thu 7/3/14	Sat 9/6/14	263	260SS,271,269	2 crews
265	Site Mobilization - Jet Grouting	18 days	Thu 5/1/14	Sat 5/17/14	261SS+12 days		
266	Jet GroutingConstruction	60 days	Sat 5/17/14	Sat 7/12/14	262SS+12 days	267,307SS+12 days,315SS+5 days,316SS+5	assume start about 2 weeks after slurry wall
267	Demob - Jet Grouting	12 days	Sat 7/12/14	Thu 7/24/14	266		
268	Demob - Slurry Wall	12 days	Tue 7/29/14	Sat 8/9/14	262		
269	Bike Trail (at Levee Crown)	10 days	Sat 9/6/14	Tue 9/16/14	264	274,270FF+6 days	
270	Revegetation/Hydroseed	18 days	Thu 9/4/14	Mon 9/22/14	269FF+6 days		3.72 AC/day
271	Surface Layer Restoration - Borrow Areas	5 days	Sat 9/6/14	Thu 9/11/14	264	272	
272	Demob - Borrow Areas	6 days	Thu 9/11/14	Wed 9/17/14	271	273	



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
273	Site Cleanup/Finish Work - Borrow Areas	6 days	Wed 9/17/14	Tue 9/23/14	272		
274	Weather Delays	6.25 days	Tue 9/16/14	Mon 9/22/14	269	275	
275	Demob - Levee Areas	6 days	Mon 9/22/14	Sat 9/27/14	274	276	
276	Site Cleanup/Finish Work - Levee Areas	6 days	Sat 9/27/14	Fri 10/3/14	275	334FF	
277	Relocations	249.5 days	Tue 4/1/14	Wed 11/19/14			
278	Roads, Construction Activities	249.5 days	Tue 4/1/14	Wed 11/19/14			
279	Site Mobilization - for Rd Relocations	15 days	Tue 4/1/14	Tue 4/15/14			
280	Paving Demo	34 days	Thu 5/1/14	Mon 6/2/14			
281	Demolition	34 days	Thu 5/1/14	Mon 6/2/14			
282	Arden-Garden Connector	8 days	Thu 5/1/14	Thu 5/8/14	253SS	283	
283	Bike Trail at Levee Crown	23 days	Thu 5/8/14	Thu 5/29/14	282	284	
284	East Levee Road	3 days	Thu 5/29/14	Mon 6/2/14	283	287FF	
285	Dead End Roads	5 days	Thu 5/1/14	Tue 5/6/14		286	about 2 days each but will be done as levee improvement passes thru
286	Natoma Street	2 days	Tue 5/6/14	Wed 5/7/14	285		will be done as levee improvement passes thru area
287	Northgate Blvd	6 days	Tue 5/27/14	Mon 6/2/14	284FF		will be done as levee improvement passes thru area
288	Road Surfacing	64 days	Sat 9/6/14	Wed 11/5/14			
289	Site Work	64 days	Sat 9/6/14	Wed 11/5/14			
290	Arden-Garden Connector	40 days	Sat 9/6/14	Tue 10/14/14	264	291	
291	Bike Trail at Levee Crown	12 days	Tue 10/14/14	Sat 10/25/14	290	292	
292	East Levee Road	12 days	Sat 10/25/14	Wed 11/5/14	291	296	
293	Dead End Roads	10 days	Sat 9/6/14	Tue 9/16/14	264		about 2 days each but will be done as levee improvement passes thru
294	Natoma Street	5 days	Sat 9/6/14	Thu 9/11/14	264		will be done as levee improvement passes thru area
295	Northgate Blvd	15 days	Sat 9/6/14	Sat 9/20/14	264		will be done as levee improvement passes thru area
296	Site Demobilization - for Rd Relocations	15 days	Wed 11/5/14	Wed 11/19/14	292	336FF,337FF	
297	Cemeteries, Utils, Structures	241.5 days	Tue 4/1/14	Wed 11/12/14			
298	Utils	241.5 days	Tue 4/1/14	Wed 11/12/14			
299	Site Mobilization - for Util Relocations	18 days	Tue 4/1/14	Thu 4/17/14	250SS	301	
300	Electrical	56 days	Thu 4/17/14	Mon 6/9/14			
301	Utility Poles	56 days	Thu 4/17/14	Mon 6/9/14	299		1/day
302	Utility Crossing Relocations	45 days	Tue 5/6/14	Tue 6/17/14			
303	6" Gas Main	30 days	Tue 5/6/14	Tue 6/3/14	262SS	304SS,305SS	

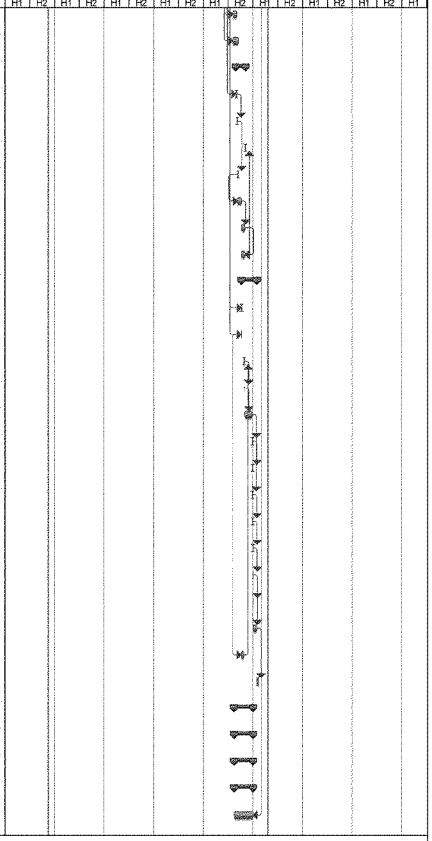


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
304	8" Water Main	30 days	Tue 5/6/14	Tue 6/3/14	303SS		
305	Fiber Optic Line	45 days	Tue 5/6/14	Tue 6/17/14	303SS		
306	PP - Sump 102	77 days	Thu 5/29/14	Fri 8/8/14			Sta ~59+80
307	Demo	8 days	Thu 5/29/14	Thu 6/5/14	266SS+12 days	308	expected to commence about 10 days before levee construction reaches this point
308	Earthwork	5 days	Thu 6/5/14	Tue 6/10/14	307	310	
309	Roads	4 days	Tue 8/5/14	Fri 8/8/14	313		
310	Pipes	8 days	Tue 6/10/14	Tue 6/17/14	308	311SS	
311	Positive Closure Vault	30 days	Tue 6/10/14	Tue 7/8/14	310SS	312	
312	Pumps & Motors	30 days	Tue 7/8/14	Tue 8/5/14	311	313FF	
313	Power & Controls	30 days	Tue 7/8/14	Tue 8/5/14	312FF	309	
314	RD 1000, PP No 6	124 days	Tue 7/8/14	Fri 10/31/14			Sta ~178+00
315	Temporary Fencing	5 days	Tue 7/8/14	Sat 7/12/14	266SS+55 days		expected to commence about 10 days before levee construction reaches this point
316	Asphalt Removal	1 day	Tue 7/8/14	Wed 7/9/14	266SS+55 days	326SS	
317	Excavate, Fill & Compact	5 days	Sat 7/26/14	Thu 7/31/14	328	318	
318	Remove Existing WSP	1 day	Thu 7/31/14	Fri 8/1/14	317	319	
319	Positive Closure Vault	60 days	Fri 8/1/14	Fri 9/26/14	318	320,322	
320	Closure Valve, 54-IN	3 days	Fri 9/26/14	Mon 9/29/14	319	321	
321	Dismantling Joint, 54-IN	2 days	Mon 9/29/14	Wed 10/1/14	320		
322	Closure Valve, 36-IN	3 days	Fri 9/26/14	Mon 9/29/14	319	323	
323	Dismantling Joint, 36-IN	2 days	Mon 9/29/14	Wed 10/1/14	322	324	
324	Siphon Breakers	2 days	Wed 10/1/14	Thu 10/2/14	323	325	
325	Backfill	1 day	Thu 10/2/14	Fri 10/3/14	324	326,327	
326	ABC	1 day	Fri 10/3/14	Sat 10/4/14	325		
327	Electrical Control Equipment	30 days	Fri 10/3/14	Fri 10/31/14	325	329	
328	Locate & Relocate Utils prior to excavation	20 days	Tue 7/8/14	Sat 7/26/14	316SS	317	
329	Site Demobilization - for Util Relocations	12 days	Fri 10/31/14	Wed 11/12/14	327		
330	Fish & Wildlife Facilities	150 days	Fri 5/16/14	Fri 10/3/14			
331	Wildlife Facilities & Sanctoaries	150 days	Fri 5/16/14	Fri 10/3/14			
332	Dry Creek	150 days	Fri 5/16/14	Fri 10/3/14			
333	Woodland Corridor & Enhancement	150 days	Fri 5/16/14	Fri 10/3/14			
334	Mob, Prep Work, Planting & Irrigation, Demob	150 days	Fri 5/16/14	Fri 10/3/14	276FF		sans O&M

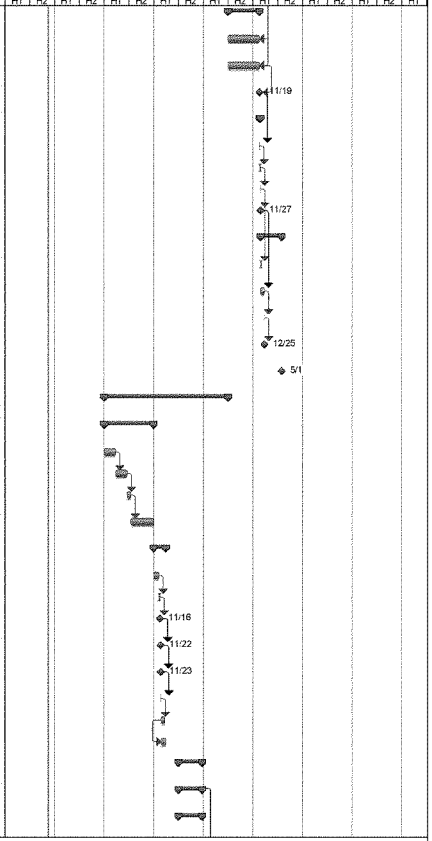


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
335	Engineering during Construction, S&A and Construction Completion	249 days	Tue 4/1/14	Wed 11/19/14			
336	Engineering During Construction	249 days	Tue 4/1/14	Wed 11/19/14	296FF		
337	Supervision and Administration	249 days	Tue 4/1/14	Wed 11/19/14	296FF	338FF	
338	Construction Completion	0 days	Wed 11/19/14	Wed 11/19/14	337FF	340	
339	**Inspection and Construction per Punch List**	**8.75 days**	**Wed 11/19/14**	**Thu 11/27/14**			
340	PreFinal Inspection	1.25 days	Wed 11/19/14	Thu 11/20/14	338	341	
341	Contractor Implement Punch List Items	6.25 days	Thu 11/20/14	Wed 11/26/14	340	342	
342	Final Inspection	1.25 days	Wed 11/26/14	Thu 11/27/14	341	343,345	
343	Construction Physical Completion	0 days	Thu 11/27/14	Thu 11/27/14	342	346	
344	**Project Closeout**	**165.5 days**	**Thu 11/27/14**	**Fri 5/1/15**			
345	Construction Prepares Project Completion Letter	6.25 days	Thu 11/27/14	Wed 12/3/14	342		
346	Contractors Complete As-Builts	28.75 days	Thu 11/27/14	Wed 12/24/14	343	347	
347	Submit As-Builts	1.25 days	Wed 12/24/14	Thu 12/25/14	346	348	
348	Notice of Completion/Assumption of OMRR&R	0 days	Thu 12/25/14	Thu 12/25/14	347		
349	Project Fiscally Complete	0 days	Fri 5/1/15	Fri 5/1/15			
350	**Construction Contract 4- Reach I**	**976.25 days**	**Mon 10/3/11**	**Tue 4/1/14**			Sta 20+50 to 115+73.3 - Work involves levee improvements and/or soil-bentonite slurry wall along the
351	**Design**	**390 days**	**Mon 10/3/11**	**Mon 10/1/12**			
352	Collect field explorations	90 days	Mon 10/3/11	Mon 12/26/11		353	
353	Conduct geotechnical evaluation	90 days	Mon 12/26/11	Mon 3/19/12	352	354	
354	Develop Basis of Design Report	30 days	Mon 3/19/12	Mon 4/16/12	353	355	
355	Develop Plans & Specifications	180 days	Mon 4/16/12	Mon 10/1/12	354		
356	**Pre-Construction**	**95.25 days**	**Mon 10/1/12**	**Sat 12/29/12**			
357	Project Bid	41.25 days	Mon 10/1/12	Thu 11/8/12		358	
358	Award Task Order	8.75 days	Thu 11/8/12	Fri 11/16/12	357	359	
359	Construction Contract Awarded	0 days	Fri 11/16/12	Fri 11/16/12	358	360FS+6.25 days	
360	Issue NTP	0 days	Thu 11/22/12	Thu 11/22/12	359FS+6.25 days	361FS+1.25 days	
361	NTP Acknowledged	0 days	Fri 11/23/12	Fri 11/23/12	360FS+1.25 days	362	
362	Pre-Con Meeting	1.25 days	Fri 11/23/12	Sat 11/24/12	361	363	
363	Prepare Pre-Construction Submittals	28.75 days	Sat 11/24/12	Fri 12/21/12	362	364SS	
364	Corps Approve Pre-Constructon Submittals	37.5 days	Sat 11/24/12	Sat 12/29/12	363SS		
365	**Construction**	**188 days**	**Mon 4/1/13**	**Mon 9/23/13**			
366	Levees & Floodwalls	188 days	Mon 4/1/13	Mon 9/23/13		419FF,420FF	
367	Levees	188 days	Mon 4/1/13	Mon 9/23/13			

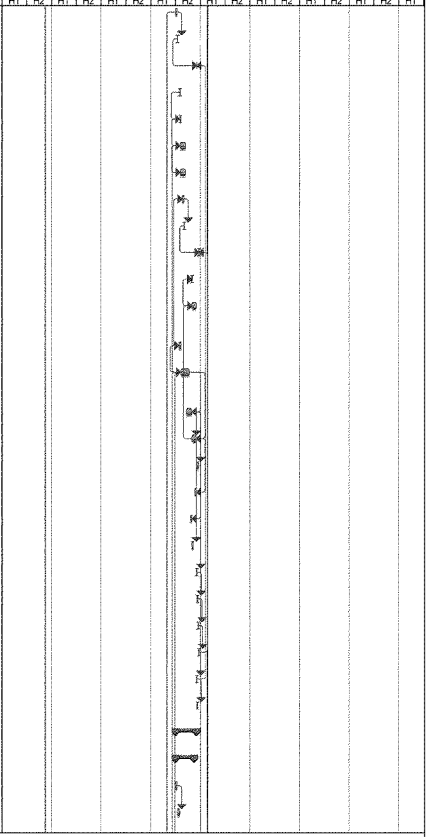


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
368	Site Mobilization - Levees	15 days	Mon 4/1/13	Mon 4/15/13		369,402SS	
369	Haul Roads & Drainage	3.75 days	Mon 4/15/13	Thu 4/18/13	368	370SS	
370	Care & Diversion of Water - Erosion Control - SWPC	1.25 days	Fri 9/6/13	Sat 9/7/13	369SS,392FF		full duration of levee constr
371	Clearing & Grubbing	5 days	Wed 5/1/13	Mon 5/6/13		372SS+2.5 days	
372	Levee Stripping	8.75 days	Fri 5/3/13	Sat 5/11/13	371SS+2.5 days	373SS+2.5 days	
373	Levee Degrading	42.5 days	Mon 5/6/13	Fri 6/14/13	372SS+2.5 days	374SS,381SS+ days	
374	Temporary Fill, Placement	42.5 days	Mon 5/6/13	Fri 6/14/13	373SS		
375	Site Mobilization - Borrow Areas	15 days	Tue 5/21/13	Tue 6/4/13	380SS+25 days	376	
376	Haul Roads & Drainage - Borrow Areas	3.75 days	Tue 6/4/13	Fri 6/7/13	375	377SS	
377	Care & Diversion of Water - Erosion Control - SWPC - Borrow Areas	1.25 days	Sat 9/21/13	Mon 9/23/13	376SS,391FF		full duration of borrow area use
378	Surface Layer Removal & Stockpile - Borrow Areas	5 days	Tue 7/30/13	Sat 8/3/13	379SS-2.5 days		
379	Excavation & Hauling - Borrow Areas	35 days	Thu 8/1/13	Tue 9/3/13	383SS	378SS-2.5 days	
380	Site Mobilization - Slurry Wall	15 days	Sat 4/27/13	Sat 5/11/13	381SS-15 days	375SS+25 days	
381	Slurry Wall Construction	67 days	Sat 5/11/13	Fri 7/12/13	373SS+6.25 days	380SS-15 days,406SS,38 days,383FF+12	
382	Embankment Fill, from Levee Degrading	46.25 days	Wed 6/19/13	Thu 8/1/13	381FF+21 days	383,386FF,387 days	
383	Emankment Fill, from Borrow	35 days	Thu 8/1/13	Tue 9/3/13	381FF+12.5 days,382	379SS,384,385	
384	Demob - Slurry Wall	15 days	Tue 9/3/13	Tue 9/17/13	383		
385	Temporary Fill, Removal	15 days	Tue 9/3/13	Tue 9/3/13	383FF	388,392	
386	Maintenance Road - ABC	12.5 days	Sat 7/20/13	Thu 8/1/13	382FF		
387	Revegetation/Hydroseed	0.75 days	Thu 8/1/13	Fri 8/9/13	382		
388	Surface Layer Restoration - Borrow Areas	5 days	Tue 9/3/13	Sat 9/7/13	385	389	
389	Weather Delays	6.25 days	Sat 9/7/13	Fri 9/13/13	388	390	
390	Demob - Borrow Areas	5 days	Fri 9/13/13	Wed 9/18/13	389	391	
391	Site Cleanup/Finish Work - Borrow Areas	5 days	Wed 9/18/13	Mon 9/23/13	390	377FF	
392	Demob - Levee Areas	5 days	Tue 9/3/13	Sat 9/7/13	385	370FF,393	
393	Site Cleanup/Finish Work - Levee Areas	5 days	Sat 9/7/13	Thu 9/12/13	392		
394	Relocations	165.75 days	Mon 4/1/13	Mon 9/2/13			
395	Roads, Construction Activities	149.25 days	Mon 4/1/13	Sat 8/17/13			
396	Site Mobilization - for Rd Relocations	15 days	Mon 4/1/13	Mon 4/15/13		397	
397	Demo Pavement	20 days	Mon 4/15/13	Fri 5/3/13	396		

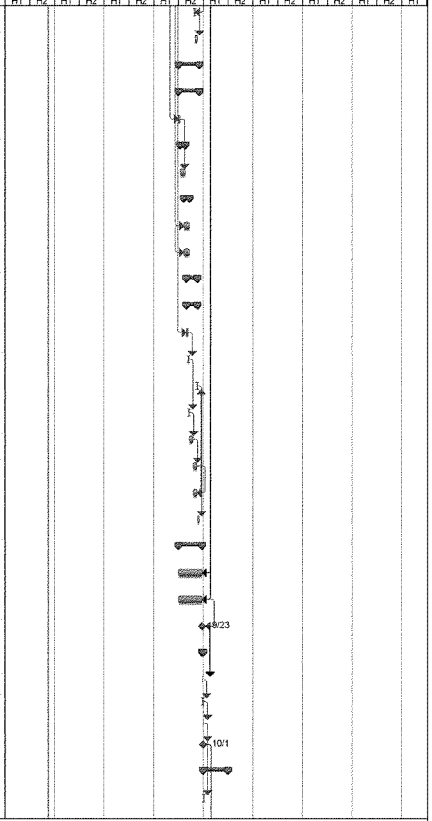


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
398	AC Pavement	10 days	Thu 7/25/13	Sat 8/3/13	382FF+2.5 days	399	
399	Site Demobilization - for Rd Relocations	15 days	Sat 8/3/13	Sat 8/17/13	398		
400	Cemeteries, Utils, Structures	165.75 days	Mon 4/1/13	Mon 9/2/13			
401	Utils	165.75 days	Mon 4/1/13	Mon 9/2/13			
402	Site Mobilization - for Util Relocations	15 days	Mon 4/1/13	Mon 4/15/13	368SS	404	
403	Electrical	40 days	Mon 4/15/13	Wed 5/22/13			
404	Utility Poles	40 days	Mon 4/15/13	Wed 5/22/13	402		1/day
405	Utility Crossing Relocations	45 days	Sat 5/11/13	Sat 6/22/13			
406	Mechanical	45 days	Sat 5/11/13	Sat 6/22/13	381SS	407SS	
407	Electrical	45 days	Sat 5/11/13	Sat 6/22/13	406SS		
408	Pump Station Rehab	87 days	Thu 5/30/13	Mon 8/19/13			
409	PP - Sump 58	87 days	Thu 5/30/13	Mon 8/19/13			Sta ~70+00
410	Demo	12 days	Thu 5/30/13	Mon 6/10/13	381SS+20 days	411	expected to commence about 15 days before levee construction
411	Earthwork	6 days	Mon 6/10/13	Sat 6/15/13	410	413	
412	Roads	4 days	Thu 8/15/13	Mon 8/19/13	416	417	
413	Pipes	5 days	Sat 6/15/13	Thu 6/20/13	411	414	
414	Positive Closure Vault	30 days	Thu 6/20/13	Thu 7/18/13	413	415	
415	Pumps & Motors	30 days	Thu 7/18/13	Thu 8/15/13	414	416FF	
416	Power & Controls	30 days	Thu 7/18/13	Thu 8/15/13	415FF	412	
417	Site Demobilization - for Util Relocations	15 days	Mon 8/19/13	Mon 9/2/13	412		
418	Engineering during Construction, S&A and Construction Completion	188 days	Mon 4/1/13	Mon 9/23/13			
419	Engineering During Construction	188 days	Mon 4/1/13	Mon 9/23/13	366FF		
420	Supervision and Administration	188 days	Mon 4/1/13	Mon 9/23/13	366FF	421FF	
421	Construction Completion	0 days	Mon 9/23/13	Mon 9/23/13	420FF	423	
422	**Inspection and Construction per Punch List**	**8.75 days**	**Mon 9/23/13**	**Tue 10/1/13**			
423	PreFinal Inspection	1.25 days	Mon 9/23/13	Tue 9/24/13	421	424	
424	Contractor Implement Punch List Items	6.25 days	Tue 9/24/13	Mon 9/30/13	423	425	
425	Final Inspection	1.25 days	Mon 9/30/13	Tue 10/1/13	424	426,428	
426	Construction Physical Completion	0 days	Tue 10/1/13	Tue 10/1/13	425	429	
427	**Project Closeout**	**194.5 days**	**Tue 10/1/13**	**Tue 4/1/14**			
428	Construction Prepares Project Completion Letter	6.25 days	Tue 10/1/13	Mon 10/7/13	425		

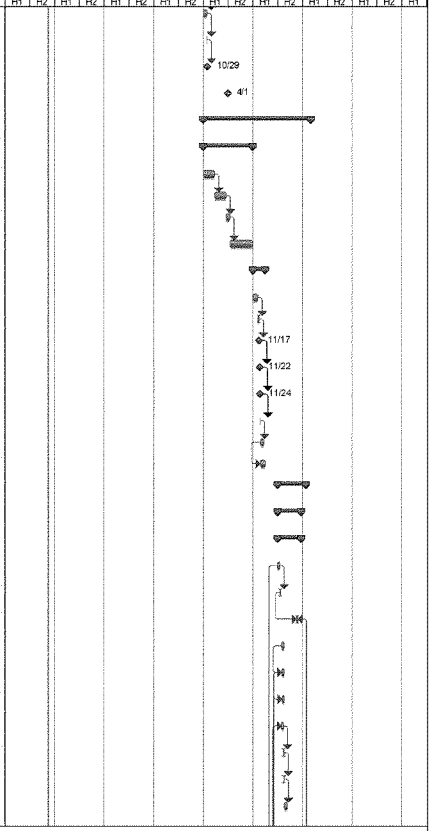


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 6/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
429	Contractors Complete As-Builts	28.75 days	Tue 10/1/13	Mon 10/28/13	426	430	
430	Submit As-Builts	1.25 days	Mon 10/28/13	Tue 10/29/13	429	431	
431	Notice of Completion/Assumption of OMRR&R	0 days	Tue 10/29/13	Tue 10/29/13	430		
432	Project Fiscally Complete	0 days	Tue 4/1/14	Tue 4/1/14			
433	**Construction Contract 5 - Reach E**	**848.5 days**	**Tue 10/1/13**	**Tue 12/1/15**			Sta 287+37 to 481+31 - Howsley Road to Sankey Road - Work involves levee improvements and/or
434	**Design**	**390 days**	**Tue 10/1/13**	**Tue 9/30/14**			
435	Collect field explorations	90 days	Tue 10/1/13	Tue 12/24/13		436	
436	Conduct geotechnical evaluation	90 days	Tue 12/24/13	Tue 3/18/14	435	437	
437	Develop Basis of Design Report	30 days	Tue 3/18/14	Tue 4/15/14	436	438	
438	Develop Plans & Specifications	180 days	Tue 4/15/14	Tue 9/30/14	437		
439	**Pre-Construction**	**96.25 days**	**Wed 10/1/14**	**Tue 12/30/14**			
440	Project Bid	41.25 days	Wed 10/1/14	Sat 11/8/14		441	
441	Award Task Order	8.75 days	Sat 11/8/14	Mon 11/17/14	440	442	
442	Construction Contract Awarded	0 days	Mon 11/17/14	Mon 11/17/14	441	443FS+6.25 days	
443	Issue NTP	0 days	Sat 11/22/14	Sat 11/22/14	442FS+6.25 days	444FS+1.25 days	
444	NTP Acknowledged	0 days	Mon 11/24/14	Mon 11/24/14	443FS+1.25 days	445	
445	Pre-Con Meeting	1.25 days	Mon 11/24/14	Tue 11/25/14	444	446	
446	Prepare Pre-Construction Submittals	28.75 days	Tue 11/25/14	Mon 12/22/14	445	447SS	
447	Corps Approve Pre-Constructon Submittals	37.5 days	Tue 11/25/14	Tue 12/30/14	446SS		
448	**Construction**	**223.5 days**	**Wed 4/1/15**	**Mon 10/26/15**			
449	Levees & Floodwalls	185.75 days	Wed 4/1/15	Mon 9/21/15			
450	Levees	185.75 days	Wed 4/1/15	Mon 9/21/15			
451	Site Mobilization - Levees	18 days	Wed 4/1/15	Fri 4/17/15		452,464SS	
452	Haul Roads & Drainage	6 days	Fri 4/17/15	Thu 4/23/15	451	453SS	
453	SWPP Installation - Levees	12 days	Tue 8/18/15	Sat 8/29/15	452SS,474FF		full duration of levee constr
454	Clearing & Grubbing (also tree removal)	18 days	Fri 5/1/15	Mon 5/18/15		455SS+2 days	
455	Levee Stripping	18 days	Sat 5/2/15	Wed 5/20/15	454SS+2 days	464SS+2 days,456SS+2	
456	Levee Degrading	15 days	Tue 5/5/15	Tue 5/19/15	455SS+2 days		
457	Site Mobilization - Borrow Areas	15 days	Wed 4/29/15	Wed 5/13/15	463SS+12 days	458	
458	Haul Roads & Drainage - Borrow Areas	5 days	Wed 5/13/15	Mon 5/18/15	457	459	
459	SWPP Installation - Borrow Areas	2 days	Mon 5/18/15	Wed 5/20/15	458	460	full duration of borrow area use
460	Surface Layer Removal & Stockpile - Borrow Areas	26 days	Wed 5/20/15	Fri 6/12/15	459		double crews

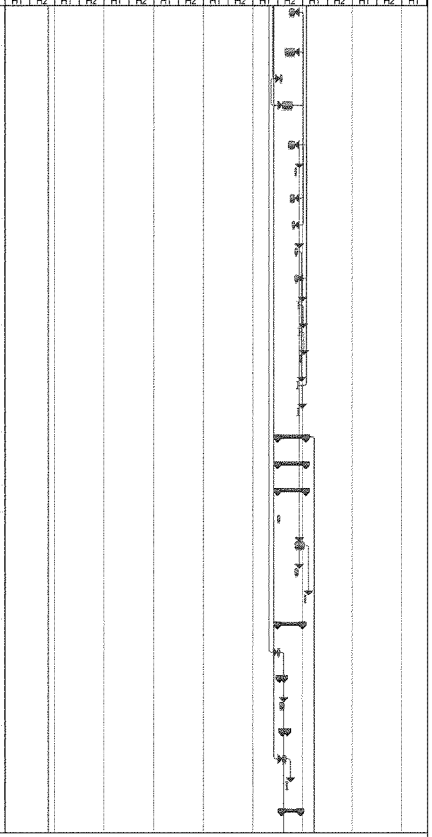


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

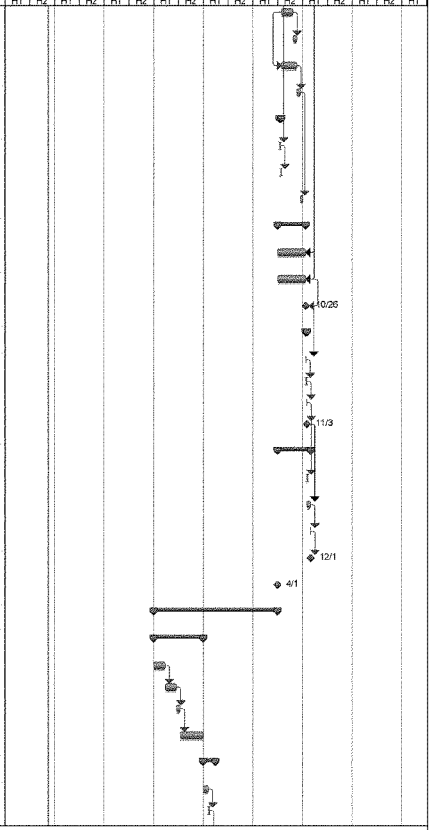
Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
461	Excavation & Hauling - Borrow Areas	48 days	Wed 6/24/15	Fri 8/7/15	464FF+21 days		double crews
462	Vinyl Sheet Pile	80 days	Mon 5/25/15	Fri 8/7/15	465FF		
463	Site Mobilization - Slurry Wall	18 days	Fri 4/17/15	Tue 5/5/15	464SS-18 days	457SS+12 days	
464	Slurry Wall Construction	81 days	Tue 5/5/15	Mon 7/20/15	465SS+2 days	461FF+21 days,463SS-18 days,465FF+21	double rig/crews
465	Embankment Fill, from Borrow	54 days	Thu 6/18/15	Fri 8/7/15	464FF+21 days	462FF,470FF+2 days,466,468FF	double crews
466	Demob - Slurry Wall	12 days	Fri 8/7/15	Wed 8/19/15	465		
467	Quarry Stone	40 days	Wed 7/1/15	Fri 8/7/15	465FF		
468	Maintenance Road - ABC	22 days	Sat 7/18/15	Fri 8/7/15	465FF		
469	Revegetation/Hydroseed	18 days	Fri 8/7/15	Tue 8/25/15	465	474	
470	Surface Layer Restoration - Borrow Areas	26 days	Fri 8/7/15	Mon 8/31/15	465FF+25 days	471	double crews
471	Weather Delays	6.25 days	Mon 8/31/15	Sat 9/5/15	470	472	
472	Demob - Borrow Areas	6 days	Sat 9/5/15	Fri 9/11/15	471	473	
473	Site Cleanup/Finish Work - Borrow Areas	10 days	Fri 9/11/15	Mon 9/21/15	472		
474	Demob - Levee Areas	5 days	Tue 8/25/15	Sat 8/29/15	469	453FF,475	
475	Site Cleanup/Finish Work - Levee Areas	5 days	Sat 8/29/15	Thu 9/3/15	474		
476	Relocations	223.5 days	Wed 4/1/15	Mon 10/26/15		500FF,501FF	
477	Roads, Construction Activities	223.5 days	Wed 4/1/15	Mon 10/26/15			
478	Roads	223.5 days	Wed 4/1/15	Mon 10/26/15			
479	Site Mobilization - for Rd Relocations	18 days	Wed 4/1/15	Fri 4/17/15			
480	Natomas Rd	73 days	Fri 8/7/15	Thu 10/15/15	465	482	
481	Access Road (at berm adjacent to canal relocation)	25 days	Fri 8/7/15	Mon 8/31/15	465		
482	Site Demobilization - for Rd Relocations	12 days	Thu 10/15/15	Mon 10/26/15	480		
483	Utils	197.5 days	Wed 4/1/15	Fri 10/2/15			
484	Site Mobilization - for Util Relocations	15 days	Wed 4/1/15	Wed 4/15/15	451SS	486,490	
485	Electrical	35 days	Wed 4/15/15	Mon 5/18/15			
486	Utility Poles	35 days	Wed 4/15/15	Mon 5/18/15	484		1/day
487	Utility Crossing Relocations	42.5 days	Tue 5/5/15	Sat 6/13/15			
488	Culverts	32.5 days	Tue 5/5/15	Thu 6/4/15	464SS	489	
489	12" Discharge Pipe	10 days	Thu 6/4/15	Sat 6/13/15	488		
490	Private Irrigation Relocations	150 days	Fri 5/1/15	Fri 9/18/15			

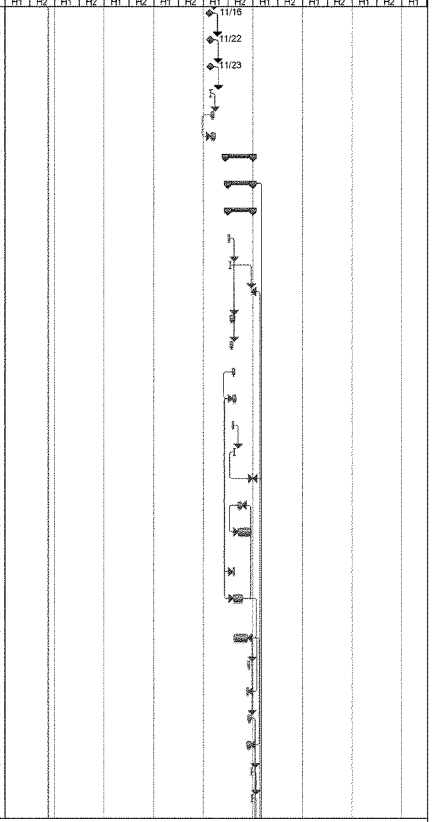


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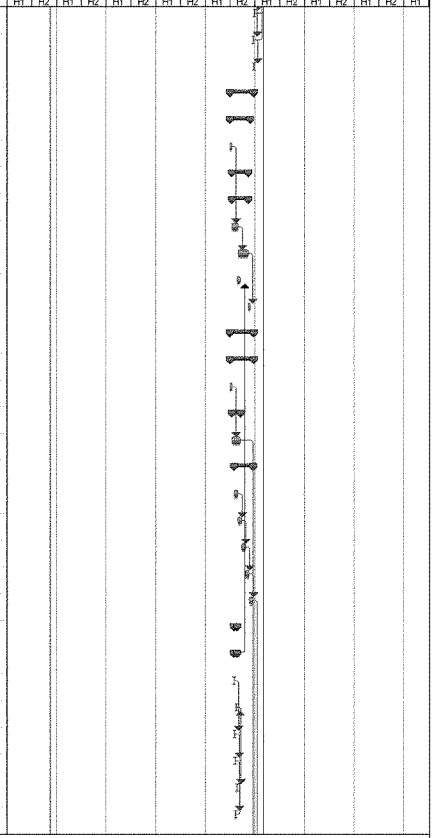
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
491	Brookfield	90 days	Fri 5/1/15	Fri 7/24/15		492,493SS	
492	Linn	30 days	Fri 7/24/15	Fri 8/21/15	491		
493	Odysseus	120 days	Fri 5/1/15	Fri 8/21/15	491SS	494	
494	Kaufman	30 days	Fri 8/21/15	Fri 9/18/15	493	498	
495	Canal Relocations	15 days	Wed 4/15/15	Wed 4/29/15			
496	Drainage Canal Relocations	10 days	Wed 4/15/15	Fri 4/24/15	484	497	
497	Irrigation Canal Relocations	5 days	Fri 4/24/15	Wed 4/29/15	496		
498	Site Demobilization - for Util Relocations	15 days	Fri 9/18/15	Fri 10/2/15	494		
499	Engineering during Construction, S&A and Construction Completion	223 days	Wed 4/1/15	Mon 10/26/15			
500	Engineering During Construction	223 days	Wed 4/1/15	Mon 10/26/15	476FF		
501	Supervision and Administration	223 days	Wed 4/1/15	Mon 10/26/15	476FF	502FF	
502	Construction Completion	0 days	Mon 10/26/15	Mon 10/26/15	501FF	504	
503	**Inspection and Construction per Punch List**	**8.75 days**	**Mon 10/26/15**	**Tue 11/3/15**			
504	PreFinal Inspection	1.25 days	Mon 10/26/15	Tue 10/27/15	502	505	
505	Contractor Implement Punch List Items	6.25 days	Tue 10/27/15	Mon 11/2/15	504	506	
506	Final Inspection	1.25 days	Mon 11/2/15	Tue 11/3/15	505	507,509	
507	Construction Physical Completion	0 days	Tue 11/3/15	Tue 11/3/15	506	510	
508	**Project Closeout**	**262.25 days**	**Wed 4/1/15**	**Tue 12/1/15**			
509	Construction Prepares Project Completion Letter	6.25 days	Tue 11/3/15	Mon 11/9/15	506		
510	Contractors Complete As-Builts	28.75 days	Tue 11/3/15	Mon 11/30/15	507	511	
511	Submit As-Builts	1.25 days	Mon 11/30/15	Tue 12/1/15	510	512	
512	Notice of Completion/Assumption of OMRR&R	0 days	Tue 12/1/15	Tue 12/1/15	511		
513	Project Fiscally Complete	0 days	Wed 4/1/15	Wed 4/1/15			
514	**Construction Contract 6 Reach F**	**977.5 days**	**Mon 10/1/12**	**Wed 4/1/15**			Sta 426+30 to 678+85 - Sankey Road to Elverta Road - Work
515	**Design**	**390 days**	**Mon 10/1/12**	**Mon 9/30/13**			
516	Collect field explorations	90 days	Mon 10/1/12	Mon 12/24/12		517	
517	Conduct geotechnical evaluation	90 days	Mon 12/24/12	Mon 3/18/13	516	518	
518	Develop Basis of Design Report	30 days	Mon 3/18/13	Mon 4/15/13	517	519	
519	Develop Plans & Specifications	180 days	Mon 4/15/13	Mon 9/30/13	518		
520	**Pre-Construction**	**96.25 days**	**Tue 10/1/13**	**Mon 12/30/13**			
521	Project Bid	41.25 days	Tue 10/1/13	Fri 11/8/13		522	
522	Award Task Order	8.75 days	Fri 11/8/13	Sat 11/16/13	521	523	



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
523	Construction Contract Awarded	0 days	Sat 11/16/13	Sat 11/16/13	522	524FS+6.25 days	
524	Issue NTP	0 days	Fri 11/22/13	Fri 11/22/13	523FS+6.25 days	525FS+1.25 days	
525	NTP Acknowledged	0 days	Sat 11/23/13	Sat 11/23/13	524FS+1.25 days	526	
526	Pre-Con Meeting	1.25 days	Sat 11/23/13	Mon 11/25/13	525	527	
527	Prepare Pre-Construction Submittals	28.75 days	Mon 11/25/13	Sat 12/21/13	526	528SS	
528	Corps Approve Pre-Constructon Submittals	37.5 days	Mon 11/25/13	Mon 12/30/13	527SS		
529	**Construction**	**215 days**	**Fri 3/14/14**	**Wed 10/1/14**			
530	Levees & Floodwalls	197 days	Tue 4/1/14	Wed 10/1/14		586FF,587FF	
531	Levees	197 days	Tue 4/1/14	Wed 10/1/14			
532	Site Mobilization - Levees - 1	15 days	Tue 4/1/14	Tue 4/15/14		533,535,536	
533	Haul Roads & Drainage	3.75 days	Tue 4/15/14	Fri 4/18/14	532	534	
534	Care & Diversion of Water - Erosion Control - SWPC	1.25 days	Fri 9/19/14	Sat 9/20/14	533,554FF		full duration of levee constr
535	Demo, Commercial Building	40 days	Tue 4/15/14	Thu 5/22/14	532		
536	Demo, Homes	25 days	Tue 4/15/14	Thu 5/8/14	532		
537	Clearing & Grubbing, Levee Stripping (plus tree removal)	21 days	Thu 5/1/14	Tue 5/20/14		538SS+2.5 days	
538	Levee Degrading	30 days	Sat 5/3/14	Sat 5/31/14	537SS+2.5 days	544SS+2.5 days,545SS+6.	
539	Site Mobilization - Borrow Areas	15 days	Thu 5/1/14	Thu 5/15/14		540	
540	Haul Roads & Drainage - Borrow Areas	5 days	Thu 5/15/14	Tue 5/20/14	539	541SS	
541	Care & Diversion of Water - Erosion Control - SWPC - Borrow Areas	1.25 days	Tue 9/30/14	Wed 10/1/14	540SS,553FF		full duration of borrow area use
542	Surface Layer Removal & Stockpile - Borrow Areas	35 days	Wed 6/11/14	Mon 7/14/14	545FF-6.25 days	543SS+2.5 days	double crews
543	Excavation & Hauling - Borrow Areas	105 days	Fri 6/13/14	Fri 9/19/14	542SS+2.5 days		double crews
544	Site Mobilization - Slurry Wall - Season 1	15 days	Tue 5/6/14	Tue 5/20/14	538SS+2.5 days		
545	Slurry Wall Construction	76.5 days	Fri 5/9/14	Sat 7/19/14	538SS+6.25 days	542FF-6.25 days,546FF+39 days	double crews
546	Emankment Fill, from Borrow	109 days	Thu 5/15/14	Mon 8/25/14	545FF+39 days	550FF+25 days,547,549,5	double crews
547	Demob - Slurry Wall - Season 1	15 days	Mon 8/25/14	Mon 9/8/14	546		
548	Maintenance Road - ABC	15 days	Sat 8/16/14	Sat 8/30/14	546FF+6.25 days		
549	Revegetation/Hydroseed	24 days	Mon 8/25/14	Tue 9/16/14	546	551,554	
550	Surface Layer Restoration - Borrow Areas - Season 1	35 days	Fri 8/15/14	Wed 9/17/14	546FF+25 days		double crews
551	Weather Delays	6.25 days	Tue 9/16/14	Mon 9/22/14	549	552	
552	Demob - Borrow Areas	5 days	Mon 9/22/14	Fri 9/26/14	551	553	



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
553	Site Cleanup/Finish Work - Borrow Areas	5 days	Fri 9/26/14	Wed 10/1/14	552	541FF	
554	Demob - Levee Areas	5 days	Tue 9/16/14	Sat 9/20/14	549	534FF,555	
555	Site Cleanup/Finish Work - Levee Areas	5 days	Sat 9/20/14	Thu 9/25/14	554		
556	Relocations	187.5 days	Tue 4/1/14	Tue 9/23/14			
557	Roads, Construction Activities	160 days	Tue 4/1/14	Thu 8/28/14			
558	Site Mobilization - for Rd Relocations	15 days	Tue 4/1/14	Tue 4/15/14		561	
559	Road Surfacing	130 days	Tue 4/15/14	Thu 8/14/14			
560	Site Work	130 days	Tue 4/15/14	Thu 8/14/14			
561	Private Driveways	50 days	Tue 4/15/14	Sat 5/31/14	558	562	
562	Natomas Road	80 days	Sat 5/31/14	Thu 8/14/14	561	564	
563	Access Road (at berm adjacent to canal relocation)	25 days	Fri 5/23/14	Mon 6/16/14	577		
564	Site Demobilization - for Rd Relocations	15 days	Thu 8/14/14	Thu 8/28/14	562		
565	Cemeteries, Utils, Structures	187.5 days	Tue 4/1/14	Tue 9/23/14			
566	Utils	187.5 days	Tue 4/1/14	Tue 9/23/14			
567	Site Mobilization - for Util Relocations	15 days	Tue 4/1/14	Tue 4/15/14		569	
568	Electrical	68 days	Tue 4/15/14	Tue 6/17/14			
569	Utility Poles	68 days	Tue 4/15/14	Tue 6/17/14	567	584	1/day
570	Utility Crossing Relocations	150 days	Thu 5/1/14	Thu 9/18/14			
571	Schiedel	30 days	Thu 5/1/14	Thu 5/29/14		572	
572	De Wit	30 days	Thu 5/29/14	Thu 6/26/14	571	573	
573	Calif Sunshine Fisheries	30 days	Thu 6/26/14	Thu 7/24/14	572	574	
574	Odysseus	30 days	Thu 7/24/14	Thu 8/21/14	573	575	
575	Family Real Properties	30 days	Thu 8/21/14	Thu 9/18/14	574	584	
576	Canal Relocations	24 days	Thu 5/1/14	Fri 5/23/14			
577	Reiego Rd Canal Relocations	24 days	Thu 5/1/14	Fri 5/23/14		563	
578	Stripping	2 days	Thu 5/1/14	Fri 5/2/14		580	
579	Compacted Embankment	7 days	Thu 5/15/14	Wed 5/21/14	583	582	
580	Excavation to Stockpile	6 days	Fri 5/2/14	Thu 5/8/14	578	581	
581	Field Irrigation Turnouts	2 days	Thu 5/8/14	Sat 5/10/14	580	583	
582	Erosion Control Seeding	2 days	Wed 5/21/14	Fri 5/23/14	579		
583	Misc Sitework	5 days	Sat 5/10/14	Thu 5/15/14	581	579	

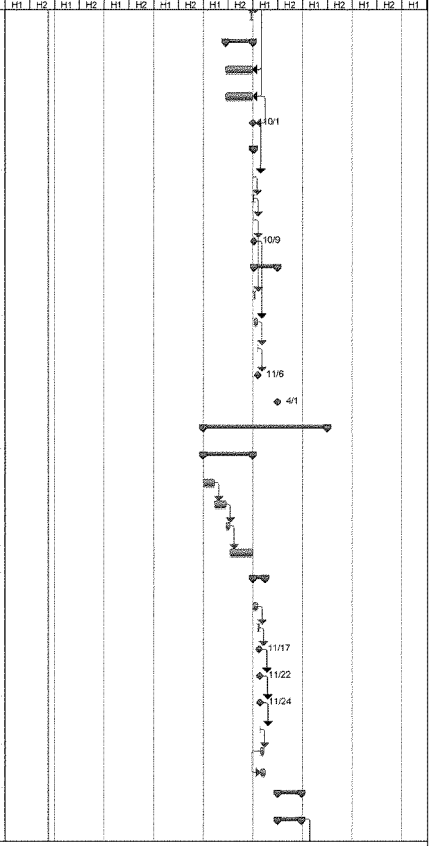


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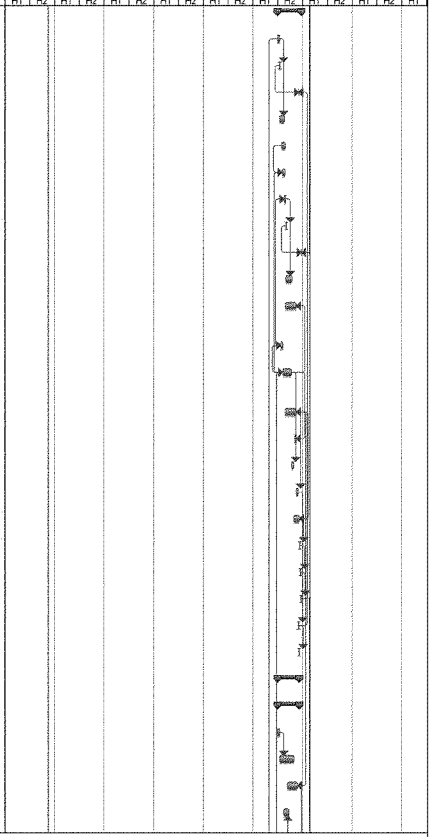
AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

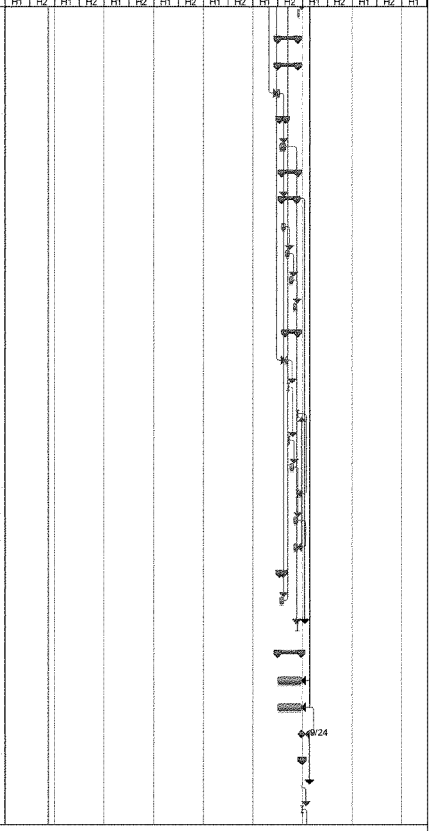
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
584	Site Demob - for Util Relocations	5 days	Thu 9/18/14	Tue 9/23/14	569,575		
585	Engineering during Construction, S&A and Construction Completion	215 days	Fri 3/14/14	Wed 10/1/14			
586	Engineering During Construction	215 days	Fri 3/14/14	Wed 10/1/14	530FF		
587	Supervision and Administration	215 days	Fri 3/14/14	Wed 10/1/14	530FF	588FF	
588	Construction Completion	0 days	Wed 10/1/14	Wed 10/1/14	587FF	590	
589	**Inspection and Construction per Punch List**	**8.75 days**	**Wed 10/1/14**	**Thu 10/9/14**			
590	PreFinal Inspection	1.25 days	Wed 10/1/14	Thu 10/2/14	588	591	
591	Contractor Implement Punch List Items	6.25 days	Thu 10/2/14	Wed 10/8/14	590	592	
592	Final Inspection	1.25 days	Wed 10/8/14	Thu 10/9/14	591	593,595	
593	Construction Physical Completion	0 days	Thu 10/9/14	Thu 10/9/14	592	596	
594	**Project Closeout**	**185.5 days**	**Thu 10/9/14**	**Wed 4/1/15**			
595	Construction Prepares Project Completion Letter	6.25 days	Thu 10/9/14	Wed 10/15/14	592		
596	Contractors Complete As-Builts	28.75 days	Thu 10/9/14	Wed 11/5/14	593	597	
597	Submit As-Builts	1.25 days	Wed 11/5/14	Thu 11/6/14	596	598	
598	Notice of Completion/Assumption of OMRR&R	0 days	Thu 11/6/14	Thu 11/6/14	597		
599	Project Fiscally Complete	0 days	Wed 4/1/15	Wed 4/1/15			
600	**Construction Contract 7 - Reach G**	**978.75 days**	**Tue 10/1/13**	**Fri 4/1/16**			Sta 237+00 to 428+30 - Elverta Road to NEMDC Pump Station - Work involves levee improvements
601	**Design**	**390 days**	**Tue 10/1/13**	**Tue 9/30/14**			
602	Collect field explorations	90 days	Tue 10/1/13	Tue 12/24/13		603	
603	Conduct geotechnical evaluation	90 days	Tue 12/24/13	Tue 3/18/14	602	604	
604	Develop Basis of Design Report	30 days	Tue 3/18/14	Tue 4/15/14	603	605	
605	Develop Plans & Specifications	180 days	Tue 4/15/14	Tue 9/30/14	604		
606	**Pre-Construction**	**96.25 days**	**Wed 10/1/14**	**Tue 12/30/14**			
607	Project Bid	41.25 days	Wed 10/1/14	Sat 11/8/14		608	
608	Award Task Order	8.75 days	Sat 11/8/14	Mon 11/17/14	607	609	
609	Construction Contract Awarded	0 days	Mon 11/17/14	Mon 11/17/14	608	610FS+6.25 days	
610	Issue NTP	0 days	Sat 11/22/14	Sat 11/22/14	609FS+6.25 days	611FS+1.25 days	
611	NTP Acknowledged	0 days	Mon 11/24/14	Mon 11/24/14	610FS+1.25 days	612	
612	Pre-Con Meeting	1.25 days	Mon 11/24/14	Tue 11/25/14	611	613	
613	Prepare Pre-Construction Submittals	28.75 days	Tue 11/25/14	Mon 12/22/14	612	614SS	
614	Corps Approve Pre-Constructon Submittals	37.5 days	Tue 11/25/14	Tue 12/30/14	613SS		
615	**Construction**	**189.5 days**	**Wed 4/1/15**	**Thu 9/24/15**			
616	Levees & Floodwalls	189.5 days	Wed 4/1/15	Thu 9/24/15		672FF,673FF	



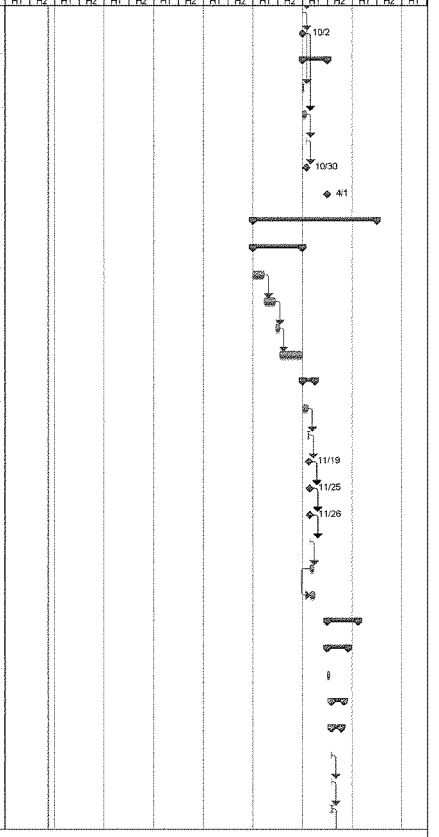
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
617	Levees	189.5 days	Wed 4/1/15	Thu 9/24/15			
618	Site Mobilization - Levees	15 days	Wed 4/1/15	Wed 4/15/15		619,621,650SS	
619	Haul Roads & Drainage	3.75 days	Wed 4/15/15	Sat 4/18/15	618	620SS	
620	Care & Diversion of Water - Erosion Control - SWPC	1.25 days	Thu 9/3/15	Fri 9/4/15	619SS,639FF		full duration of levee constr
621	Demo, Homes	40 days	Wed 4/15/15	Fri 5/22/15	618		
622	Clearing & Grubbing, Levee Stripping (plus tree removal)	31 days	Fri 5/1/15	Fri 5/29/15		623SS+2.5 days	
623	Levee Degrading	27 days	Mon 5/4/15	Thu 5/28/15	622SS+2.5 days	630SS+6.25 days	
624	Site Mobilization - Borrow Areas	15 days	Tue 5/19/15	Tue 6/2/15	629SS+25 days	625,627	
625	Haul Roads & Drainage - Borrow Areas	5 days	Tue 6/2/15	Sat 6/6/15	624	626SS	
626	Care & Diversion of Water - Erosion Control - SWPC - Borrow Areas	1.25 days	Wed 9/23/15	Thu 9/24/15	625SS,638FF		full duration of borrow area use
627	Surface Layer Removal & Stockpile - Borrow Areas	48 days	Tue 6/2/15	Thu 7/16/15	624		
628	Excavation & Hauling - Borrow Areas	85 days	Fri 5/29/15	Mon 8/17/15	630FF+38 days		double crew
629	Site Mobilization - Slurry Wall	15 days	Sat 4/25/15	Sat 5/9/15	630SS-15 days	624SS+25 days	
630	Slurry Wall Construction	69 days	Sat 5/9/15	Mon 7/13/15	623SS+6.25 days	628FF+38 days,629SS-15 days,631FF+38	double rigs/crew
631	Emankment Fill, from Borrow	90 days	Mon 5/25/15	Mon 8/17/15	630FF+38 days	635FF+25 days,632FF,634	double crew
632	Maintenance Road - ABC	12.5 days	Wed 8/5/15	Mon 8/17/15	631FF		
633	Demob - Slurry Wall	15 days	Mon 7/13/15	Mon 7/27/15	630		
634	Revegetation/Hydroseed	15 days	Mon 8/17/15	Mon 8/31/15	631	639	
635	Surface Layer Restoration - Borrow Areas	48 days	Mon 7/27/15	Wed 9/9/15	631FF+25 days	636	double crews
636	Weather Delays	6.25 days	Wed 9/9/15	Tue 9/15/15	635	637	
637	Demob - Borrow Areas	5 days	Tue 9/15/15	Sat 9/19/15	636	638	
638	Site Cleanup/Finish Work - Borrow Areas	5 days	Sat 9/19/15	Thu 9/24/15	637	626FF	
639	Demob - Levee Areas	5 days	Mon 8/31/15	Fri 9/4/15	634	620FF,640	
640	Site Cleanup/Finish Work - Levee Areas	5 days	Fri 9/4/15	Wed 9/9/15	639		
641	Relocations	172.5 days	Wed 4/1/15	Wed 9/9/15			
642	Roads, Construction Activities	172.5 days	Wed 4/1/15	Wed 9/9/15			
643	Site Mobilization - for Rd Relocations	15 days	Wed 4/1/15	Wed 4/15/15		644	
644	Private Driveways	115 days	Wed 4/15/15	Fri 7/31/15	643		
645	Natomas Road	80 days	Fri 6/12/15	Wed 8/26/15	631FF	647	
646	Access Road (at berm adjacent to canal relocation)	42 days	Fri 5/15/15	Tue 6/23/15	669		



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
647	Site Demobilization - for Rd Relocations	15 days	Wed 8/26/15	Wed 9/9/15	645		
648	Cemeteries, Utils, Structures	161.25 days	Wed 4/1/15	Sat 8/29/15			
649	Utils	161.25 days	Wed 4/1/15	Sat 8/29/15			
650	Site Mobilization - for Util Relocations	15 days	Wed 4/1/15	Wed 4/15/15	618SS	669,652,654	
651	Electrical	51 days	Wed 4/15/15	Mon 6/1/15			
652	Utility Poles	51 days	Wed 4/15/15	Mon 6/1/15	650	670	1/day
653	Utility Crossing Relocations	128.75 days	Fri 5/1/15	Sat 8/29/15			
654	Well Relocations	120 days	Fri 5/1/15	Fri 8/21/15	650	670	
655	Avids	30 days	Fri 5/1/15	Fri 5/29/15		656	
656	Cayocca	30 days	Fri 5/29/15	Fri 6/26/15	655	657	
657	Driggs	30 days	Fri 6/26/15	Fri 7/24/15	656	658	
658	Hendrix	30 days	Fri 7/24/15	Fri 8/21/15	657		
659	PP - No 6	100 days	Thu 5/28/15	Sat 8/29/15			Sta ~362+50
660	Demo	21 days	Thu 5/28/15	Tue 6/16/15	630SS+20 days	661	expected to commence about 25 days before levee construction reaches this point
661	Earthwork	5 days	Tue 6/16/15	Sat 6/20/15	660	663	
662	Roads	4 days	Tue 8/25/15	Sat 8/29/15	667	665FF	
663	Pipes	10 days	Sat 6/20/15	Tue 6/30/15	661	664	
664	Positive Closure Vault	30 days	Tue 6/30/15	Tue 7/28/15	663	666	
665	Security Fence	3 days	Wed 8/26/15	Sat 8/29/15	662FF		
666	Pumps & Motors	30 days	Tue 7/28/15	Tue 8/25/15	664	667FF	
667	Power & Controls	30 days	Tue 7/28/15	Tue 8/25/15	666FF	662	
668	Canal Relocations	32.5 days	Wed 4/15/15	Fri 5/15/15			
669	Drainage Canal Relocations	32.5 days	Wed 4/15/15	Fri 5/15/15	650	646	
670	Site Demob - for Util Relocations	5 days	Fri 8/21/15	Wed 8/26/15	652,654		
671	Engineering during Construction, S&A and Construction Completion	189 days	Wed 4/1/15	Thu 9/24/15			
672	Engineering During Construction	189 days	Wed 4/1/15	Thu 9/24/15	616FF		
673	Supervision and Administration	189 days	Wed 4/1/15	Thu 9/24/15	616FF	674FF	
674	Construction Completion	0 days	Thu 9/24/15	Thu 9/24/15	673FF	676	
675	**Inspection and Construction per Punch List**	**8.75 days**	**Thu 9/24/15**	**Fri 10/2/15**			
676	ProFinal Inspection	1.25 days	Thu 9/24/15	Fri 9/25/15	674	677	
677	Contractor Implement Punch List Items	8.25 days	Fri 9/25/15	Thu 10/1/15	676	678	

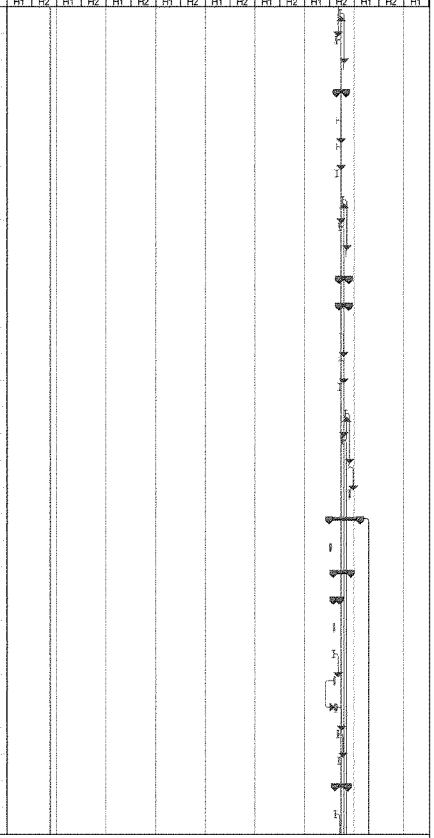


ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
678	Final Inspection	1.25 days	Thu 10/1/15	Fri 10/2/15	677	679,681	
679	Construction Physical Completion	0 days	Fri 10/2/15	Fri 10/2/15	678	682	
680	**Project Closeout**	**194.25 days**	**Fri 10/2/15**	**Fri 4/1/16**			
681	Construction Prepares Project Completion Letter	6.25 days	Fri 10/2/15	Thu 10/8/15	678		
682	Contractors Complete As-Builts	28.75 days	Fri 10/2/15	Thu 10/29/15	679	683	
683	Submit As-Builts	1.25 days	Thu 10/29/15	Fri 10/30/15	682	684	
684	Notice of Completion/Assumption of OMRR&R	0 days	Fri 10/30/15	Fri 10/30/15	683		
685	Project Fiscally Complete	0 days	Fri 4/1/16	Fri 4/1/16			
686	**Construction Contract 8 - Reaches B, C, and D (utility relocations)**	**978.75 days**	**Wed 10/1/14**	**Sat 4/1/17**			Work consists of required changes to Pumping Plants in Reaches B, C & D. Gone items left in the cutoff
687	**Design**	390 days	Wed 10/1/14	Wed 9/30/15			
688	Collect field explorations	90 days	Wed 10/1/14	Wed 12/24/14		689	
689	Conduct geotechnical evaluation	90 days	Wed 12/24/14	Wed 3/18/15	688	690	
690	Develop Basis of Design Report	30 days	Wed 3/18/15	Wed 4/15/15	689	691	
691	Develop Plans & Specifications	180 days	Wed 4/15/15	Wed 9/30/15	690		
692	**Pre-Construction**	96.25 days	Sat 10/3/15	Fri 1/1/16			
693	Project Bid	41.25 days	Sat 10/3/15	Wed 11/11/15		694	
694	Award Task Order	8.75 days	Wed 11/11/15	Thu 11/19/15	693	695	
695	Construction Contract Awarded	0 days	Thu 11/19/15	Thu 11/19/15	694	696FS+6.25 days	
696	Issue NTP	0 days	Wed 11/25/15	Wed 11/25/15	695FS+6.25 days	697FS+1.25 days	
697	NTP Acknowledged	0 days	Thu 11/26/15	Thu 11/26/15	696FS+1.25 days	698	
698	Pre-Con Meeting	1.25 days	Thu 11/26/15	Fri 11/27/15	697	699	
699	Prepare Pre-Construction Submittals	28.75 days	Fri 11/27/15	Thu 12/24/15	698	700SS	
700	Corps Approve Pre-Constructon Submittals	37.5 days	Fri 11/27/15	Fri 1/1/16	699SS		
701	**Construction**	244 days	Fri 4/1/16	Tue 11/15/16			
702	Levees, fill slurry wall gaps	165.94 days	Fri 4/1/16	Fri 9/2/16			
703	Mobilization	18 days	Fri 4/1/16	Mon 4/18/16			
704	Reach B	100.13 days	Mon 5/2/16	Wed 8/3/16			
705	Elkhorn PP	78.81 days	Mon 5/2/16	Thu 7/14/16			
706	Clearing & Grubbing	1 day	Mon 5/2/16	Mon 5/2/16		707	
707	Stripping	1 day	Mon 5/2/16	Tue 5/3/16	706	708	
708	Levee Degrading	2 days	Tue 5/3/16	Thu 5/5/16	707	710	



CESPK | AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE | Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
709	Levee Fill	3 days	Thu 6/16/16	Sat 6/18/16	710FS+21 days	711	
710	Cutoff Wall	10 days	Thu 5/5/16	Fri 5/27/16	708	709FS+21 days,717FS+2	
711	Revegetation	1 day	Mon 6/20/16	Thu 7/14/16	709		
712	RD 1000, PP No 5	75.13 days	Wed 5/25/16	Wed 8/3/16			
713	Clearing & Grubbing	1 day	Wed 5/25/16	Wed 5/25/16		714	
714	Stripping	1 day	Wed 5/25/16	Thu 5/26/16	713	715	
715	Levee Degrading	2 days	Thu 5/26/16	Sat 5/28/16	714		
716	Levee Fill	3 days	Wed 7/6/16	Sat 7/9/16	717FS+21 days	718	
717	Cutoff Wall	5 days	Mon 5/30/16	Thu 6/16/16	710FS+2 days	716FS+21 days,725FS+2	
718	Revegetation	1 day	Sat 7/9/16	Wed 8/3/16	716		
719	Reach C	75.19 days	Tue 6/14/16	Tue 8/23/16			
720	Prichard PP & RD 1000, PP No 2	75.19 days	Tue 6/14/16	Tue 8/23/16			
721	Clearing & Grubbing	1 day	Tue 6/14/16	Tue 6/14/16		722	
722	Stripping	1 day	Tue 6/14/16	Wed 6/15/16	721	723	
723	Levee Degrading	2 days	Wed 6/15/16	Fri 6/17/16	722		
724	Levee Fill	3 days	Tue 7/26/16	Fri 7/29/16	725FS+21 days	726	
725	Cutoff Wall	5 days	Sat 6/18/16	Wed 7/6/16	717FS+2 days	724FS+21 days,772,779	
726	Revegetation	1 day	Fri 7/29/16	Tue 8/23/16	724	727	
727	Demobilization	12 days	Tue 8/23/16	Fri 9/2/16	726		
728	Relocations	244 days	Fri 4/1/16	Tue 11/15/16		819FF,818FF	
729	Mobilization	18 days	Fri 4/1/16	Mon 4/18/16			
730	Reach B	138.63 days	Mon 5/2/16	Thu 9/8/16			
731	W Drainage Canal (EOPC)	47.5 days	Mon 5/2/16	Wed 6/15/16			
732	Demolition	12.5 days	Mon 5/2/16	Fri 5/13/16			
733	Clearing & Grubbing	3.75 days	Mon 5/2/16	Thu 5/5/16		734	
734	Stripping	11.25 days	Thu 5/5/16	Mon 5/16/16	733	735SS+2.5 days	
735	Excavation	25 days	Sat 5/7/16	Tue 5/31/16	734SS+2.5 days	736	
736	Fill	10 days	Tue 5/31/16	Thu 6/9/16	735	737	
737	Demob	6.25 days	Thu 6/9/16	Wed 6/15/16	736		
738	Elkhorn PP	100.56 days	Sat 5/14/16	Tue 8/16/16			
739	Demo	5 days	Sat 5/14/16	Thu 5/19/16		740	



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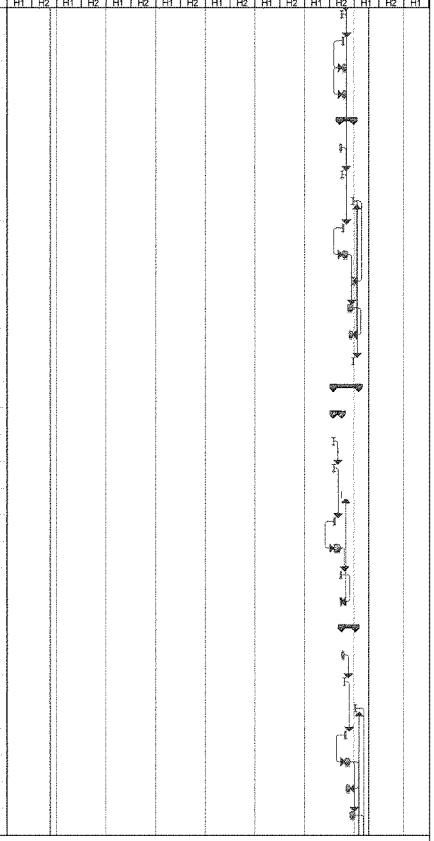
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
740	Earthwork	8 days	Thu 5/19/16	Thu 5/25/16	739	742	
741	Roads	4 days	Wed 8/10/16	Sat 8/13/16	746	744FF,747	
742	Pipes	14 days	Fri 5/27/16	Thu 6/9/16	740,710	743SS	follows cutoff wall placement
743	Positive Closure & Flow Meter Vaults	40 days	Fri 5/27/16	Mon 7/4/16	742SS	745	
744	Pump Platform Rehabilitation	15 days	Mon 8/1/16	Sat 8/13/16	741FF		
745	Pumps & Motors	40 days	Mon 7/4/16	Wed 8/10/16	743	746FF	
746	Power & Controls	30 days	Wed 7/13/16	Wed 8/10/16	745FF	741	
747	Bank Stabilization	2 days	Mon 8/15/16	Tue 8/16/16	741		
748	Riverside PP, Phase 2	108 days	Mon 5/2/16	Wed 8/10/16			assumption is this takes place after the Riverside Canal work
749	Demo	17 days	Mon 5/2/16	Tue 5/17/16		750	
750	Earthwork	2 days	Tue 5/17/16	Thu 5/19/16	749	752	
751	Roads	4 days	Tue 8/2/16	Fri 8/5/16	756	754FF,757	
752	Pipes	10 days	Thu 5/19/16	Sat 5/28/16	750	753SS	
753	Positive Closure & Flow Meter Vaults	40 days	Thu 5/19/16	Sat 6/25/16	752SS	755	
754	Security Fence	2 days	Wed 8/3/16	Fri 8/5/16	751FF		
755	Pumps & Motors	40 days	Sat 6/25/16	Tue 8/2/16	753	756FF	
756	Power & Controls	30 days	Tue 7/5/16	Tue 8/2/16	755FF	751	
757	Flow Meters	5 days	Fri 8/5/16	Wed 8/10/16	751		
758	RD 1000, PP No 5	109.88 days	Sat 5/28/16	Thu 9/8/16			
759	Demo	17 days	Sat 5/28/16	Mon 6/13/16		760	
760	Earthwork	2 days	Mon 6/13/16	Wed 6/15/16	759	762	
761	Roads	4 days	Tue 8/30/16	Sat 9/3/16	766	764FF,767	
762	Pipes	10 days	Thu 6/16/16	Sat 6/25/16	760,717	763SS	follows cutoff wall placement
763	Positive Closure & Flow Meter Vaults	40 days	Thu 6/16/16	Sat 7/23/16	762SS	765	
764	Security Fence	2 days	Thu 9/1/16	Sat 9/3/16	761FF		
765	Pumps & Motors	40 days	Sat 7/23/16	Tue 8/30/16	763	766FF	
766	Power & Controls	30 days	Tue 8/2/16	Tue 8/30/16	765FF	761	
767	Flow Meters	5 days	Sat 9/3/16	Thu 9/8/16	761		
768	Reach C	109.94 days	Fri 6/17/16	Wed 9/28/16			
769	Prichard PP	40.94 days	Mon 6/27/16	Wed 8/3/16			
770	Demo	2 days	Mon 6/27/16	Tue 6/28/16		771	

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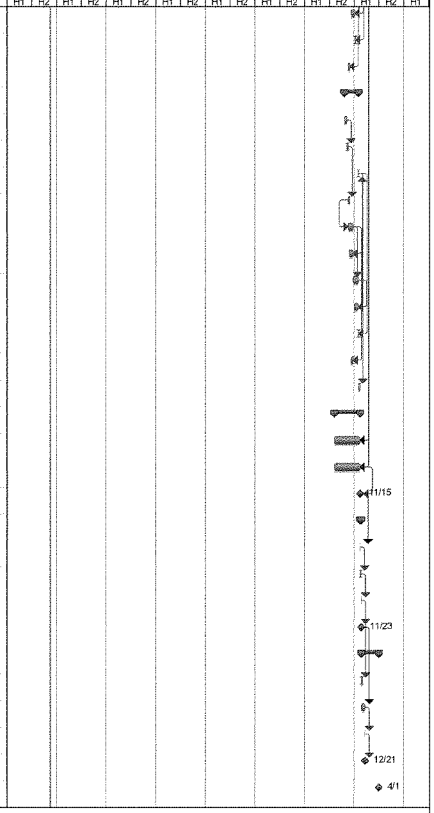
AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
771	Earthwork	7 days	Tue 6/28/16	Tue 7/5/16	770	772	
772	Pipes	9 days	Wed 7/6/16	Fri 7/15/16	771,725	773SS	follows cutoff wall placement
773	Transition Structure	30 days	Wed 7/6/16	Wed 8/3/16	772SS	774SS	
774	Concrete Outlet Structure	30 days	Wed 7/6/16	Wed 8/3/16	773SS		
775	RD 1000, PP No 2	109.94 days	Fri 6/17/16	Wed 9/28/16			
776	Demo	17 days	Fri 6/17/16	Sat 7/2/16		777	
777	Earthwork	2 days	Sat 7/2/16	Tue 7/5/16	776	779	
778	Roads	4 days	Mon 9/19/16	Fri 9/23/16	783	781FF,784	
779	Pipes	10 days	Wed 7/6/16	Fri 7/15/16	777,725	780SS	follows cutoff wall placement
780	Positive Closure & Flow Meter Vaults	40 days	Wed 7/6/16	Fri 8/12/16	779SS	782	
781	Security Fence	2 days	Wed 9/21/16	Fri 9/23/16	778FF		
782	Pumps & Motors	40 days	Fri 8/12/16	Mon 9/19/16	780	783FF	
783	Power & Controls	30 days	Mon 8/22/16	Mon 9/19/16	782FF	778	
784	Flow Meters	5 days	Fri 9/23/16	Wed 9/28/16	778		
785	Reach D	199.5 days	Mon 5/2/16	Thu 11/3/16			
786	RD 1000, PP No 4	65 days	Mon 5/2/16	Fri 7/1/16			
787	Demo	2 days	Mon 5/2/16	Tue 5/3/16		788	
788	Earthwork	2 days	Tue 5/3/16	Thu 5/5/16	787	790	
789	Roads	1 day	Thu 6/30/16	Fri 7/1/16	793		
790	Concrete Footing	10 days	Thu 5/5/16	Sat 5/14/16	788	791SS	
791	New Building	50 days	Thu 5/5/16	Tue 6/21/16	790SS	792	
792	Pumps & Motors	10 days	Tue 6/21/16	Thu 6/30/16	791	793FF	
793	Power & Controls	10 days	Tue 6/21/16	Thu 6/30/16	792FF	789	
794	Bennett PP	110 days	Fri 7/1/16	Wed 10/12/16			
795	Demo	20 days	Fri 7/1/16	Wed 7/20/16		796	
796	Earthwork	6 days	Wed 7/20/16	Mon 7/25/16	795	798	
797	Roads	4 days	Fri 10/7/16	Wed 10/12/16	802	803FF	
798	Pipes	9 days	Mon 7/25/16	Wed 8/3/16	796	799SS	follows cutoff wall placement
799	Positive Closure & Flow Meter Vaults	40 days	Mon 7/25/16	Wed 8/31/16	798SS	801,800FF,804	
800	Concrete Outlet Structure	30 days	Wed 8/3/16	Wed 8/31/16	799FF		
801	Pumps & Motors	40 days	Wed 8/31/16	Fri 10/7/16	799	802FF	



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
802	Power & Controls	30 days	Fri 9/9/16	Fri 10/7/16	801FF	797	
803	Security Fence	2 days	Mon 10/10/16	Wed 10/12/16	797FF		
804	Misc Repairs	15 days	Wed 8/17/16	Wed 8/31/16	799FF		
805	Northern PP	112 days	Fri 7/22/16	Thu 11/3/16			
806	Demo	20 days	Fri 7/22/16	Wed 8/10/16		807	
807	Earthwork	8 days	Wed 8/10/16	Wed 8/17/16	806	809	
808	Roads	4 days	Mon 10/31/16	Thu 11/3/16	813	814FF,816	
809	Pipes	13 days	Wed 8/17/16	Mon 8/29/16	807	810SS	follows cutoff wall placement
810	Positive Closure & Flow Meter Vaults	40 days	Wed 8/17/16	Fri 9/23/16	809SS	812,811FF,815	
811	Concrete Outlet Structure	30 days	Fri 8/26/16	Fri 9/23/16	810FF		
812	Pumps & Motors	40 days	Fri 9/23/16	Mon 10/31/16	810	813FF	
813	Power & Controls	30 days	Mon 10/3/16	Mon 10/31/16	812FF	808	
814	Security Fence	2 days	Wed 11/2/16	Thu 11/3/16	808FF		
815	Misc Repairs	15 days	Fri 9/9/16	Fri 9/23/16	810FF		
816	Demobilization	12 days	Thu 11/3/16	Tue 11/15/16	808		
817	Engineering during Construction, S&A and Construction Completion	204 days	Mon 5/9/16	Tue 11/15/16			
818	Engineering During Construction	204 days	Mon 5/9/16	Tue 11/15/16	728FF		
819	Supervision and Administration	204 days	Mon 5/9/16	Tue 11/15/16	728FF	820FF	
820	Construction Completion	0 days	Tue 11/15/16	Tue 11/15/16	819FF	822	
821	**Inspection and Construction per Punch List**	8.75 days	Tue 11/15/16	Wed 11/23/16			
822	PreFinal Inspection	1.25 days	Tue 11/15/16	Wed 11/16/16	820	823	
823	Contractor Implement Punch List Items	6.25 days	Wed 11/16/16	Tue 11/22/16	822	824	
824	Final Inspection	1.25 days	Tue 11/22/16	Wed 11/23/16	823	825,827	
825	Construction Physical Completion	0 days	Wed 11/23/16	Wed 11/23/16	824	828	
826	**Project Closeout**	138.5 days	Wed 11/23/16	Sat 4/1/17			
827	Construction Prepares Project Completion Letter	6.25 days	Wed 11/23/16	Tue 11/29/16	824		
828	Contractors Complete As-Builts	28.75 days	Wed 11/23/16	Tue 12/20/16	825	829	
829	Submit As-Builts	1.25 days	Tue 12/20/16	Wed 12/21/16	828	830	
830	Notice of Completion/Assumption of OMRR&R	0 days	Wed 12/21/16	Wed 12/21/16	829		
831	Project Fiscally Complete	0 days	Sat 4/1/17	Sat 4/1/17			

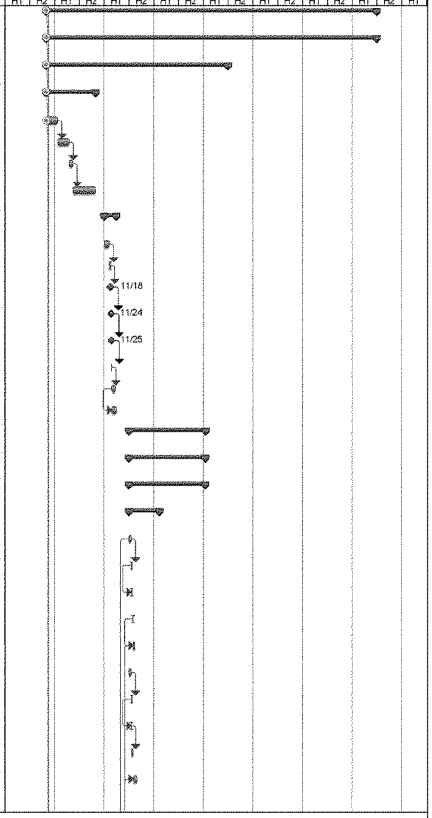


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
1	**Natomas PACR (LPP)**	**2608.75 days**	**Mon 8/2/10**	**Sat 4/1/17**			
2	**Construction of Reaches A, B (remaining), H, I, E, F, G, and B,C,D (utility relocations)**	**2608.75 days**	**Mon 8/2/10**	**Sat 4/1/17**			
3	**Construction Contract 1 - Reach A**	**1433.75 days**	**Mon 8/2/10**	**Tue 4/1/14**			SREL Sta 742+60 to Sta 956+83 and Sta 0+00 to 20+50. Work involves levee improvements and/or
4	**Design**	**390 days**	**Mon 8/2/10**	**Mon 8/1/11**			
5	Collect field explorations	90 days	Mon 8/2/10	Mon 10/25/10		6	
6	Conduct geotechnical evaluation	90 days	Mon 10/25/10	Mon 1/17/11	5	7	
7	Develop Basis of Design Report	30 days	Mon 1/17/11	Mon 2/14/11	6	8	
8	Develop Plans & Specifications	180 days	Mon 2/14/11	Mon 8/1/11	7		
9	**Pre-Construction**	**96.25 days**	**Mon 10/3/11**	**Sat 12/31/11**			
10	Project Bid	41.25 days	Mon 10/3/11	Thu 11/10/11		11	
11	Award Task Order	8.75 days	Thu 11/10/11	Fri 11/18/11	10	12	
12	Construction Contract Awarded	0 days	Fri 11/18/11	Fri 11/18/11	11	13FS+6.25 days	
13	Issue NTP	0 days	Thu 11/24/11	Thu 11/24/11	12FS+6.25 days	14FS+1.25 days	
14	NTP Acknowledged	0 days	Fri 11/25/11	Fri 11/25/11	13FS+1.25 days	15	
15	Pre-Con Meeting	1.25 days	Fri 11/25/11	Sat 11/26/11	14	16	
16	Prepare Pre-Construction Submittals	28.75 days	Sat 11/26/11	Fri 12/23/11	15	17SS	
17	Corps Approve Pre-Constructon Submittals	37.5 days	Sat 11/26/11	Sat 12/31/11	16SS		
18	**Construction**	**605.69 days**	**Mon 4/2/12**	**Fri 10/18/13**			
19	Levees & Floodwalls	603.5 days	Mon 4/2/12	Wed 10/16/13			
20	Levees	603.5 days	Mon 4/2/12	Wed 10/16/13			
21	Season 1	241.25 days	Mon 4/2/12	Tue 11/13/12			
22	Site Mobilization - Levees	18 days	Mon 4/2/12	Wed 4/18/12		23,74SS,127SS	
23	Haul Roads & Drainage	6 days	Wed 4/18/12	Tue 4/24/12	22	24SS	
24	SWPP Installation - Levees	5 days	Wed 4/18/12	Mon 4/23/12	23SS		full duration of levee constr
25	Clearing & Grubbing	3 days	Tue 5/1/12	Thu 5/3/12		26SS+2 days	
26	Levee Stripping	12 days	Wed 5/2/12	Mon 5/14/12	25SS+2 days	35SS+2 days	
27	Site Mobilization - Borrow Areas	18 days	Mon 4/2/12	Wed 4/18/12		28	
28	Haul Roads & Drainage - Borrow Areas	6 days	Wed 4/18/12	Tue 4/24/12	27	29SS	
29	SWPP Installation - Borrow Areas	2 days	Wed 4/18/12	Fri 4/20/12	28SS	30	full duration of borrow area use
30	Borrow Areas - Surface Layer Removal & Stockpile	13 days	Fri 4/20/12	Wed 5/2/12	29		
31	Borrow Areas - Excavation & Hauling (to replace std depth CO Wall Waste)	28 days	Fri 5/4/12	Wed 5/30/12	35SS		assumes 2 crews used

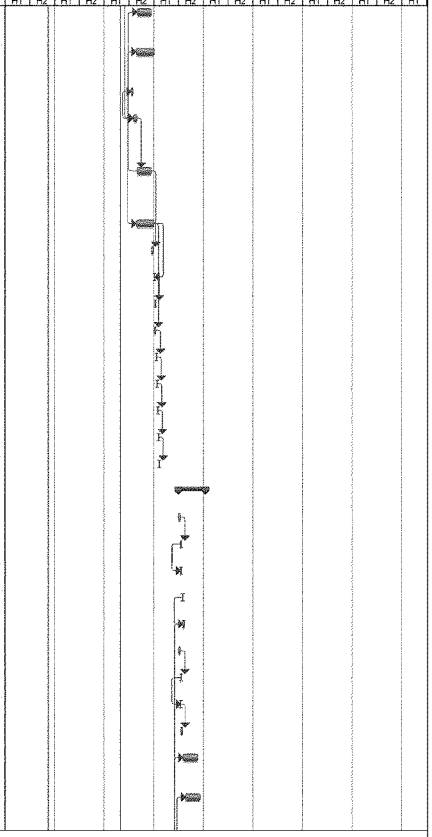


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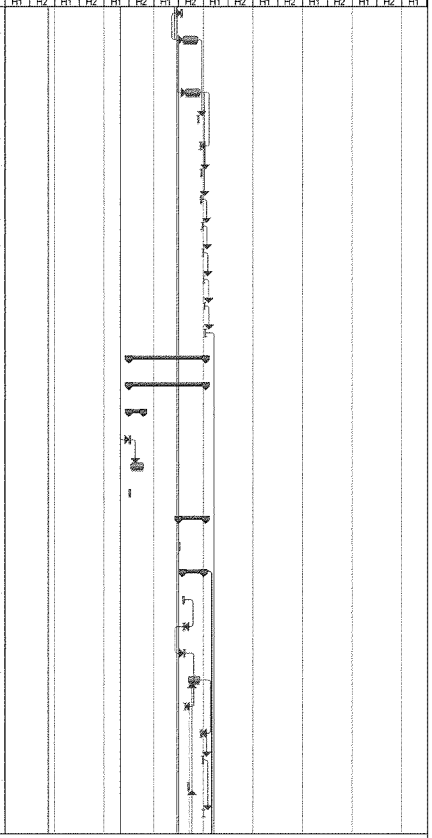
AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

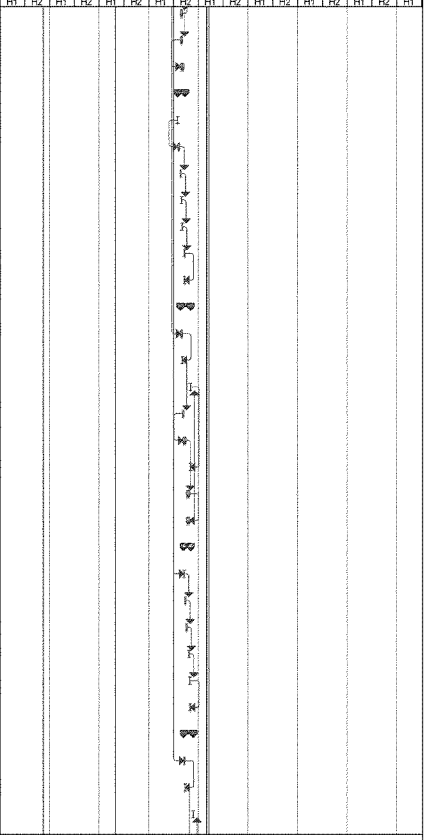
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
32	Borrow Areas - Excavation & Hauling (to replace deep CO Wall Waste)	115 days	Wed 5/30/12	Fri 9/14/12	36SS		assumes 2 crews used
33	Borrow Areas - Excavation & Hauling	143 days	Thu 5/24/12	Thu 10/4/12	37SS		assumes 2 crews used
34	Site Mobilization - Slurry Wall	15 days	Tue 4/17/12	Tue 5/1/12	35SS-18 days		
35	Slurry Wall Construction (depth less than 75')	28 days	Fri 5/4/12	Wed 5/30/12	26SS+2 days	36,31SS,37SS+ days,34SS-18 days	
36	Slurry Wall Construction (depth 75' or more)	115 days	Wed 5/30/12	Fri 9/14/12	35	38,32SS	Assumes 2 crews used
37	Select/Levee Fill & Random Fill	143 days	Thu 5/24/12	Thu 10/4/12	35SS+21 days	33SS,41,39FF+ days	asssumes 2 crews used
38	Demob - Slurry Wall	12 days	Fri 9/14/12	Wed 9/26/12	36		
39	Maintenance Road - ABC	3 days	Sat 10/6/12	Tue 10/9/12	37FF+5 days	40	
40	Revegetation/Hydroseed	10 days	Tue 10/9/12	Thu 10/18/12	39		
41	Surface Layer Restoration - Borrow Areas	15 days	Thu 10/4/12	Thu 10/18/12	37	42	
42	Demob - Borrow Areas	6 days	Thu 10/18/12	Wed 10/24/12	41	43	
43	Site Cleanup/Finish Work - Borrow Areas	5 days	Wed 10/24/12	Mon 10/29/12	42	44	
44	Weather Delays	6 days	Mon 10/29/12	Sat 11/3/12	43	45	
45	Demob - Levee Areas	5 days	Sat 11/3/12	Thu 11/8/12	44	46	
46	Site Cleanup/Finish Work - Levee Areas	5 days	Thu 11/8/12	Tue 11/13/12	45		
47	Season 2	213.5 days	Mon 4/1/13	Wed 10/16/13			
48	Site Mobilization - Levees - Season 1	18 days	Mon 4/1/13	Wed 4/17/13		49	
49	Haul Roads & Drainage	6 days	Wed 4/17/13	Tue 4/23/13	48	50SS	
50	SWPP Installation - Levees	5 days	Wed 4/17/13	Mon 4/22/13	49SS		full duration of levee constr
51	Clearing & Grubbing	3 days	Wed 5/1/13	Fri 5/3/13		52SS+2 days	
52	Levee Stripping	12 days	Thu 5/2/13	Tue 5/14/13	51SS+2 days	60SS+2 days	
53	Site Mobilization - Borrow Areas	18 days	Mon 4/1/13	Wed 4/17/13		54	
54	Haul Roads & Drainage - Borrow Areas	6 days	Wed 4/17/13	Tue 4/23/13	53	55SS	
55	SWPP Installation - Borrow Areas	2 days	Wed 4/17/13	Fri 4/19/13	54SS	56	full duration of borrow area use
56	Borrow Areas - Surface Layer Removal & Stockpile	13 days	Fri 4/19/13	Wed 5/1/13	55		
57	Borrow Areas - Excavation & Hauling (to replace deep CO Wall Waste)	115 days	Sat 5/4/13	Tue 8/20/13	60SS		assumes 2 crews used
58	Borrow Areas - Excavation & Hauling	115 days	Fri 5/24/13	Mon 9/9/13	61SS		assumes 2 crews used



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
59	Site Mobilization - Slurry Wall	15 days	Wed 4/17/13	Wed 5/1/13	60SS-18 days		
60	Slurry Wall Construction (depth 75' or more)	115 days	Sat 5/4/13	Tue 8/20/13	52SS+2 days	57SS,62,61SS+ days,59SS-18 days,101SS+20 days,110SS+45	Assumes 2 crews used
61	Select/Levee Fill & Random Fill	115 days	Fri 5/24/13	Mon 9/9/13	60SS+21 days	58SS,65,63FF+ days	assumes 2 crews used
62	Demob - Slurry Wall	12 days	Tue 8/20/13	Fri 8/30/13	60		
63	Maintenance Road - ABC	3 days	Tue 9/10/13	Fri 9/13/13	61FF+5 days	64	
64	Revegetation/Hydroseed	10 days	Fri 9/13/13	Mon 9/23/13	63		
65	Surface Layer Restoration - Borrow Areas	15 days	Mon 9/9/13	Mon 9/23/13	61	66	
66	Demob - Borrow Areas	5 days	Mon 9/23/13	Fri 9/27/13	65	67	
67	Site Cleanup/Finish Work - Borrow Areas	5 days	Fri 9/27/13	Wed 10/2/13	66	68	
68	Weather Delays	6 days	Wed 10/2/13	Mon 10/7/13	67	69	
69	Demob - Levee Areas	5 days	Mon 10/7/13	Fri 10/11/13	68	70	
70	Site Cleanup/Finish Work - Levee Areas	5 days	Fri 10/11/13	Wed 10/16/13	69	127FF,128FF	
71	Pumping Plants & Relocations	605.69 days	Mon 4/2/12	Fri 10/18/13			
72	Utilities	605.69 days	Mon 4/2/12	Fri 10/18/13			
73	Season 1	115.19 days	Mon 4/2/12	Wed 7/18/12			
74	Site Mobilization - for Util Relocations	15 days	Mon 4/2/12	Mon 4/16/12	22SS	75	
75	Utility Poles	100 days	Mon 4/16/12	Wed 7/18/12	74		1/day
76	Site Demob - for Util Relocations	15 days	Mon 4/2/12	Sat 4/14/12			
77	Season 2	215.5 days	Mon 4/1/13	Fri 10/18/13			
78	Site Mobilization - for Util Relocations	15 days	Mon 4/1/13	Mon 4/15/13			
79	Riverside Canal, SREL 3B	168 days	Wed 5/1/13	Fri 10/4/13		124	
80	Demo	10 days	Wed 5/1/13	Wed 5/15/13		81FF	
81	Clear & Grub	8 days	Wed 5/8/13	Wed 5/15/13	80FF	82SS+2 days	
82	Stripping	11 days	Fri 5/10/13	Mon 5/20/13	81SS+2 days	84FF+1 day	
83	Compacted Embankment	89 days	Thu 6/13/13	Wed 9/4/13	89FS+5 days	85FF+20 days	
84	Excavation to Stockpile	3 days	Sat 5/18/13	Tue 5/21/13	82FF+1 day	89,90	
85	Concrete Canal Lining	14 days	Tue 9/10/13	Mon 9/23/13	83FF+20 days	86	
86	ABC	9 days	Mon 9/23/13	Wed 10/2/13	85	88	
87	Field Irrigation Turnouts	10 days	Sat 6/8/13	Tue 6/18/13	89		
88	Erosion Control Seeding	3 days	Wed 10/2/13	Fri 10/4/13	86		



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
89	30-IN Solid Wall HDPE Pipeline	20 days	Tue 5/21/13	Sat 6/8/13	84	83FS+5 days,87	
90	Pumping Plant Outfall	20 days	Tue 5/21/13	Sat 6/8/13	84	91SS	
91	Water Control Facilities	30 days	Tue 5/21/13	Tue 6/18/13	90SS		
92	Private Irrigation Facility Relocation (Tennet-Labvitch)	60 days	Wed 5/1/13	Wed 6/26/13			Sta ~853+00
93	Demo	2 days	Wed 5/1/13	Thu 5/2/13		94SS	
94	Earthwork	20 days	Wed 5/1/13	Mon 5/20/13	93SS	95	
95	Well Drilling	10 days	Mon 5/20/13	Wed 5/29/13	94	96	
96	Well Development	5 days	Wed 5/29/13	Mon 6/3/13	95	97	
97	Concrete Pad	5 days	Mon 6/3/13	Fri 6/7/13	96	98FS+10 days	
98	Pump & Discharge Pipe	10 days	Mon 6/17/13	Wed 6/26/13	97FS+10 days	99FF	
99	Electrical Service	10 days	Mon 6/17/13	Wed 6/26/13	98FF		
100	Pumping Plant - Sump 160	60 days	Thu 5/23/13	Tue 8/6/13			Sta ~900+00
101	Demo	16 days	Thu 5/23/13	Fri 6/7/13	60SS+20 days	102FF	expected to commence about 20 days before levee construction reaches this point
102	Earthwork	4 days	Mon 6/3/13	Fri 6/7/13	101FF	104	
103	Roads	4 days	Fri 8/2/13	Tue 8/6/13	108	106FF	
104	Pipes	12 days	Fri 6/7/13	Tue 6/18/13	102	105SS	
105	Positive Closure Vault	30 days	Fri 6/7/13	Fri 7/5/13	104SS	107	
106	Security Fence	2 days	Sat 8/3/13	Tue 8/6/13	103FF		
107	Pumps & Motors	30 days	Fri 7/5/13	Fri 8/2/13	105	108FF	
108	Power & Controls	30 days	Fri 7/5/13	Fri 8/2/13	107FF	103	
109	RD 1000, PP No 1A	56 days	Sat 6/15/13	Wed 8/7/13			Sta ~924+50
110	Demo	6 days	Sat 6/15/13	Fri 6/21/13	60SS+45 days	111	expected to commence about 20 days before levee construction reaches this point
111	Site Work	12 days	Fri 6/21/13	Tue 7/2/13	110	112	
112	Construct Chamber for Sluice Gates & Flap Gates	10 days	Tue 7/2/13	Thu 7/11/13	111	113FS+10 days	
113	New Slide/Sluice Gates	8 days	Sat 7/20/13	Mon 7/29/13	112FS+10 days	114	
114	New Flap Gates & Power Winch for Opening	5 days	Mon 7/29/13	Fri 8/2/13	113	115FF+5 days	
115	Powr & Controls for Gate Facilities	10 days	Mon 7/29/13	Wed 8/7/13	114FF+5 days		
116	RD 1000, PP No 1B	78 days	Sat 6/15/13	Tue 8/27/13			Sta ~924+50
117	Demo	13 days	Sat 6/15/13	Thu 6/27/13	60SS+45 days	118FF	expected to commence about 20 days before levee construction reaches this point
118	Earthwork	3 days	Tue 6/25/13	Thu 6/27/13	117FF	120	
119	Roads	5 days	Thu 8/22/13	Tue 8/27/13	123		

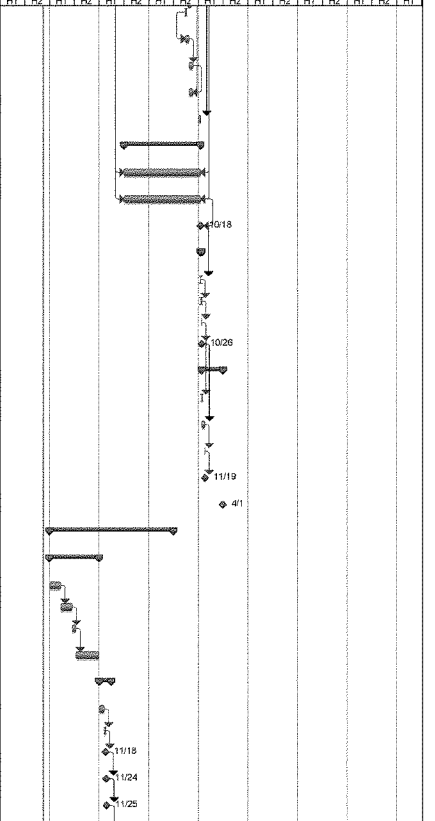


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
120	Pipes	10 days	Thu 6/27/13	Sat 7/6/13	118	121SS	
121	Positive Closure Vault	30 days	Thu 6/27/13	Thu 7/25/13	120SS	122	
122	Pumps & Motors	30 days	Thu 7/25/13	Thu 8/22/13	121	123FF	
123	Power & Controls	30 days	Thu 7/25/13	Thu 8/22/13	122FF	119	
124	Site Demob - for Util Relocations	15 days	Fri 10/4/13	Fri 10/18/13	79		
125	Engineering during Construction, S&A and Construction Completion	605 days	Mon 4/2/12	Fri 10/18/13			
126	Engineering During Construction	605 days	Mon 4/2/12	Fri 10/18/13	22SS,70FF		
127	Supervision and Administration	605 days	Mon 4/2/12	Fri 10/18/13	22SS,70FF	128FF	
128	Construction Completion	0 days	Fri 10/18/13	Fri 10/18/13	127FF	130	
129	**Inspection and Construction per Punch List**	**9 days**	**Fri 10/18/13**	**Sat 10/26/13**			
130	PreFinal Inspection	2 days	Fri 10/18/13	Sat 10/19/13	128	131	
131	Contractor Implement Punch List Items	6 days	Sat 10/19/13	Fri 10/25/13	130	132	
132	Final Inspection	1 day	Fri 10/25/13	Sat 10/26/13	131	133,135	
133	Construction Physical Completion	0 days	Sat 10/26/13	Sat 10/26/13	132	136	
134	**Project Closeout**	**167.25 days**	**Sat 10/26/13**	**Tue 4/1/14**			
135	Construction Prepares Project Completion Letter	6 days	Sat 10/26/13	Fri 11/1/13	132		
136	Contractors Complete As-Builts	24 days	Sat 10/26/13	Mon 11/18/13	133	137	
137	Submit As-Builts	1 day	Mon 11/18/13	Tue 11/19/13	136	138	
138	Notice of Completion/Assumption of OMRR&R	0 days	Tue 11/19/13	Tue 11/19/13	137		
139	Project Fiscally Complete	0 days	Tue 4/1/14	Tue 4/1/14			
140	**Construction Contract 2 - Reach B (remaining work)**	**977.5 days**	**Fri 10/1/10**	**Mon 4/1/13**			SREL Sta 635+00 to 742+60 - Work involves changes to several
141	**Design**	**390 days**	**Fri 10/1/10**	**Fri 9/30/11**			
142	Collect field explorations	90 days	Fri 10/1/10	Fri 12/24/10		143	
143	Conduct geotechnical evaluation	90 days	Fri 12/24/10	Fri 3/18/11	142	144	
144	Develop Basis of Design Report	30 days	Fri 3/18/11	Fri 4/15/11	143	145	
145	Develop Plans & Specifications	180 days	Fri 4/15/11	Fri 9/30/11	144		
146	**Pre-Construction**	**96.25 days**	**Mon 10/3/11**	**Sat 12/31/11**			
147	Project Bid	41.25 days	Mon 10/3/11	Thu 11/10/11		148	
148	Award Task Order	8.75 days	Thu 11/10/11	Fri 11/18/11	147	149	
149	Construction Contract Awarded	0 days	Fri 11/18/11	Fri 11/18/11	148	150FS+6.25 days	
150	Issue NTP	0 days	Thu 11/24/11	Thu 11/24/11	149FS+6.25 days	151FS+1.25 days	
151	NTP Acknowledged	0 days	Fri 11/25/11	Fri 11/25/11	150FS+1.25 days	152	

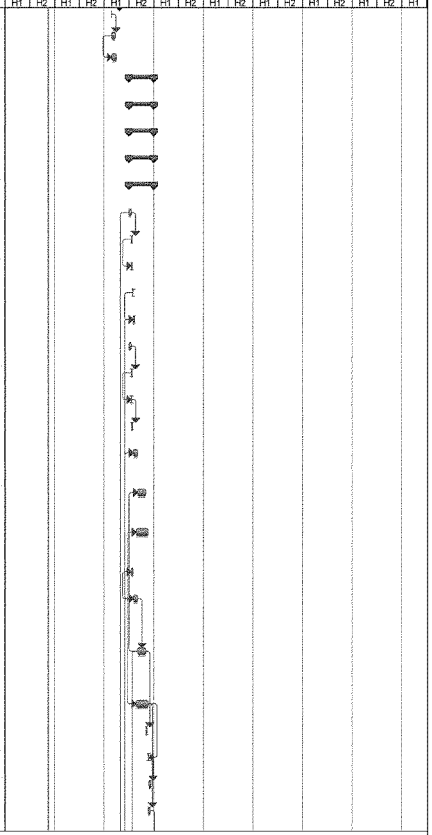


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

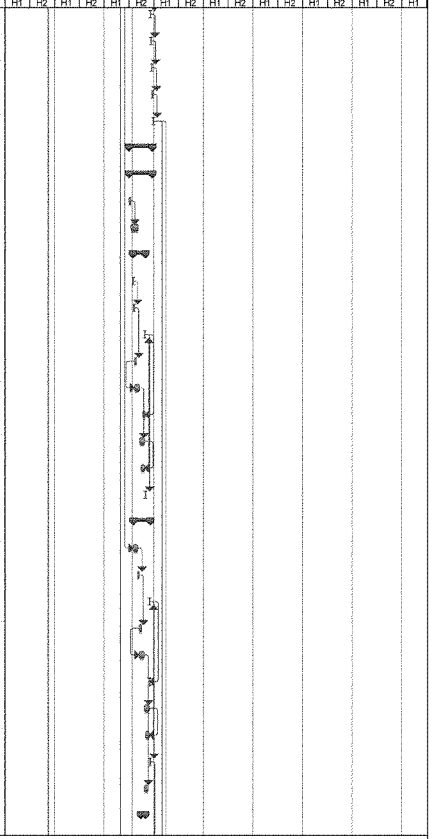
Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
152	Pre-Con Meeting	1.25 days	Fri 11/25/11	Sat 11/26/11	151	153	
153	Prepare Pre-Construction Submittals	28.75 days	Sat 11/26/11	Fri 12/23/11	152	154SS	
154	Corps Approve Pre-Construcion Submittals	37.5 days	Sat 11/26/11	Sat 12/31/11	153SS		
155	**Construction**	**195.44 days**	**Mon 4/2/12**	**Mon 10/1/12**			
156	Levees & Floodwalls	195.25 days	Mon 4/2/12	Mon 10/1/12			
157	Levees	195.25 days	Mon 4/2/12	Mon 10/1/12			
158	General Construction Schedule	195.25 days	Mon 4/2/12	Mon 10/1/12			
159	Season 1	195.25 days	Mon 4/2/12	Mon 10/1/12			
160	Site Mobilization - Levees	18 days	Mon 4/2/12	Wed 4/18/12		161,218SS,219	
161	Haul Roads & Drainage	6 days	Wed 4/18/12	Tue 4/24/12	160	162SS	
162	SWPP Installation - Levees	8 days	Wed 4/18/12	Wed 4/25/12	161SS		full duration of levee constr
163	Clearing & Grubbing	3 days	Tue 5/1/12	Thu 5/3/12		164SS+2 days	
164	Levee Stripping	12 days	Wed 5/2/12	Mon 5/14/12	163SS+2 days	173SS+2 days	
165	Site Mobilization - Borrow Areas	18 days	Mon 4/2/12	Wed 4/18/12		166	
166	Haul Roads & Drainage - Borrow Areas	6 days	Wed 4/18/12	Tue 4/24/12	165	167SS	
167	SWPP Installation - Borrow Areas	2 days	Wed 4/18/12	Fri 4/20/12	166SS	168	full duration of borrow area use
168	Borrow Areas - Surface Layer Removal & Stockpile	10 days	Fri 4/20/12	Mon 4/30/12	167		
169	Borrow Areas - Excavation & Hauling (to replace std depth CO Wall Waste)	34 days	Fri 5/4/12	Tue 6/5/12	173SS		
170	Borrow Areas - Excavation & Hauling (to replace deep CO Wall Waste)	62 days	Tue 6/5/12	Thu 8/2/12	174SS		
171	Borrow Areas - Excavation & Hauling	96 days	Thu 5/24/12	Tue 8/21/12	175SS		assumes 2 crews used
172	Site Mobilization - Slurry Wall	15 days	Tue 4/17/12	Tue 5/1/12	173SS-18 days		
173	Slurry Wall Construction (depth 75' or more)	34 days	Fri 5/4/12	Tue 6/5/12	164SS+2 days	169SS,172SS-1 days,174,175SS days,200SS	
174	Slurry Wall Construction (depth less than 75')	62 days	Tue 6/5/12	Thu 8/2/12	173	170SS,176,211 days	asssumes 2 crews used
175	Select/Levee Fill & Random Fill	96 days	Thu 5/24/12	Tue 8/21/12	173SS+21 days	171SS,179,177 days	asssumes 2 crews used
176	Demob - Slurry Wall	12 days	Thu 8/2/12	Mon 8/13/12	174		
177	Maintenance Road - ABC	4 days	Wed 8/22/12	Sat 8/25/12	175FF+5 days	178	
178	Revegetation/Hydroseed	16 days	Sat 8/25/12	Mon 9/10/12	177		
179	Surface Layer Restoration - Borrow Areas	15 days	Tue 8/21/12	Tue 9/4/12	175	180	



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ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
180	Demob - Borrow Areas	5 days	Tue 9/4/12	Sat 9/8/12	179	181	
181	Site Cleanup/Finish Work - Borrow Areas	5 days	Sat 9/8/12	Thu 9/13/12	180	182	
182	Weather Delays	6 days	Thu 9/13/12	Wed 9/19/12	181	183	
183	Demob - Levee Areas	6 days	Wed 9/19/12	Tue 9/25/12	182	184	
184	Site Cleanup/Finish Work - Levee Areas	6 days	Tue 9/25/12	Mon 10/1/12	183	218FF,219FF,2	
185	Pumping Plants & Relocations	184.44 days	Mon 4/2/12	Thu 9/20/12			
186	Utilities	184.44 days	Mon 4/2/12	Thu 9/20/12			
187	Site Mobilization - for Util Relocations	15 days	Mon 4/2/12	Sat 4/14/12		188	
188	Utility Poles	60 days	Mon 4/16/12	Sat 6/9/12	187		1/day
189	Elkhorn PP, Phase 2	100 days	Tue 5/1/12	Thu 8/2/12			
190	Demo	5 days	Tue 5/1/12	Sat 5/5/12		191	
191	Earthwork	8 days	Sat 5/5/12	Sat 5/12/12	190	193	
192	Roads	4 days	Thu 7/26/12	Mon 7/30/12	197	195FF,198	
193	Pipes	14 days	Sat 5/12/12	Fri 5/25/12	191	194SS	
194	Positive Closure Vault	40 days	Sat 5/12/12	Tue 6/19/12	193SS	196	
195	Pump Platform Rehab	20 days	Wed 7/11/12	Mon 7/30/12	192FF		
196	Pumps & Motors	40 days	Tue 6/19/12	Thu 7/26/12	194	197FF	
197	Power & Controls	30 days	Thu 6/28/12	Thu 7/26/12	196FF	192	
198	Bank Stabilization	3 days	Mon 7/30/12	Thu 8/2/12	192		
199	RD 1000, PP No 3	134 days	Fri 5/4/12	Thu 9/6/12			Sta ~676+00
200	Demo	35 days	Fri 5/4/12	Wed 6/6/12	173SS	201	expected to commence about 35 days before levee construction
201	Earthwork	10 days	Wed 6/6/12	Fri 6/15/12	200	203	
202	Roads	4 days	Wed 8/29/12	Sat 9/1/12	207	205FF,208	
203	Pipes	20 days	Fri 6/15/12	Wed 7/4/12	201	204SS	
204	Positive Closure & Flow Meter Vaults	40 days	Fri 6/15/12	Mon 7/23/12	203SS	206,209	
205	Security Fence	2 days	Thu 8/30/12	Sat 9/1/12	202FF		
206	Pumps & Motors	40 days	Mon 7/23/12	Wed 8/29/12	204	207FF	
207	Power & Controls	30 days	Wed 8/1/12	Wed 8/29/12	206FF	202	
208	Flap Gates	5 days	Sat 9/1/12	Thu 9/6/12	202	216	
209	C-I-P Concrete Baffles	30 days	Mon 7/23/12	Mon 8/20/12	204		
210	Riverside PP, Phase 1	37 days	Thu 6/28/12	Thu 8/2/12			Sta ~707+50

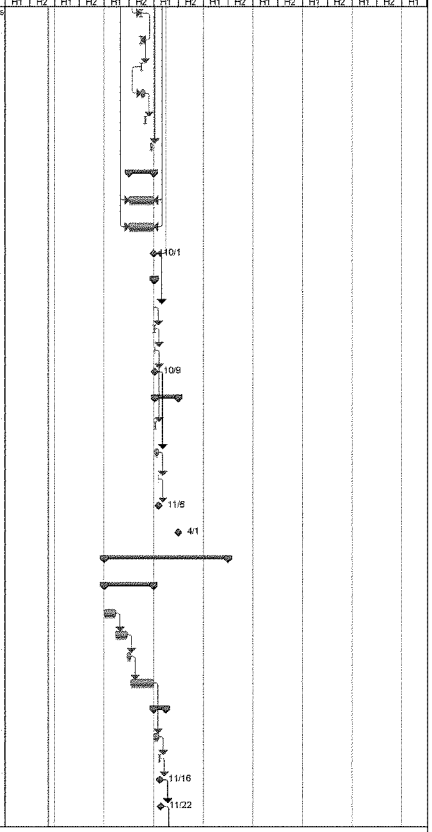


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AMERICAN RIVER COMMON FEATURES WRDA 1986 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
211	Demo	2 days	Thu 6/28/12	Sat 6/30/12	174SS+25 days	212FF	expected to commence about 5 days before levee construction reaches this point
212	Earthwork	2 days	Thu 6/28/12	Sat 6/30/12	211FF	213	
213	Pipes	5 days	Sat 6/30/12	Thu 7/5/12	212	214SS	
214	Flow Meter Vault	30 days	Sat 6/30/12	Sat 7/28/12	213SS	215	
215	Bollards	5 days	Sat 7/28/12	Thu 8/2/12	214		
216	Site Demobilization - for Util Relocations	15 days	Thu 9/6/12	Thu 9/20/12	208		
217	Engineering during Construction, S&A and Construction Completion	195 days	Mon 4/2/12	Mon 10/1/12			
218	Engineering During Construction	195 days	Mon 4/2/12	Mon 10/1/12	160SS,184FF		
219	Supervision and Administration	195 days	Mon 4/2/12	Mon 10/1/12	160SS,184FF		
220	Construction Completion	0 days	Mon 10/1/12	Mon 10/1/12	184FF	222	
221	**Inspection and Construction per Punch List**	**8.75 days**	**Mon 10/1/12**	**Tue 10/9/12**			
222	PreFinal Inspection	1.25 days	Mon 10/1/12	Tue 10/2/12	220	223	
223	Contractor Implement Punch List Items	6.25 days	Tue 10/2/12	Mon 10/8/12	222	224	
224	Final Inspection	1.25 days	Mon 10/8/12	Tue 10/9/12	223	225,227	
225	Construction Physical Completion	0 days	Tue 10/9/12	Tue 10/9/12	224	228	
226	**Project Closeout**	**186 days**	**Tue 10/9/12**	**Mon 4/1/13**			
227	Construction Prepares Project Completion Letter	6.25 days	Tue 10/9/12	Mon 10/15/12	224		
228	Contractors Complete As-Builts	28.75 days	Tue 10/9/12	Mon 11/5/12	225	229	
229	Submit As-Builts	1.25 days	Mon 11/5/12	Tue 11/6/12	228	230	
230	Notice of Completion/Assumption of OMRR&R	0 days	Tue 11/6/12	Tue 11/6/12	229		
231	Project Fiscally Complete	0 days	Mon 4/1/13	Mon 4/1/13			
232	**Construction Contract 3 - Reach H**	**976.25 days**	**Mon 10/3/11**	**Tue 4/1/14**			Sta 0+00 to 237+00 - Work involves levee improvements and/or [illegible]
233	**Design**	**390 days**	**Mon 10/3/11**	**Mon 10/1/12**			
234	Collect field explorations	90 days	Mon 10/3/11	Mon 12/26/11		235	
235	Conduct geotechnical evaluation	90 days	Mon 12/26/11	Mon 3/19/12	234	236	
236	Develop Basis of Design Report	30 days	Mon 3/19/12	Mon 4/16/12	235	237	
237	Develop Plans & Specifications	180 days	Mon 4/16/12	Mon 10/1/12	236	239	
238	**Pre-Construction**	**96.25 days**	**Mon 10/1/12**	**Sat 12/29/12**			
239	Project Bid	41.25 days	Mon 10/1/12	Thu 11/8/12	237	240	
240	Award Task Order	8.75 days	Thu 11/8/12	Fri 11/16/12	239	241	
241	Construction Contract Awarded	0 days	Fri 11/16/12	Fri 11/16/12	240	242FS+6.25 days	
242	Issue NTP	0 days	Thu 11/22/12	Thu 11/22/12	241FS+6.25 days	243FS+1.25 days	

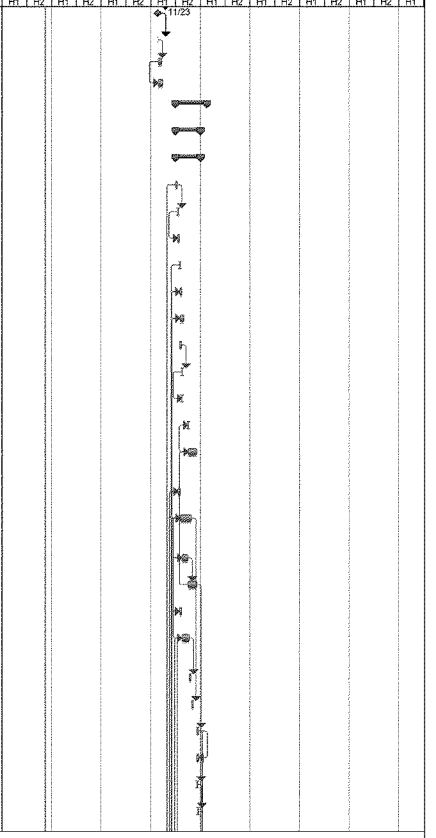


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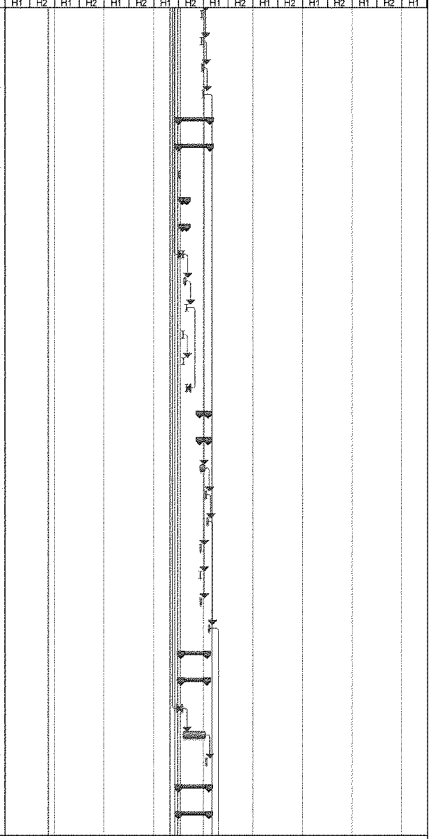
AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

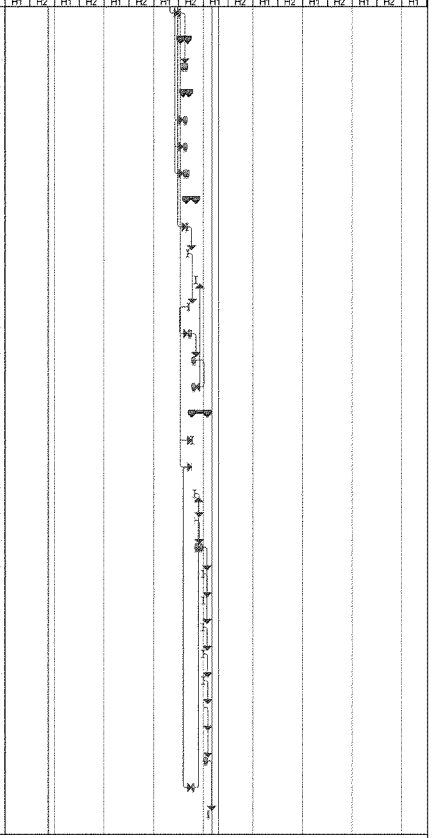
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
243	NTP Acknowledged	0 days	Fri 11/23/12	Fri 11/23/12	242FS+1.25 days	244	
244	Pre-Con Meeting	1.25 days	Fri 11/23/12	Sat 11/24/12	243	245	
245	Prepare Pre-Construction Submittals	28.75 days	Sat 11/24/12	Fri 12/21/12	244	246SS	
246	Corps Approve Pre-Constructon Submittals	37.5 days	Sat 11/24/12	Sat 12/29/12	245SS		
247	**Construction**	**249.5 days**	**Mon 4/1/13**	**Tue 11/19/13**			
248	Levees & Floodwalls	198.75 days	Mon 4/1/13	Thu 10/3/13			
249	Levees	198.75 days	Mon 4/1/13	Thu 10/3/13			
250	Site Mobilization - Levees	18 days	Mon 4/1/13	Wed 4/17/13		251,304SS	
251	Haul Roads & Drainage	6 days	Wed 4/17/13	Tue 4/23/13	250	252SS	maintain for full duration of levee constr
252	SWPP Installation - Levees	13 days	Wed 4/17/13	Mon 4/29/13	251SS		full duration of levee constr
253	Clearing & Grubbing	5 days	Wed 5/1/13	Mon 5/6/13		254SS+2 days,282SS	
254	Levee Stripping	16 days	Thu 5/2/13	Fri 5/17/13	253SS+2 days	255SS+2 days	2 crews
255	Levee Degrading	31 days	Sat 5/4/13	Mon 6/3/13	254SS+2 days	262SS+2 days	2 crews
256	Site Mobilization - Borrow Areas	18 days	Wed 5/1/13	Fri 5/17/13		257	
257	Haul Roads & Drainage - Borrow Areas	5 days	Fri 5/17/13	Wed 5/22/13	256	258SS	full duration of borrow area use
258	SWPP Installation - Borrow Areas	2 days	Fri 5/17/13	Mon 5/20/13	257SS		full duration of borrow area use
259	Surface Layer Removal & Stockpile - Borrow Areas	5 days	Mon 7/1/13	Fri 7/5/13	260SS-2 days		0.66 AC/hr, 4 scrapers
260	Excavation & Hauling - Borrow Areas	70 days	Wed 7/3/13	Fri 9/6/13	264SS	259SS-2 days	
261	Site Mobilization - Slurry Wall	18 days	Fri 4/19/13	Mon 5/6/13	262SS-18 days	299SS,265SS+ days	
262	Slurry Wall Construction	90 days	Mon 5/6/13	Mon 7/29/13	255SS+2 days	261SS-18 days,308SS,26 days,263SS+12	2 rigs/crews
263	Embankment Fill, from Levee Degrading	50 days	Fri 5/17/13	Wed 7/3/13	262SS+12 days	264	2 crews
264	Emankment Fill, from Borrow	70 days	Wed 7/3/13	Fri 9/6/13	263	260SS,271,269	2 crews
265	Site Mobilization - Jet Grouting	18 days	Wed 5/1/13	Fri 5/17/13	261SS+12 days		
266	Jet GroutingConstruction	60 days	Fri 5/17/13	Fri 7/12/13	262SS+12 days	267,312SS+12 days,320SS+55 days,321SS+55	assume start about 2 weeks after slurry wall
267	Demob - Jet Grouting	12 days	Fri 7/12/13	Wed 7/24/13	266		
268	Demob - Slurry Wall	12 days	Mon 7/29/13	Fri 8/9/13	262		
269	Bike Trail (at Levee Crown)	10 days	Fri 9/6/13	Mon 9/16/13	264	274,270FF+6 days	
270	Revegetation/Hydroseed	18 days	Wed 9/4/13	Sat 9/21/13	269FF+6 days		3.72 AC/day
271	Surface Layer Restoration - Borrow Areas	5 days	Fri 9/6/13	Wed 9/11/13	264	272	
272	Demob - Borrow Areas	6 days	Wed 9/11/13	Tue 9/17/13	271	273	



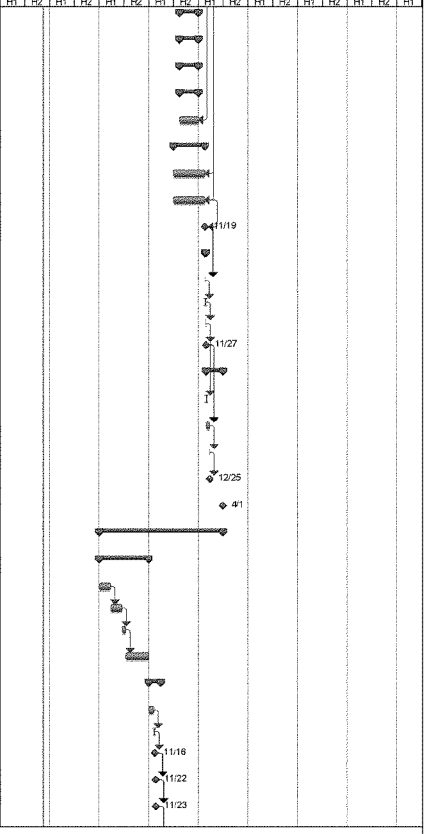
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
273	Site Cleanup/Finish Work - Borrow Areas	6 days	Tue 9/17/13	Mon 9/23/13	272		
274	Weather Delays	6.25 days	Mon 9/16/13	Sat 9/21/13	269	275	
275	Demob - Levee Areas	6 days	Sat 9/21/13	Fri 9/27/13	274	276	
276	Site Cleanup/Finish Work - Levee Areas	6 days	Fri 9/27/13	Thu 10/3/13	275	339FF	
277	Pumping Plants & Relocations	249.5 days	Mon 4/1/13	Tue 11/19/13			
278	Roads, Construction Activities	248.25 days	Tue 4/2/13	Tue 11/19/13			
279	Site Mobilization - for Rd Relocations	15 days	Tue 4/2/13	Tue 4/16/13			
280	Paving Demo	34 days	Wed 5/1/13	Sat 6/1/13			
281	Demolition	34 days	Wed 5/1/13	Sat 6/1/13			
282	Arden-Garden Connector	8 days	Wed 5/1/13	Wed 5/8/13	253SS	283	
283	Bike Trail at Levee Crown	23 days	Wed 5/8/13	Wed 5/29/13	282	284	
284	East Levee Road	3 days	Wed 5/29/13	Sat 6/1/13	283	287FF	
285	Dead End Roads	5 days	Wed 5/1/13	Mon 5/6/13		286	about 2 days each but will be done as levee improvement passes thru area
286	Natoma Street	2 days	Mon 5/6/13	Tue 5/7/13	285		will be done as levee improvement passes thru area
287	Northgate Blvd	6 days	Mon 5/27/13	Sat 6/1/13	284FF		will be done as levee improvement passes thru area
288	Road Surfacing	64 days	Fri 9/6/13	Tue 11/5/13			
289	Site Work	64 days	Fri 9/6/13	Tue 11/5/13			
290	Arden-Garden Connector	40 days	Fri 9/6/13	Mon 10/14/13	264	291	
291	Bike Trail at Levee Crown	12 days	Mon 10/14/13	Fri 10/25/13	290	292	
292	East Levee Road	12 days	Fri 10/25/13	Tue 11/5/13	291	296	
293	Dead End Roads	10 days	Fri 9/6/13	Mon 9/16/13	264		about 2 days each but will be done as levee improvement passes thru area
294	Natoma Street	5 days	Fri 9/6/13	Wed 9/11/13	264		will be done as levee improvement passes thru area
295	Northgate Blvd	15 days	Fri 9/6/13	Fri 9/20/13	264		will be done as levee improvement passes thru area
296	Site Demobilization - for Rd Relocations	15 days	Tue 11/5/13	Tue 11/19/13	292	341FF,342FF	
297	Bridge Modifications, W El Camino	205 days	Fri 4/19/13	Mon 10/28/13			
298	Site Work	205 days	Fri 4/19/13	Mon 10/28/13			
299	Mob for Bridge Work	15 days	Fri 4/19/13	Fri 5/3/13	261SS	300	
300	Bridge Modifications, W El Camino	180 days	Fri 5/3/13	Fri 10/18/13	299	301	
301	Demob for Bridge Work	10 days	Fri 10/18/13	Mon 10/28/13	300		
302	Cemeteries, Utils, Structures	241.5 days	Mon 4/1/13	Tue 11/12/13			
303	Utils	241.5 days	Mon 4/1/13	Tue 11/12/13			



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
304	Site Mobilization - for Util Relocations	18 days	Mon 4/1/13	Wed 4/17/13	250SS	306	
305	Electrical	56 days	Wed 4/17/13	Sat 6/8/13			
306	Utility Poles	56 days	Wed 4/17/13	Sat 6/8/13	304		1/day
307	Utility Crossing Relocations	45 days	Mon 5/6/13	Mon 6/17/13			
308	6" Gas Main	30 days	Mon 5/6/13	Mon 6/3/13	262SS	309SS,310SS	
309	8" Water Main	30 days	Mon 5/6/13	Mon 6/3/13	308SS		
310	Fiber Optic Line	45 days	Mon 5/6/13	Mon 6/17/13	308SS		
311	PP - Sump 102	77 days	Wed 5/29/13	Thu 8/8/13			Sta ~59+00
312	Demo	8 days	Wed 5/29/13	Wed 6/5/13	266SS+12 days	313	expected to commence about 10 days before levee construction reaches this point
313	Earthwork	5 days	Wed 6/5/13	Mon 6/10/13	312	315	
314	Roads	4 days	Mon 8/5/13	Thu 8/8/13	318		
315	Pipes	8 days	Mon 6/10/13	Mon 6/17/13	313	316SS	
316	Positive Closure Vault	30 days	Mon 6/10/13	Mon 7/8/13	315SS	317	
317	Pumps & Motors	30 days	Mon 7/8/13	Mon 8/5/13	316	318FF	
318	Power & Controls	30 days	Mon 7/8/13	Mon 8/5/13	317FF	314	
319	RD 1000, PP No 8	124 days	Mon 7/8/13	Thu 10/31/13			Sta ~178+00
320	Temporary Fencing	5 days	Mon 7/8/13	Fri 7/12/13	266SS+55 days		expected to commence about 10 days before levee construction reaches this point
321	Asphalt Removal	1 day	Mon 7/8/13	Tue 7/9/13	266SS+55 days	333SS	
322	Excavate, Fill & Compact	5 days	Fri 7/26/13	Wed 7/31/13	333	323	
323	Remove Existing WSP	1 day	Wed 7/31/13	Thu 8/1/13	322	324	
324	Positive Closure Vault	60 days	Thu 8/1/13	Thu 9/26/13	323	325,327	
325	Closure Valve, 54-IN	3 days	Thu 9/26/13	Sat 9/28/13	324	326	
326	Dismantling Joint, 54-IN	2 days	Sat 9/28/13	Tue 10/1/13	325		
327	Closure Valve, 36-IN	3 days	Thu 9/26/13	Sat 9/28/13	324	328	
328	Dismantling Joint, 36-IN	2 days	Sat 9/28/13	Tue 10/1/13	327	329	
329	Siphon Breakers	2 days	Tue 10/1/13	Wed 10/2/13	328	330	
330	Backfill	1 day	Wed 10/2/13	Thu 10/3/13	329	331,332	
331	ABC	1 day	Thu 10/3/13	Fri 10/4/13	330		
332	Electrical Control Equipment	30 days	Thu 10/3/13	Thu 10/31/13	330	334	
333	Locate & Relocate Utils prior to excavation	20 days	Mon 7/8/13	Fri 7/26/13	321SS	322	
334	Site Demobilization - for Util Relocations	12 days	Thu 10/31/13	Tue 11/12/13	332		



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
335	Fish & Wildlife Facilities	150 days	Thu 5/16/13	Thu 10/3/13			
336	Wildlife Facilities & Sanctuaries	150 days	Thu 5/16/13	Thu 10/3/13			
337	Dry Creek	150 days	Thu 5/16/13	Thu 10/3/13			
338	Woodland Corridor & Enhancement	150 days	Thu 5/16/13	Thu 10/3/13			
339	Mob, Prep Work, Planting & Irrigation, Demob	150 days	Thu 5/16/13	Thu 10/3/13	276FF		sans O&M
340	Engineering during Construction, S&A and Construction Completion	249 days	Mon 4/1/13	Tue 11/19/13			
341	Engineering During Construction	249 days	Mon 4/1/13	Tue 11/19/13	296FF		
342	Supervision and Administration	249 days	Mon 4/1/13	Tue 11/19/13	296FF	343FF	
343	Construction Completion	0 days	Tue 11/19/13	Tue 11/19/13	342FF	345	
344	**Inspection and Construction per Punch List**	**8.75 days**	**Tue 11/19/13**	**Wed 11/27/13**			
345	PreFinal Inspection	1.25 days	Tue 11/19/13	Wed 11/20/13	343	346	
346	Contractor Implement Punch List Items	6.25 days	Wed 11/20/13	Tue 11/26/13	345	347	
347	Final Inspection	1.25 days	Tue 11/26/13	Wed 11/27/13	346	348,350	
348	Construction Physical Completion	0 days	Wed 11/27/13	Wed 11/27/13	347	351	
349	**Project Closeout**	**133 days**	**Wed 11/27/13**	**Tue 4/1/14**			
350	Construction Prepares Project Completion Letter	6.25 days	Wed 11/27/13	Tue 12/3/13	347		
351	Contractors Complete As-Builts	28.75 days	Wed 11/27/13	Tue 12/24/13	348	352	
352	Submit As-Builts	1.25 days	Tue 12/24/13	Wed 12/25/13	351	353	
353	Notice of Completion/Assumption of OMRR&R	0 days	Wed 12/25/13	Wed 12/25/13	352		
354	Project Fiscally Complete	0 days	Tue 4/1/14	Tue 4/1/14			
355	**Construction Contract 4- Reach I**	**976.25 days**	**Mon 10/3/11**	**Tue 4/1/14**			Sta 20+50 to 115+73.3 - Work involves levee improvements and/or
356	**Design**	**390 days**	**Mon 10/3/11**	**Mon 10/1/12**			
357	Collect field explorations	90 days	Mon 10/3/11	Mon 12/26/11		358	
358	Conduct geotechnical evaluation	90 days	Mon 12/26/11	Mon 3/19/12	357	359	
359	Develop Basis of Design Report	30 days	Mon 3/19/12	Mon 4/16/12	358	360	
360	Develop Plans & Specifications	180 days	Mon 4/16/12	Mon 10/1/12	359		
361	**Pre-Construction**	**96.25 days**	**Mon 10/1/12**	**Sat 12/29/12**			
362	Project Bid	41.25 days	Mon 10/1/12	Thu 11/8/12		363	
363	Award Task Order	6.75 days	Thu 11/8/12	Fri 11/16/12	362	364	
364	Construction Contract Awarded	0 days	Fri 11/16/12	Fri 11/16/12	363	365FS+6.25 days	
365	Issue NTP	0 days	Thu 11/22/12	Thu 11/22/12	364FS+6.25 days	366FS+1.25 days	
366	NTP Acknowledged	0 days	Fri 11/23/12	Fri 11/23/12	365FS+1.25 days	367	

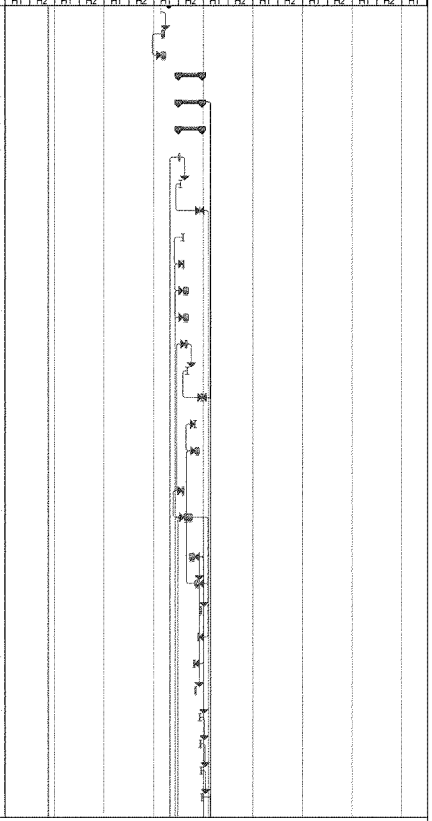


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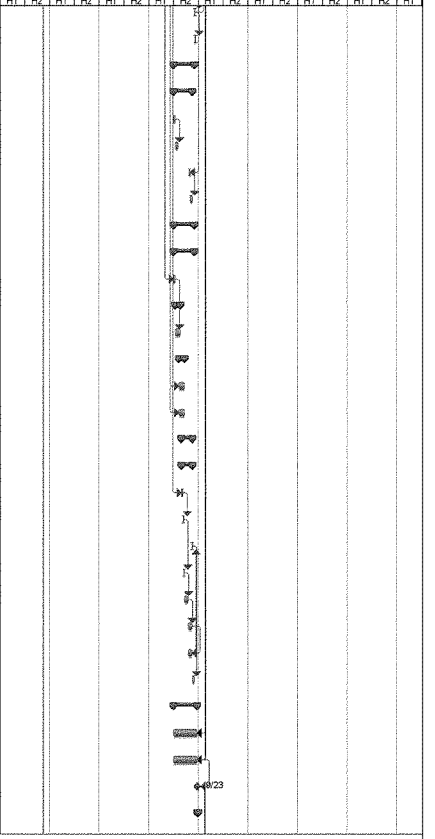
AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
367	Pre-Con Meeting	1.25 days	Fri 11/23/12	Sat 11/24/12	366	368	
368	Prepare Pre-Construction Submittals	28.75 days	Sat 11/24/12	Fri 12/21/12	367	369SS	
369	Corps Approve Pre-Construction Submittals	37.5 days	Sat 11/24/12	Sat 12/29/12	368SS		
370	**Construction**	**188 days**	**Mon 4/1/13**	**Mon 9/23/13**			
371	Levees & Floodwalls	188 days	Mon 4/1/13	Mon 9/23/13		424FF,425FF	
372	Levees	188 days	Mon 4/1/13	Mon 9/23/13			
373	Site Mobilization - Levees	15 days	Mon 4/1/13	Mon 4/15/13		374,407SS	
374	Haul Roads & Drainage	3.75 days	Mon 4/15/13	Thu 4/18/13	373	375SS	
375	Care & Diversion of Water - Erosion Control - SWPC	1.25 days	Fri 9/6/13	Sat 9/7/13	374SS,397FF		full duration of levee constr
376	Clearing & Grubbing	5 days	Wed 5/1/13	Mon 5/6/13		377SS+2.5 days	
377	Levee Stripping	8.75 days	Fri 5/3/13	Sat 5/11/13	376SS+2.5 days	378SS+2.5 days	
378	Levee Degrading	42.5 days	Mon 5/6/13	Fri 6/14/13	377SS+2.5 days	379SS,386SS+ days	
379	Temporary Fill, Placement	42.5 days	Mon 5/6/13	Fri 6/14/13	378SS		
380	Site Mobilization - Borrow Areas	15 days	Tue 5/21/13	Tue 6/4/13	385SS+25 days	381	
381	Haul Roads & Drainage - Borrow Areas	3.75 days	Tue 6/4/13	Fri 6/7/13	380	382SS	
382	Care & Diversion of Water - Erosion Control - SWPC - Borrow Areas	1.25 days	Sat 9/21/13	Mon 9/23/13	381SS,396FF		full duration of borrow area use
383	Surface Layer Removal & Stockpile - Borrow Areas	5 days	Tue 7/30/13	Sat 8/3/13	384SS-2.5 days		
384	Excavation & Hauling - Borrow Areas	35 days	Thu 8/1/13	Tue 9/3/13	388SS	383SS-2.5 days	
385	Site Mobilization - Slurry Wall	15 days	Sat 4/27/13	Sat 5/11/13	386SS-15 days	380SS+25 days	
386	Slurry Wall Construction	67 days	Sat 5/11/13	Fri 7/12/13	378SS+6.25 days	385SS-15 days,411SS,38 days,388FF+12	
387	Embankment Fill, from Levee Degrading	46.25 days	Wed 6/19/13	Thu 8/1/13	388FF+21 days	388,391FF,392, days	
388	Emankment Fill, from Borrow	35 days	Thu 9/1/13	Tue 9/3/13	386FF+12.5 days,387	384SS,389,390	
389	Demob - Slurry Wall	15 days	Tue 9/3/13	Tue 9/17/13	388		
390	Temporary Fill, Removal	15 days	Tue 8/20/13	Tue 9/3/13	388FF	393,397	
391	Maintenance Road - ABC	12.5 days	Sat 7/20/13	Thu 8/1/13	387FF		
392	Revegetation/Hydroseed	8.75 days	Thu 8/1/13	Fri 8/9/13	387		
393	Surface Layer Restoration - Borrow Areas	5 days	Tue 9/3/13	Sat 9/7/13	390	394	
394	Weather Delays	6.25 days	Sat 9/7/13	Fri 9/13/13	393	395	
395	Demob - Borrow Areas	5 days	Fri 9/13/13	Wed 9/18/13	394	396	
396	Site Cleanup/Finish Work - Borrow Areas	5 days	Wed 9/18/13	Mon 9/23/13	395	382FF	



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
397	Demob - Levee Areas	5 days	Tue 9/3/13	Sat 9/7/13	390	375FF,398	
398	Site Cleanup/Finish Work - Levee Areas	5 days	Sat 9/7/13	Thu 9/12/13	397		
399	Pumping Plants & Relocations	165.75 days	Mon 4/1/13	Mon 9/2/13			
400	Roads, Construction Activities	149.25 days	Mon 4/1/13	Sat 8/17/13			
401	Site Mobilization - for Rd Relocations	15 days	Mon 4/1/13	Mon 4/15/13		402	
402	Demo Pavement	20 days	Mon 4/15/13	Fri 5/3/13	401		
403	AC Pavement	10 days	Thu 7/25/13	Sat 8/3/13	387FF+2.5 days	404	
404	Site Demobilization - for Rd Relocations	15 days	Sat 8/3/13	Sat 8/17/13	403		
405	Cemeteries, Utils, Structures	165.75 days	Mon 4/1/13	Mon 9/2/13			
406	Utils	165.75 days	Mon 4/1/13	Mon 9/2/13			
407	Site Mobilization - for Util Relocations	15 days	Mon 4/1/13	Mon 4/15/13	373SS	409	
408	Electrical	40 days	Mon 4/15/13	Wed 5/22/13			
409	Utility Poles	40 days	Mon 4/15/13	Wed 5/22/13	407		1/day
410	Utility Crossing Relocations	45 days	Sat 5/11/13	Sat 6/22/13			
411	Mechanical	45 days	Sat 5/11/13	Sat 6/22/13	386SS	412SS	
412	Electrical	45 days	Sat 5/11/13	Sat 6/22/13	411SS		
413	Pump Station Rehab	87 days	Thu 5/30/13	Mon 8/19/13			
414	PP - Sump 58	87 days	Thu 5/30/13	Mon 8/19/13			Sta ~70+00
415	Demo	12 days	Thu 5/30/13	Mon 6/10/13	386SS+20 days	416	expected to commence about 15 days before levee construction reaches this point
416	Earthwork	6 days	Mon 6/10/13	Sat 6/15/13	415	418	
417	Roads	4 days	Thu 8/15/13	Mon 8/19/13	421	422	
418	Pipes	5 days	Sat 6/15/13	Thu 6/20/13	416	419	
419	Positive Closure Vault	30 days	Thu 6/20/13	Thu 7/18/13	418	420	
420	Pumps & Motors	30 days	Thu 7/18/13	Thu 8/15/13	419	421FF	
421	Power & Controls	30 days	Thu 7/18/13	Thu 8/15/13	420FF	417	
422	Site Demobilization - for Util Relocations	15 days	Mon 8/19/13	Mon 9/2/13	417		
423	Engineering during Construction, S&A and Construction Completion	188 days	Mon 4/1/13	Mon 9/23/13			
424	Engineering During Construction	188 days	Mon 4/1/13	Mon 9/23/13	371FF		
425	Supervision and Administration	188 days	Mon 4/1/13	Mon 9/23/13	371FF	426FF	
426	Construction Completion	0 days	Mon 9/23/13	Mon 9/23/13	425FF	428	9/23
427	**Inspection and Construction per Punch List**	**8.75 days**	**Mon 9/23/13**	**Tue 10/1/13**			

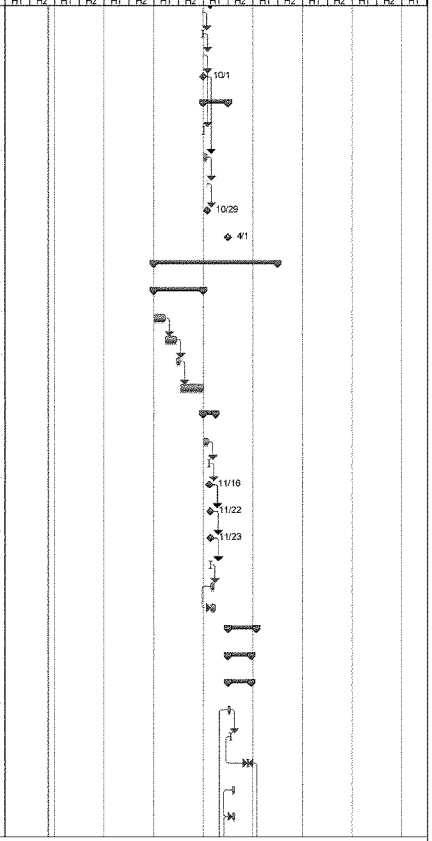


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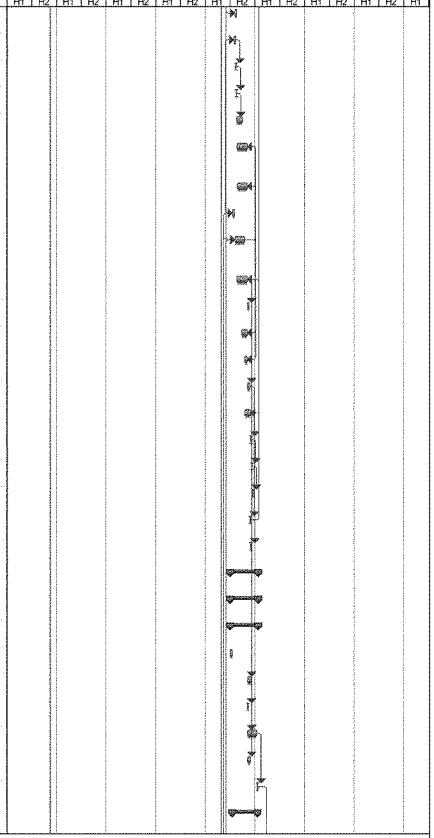
AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

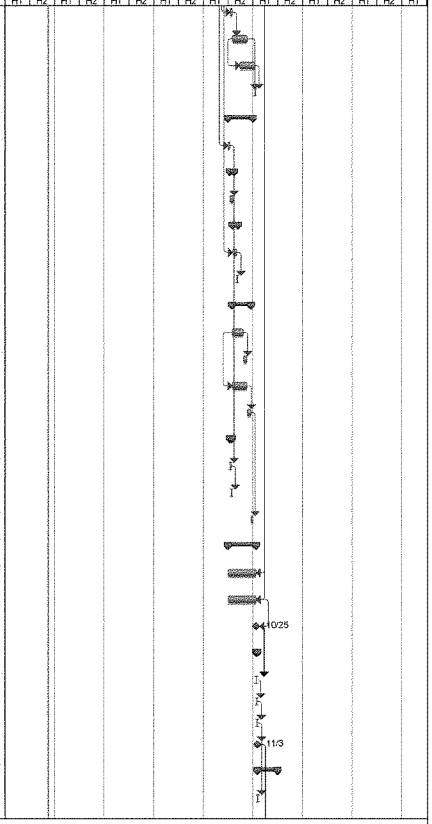
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
428	PreFinal Inspection	1.25 days	Mon 9/23/13	Tue 9/24/13	426	429	
429	Contractor Implement Punch List Items	6.25 days	Tue 9/24/13	Mon 9/30/13	428	430	
430	Final Inspection	1.25 days	Mon 9/30/13	Tue 10/1/13	429	431,433	
431	Construction Physical Completion	0 days	Tue 10/1/13	Tue 10/1/13	430	434	
432	**Project Closeout**	**194.5 days**	**Tue 10/1/13**	**Tue 4/1/14**			
433	Construction Prepares Project Completion Letter	6.25 days	Tue 10/1/13	Mon 10/7/13	430		
434	Contractors Complete As-Builts	28.75 days	Tue 10/1/13	Mon 10/28/13	431	435	
435	Submit As-Builts	1.25 days	Mon 10/28/13	Tue 10/29/13	434	436	
436	Notice of Completion/Assumption of OMRR&R	0 days	Tue 10/29/13	Tue 10/29/13	435		
437	Project Fiscally Complete	0 days	Tue 4/1/14	Tue 4/1/14			
438	**Construction Contract 5 - Reach E**	**977.5 days**	**Mon 10/1/12**	**Wed 4/1/15**			Sta 287+37 to 451+31 - Howsley Road to Sankey Road - Work involves levee improvements and/or
439	**Design**	**390 days**	**Mon 10/1/12**	**Mon 9/30/13**			
440	Collect field explorations	90 days	Mon 10/1/12	Mon 12/24/12		441	
441	Conduct geotechnical evaluation	90 days	Mon 12/24/12	Mon 3/18/13	440	442	
442	Develop Basis of Design Report	30 days	Mon 3/18/13	Mon 4/15/13	441	443	
443	Develop Plans & Specifications	180 days	Mon 4/15/13	Mon 9/30/13	442		
444	**Pre-Construction**	**96.25 days**	**Tue 10/1/13**	**Mon 12/30/13**			
445	Project Bid	41.25 days	Tue 10/1/13	Fri 11/8/13		446	
446	Award Task Order	8.75 days	Fri 11/8/13	Sat 11/16/13	445	447	
447	Construction Contract Awarded	0 days	Sat 11/16/13	Sat 11/16/13	446	448FS+6.25 days	
448	Issue NTP	0 days	Fri 11/22/13	Fri 11/22/13	447FS+6.25 days	449FS+1.25 days	
449	NTP Acknowledged	0 days	Sat 11/23/13	Sat 11/23/13	448FS+1.25 days	450	
450	Pre-Con Meeting	1.25 days	Sat 11/23/13	Mon 11/25/13	449	451	
451	Prepare Pre-Construction Submittals	28.75 days	Mon 11/25/13	Sat 12/21/13	450	452SS	
452	Corps Approve Pre-Construcion Submittals	37.5 days	Mon 11/25/13	Mon 12/30/13	451SS		
453	**Construction**	**223.5 days**	**Tue 4/1/14**	**Sat 10/25/14**			
454	Levees & Floodwalls	185.75 days	Tue 4/1/14	Sat 9/20/14			
455	Levees	185.75 days	Tue 4/1/14	Sat 9/20/14			
456	Site Mobilization - Levees	18 days	Tue 4/1/14	Thu 4/17/14		457,496SS	
457	Haul Roads & Drainage	6 days	Thu 4/17/14	Wed 4/23/14	456	458SS	
458	SWPP Installation - Levees	12 days	Wed 8/20/14	Sat 8/30/14	457SS,479FF		full duration of levee constr
459	Clearing & Grubbing (also tree removal)	20 days	Thu 5/1/14	Tue 5/20/14		460SS+2 days	
460	Levee Stripping	21 days	Fri 5/2/14	Thu 5/22/14	459SS+2 days	469SS+2 days,461SS+2	



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
461	Levee Degrading	15 days	Mon 5/5/14	Mon 5/19/14	460SS+2 days		
462	Site Mobilization - Borrow Areas	15 days	Tue 4/29/14	Tue 5/13/14	468SS+12 days	463	
463	Haul Roads & Drainage - Borrow Areas	5 days	Tue 5/13/14	Sat 5/17/14	462	464	
464	SWPP Installation - Borrow Areas	2 days	Sat 5/17/14	Tue 5/20/14	463	465	full duration of borrow area use
465	Surface Layer Removal & Stockpile - Borrow Areas	46 days	Tue 5/20/14	Tue 7/1/14	464		double crews
466	Excavation & Hauling - Borrow Areas	84 days	Wed 5/21/14	Thu 8/7/14	469FF+21 days		double crews
467	Vinyl Sheet Pile	80 days	Sat 5/24/14	Thu 8/7/14	470FF		
468	Site Mobilization - Slurry Wall	18 days	Thu 4/17/14	Mon 5/5/14	469SS-18 days	462SS+12 days,491SS	
469	Slurry Wall Construction	81 days	Mon 5/5/14	Sat 7/19/14	460SS+2 days	466FF+21 days,468SS-18 days,470FF+21	double rig/crews
470	Embankment Fill, from Borrow	84 days	Wed 5/21/14	Thu 8/7/14	469FF+21 days	467FF,475FF+; days,471,473FF	double crews
471	Demob - Slurry Wall	12 days	Thu 8/7/14	Tue 8/19/14	470		
472	Quarry Stone	46 days	Thu 6/26/14	Thu 8/7/14	470FF		
473	Maintenance Road - ABC	22 days	Fri 7/18/14	Thu 8/7/14	470FF		
474	Revegetation/Hydroseed	20 days	Thu 8/7/14	Tue 8/26/14	470	479	
475	Surface Layer Restoration - Borrow Areas	45 days	Sat 7/19/14	Sat 8/30/14	470FF+25 days	476	double crews
476	Weather Delays	6.25 days	Sat 8/30/14	Fri 9/5/14	475	477	
477	Demob - Borrow Areas	6 days	Fri 9/5/14	Thu 9/11/14	476	478	
478	Site Cleanup/Finish Work - Borrow Areas	10 days	Thu 9/11/14	Sat 9/20/14	477		
479	Demob - Levee Areas	5 days	Tue 8/26/14	Sat 8/30/14	474	458FF,480	
480	Site Cleanup/Finish Work - Levee Areas	5 days	Sat 8/30/14	Thu 9/4/14	479		
481	Relocations	223.5 days	Tue 4/1/14	Sat 10/25/14			
482	Roads, Construction Activities	223.5 days	Tue 4/1/14	Sat 10/25/14			
483	Roads	223.5 days	Tue 4/1/14	Sat 10/25/14			
484	Site Mobilization - for Rd Relocations	18 days	Tue 4/1/14	Thu 4/17/14			
485	Howsley Road	30 days	Thu 8/7/14	Thu 9/4/14	470		
486	Fifeld Road	5 days	Thu 8/7/14	Tue 8/12/14	470		
487	Natomas Rd	73 days	Thu 8/7/14	Wed 10/15/14	470	489	
488	Access Road (at berm adjacent to canal relocation)	25 days	Thu 8/7/14	Sat 8/30/14	470		
489	Site Demobilization - for Rd Relocations	12 days	Wed 10/15/14	Sat 10/25/14	487	512FF,513FF	
490	Bridge Modifications, Howsley Rd & Fifeld Rd	200 days	Thu 4/17/14	Tue 10/21/14			



ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
491	Mob for Bridge Work	15 days	Thu 4/17/14	Thu 5/1/14	468SS	492	
492	Bridge Modifications, Howsley Road	120 days	Thu 5/1/14	Thu 8/21/14	491	494,493SS+60 days	
493	Bridge Modifications, Fifeld Road	120 days	Thu 6/26/14	Thu 10/16/14	492SS+60 days	494	
494	Demob for Bridge Work	5 days	Thu 10/16/14	Tue 10/21/14	492,493		
495	Utils	197.5 days	Tue 4/1/14	Thu 10/2/14			
496	Site Mobilization - for Util Relocations	15 days	Tue 4/1/14	Tue 4/15/14	456SS	498,508	
497	Electrical	35 days	Tue 4/15/14	Sat 5/17/14			
498	Utility Poles	35 days	Tue 4/15/14	Sat 5/17/14	496		1/day
499	Utility Crossing Relocations	42.5 days	Mon 5/5/14	Fri 6/13/14			
500	Culverts	32.5 days	Mon 5/5/14	Wed 6/4/14	469SS	501	
501	12" Discharge Pipe	10 days	Wed 6/4/14	Fri 6/13/14	500		
502	Private Irrigation Relocations	150 days	Thu 5/1/14	Thu 9/18/14			
503	Brookfield	90 days	Thu 5/1/14	Thu 7/24/14		504,505SS	
504	Linn	30 days	Thu 7/24/14	Thu 8/21/14	503		
505	Odysseus	120 days	Thu 5/1/14	Thu 8/21/14	503SS	506	
506	Kaufman	30 days	Thu 8/21/14	Thu 9/18/14	505	510	
507	Canal Relocations	15 days	Tue 4/15/14	Tue 4/29/14			
508	Drainage Canal Relocations	10 days	Tue 4/15/14	Thu 4/24/14	496	509	
509	Irrigation Canal Relocations	5 days	Thu 4/24/14	Tue 4/29/14	508		
510	Site Demobilization - for Util Relocations	15 days	Thu 9/18/14	Thu 10/2/14	506		
511	Engineering during Construction, S&A and Construction Completion	223.5 days	Tue 4/1/14	Sat 10/25/14			
512	Engineering During Construction	223.5 days	Tue 4/1/14	Sat 10/25/14	489FF		
513	Supervision and Administration	223.5 days	Tue 4/1/14	Sat 10/25/14	489FF	514FF	
514	Construction Completion	0 days	Sat 10/25/14	Sat 10/25/14	513FF	516	
515	**Inspection and Construction per Punch List**	**8.75 days**	**Sat 10/25/14**	**Mon 11/3/14**			
516	PreFinal Inspection	1.25 days	Sat 10/25/14	Mon 10/27/14	514	517	
517	Contractor Implement Punch List Items	6.25 days	Mon 10/27/14	Sat 11/1/14	516	518	
518	Final Inspection	1.25 days	Sat 11/1/14	Mon 11/3/14	517	519,521	
519	Construction Physical Completion	0 days	Mon 11/3/14	Mon 11/3/14	518	522	
520	**Project Closeout**	**159 days**	**Mon 11/3/14**	**Wed 4/1/15**			
521	Construction Prepares Project Completion Letter	6.25 days	Mon 11/3/14	Sat 11/8/14	518		

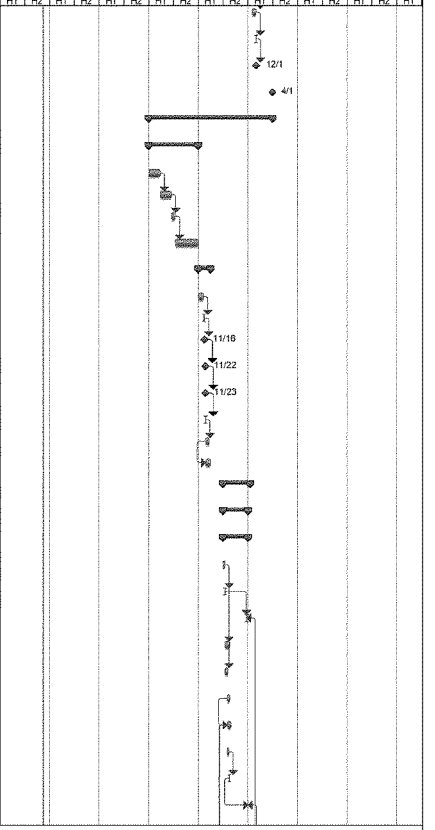


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
522	Contractors Complete As-Builts	28.75 days	Mon 11/3/14	Sat 11/29/14	519	523	
523	Submit As-Builts	1.25 days	Sat 11/29/14	Mon 12/1/14	522	524	
524	Notice of Completion/Assumption of OMRR&R	0 days	Mon 12/1/14	Mon 12/1/14	523		
525	Project Fiscally Complete	0 days	Wed 4/1/15	Wed 4/1/15			
526	**Construction Contract 6 Reach F**	**977.5 days**	**Mon 10/1/12**	**Wed 4/1/15**			Sta 426+30 to 675+65 - Sankey Road to Elverta Road - Work involves levee improvements and/or
527	**Design**	**390 days**	**Mon 10/1/12**	**Mon 9/30/13**			
528	Collect field explorations	90 days	Mon 10/1/12	Mon 12/24/12		529	
529	Conduct geotechnical evaluation	90 days	Mon 12/24/12	Mon 3/18/13	528	530	
530	Develop Basis of Design Report	30 days	Mon 3/18/13	Mon 4/15/13	529	531	
531	Develop Plans & Specifications	180 days	Mon 4/15/13	Mon 9/30/13	530		
532	**Pre-Construction**	**96.25 days**	**Tue 10/1/13**	**Mon 12/30/13**			
533	Project Bid	41.25 days	Tue 10/1/13	Fri 11/8/13		534	
534	Award Task Order	8.75 days	Fri 11/8/13	Sat 11/16/13	533	535	
535	Construction Contract Awarded	0 days	Sat 11/16/13	Sat 11/16/13	534	536FS+6.25 days	
536	Issue NTP	0 days	Fri 11/22/13	Fri 11/22/13	535FS+6.25 days	537FS+1.25 days	
537	NTP Acknowledged	0 days	Sat 11/23/13	Sat 11/23/13	536FS+1.25 days	538	
538	Pre-Con Meeting	1.25 days	Sat 11/23/13	Mon 11/25/13	537	539	
539	Prepare Pre-Construction Submittals	28.75 days	Mon 11/25/13	Sat 12/21/13	538	540SS	
540	Corps Approve Pre-Construcion Submittals	37.5 days	Mon 11/25/13	Mon 12/30/13	539SS		
541	**Construction**	**215 days**	**Tue 4/1/14**	**Sat 10/18/14**			
542	Levees & Floodwalls	198 days	Tue 4/1/14	Thu 10/2/14			
543	Levees	198 days	Tue 4/1/14	Thu 10/2/14			
544	Site Mobilization - Levees - 1	15 days	Tue 4/1/14	Tue 4/15/14		545,547,548	
545	Haul Roads & Drainage	3.75 days	Tue 4/15/14	Fri 4/18/14	544	546	
546	Care & Diversion of Water - Erosion Control - SWPC	1.25 days	Sat 9/20/14	Mon 9/22/14	545,566FF		full duration of levee constr
547	Demo, Commercial Building	40 days	Tue 4/15/14	Thu 5/22/14	544		
548	Demo, Homes	25 days	Tue 4/15/14	Thu 5/8/14	544		
549	Clearing & Grubbing, Levee Stripping (plus tree removal)	22 days	Thu 5/1/14	Wed 5/21/14		550SS+2.5 days	
550	Levee Degrading	30 days	Sat 5/3/14	Sat 5/31/14	549SS+2.5 days	556SS+2.5 days,557SS+2.	
551	Site Mobilization - Borrow Areas	15 days	Thu 5/1/14	Thu 5/15/14		552	
552	Haul Roads & Drainage - Borrow Areas	5 days	Thu 5/15/14	Tue 5/20/14	551	553SS	
553	Care & Diversion of Water - Erosion Control - SWPC - Borrow Areas	1.25 days	Wed 10/1/14	Thu 10/2/14	552SS,565FF		full duration of borrow area use

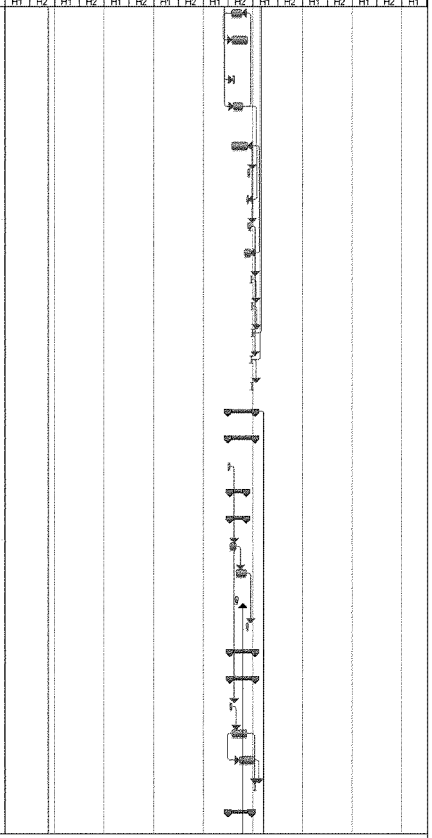


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
554	Surface Layer Removal & Stockpile - Borrow Areas	85 days	Fri 4/25/14	Mon 7/14/14	557FF-6.25 days	555SS+2.5 days	double crews
555	Excavation & Hauling - Borrow Areas	128 days	Mon 4/28/14	Mon 8/25/14	554SS+2.5 days		double crews
556	Site Mobilization - Slurry Wall - Season 1	15 days	Tue 5/6/14	Tue 5/20/14	550SS+2.5 days		
557	Slurry Wall Construction	76.5 days	Fri 5/9/14	Sat 7/19/14	550SS+6.25 days	554FF-6.25 days,558FF+39 days	double crews
558	Emankment Fill, from Borrow	129 days	Sat 4/26/14	Mon 8/25/14	557FF+39 days	562FF+25 days,559,561,5	double crews
559	Demob - Slurry Wall - Season 1	15 days	Mon 8/25/14	Mon 9/8/14	558		
560	Maintenance Road - ABC	15 days	Sat 8/16/14	Sat 8/30/14	558FF+6.25 days		
561	Revegetation/Hydroseed	25 days	Mon 8/25/14	Wed 9/17/14	558	563,568	
562	Surface Layer Restoration - Borrow Areas - Season 1	52.5 days	Wed 7/30/14	Wed 9/17/14	558FF+25 days		double crews
563	Weather Delays	6.25 days	Wed 9/17/14	Tue 9/23/14	561	564	
564	Demob - Borrow Areas	5 days	Tue 9/23/14	Sat 9/27/14	563	565	
565	Site Cleanup/Finish Work - Borrow Areas	5 days	Sat 9/27/14	Thu 10/2/14	564	553FF	
566	Demob - Levee Areas	5 days	Wed 9/17/14	Mon 9/22/14	561	548FF,567	
567	Site Cleanup/Finish Work - Levee Areas	5 days	Mon 9/22/14	Fri 9/26/14	566		
568	Relocations	215 days	Tue 4/1/14	Sat 10/18/14		604FF,605FF	
569	Roads, Construction Activities	215 days	Tue 4/1/14	Sat 10/18/14			
570	Site Mobilization - for Rd Relocations	15 days	Tue 4/1/14	Tue 4/15/14		579,573	
571	Road Surfacing	130 days	Tue 4/15/14	Thu 8/14/14			
572	Site Work	130 days	Tue 4/15/14	Thu 8/14/14			
573	Private Driveways	50 days	Tue 4/15/14	Sat 5/31/14	570	574	
574	Natomas Road	80 days	Sat 5/31/14	Thu 8/14/14	573	576	
575	Access Road (at berm adjacent to canal relocation)	25 days	Fri 5/23/14	Mon 6/16/14	595		
576	Site Demobilization - for Rd Relocations	15 days	Thu 8/14/14	Thu 8/28/14	574		
577	Bridge Modifications, Riego Rd & Elverta Rd	200 days	Tue 4/15/14	Sat 10/18/14			
578	Site Work	200 days	Tue 4/15/14	Sat 10/18/14			
579	Mob for Bridge Work	15 days	Tue 4/15/14	Tue 4/29/14	570	580	
580	Bridge Modifications, Riego Rd	120 days	Tue 4/29/14	Tue 8/19/14	579	582,581SS+60 days	
581	Bridge Modifications, Elverta Rd	120 days	Tue 6/24/14	Tue 10/14/14	580SS+60 days	582	
582	Demob for Bridge Work	5 days	Tue 10/14/14	Sat 10/18/14	581,580		
583	Cemeteries, Utils, Structures	187.5 days	Tue 4/1/14	Tue 9/23/14			

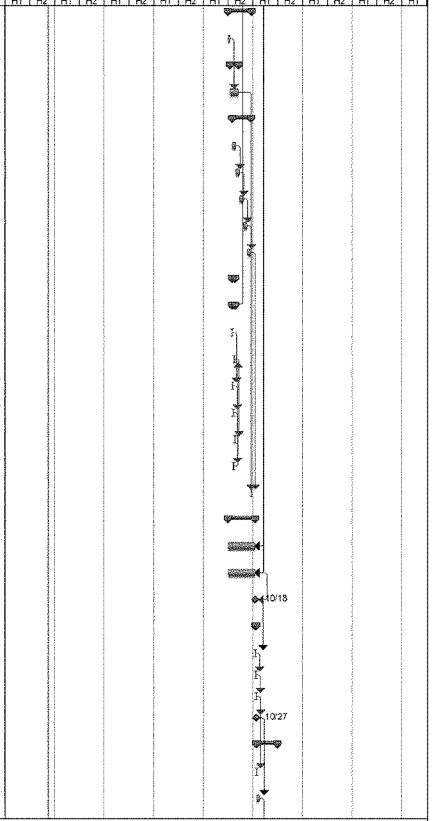


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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
584	Utils	187.5 days	Tue 4/1/14	Tue 9/23/14			
585	Site Mobilization - for Util Relocations	15 days	Tue 4/1/14	Tue 4/15/14		587	
586	Electrical	68 days	Tue 4/15/14	Tue 6/17/14			
587	Utility Poles	68 days	Tue 4/15/14	Tue 6/17/14	585	602	1/day
588	Utility Crossing Relocations	150 days	Thu 5/1/14	Thu 9/18/14			
589	Schiedel	30 days	Thu 5/1/14	Thu 5/29/14		590	
590	De Wit	30 days	Thu 5/29/14	Thu 6/26/14	589	591	
591	Calif Sunshine Fisheries	30 days	Thu 6/26/14	Thu 7/24/14	590	592	
592	Odysseus	30 days	Thu 7/24/14	Thu 8/21/14	591	593	
593	Family Real Properties	30 days	Thu 8/21/14	Thu 9/18/14	592	602	
594	Canal Relocations	24 days	Thu 5/1/14	Fri 5/23/14			
595	Reiego Rd Canal Relocations	24 days	Thu 5/1/14	Fri 5/23/14		575	
596	Stripping	2 days	Thu 5/1/14	Fri 5/2/14		598	
597	Compacted Embankment	7 days	Thu 5/15/14	Wed 5/21/14	601	600	
598	Excavation to Stockpile	6 days	Fri 5/2/14	Thu 5/8/14	596	599	
599	Field Irrigation Turnouts	2 days	Thu 5/8/14	Sat 5/10/14	598	601	
600	Erosion Control Seeding	2 days	Wed 5/21/14	Fri 5/23/14	597		
601	Misc Sitework	5 days	Sat 5/10/14	Thu 5/15/14	599	597	
602	Site Demob - for Util Relocations	5 days	Thu 9/18/14	Tue 9/23/14	587,593		
603	Engineering during Construction, S&A and Construction Completion	215 days	Tue 4/1/14	Sat 10/18/14			
604	Engineering During Construction	215 days	Tue 4/1/14	Sat 10/18/14	568FF		
605	Supervision and Administration	215 days	Tue 4/1/14	Sat 10/18/14	568FF	606FF	
606	Construction Completion	0 days	Sat 10/18/14	Sat 10/18/14	605FF	608	
607	**Inspection and Construction per Punch List**	**8.75 days**	**Sat 10/18/14**	**Mon 10/27/14**			
608	PreFinal Inspection	1.25 days	Sat 10/18/14	Mon 10/20/14	606	609	
609	Contractor Implement Punch List Items	6.25 days	Mon 10/20/14	Sat 10/25/14	608	610	
610	Final Inspection	1.25 days	Sat 10/25/14	Mon 10/27/14	609	611,613	
611	Construction Physical Completion	0 days	Mon 10/27/14	Mon 10/27/14	610	614	
612	**Project Closeout**	**167.5 days**	**Mon 10/27/14**	**Wed 4/1/15**			
613	Construction Prepares Project Completion Letter	6.25 days	Mon 10/27/14	Sat 11/1/14	610		
614	Contractors Complete As-Builts	28.75 days	Mon 10/27/14	Sat 11/22/14	611	615	



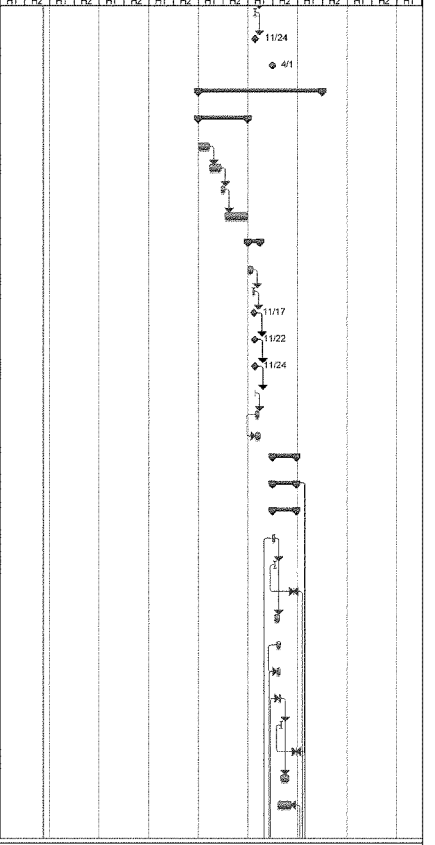
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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
615	Submit As-Builts	1.25 days	Sat 11/22/14	Mon 11/24/14	614	616	
616	Notice of Completion/Assumption of OMRR&R	0 days	Mon 11/24/14	Mon 11/24/14	615		
617	Project Fiscally Complete	0 days	Wed 4/1/15	Wed 4/1/15			
618	**Construction Contract 7 - Reach G**	**978.75 days**	**Tue 10/1/13**	**Fri 4/1/16**			Sta 237+00 to 426+30 - Elverta Road to NEMDC Pump Station - Work includes levee improvements
619	**Design**	**390 days**	**Tue 10/1/13**	**Tue 9/30/14**			
620	Collect field explorations	90 days	Tue 10/1/13	Tue 12/24/13		621	
621	Conduct geotechnical evaluation	90 days	Tue 12/24/13	Tue 3/18/14	620	622	
622	Develop Basis of Design Report	30 days	Tue 3/18/14	Tue 4/15/14	621	623	
623	Develop Plans & Specifications	180 days	Tue 4/15/14	Tue 9/30/14	622		
624	**Pre-Construction**	**96.25 days**	**Wed 10/1/14**	**Tue 12/30/14**			
625	Project Bid	41.25 days	Wed 10/1/14	Sat 11/8/14		626	
626	Award Task Order	8.75 days	Sat 11/8/14	Mon 11/17/14	625	627	
627	Construction Contract Awarded	0 days	Mon 11/17/14	Mon 11/17/14	626	628FS+6.25 days	
628	Issue NTP	0 days	Sat 11/22/14	Sat 11/22/14	627FS+6.25 days	629FS+1.25 days	
629	NTP Acknowledged	0 days	Mon 11/24/14	Mon 11/24/14	628FS+1.25 days	630	
630	Pre-Con Meeting	1.25 days	Mon 11/24/14	Tue 11/25/14	629	631	
631	Prepare Pre-Construction Submittals	28.75 days	Tue 11/25/14	Mon 12/22/14	630	632SS	
632	Corps Approve Pre-Constructon Submittals	37.5 days	Tue 11/25/14	Tue 12/30/14	631SS		
633	**Construction**	**189.5 days**	**Wed 4/1/15**	**Thu 9/24/15**			
634	Levees & Floodwalls	189.5 days	Wed 4/1/15	Thu 9/24/15		695FF,696FF	
635	Levees	189.5 days	Wed 4/1/15	Thu 9/24/15			
636	Site Mobilization - Levees	15 days	Wed 4/1/15	Wed 4/15/15		637,639,673SS	
637	Haul Roads & Drainage	3.75 days	Wed 4/15/15	Sat 4/18/15	636	638SS	
638	Care & Diversion of Water - Erosion Control - SWPC	1.25 days	Thu 9/3/15	Fri 9/4/15	637SS,657FF		full duration of levee constr
639	Demo, Homes	40 days	Wed 4/15/15	Fri 5/22/15	636		
640	Clearing & Grubbing, Levee Stripping (plus tree removal)	32 days	Fri 5/1/15	Sat 5/30/15		641SS+2.5 days	
641	Levee Degrading	27 days	Mon 5/4/15	Thu 5/28/15	640SS+2.5 days	648SS+6.25 days	
642	Site Mobilization - Borrow Areas	15 days	Tue 5/19/15	Tue 6/2/15	647SS+25 days	643,645	
643	Haul Roads & Drainage - Borrow Areas	5 days	Tue 6/2/15	Sat 6/6/15	642	644SS	
644	Care & Diversion of Water - Erosion Control - SWPC - Borrow Areas	1.25 days	Wed 9/23/15	Thu 9/24/15	643SS,656FF		full duration of borrow area use
645	Surface Layer Removal & Stockpile - Borrow Areas	60 days	Tue 6/2/15	Tue 7/28/15	642		
646	Excavation & Hauling - Borrow Areas	107 days	Sat 5/9/15	Mon 8/17/15	648FF+38 days		double crew



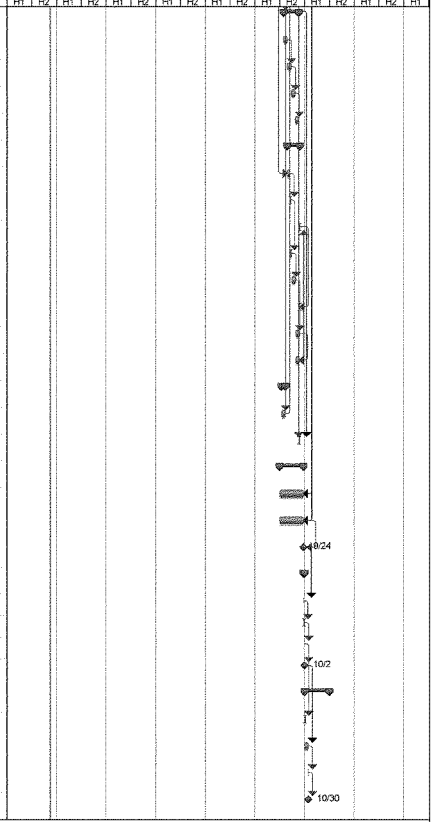
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
647	Site Mobilization - Slurry Wall	15 days	Sat 4/25/15	Sat 5/9/15	648SS-15 days	642SS+25 days	
648	Slurry Wall Construction	69 days	Sat 5/9/15	Mon 7/13/15	641SS+6.25 days	646FF+38 days,647SS-15 days,649FF+38	double rigs/crew
649	Emankment Fill, from Borrow	107 days	Sat 5/9/15	Mon 8/17/15	648FF+38 days	653FF+25 days,650FF,65	double crew
650	Maintenance Road - ABC	12.5 days	Wed 8/5/15	Mon 8/17/15	649FF		
651	Demob - Slurry Wall	15 days	Mon 7/13/15	Mon 7/27/15	648		
652	Revegetation/Hydroseed	15 days	Mon 8/17/15	Mon 8/31/15	649	657	
653	Surface Layer Restoration - Borrow Areas	60 days	Wed 7/15/15	Wed 9/9/15	649FF+25 days	654	double crews
654	Weather Delays	6.25 days	Wed 9/9/15	Tue 9/15/15	653	655	
655	Demob - Borrow Areas	5 days	Tue 9/15/15	Sat 9/19/15	654	656	
656	Site Cleanup/Finish Work - Borrow Areas	5 days	Sat 9/19/15	Thu 9/24/15	655	644FF	
657	Demob - Levee Areas	5 days	Mon 8/31/15	Fri 9/4/15	652	638FF,658	
658	Site Cleanup/Finish Work - Levee Areas	5 days	Fri 9/4/15	Wed 9/9/15	657		
659	Pumping Plants & Relocations	185 days	Wed 4/1/15	Mon 9/21/15			
660	Roads, Construction Activities	185 days	Wed 4/1/15	Mon 9/21/15			
661	Site Mobilization - for Rd Relocations	15 days	Wed 4/1/15	Wed 4/15/15		662	
662	Private Driveways	115 days	Wed 4/15/15	Fri 7/31/15	661		
663	Natomas Road	80 days	Fri 6/12/15	Wed 8/26/15	649FF	665	
664	Access Road (at berm adjacent to canal relocation)	42 days	Fri 5/15/15	Tue 6/23/15	692		
665	Site Demobilization - for Rd Relocations	15 days	Wed 8/26/15	Wed 9/9/15	663		
666	Bridge Modifications	170 days	Wed 4/15/15	Mon 9/21/15			
667	Site Work	170 days	Wed 4/15/15	Mon 9/21/15			
668	Mob for Bridge Work	15 days	Wed 4/15/15	Wed 4/29/15		669	
669	Bridge Modifications, Elkhorn Blvd	150 days	Wed 4/29/15	Wed 9/16/15	668	670	
670	Demob for Bridge Work	5 days	Wed 9/16/15	Mon 9/21/15	669		
671	Cemeteries, Utils, Structures	161.25 days	Wed 4/1/15	Sat 8/29/15			
672	Utils	161.25 days	Wed 4/1/15	Sat 8/29/15			
673	Site Mobilization - for Util Relocations	15 days	Wed 4/1/15	Wed 4/15/15	636SS	692,675,677	
674	Electrical	51 days	Wed 4/15/15	Mon 6/1/15			
675	Utility Poles	51 days	Wed 4/15/15	Mon 6/1/15	673	693	1/day
676	Utility Crossing Relocations	129.75 days	Fri 5/1/15	Sat 8/29/15			

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AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
677	Well Relocations	120 days	Fri 5/1/15	Fri 8/21/15	673	693	
678	Avids	30 days	Fri 5/1/15	Fri 5/29/15		679	
679	Cayocca	30 days	Fri 5/29/15	Fri 6/26/15	678	680	
680	Driggs	30 days	Fri 6/26/15	Fri 7/24/15	679	681	
681	Hendrix	30 days	Fri 7/24/15	Fri 8/21/15	680		
682	PP - No 6	100 days	Thu 5/28/15	Sat 8/29/15			Sta ~362+50
683	Demo	21 days	Thu 5/28/15	Tue 6/16/15	648SS+20 days	684	expected to commence about 25 days before levee construction reaches this point
684	Earthwork	5 days	Tue 6/16/15	Sat 6/20/15	683	686	
685	Roads	4 days	Tue 8/25/15	Sat 8/29/15	690	688FF	
686	Pipes	10 days	Sat 6/20/15	Tue 6/30/15	684	687	
687	Positive Closure Vault	30 days	Tue 6/30/15	Tue 7/28/15	686	689	
688	Security Fence	3 days	Wed 8/26/15	Sat 8/29/15	685FF		
689	Pumps & Motors	30 days	Tue 7/28/15	Tue 8/25/15	687	690FF	
690	Power & Controls	30 days	Tue 7/28/15	Tue 8/25/15	689FF	685	
691	Canal Relocations	32.5 days	Wed 4/15/15	Fri 5/15/15			
692	Drainage Canal Relocations	32.5 days	Wed 4/15/15	Fri 5/15/15	673	664	
693	Site Demob - for Util Relocations	5 days	Fri 8/21/15	Wed 8/26/15	675,677		
694	Engineering during Construction, S&A and Construction Completion	189 days	Wed 4/1/15	Thu 9/24/15			
695	Engineering During Construction	189 days	Wed 4/1/15	Thu 9/24/15	634FF		
696	Supervision and Administration	189 days	Wed 4/1/15	Thu 9/24/15	634FF	697FF	
697	Construction Completion	0 days	Thu 9/24/15	Thu 9/24/15	696FF	699	
698	**Inspection and Construction per Punch List**	**8.75 days**	**Thu 9/24/15**	**Fri 10/2/15**			
699	PreFinal Inspection	1.25 days	Thu 9/24/15	Fri 9/25/15	697	700	
700	Contractor Implement Punch List Items	6.25 days	Fri 9/25/15	Thu 10/1/15	699	701	
701	Final Inspection	1.25 days	Thu 10/1/15	Fri 10/2/15	700	702,704	
702	Construction Physical Completion	0 days	Fri 10/2/15	Fri 10/2/15	701	705	
703	**Project Closeout**	**194.25 days**	**Fri 10/2/15**	**Fri 4/1/16**			
704	Construction Prepares Project Completion Letter	6.25 days	Fri 10/2/15	Thu 10/8/15	701		
705	Contractors Complete As-Builts	28.75 days	Fri 10/2/15	Thu 10/29/15	702	706	
706	Submit As-Builts	1.25 days	Thu 10/29/15	Fri 10/30/15	705	707	
707	Notice of Completion/Assumption of OMRR&R	0 days	Fri 10/30/15	Fri 10/30/15	706		

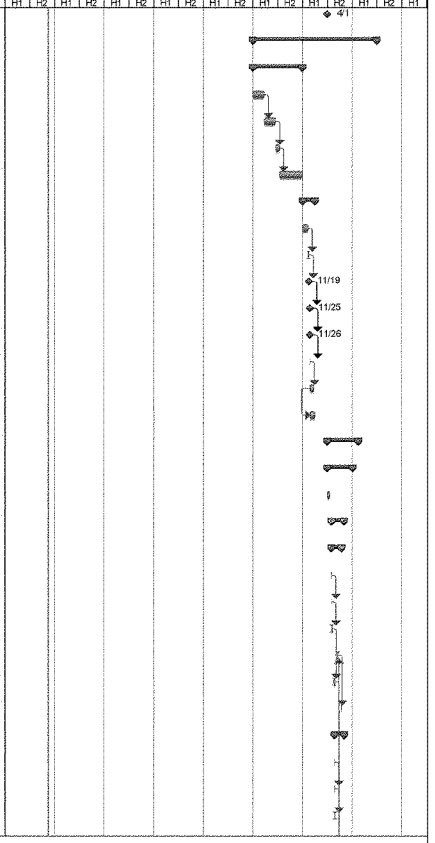


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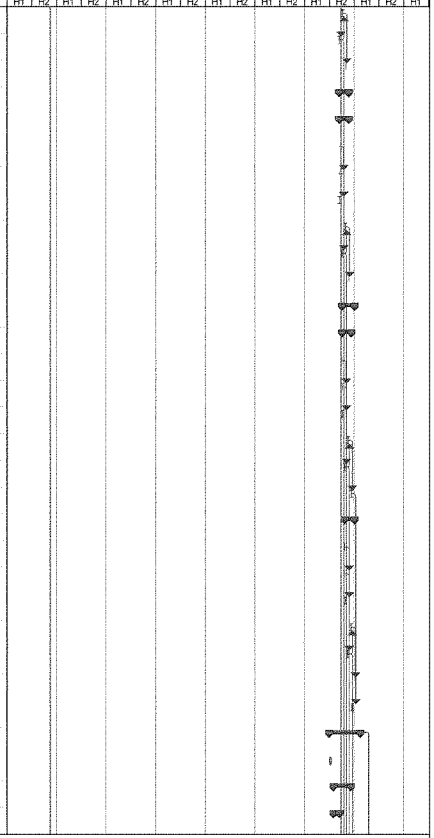
AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE

Fri 6/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
708	Project Fiscally Complete	0 days	Fri 4/1/16	Fri 4/1/16			
709	**Construction Contract 8 - Reaches B, C, and D (utility relocations)**	**978.75 days**	**Wed 10/1/14**	**Sat 4/1/17**			Work consists of required changes to Pumping Plants in Reaches B, C & D. Some areas left in the cutoff
710	**Design**	390 days	Wed 10/1/14	Wed 9/30/15			
711	Collect field explorations	90 days	Wed 10/1/14	Wed 12/24/14		712	
712	Conduct geotechnical evaluation	90 days	Wed 12/24/14	Wed 3/18/15	711	713	
713	Develop Basis of Design Report	30 days	Wed 3/18/15	Wed 4/15/15	712	714	
714	Develop Plans & Specifications	180 days	Wed 4/15/15	Wed 9/30/15	713		
715	**Pre-Construction**	96.25 days	Sat 10/3/15	Fri 1/1/16			
716	Project Bid	41.25 days	Sat 10/3/15	Wed 11/11/15		717	
717	Award Task Order	8.75 days	Wed 11/11/15	Thu 11/19/15	716	718	
718	Construction Contract Awarded	0 days	Thu 11/19/15	Thu 11/19/15	717	719FS+6.25 days	
719	Issue NTP	0 days	Wed 11/25/15	Wed 11/25/15	718FS+6.25 days	720FS+1.25 days	
720	NTP Acknowledged	0 days	Thu 11/26/15	Thu 11/26/15	719FS+1.25 days	721	
721	Pre-Con Meeting	1.25 days	Thu 11/26/15	Fri 11/27/15	720	722	
722	Prepare Pre-Construction Submittals	28.75 days	Fri 11/27/15	Thu 12/24/15	721	723SS	
723	Corps Approve Pre-Constructon Submittals	37.5 days	Fri 11/27/15	Fri 1/1/16	722SS		
724	**Construction**	245.06 days	Fri 4/1/16	Wed 11/16/16			
725	Levees, fill slurry wall gaps	199.56 days	Fri 4/1/16	Tue 10/4/16			
726	Mobilization	18 days	Fri 4/1/16	Mon 4/18/16			
727	Reach B	100.13 days	Mon 5/2/16	Wed 8/3/16			
728	Elkhorn PP	78.81 days	Mon 5/2/16	Thu 7/14/16			
729	Clearing & Grubbing	1 day	Mon 5/2/16	Mon 5/2/16		730	
730	Stripping	1 day	Mon 5/2/16	Tue 5/3/16	729	731	
731	Levee Degrading	2 days	Tue 5/3/16	Thu 5/5/16	730	733	
732	Levee Fill	3 days	Thu 6/16/16	Sat 6/18/16	733FS+21 days	734	
733	Cutoff Wall	10 days	Thu 5/5/16	Fri 5/27/16	731	732FS+21 days,740FS+2	
734	Revegetation	1 day	Mon 6/20/16	Thu 7/14/16	732		
735	RD 1000, PP No 5	75.13 days	Wed 5/25/16	Wed 8/3/16			
736	Clearing & Grubbing	1 day	Wed 5/25/16	Wed 5/25/16		737	
737	Stripping	1 day	Wed 5/25/16	Thu 5/26/16	736	738	
738	Levee Degrading	2 days	Thu 5/26/16	Sat 5/28/16	737		

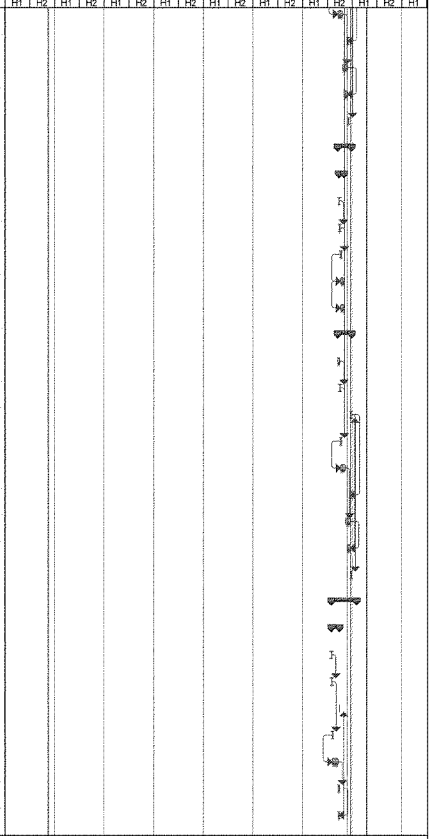


ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
739	Levee Fill	3 days	Wed 7/6/16	Sat 7/9/16	740FS+21 days	741	
740	Cutoff Wall	5 days	Mon 5/30/16	Thu 6/16/16	733FS+2 days	739FS+21 days,748FS+2	
741	Revegetation	1 day	Sat 7/9/16	Wed 8/3/16	739		
742	Reach C	75.19 days	Tue 6/14/16	Tue 8/23/16			
743	Prichard PP & RD 1000, PP No 2	75.19 days	Tue 6/14/16	Tue 8/23/16			
744	Clearing & Grubbing	1 day	Tue 6/14/16	Tue 6/14/16		745	
745	Stripping	1 day	Tue 6/14/16	Wed 6/15/16	744	746	
746	Levee Degrading	2 days	Wed 6/15/16	Fri 6/17/16	745		
747	Levee Fill	3 days	Tue 7/26/16	Fri 7/29/16	748FS+21 days	749	
748	Cutoff Wall	5 days	Sat 6/18/16	Wed 7/6/16	740FS+2 days	747FS+21 days,810,817,7	
749	Revegetation	1 day	Fri 7/29/16	Tue 8/23/16	747		
750	Reach D	99.56 days	Mon 7/4/16	Tue 10/4/16			
751	Bennett PP	75.25 days	Mon 7/4/16	Mon 9/12/16			
752	Clearing & Grubbing	1 day	Mon 7/4/16	Mon 7/4/16		753	
753	Stripping	1 day	Mon 7/4/16	Tue 7/5/16	752	754	
754	Levee Degrading	2 days	Tue 7/5/16	Thu 7/7/16	753		
755	Levee Fill	3 days	Mon 8/15/16	Thu 8/18/16	756FS+21 days	757	
756	Cutoff Wall	5 days	Fri 7/8/16	Tue 7/26/16	748FS+2 days	755FS+21 days,763FS+2	
757	Revegetation	1 day	Thu 8/18/16	Mon 9/12/16	755	765	
758	Northern PP	77.06 days	Mon 7/25/16	Tue 10/4/16			
759	Clearing & Grubbing	1 day	Mon 7/25/16	Mon 7/25/16		760	
760	Stripping	1 day	Mon 7/25/16	Tue 7/26/16	759	761	
761	Levee Degrading	2 days	Tue 7/26/16	Thu 7/28/16	760		
762	Levee Fill	3 days	Wed 9/7/16	Fri 9/9/16	763FS+21 days	764	
763	Cutoff Wall	8 days	Thu 7/28/16	Thu 8/18/16	756FS+2 days	762FS+21 days,847	
764	Revegetation	1 day	Fri 9/9/16	Tue 10/4/16	762		
765	Demobilization	12 days	Mon 9/12/16	Thu 9/22/16	757		
766	Pumping Plants & Relocations	245.06 days	Fri 4/1/16	Wed 11/16/16		857FF,858FF	
767	Mobilization	18 days	Fri 4/1/16	Mon 4/18/16			
768	Reach B	139.63 days	Mon 5/2/16	Thu 9/8/16			
769	W Drainage Canal (EOPC)	47.5 days	Mon 5/2/16	Wed 6/15/16			



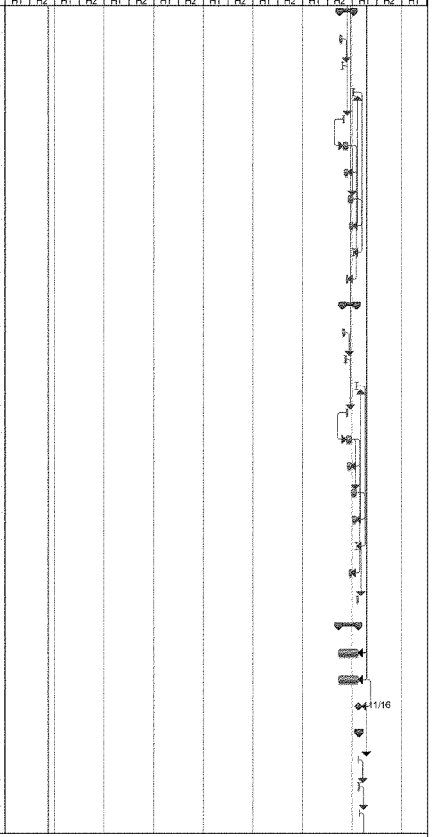
ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
770	Demolition	12.5 days	Mon 5/2/16	Fri 5/13/16			
771	Clearing & Grubbing	3.75 days	Mon 5/2/16	Thu 5/5/16		772	
772	Stripping	11.25 days	Thu 5/5/16	Mon 5/16/16	771	773SS+2.5 days	
773	Excavation	25 days	Sat 5/7/16	Tue 5/31/16	772SS+2.5 days	774	
774	Fill	10 days	Tue 5/31/16	Thu 6/9/16	773	775	
775	Demob	6.25 days	Thu 6/9/16	Wed 6/15/16	774		
776	Elkhorn PP	100.56 days	Sat 5/14/16	Tue 8/16/16			
777	Demo	5 days	Sat 5/14/16	Thu 5/19/16		778	
778	Earthwork	8 days	Thu 5/19/16	Thu 5/26/16	777	780	
779	Roads	4 days	Wed 8/10/16	Sat 8/13/16	784	782FF,785	
780	Pipes	14 days	Fri 5/27/16	Thu 6/9/16	778,733	781SS	follows cutoff wall placement
781	Positive Closure & Flow Meter Vaults	40 days	Fri 5/27/16	Mon 7/4/16	780SS	783	
782	Pump Platform Rehabilitation	15 days	Mon 8/1/16	Sat 8/13/16	779FF		
783	Pumps & Motors	40 days	Mon 7/4/16	Wed 8/10/16	781	784FF	
784	Power & Controls	30 days	Wed 7/13/16	Wed 8/10/16	783FF	779	
785	Bank Stabilization	2 days	Mon 8/15/16	Tue 8/16/16	779		
786	Riverside PP, Phase 2	108 days	Mon 5/2/16	Wed 8/10/16			assumption is this takes place after the Riverside Canal work
787	Demo	17 days	Mon 5/2/16	Tue 5/17/16		788	
788	Earthwork	2 days	Tue 5/17/16	Thu 5/19/16	787	790	
789	Roads	4 days	Tue 8/2/16	Fri 8/5/16	794	792FF,795	
790	Pipes	10 days	Thu 5/19/16	Sat 5/28/16	788	791SS	
791	Positive Closure & Flow Meter Vaults	40 days	Thu 5/19/16	Sat 6/25/16	790SS	793	
792	Security Fence	2 days	Wed 8/3/16	Fri 8/5/16	789FF		
793	Pumps & Motors	40 days	Sat 6/25/16	Tue 8/2/16	791	794FF	
794	Power & Controls	30 days	Tue 7/5/16	Tue 8/2/16	793FF	789	
795	Flow Meters	5 days	Fri 8/5/16	Wed 8/10/16	789		
796	RD 1000, PP No 5	109.88 days	Sat 5/28/16	Thu 9/8/16			
797	Demo	17 days	Sat 5/28/16	Mon 6/13/16		798	
798	Earthwork	2 days	Mon 6/13/16	Wed 6/15/16	797	800	
799	Roads	4 days	Tue 8/30/16	Sat 9/3/16	804	802FF,805	
800	Pipes	10 days	Thu 8/16/16	Sat 6/25/16	798,740	801SS	follows cutoff wall placement

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
801	Positive Closure & Flow Meter Vaults	40 days	Thu 6/16/16	Sat 7/23/16	800SS	803	
802	Security Fence	2 days	Thu 9/1/16	Sat 9/3/16	799FF		
803	Pumps & Motors	40 days	Sat 7/23/16	Tue 8/30/16	801	804FF	
804	Power & Controls	30 days	Tue 8/2/16	Tue 8/30/16	803FF	799	
805	Flow Meters	5 days	Sat 9/3/16	Thu 9/8/16	799		
806	Reach C	109.94 days	Fri 6/17/16	Wed 9/28/16			
807	Prichard PP	40.94 days	Mon 6/27/16	Wed 8/3/16			
808	Demo	2 days	Mon 6/27/16	Tue 6/28/16		809	
809	Earthwork	7 days	Tue 6/28/16	Tue 7/5/16	808	810	
810	Pipes	9 days	Wed 7/6/16	Fri 7/15/16	809,748	811SS	follows cutoff wall placement
811	Transition Structure	30 days	Wed 7/6/16	Wed 8/3/16	810SS	812SS	
812	Concrete Outlet Structure	30 days	Wed 7/6/16	Wed 8/3/16	811SS		
813	RD 1000, PP No 2	109.94 days	Fri 6/17/16	Wed 9/28/16			
814	Demo	17 days	Fri 6/17/16	Sat 7/2/16		815	
815	Earthwork	2 days	Sat 7/2/16	Tue 7/5/16	814	817	
816	Roads	4 days	Mon 9/19/16	Fri 9/23/16	821	819FF,822	
817	Pipes	10 days	Wed 7/6/16	Fri 7/15/16	815,748	818SS	follows cutoff wall placement
818	Positive Closure & Flow Meter Vaults	40 days	Wed 7/6/16	Fri 8/12/16	817SS	820	
819	Security Fence	2 days	Wed 9/21/16	Fri 9/23/16	816FF		
820	Pumps & Motors	40 days	Fri 8/12/16	Mon 9/19/16	818	821FF	
821	Power & Controls	30 days	Mon 8/22/16	Mon 9/19/16	820FF	816	
822	Flow Meters	5 days	Fri 9/23/16	Wed 9/28/16	816		
823	Reach D	200.56 days	Mon 5/2/16	Fri 11/4/16			
824	RD 1000, PP No 4	65 days	Mon 5/2/16	Fri 7/1/16			
825	Demo	2 days	Mon 5/2/16	Tue 5/3/16		826	
826	Earthwork	2 days	Tue 5/3/16	Thu 5/5/16	825	828	
827	Roads	1 day	Thu 6/30/16	Fri 7/1/16	831		
828	Concrete Footing	10 days	Thu 5/5/16	Sat 5/14/16	826	829SS	
829	New Building	50 days	Thu 5/5/16	Tue 6/21/16	828SS	830	
830	Pumps & Motors	10 days	Tue 6/21/16	Thu 6/30/16	829	831FF	
831	Power & Controls	10 days	Tue 6/21/16	Thu 6/30/16	830FF	827	



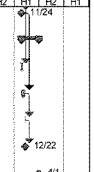
CESPK | AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE | Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
832	Bennett PP	111.25 days	Fri 7/1/16	Thu 10/13/16			
833	Demo	20 days	Fri 7/1/16	Wed 7/20/16		834	
834	Earthwork	6 days	Wed 7/20/16	Mon 7/25/16	833	836	
835	Roads	4 days	Sat 10/8/16	Thu 10/13/16	840	841FF	
836	Pipes	9 days	Tue 7/26/16	Thu 8/4/16	834,756	837SS	follows cutoff wall placement
837	Positive Closure & Flow Meter Vaults	40 days	Tue 7/26/16	Thu 9/1/16	836SS	839,838FF,842	
838	Concrete Outlet Structure	30 days	Thu 8/4/16	Thu 9/1/16	837FF		
839	Pumps & Motors	40 days	Thu 9/1/16	Sat 10/8/16	837	840FF	
840	Power & Controls	30 days	Sat 9/10/16	Sat 10/8/16	839FF	835	
841	Security Fence	2 days	Tue 10/11/16	Thu 10/13/16	835FF		
842	Misc Repairs	15 days	Thu 8/18/16	Thu 9/1/16	837FF		
843	Northern PP	113.06 days	Fri 7/22/16	Fri 11/4/16			
844	Demo	20 days	Fri 7/22/16	Wed 8/10/16		845	
845	Earthwork	8 days	Wed 8/10/16	Wed 8/17/16	844	847	
846	Roads	4 days	Tue 11/1/16	Fri 11/4/16	851	852FF	
847	Pipes	13 days	Thu 8/18/16	Tue 8/30/16	845,763	848SS	follows cutoff wall placement
848	Positive Closure & Flow Meter Vaults	40 days	Thu 8/18/16	Sat 9/24/16	847SS	850,849FF,853	
849	Concrete Outlet Structure	30 days	Sat 8/27/16	Sat 9/24/16	848FF		
850	Pumps & Motors	40 days	Sat 9/24/16	Tue 11/1/16	848	851FF	
851	Power & Controls	30 days	Tue 10/4/16	Tue 11/1/16	850FF	846	
852	Security Fence	2 days	Thu 11/3/16	Fri 11/4/16	846FF	854	
853	Misc Repairs	15 days	Sat 9/10/16	Sat 9/24/16	848FF		
854	Demobilization	12 days	Fri 11/4/16	Wed 11/16/16	852		
855	Engineering during Construction, S&A and Construction Completion	156 days	Thu 6/23/16	Wed 11/16/16			
856	Engineering During Construction	156 days	Thu 6/23/16	Wed 11/16/16	766FF		
857	Supervision and Administration	156 days	Thu 6/23/16	Wed 11/16/16	766FF	858FF	
858	Construction Completion	0 days	Wed 11/16/16	Wed 11/16/16	857FF	860	
859	**Inspection and Construction per Punch List**	8.75 days	Wed 11/16/16	Thu 11/24/16			
860	PreFinal Inspection	1.25 days	Wed 11/16/16	Thu 11/17/16	858	861	
861	Contractor Implement Punch List Items	6.25 days	Thu 11/17/16	Wed 11/23/16	860	862	
862	Final Inspection	1.25 days	Wed 11/23/16	Thu 11/24/16	861	863,865	



CESPK | AMERICAN RIVER COMMON FEATURES WRDA 1996 REMAINING SITES PROJECT SCHEDULE | Fri 8/13/10

ID	Task Name	Duration	Start	Finish	Predecessors	Successors	Notes
863	Construction Physical Completion	0 days	Thu 11/24/16	Thu 11/24/16	862	866	
864	**Project Closeout**	137.44 days	Thu 11/24/16	Sat 4/1/17			
865	Construction Prepares Project Completion Letter	6.25 days	Thu 11/24/16	Wed 11/30/16	862		
866	Contractors Complete As-Builts	20.75 days	Thu 11/24/16	Wed 12/21/16	863	867	
867	Submit As-Builts	1.25 days	Wed 12/21/16	Thu 12/22/16	866	868	
868	Notice of Completion/Assumption of OMRR&R	0 days	Thu 12/22/16	Thu 12/22/16	867		
869	Project Fiscally Complete	0 days	Sat 4/1/17	Sat 4/1/17			





US Army Corps
of Engineers®

American River Common Features Project
Natomas Post Authorization Change Report and
Interim General Reevaluation Report Design Level
Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Sacramento District

Prepared by:

U.S. Army Corps of Engineers
Cost Engineering Directory of Expertise, Walla Walla

September 21, 2010

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EXECUTIVE SUMMARY

Under the auspices of the US Army Corps of Engineers (USACE), Sacramento District, this report presents a recommendation for the project cost and schedule contingencies for the American River Common Features Project, Natomas Post Authorization Change Report National Economic Development Plan (Natomas Project). In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis study was conducted for the development of contingency on the total project cost. The purpose of this risk analysis study was to establish project contingencies by identifying and measuring the cost and schedule impact of project uncertainties with respect to the estimated total project cost.

The cost and schedule risk analysis relies upon information for both the National Economic Development (NED) Plan, and the Locally Preferred Plan (LPP). Due to the complexity of the estimates, and the nature of the work, the risk analysis was developed from the estimate supporting the LPP. However, the Cost and Schedule Risk Analysis Report, herein, refers to both the NED Plan and LPP costs with contingencies applied, as developed for the LPP cost estimates. For comparison purposes, the price level costs for both the NED Plan and the LPP are provided in Table ES-1 below.

Note that during the course of risk study, it became clear that risks varied between contracts and cost feature accounts. Those risk variances related to the understanding that there were construction contracts already completed, some underway, and various contracts in various stages of design and projected schedule. It was also understood that the technical construction elements varied per contracts and that the differing cost feature accounts also varied in risk. For this reason, and to better enable project management of costs per contract and feature, it was decided that the risk models should be developed at the contract and feature cost levels. Upon completion of the study, the average total contingency would then be presented, knowing that the subfeature levels carried the different studied risks and resulting contingency values.

Table ES-1. NED Plan vs. LPP Price Level Comparison

Estimate ($1,000s)	NED Plan ($1,000s)	LPP ($1,000s)
Sunk Costs	$312,433	$326,561
Estimated Balance to Complete	$608,054	$637,019
Most Likely Project Cost	$920,487	$963,580
Balance to Complete Costs with Contingency (80% Confidence Level)	**$1,111,560**	**$1,164,000**

Specific to the Natomas Project (NED Plan), the most likely project cost (at price level) is estimated at approximately $920 Million. Based on the results of the analysis, the recommended contingency is $191 Million, or 31%, reflecting total price level project costs (including sunk costs and balance to finish) of $1.1 Billion.

Specific to the Natomas Project (LPP), the most likely project cost (at price level) is estimated at approximately $964 Million. Based on the results of the analysis, the recommended contingency is $201 Million, or 31%, reflecting total price level project costs (including sunk costs and balance to finish) of $1.2 Billion.

The PDT performed risk analysis using the *Monte Carlo* technique, producing the aforementioned contingencies and identifying key risk drivers.

The following tables portray the contingency results for both the NED and LPP based on an 80% confidence level that includes both cost and schedule risks related to dollars. This presentation is per USACE Civil Works guidance. The contingency percent is a weighted average of the contingencies determined at the contract and cost feature account level.

Table ES-2. Contingency Analysis Table (NED Plan)

Most Likely Cost Estimate	**$920,487,000**	
Confidence Level	**Value ($1,000s)**	**Contingency (%)**
50%	$979,787	9.75%
80%	**$1,111,560**	**31.42%**
100%	$1,611,132	113.58%

Note: A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Table ES-3. Contingency Analysis Table (LPP)

Most Likely Cost Estimate	**$963,580,000**	
Confidence Level	**Value ($1,000s)**	**Contingency (%)**
50%	$1,026,435	9.87%
80%	**$1,164,100**	**31.48%**
100%	$1,687,076	113.58%

Note: A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The key cost risk driver identified through sensitivity analysis were Unexpected Escalation on Key Materials and Uncertainty with the Cutoff Wall for the Reach A Levees and Floodwalls, which together contribute over 31 percent of the statistical cost variance.

The key schedule risk drivers identified through sensitivity analysis were Easement Acquisition for the Reach A Relocations, Pumping Plant, and Levees and Floodwall Accounts, which contributes nearly 30 percent of the statistical schedule variance.

Recommendations, as detailed within the main report, include the implementation of cost and schedule contingencies, further iterative study of risks throughout the project life-cycle, potential mitigation throughout the PED phase, and proactive monitoring and control of risk identified in this study.

MAIN REPORT

1.0 PURPOSE

Under the auspices of the US Army Corps of Engineers (USACE), Sacramento District, this report presents a recommendation for the project cost and schedule contingencies for the American River Common Features Project, Natomas Post Authorization Change Report National Economic Development Plan.

2.0 BACKGROUND

This CSRA report is for the American River Common Features Project, Natomas Post Authorization Change Report National Economic Development Plan (Natomas Project). The project covers approximately 42 miles of levee repairs protecting the Natomas basin portion of the City of Sacramento; the levee repairs primarily focus on seepage and stability deficiency remediation. The Natomas Project is a feasibility study, that if acted upon by Congress, will lead to design and construction efforts. As discussed above, this CSRA will act as a tool for managing risks during the design and construction phases.

As a part of this effort, Sacramento District requested that the USACE Cost Engineering Directory of Expertise for Civil Works (Cost Engineering Dx) provide an agency technical review (ATR) of the cost estimate and schedule for Recommended Project Plan. That tasking also included providing a risk analysis report, substantiating the resulting contingencies.

3.0 REPORT SCOPE

The scope of the risk analysis report is to calculate and present the cost and schedule contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for all project features. The study and presentation does not include consideration for life cycle costs.

3.1 Project Scope

The American River Watershed Investigation began shortly after the flood of 1986. The flood of 1986 nearly led to the inundation of the City of Sacramento. The Sacramento

District completed a feasibility study in 1991. The recommended plan from this study was a new flood control dam in the Auburn Canyon upstream of the existing Folsom Dam and Reservoir, along with levee improvements in the City of Sacramento. Congress chose not to act upon Auburn Dam and instead directed the Corps to address various aspects of this as part of a supplemental study. The Sacramento District completed this supplemental study in 1996, with essentially the same recommended plan. Again, Congress chose not to act on Auburn Dam, and instead authorized the American River Common Features Project as part of WRDA 1996, in order to start design and construction on elements that were common to all plans presented in the 1991 and 1996 studies. Common features for the most part included levee improvements on the American and Sacramento Rivers with regards to seepage and stability deficiency remediation. The authorization for the Common Features project was modified as part of WRDA 1999 to include additional levee improvements needed to work with the plan Congress choose, Folsom Dam improvements. Common Features was authorized once more in order to adjust a 902 limit, as part of the EWDA of 2004. For a more thorough discussion of the Common Features project background, refer to the main Natomas Project report.

The Natomas Project addresses levee deficiency remediation of the approximately 42 miles of levee completely surrounding the basin. The remediation includes construction of seepage cutoff walls, seepage berms, stability berms, and adjacent levees, depending on specific deficiencies in a given reach. In addition to the general remediation, there are also utilities requiring additional work, in order to remediate the seepage and stability deficiencies. Utility types are widespread but the major utility efforts involve pump station relocations and bridge improvements. Pump stations are being addressed by either completely replacing the pump station and taking outlet pipes up and over the levee, or simply replacing the pipes through the levee and including a positive closure device on the new pipes. The second option is much less expensive and preferable. However, the first option is required at various pump stations because the actual pumping plant is in the way of the necessary levee improvements.

For the Natomas Project, feasibility level geotechnical and civil designs have occurred for the seepage and stability deficiency remediation and for the utility relocations. Information from this design effort has been used in developing the cost estimate. The cost estimate has been developed using the software package MII, which is a cost estimating software package.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering Dx. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key

assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering Dx.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve any desired level of cost confidence.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost Dx guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted

that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

Checklists or historical databases of common risk factors are sometimes used to facilitate risk factor identification. However, key risk factors are often unique to a project and not readily derivable from historical information. Therefore, input from the entire PDT was obtained using creative processes such as brainstorming or other facilitated risk assessment meetings.

The Sacramento District assembled a risk team comprised of key PDT members and a risk analysis representative from the Cost Engineering Dx to further augment labor, expertise and information gathering.

A meeting was held on May 11th and 12th, 2010, near the Sacramento District, USACE, with the PDT members, sponsors of the project, consultants to the district, and Sacramento and Walla Walla District facilitators. This meeting focused primarily on risk identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Those in attendance of this meeting can be found in Table 1 below.

Table 1. Initial Risk Register Development Meeting Attendees

Organization	Discipline
USACE	Cost Risk Facilitator
USACE	Project Manager
USACE	Civil Designer
USACE	Geotechnical Engineer
USACE	Cost Engineer
USACE	Hydraulic Engineer
USACE	GIS Specialist
USACE	Construction Engineer
USACE	Contracting Specialist
USACE	Planner
USACE	Environmental Scientist
USACE	Real Estate Specialist
Calif. DWR	Project Manager
SAFCA	Project Manager
SAFCA	Planner
URS	Administrative Support
MBK Engineers	Project Manager
MBK Engineers	Civil Designer
HDR	Civil Designer
Wood Rodgers	Civil Designer
Mead & Hunt	Civil Designer
Kleinfelder	Geotechnical Engineer

Subsequent meetings focused primarily on identifying project management and programmatic risks, risk factor assessment, and quantification; any new risk factors were also addressed during the follow-up discussions. Risk factors were identified and quantified through several face-to-face meetings, telephone calls, and email correspondence. Individuals who were involved with the follow-up discussions were the same as in the initial risk analysis work shop.

4.2 Quantify Risk Factor Impacts

During the course of risk study, it became clear that risks varied between contracts and cost feature accounts. Those risk variances related to the understanding that there were construction contracts already completed, some underway, and various contracts in various stages of design and projected schedule. It was also understood that the technical construction elements varied per contracts and that the differing cost feature accounts also varied in risk. For this reason, and to better enable project management of costs per contract and feature, it was decided that the risk models should be

developed at the contract and feature cost levels. Upon completion of the study, the average total contingency would then be presented, knowing that the subfeature levels carried the different studied risks and resulting contingency values.

The quantitative impacts of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in section 6 for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in quantifying the costs associated with the Natomas Project.

a. The Excel file "Natomas Apr 5 2010wRISKv4" was the basis for the cost and schedule risk analyses.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the preconstruction engineering and design (PED) level.

c. The schedule was analyzed for impact to the project cost in terms of uncaptured escalation (variance from OMB factors and the local market).

d. Per the Sacramento District's research on the comparative inflation rates between the Civil Works Construction Cost Index System (CWCCIS) rates and the local Sacramento area historical inflation rates, the typical inflation rate in the Sacramento Metro area is approximately 3%. The projected inflationary difference accounts for approximately 10% of the recommended contingency of 31%.

e. The Cost Dx guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

g. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk "watch list" for further monitoring and evaluation.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

Tables 2 and 3 provide the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand for both the NED Plan and LPP. The construction cost contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes only. The contingency percents presented are a weighted average of the contingencies determined at the contract and cost feature account level.

At the P80 confidence level, contingency was quantified as approximately $191 Million for the NED Plan and $201 Million for the LPP (31% of the baseline cost estimate). For comparison, the cost contingency at the P50 and P100 confidence levels was quantified as 10% and 114% of the baseline cost estimate, respectively.

Table 2. Project Cost Contingency Summary (NED Plan)

Risk Analysis Forecast	Baseline Estimate	Total Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Project Cost (in 1,000s)	$920,487	$59,300	9.75%
80% Confidence Level			
Project Cost (in 1,000s)	$920,487	$191,073	31.42%
100% Confidence Level			
Project Cost (in 1,000s)	$920,487	$690,645	113.58%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Table 3. Project Cost Contingency Summary (LPP)

Risk Analysis Forecast	Baseline Estimate	Total Contingency[1,2] ($)	Total Contingency (%)
50% Confidence Level			
Project Cost (in 1,000s)	$963,580	$62,855	9.87%
80% Confidence Level			
Project Cost (in 1,000s)	$963,580	$200,520	31.48%
100% Confidence Level			
Project Cost (in 1,000s)	$963,580	$723,496	113.58%

Notes:
1) These figures combine uncertainty in the baseline cost estimates and schedule.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and

their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to total project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

6.3 Schedule and Contingency Risk Analysis

Table 4 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P100 confidence levels are also provided for illustrative purposes.

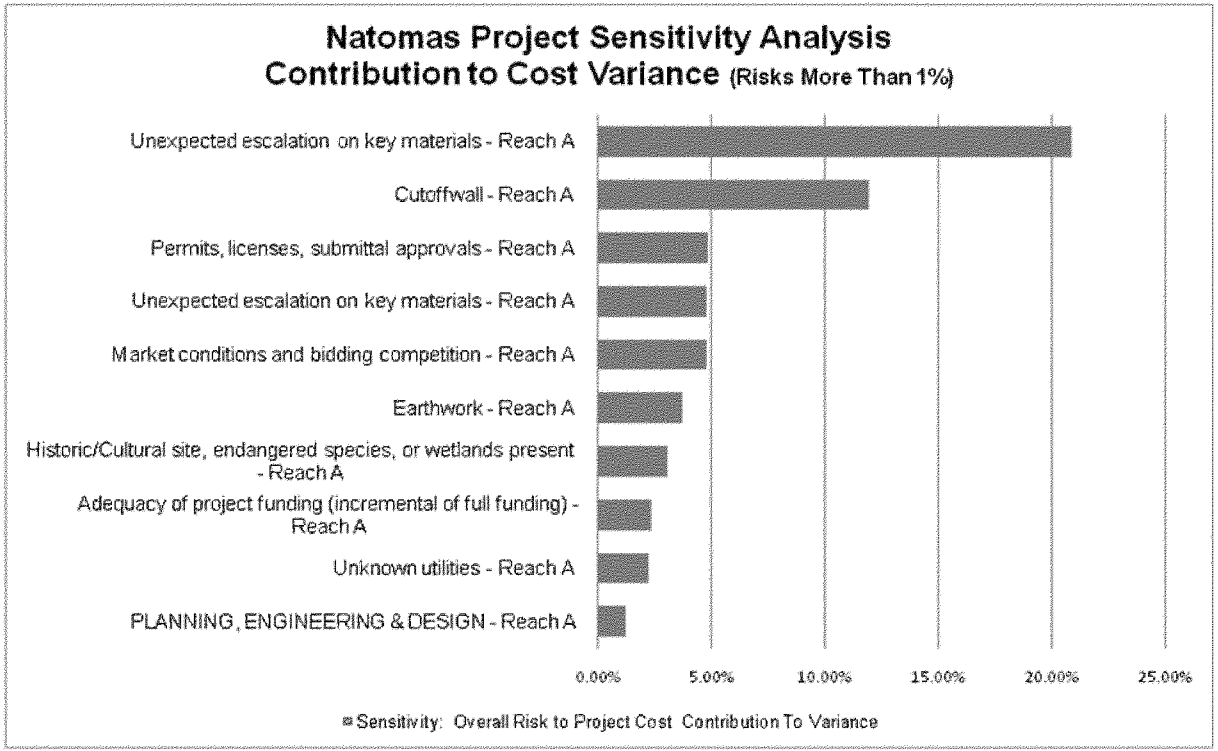
Schedule duration contingency was quantified as 13 months based on the P80 level of confidence. The schedule contingencies were calculated by applying the high level schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

Table 4. Schedule Duration Contingency Summary (NED Plan and LPP)

Risk Analysis Forecast	Baseline Schedule Duration (months)	Contingency[1] (months)
50% Confidence Level		
Project Duration	54.5	6.7
80% Confidence Level		
Project Duration	54.5	13.0
100% Confidence Level		
Project Duration	54.5	50.3

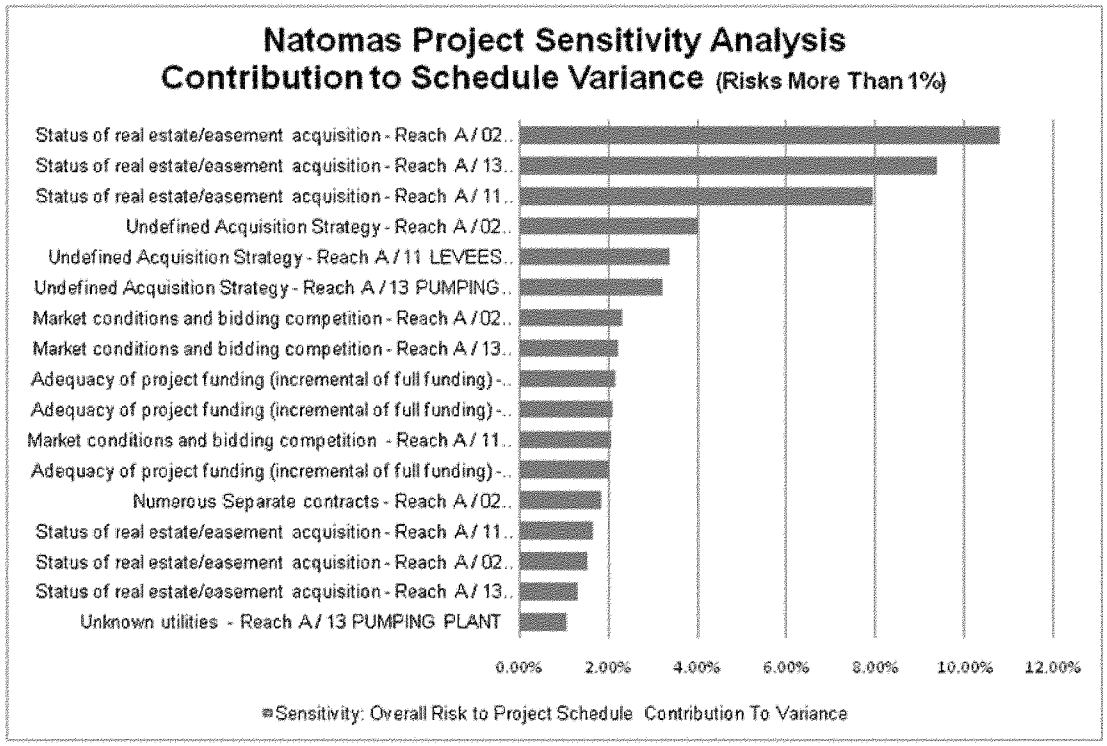
Notes:
1) The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented in Table 4.
2) A P100 confidence level is an abstract concept for illustration only, as the nature of risk and uncertainty (specifically the presence of "unknown unknowns") makes 100% confidence a theoretical impossibility.

Figure 1. Cost Sensitivity Analysis (NED Plan and LPP)



905

Figure 2. Schedule Sensitivity Analysis (NED Plan and LPP)



906

7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost comparison summaries are provided in Tables 5 and 6. Additional major findings and observations of the risk analysis are listed below.

1. The key cost risk driver identified through sensitivity analysis were Unexpected Escalation on Key Materials and Uncertainty with the Cutoff Wall for the Reach A Levees and Floodwalls, which together contribute over 31 percent of the statistical cost variance.

2. The key schedule risk driver identified through sensitivity analysis was Easement Acquisition for the Reach A Relocations, Pumping Plant, and Levees and Floodwall Accounts, which contributes nearly 30 percent of the statistical schedule variance.

3. The schedule was not resource loaded and contains open-ended tasks, and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected "Hotel" costs. Resource impacts related to potential schedule delays could not be evaluated.

4. Operation and maintenance activities were not included in the cost estimate or schedules. Therefore, a full lifecycle risk analysis could not be performed. Risk analysis results or conclusions could be significantly different if the necessary operation and maintenance activities were included.

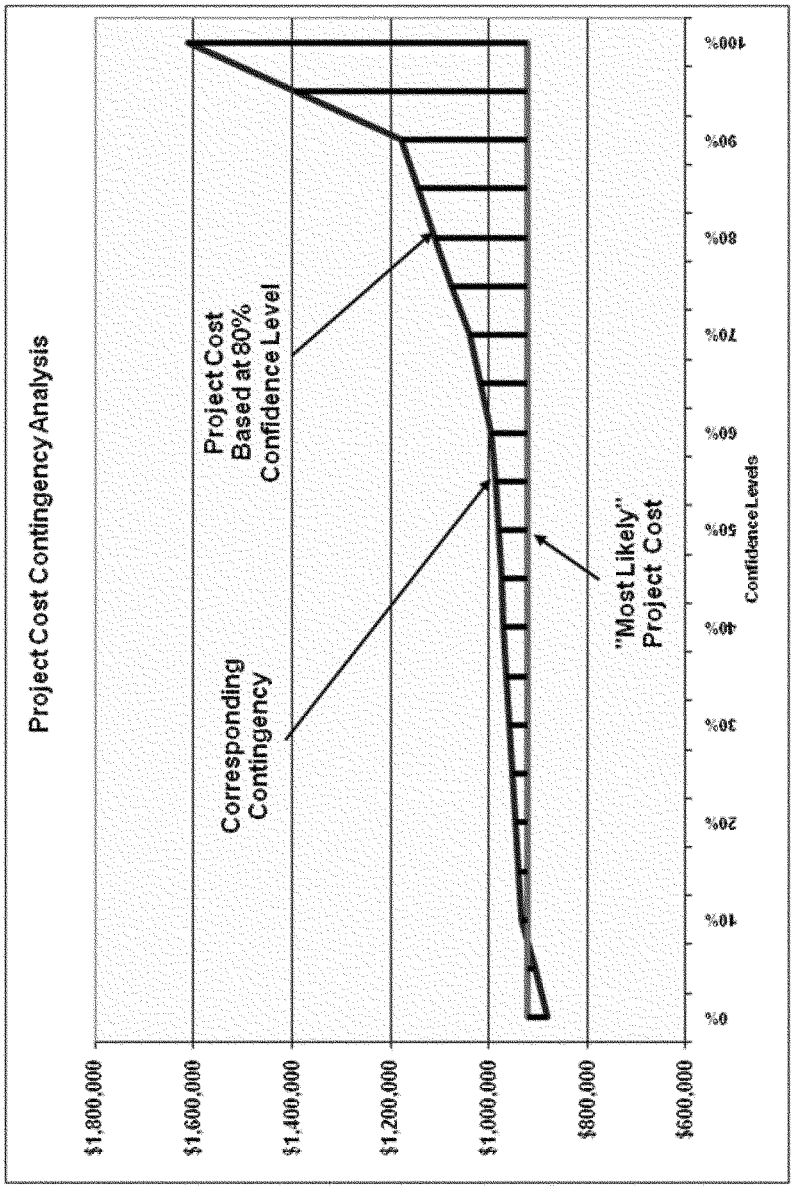
Table 5. Project Cost Comparison Summary – NED Plan (Federal and Non-Federal Costs)

Confidence Level	Project Cost ($ in 1,000s)	Contingency (%)
P0	$880,617	-6.56%
P10	$933,081	2.07%
P20	$945,958	4.19%
P30	$958,360	6.23%
P40	$970,064	8.15%
P50	$979,787	9.75%
P60	$994,738	12.21%
P70	$1,039,707	19.61%
P80	$1,111,560	31.42%
P90	$1,179,336	42.57%
P100	$1,611,132	113.58%

Table 6. Project Cost Comparison Summary – LPP (Federal and Non-Federal Costs)

Confidence Level	Project Cost ($ in 1,000s)	Contingency (%)
P0	$922,915	-6.38%
P10	$977,503	2.19%
P20	$991,367	4.36%
P30	$1,004,154	6.37%
P40	$1,015,142	8.09%
P50	$1,026,435	9.87%
P60	$1,041,524	12.24%
P70	$1,088,930	19.68%
P80	$1,164,100	31.48%
P90	$1,235,817	42.74%
P100	$1,687,076	113.58%

Figure 3. Project Cost Summary (NED Plan)



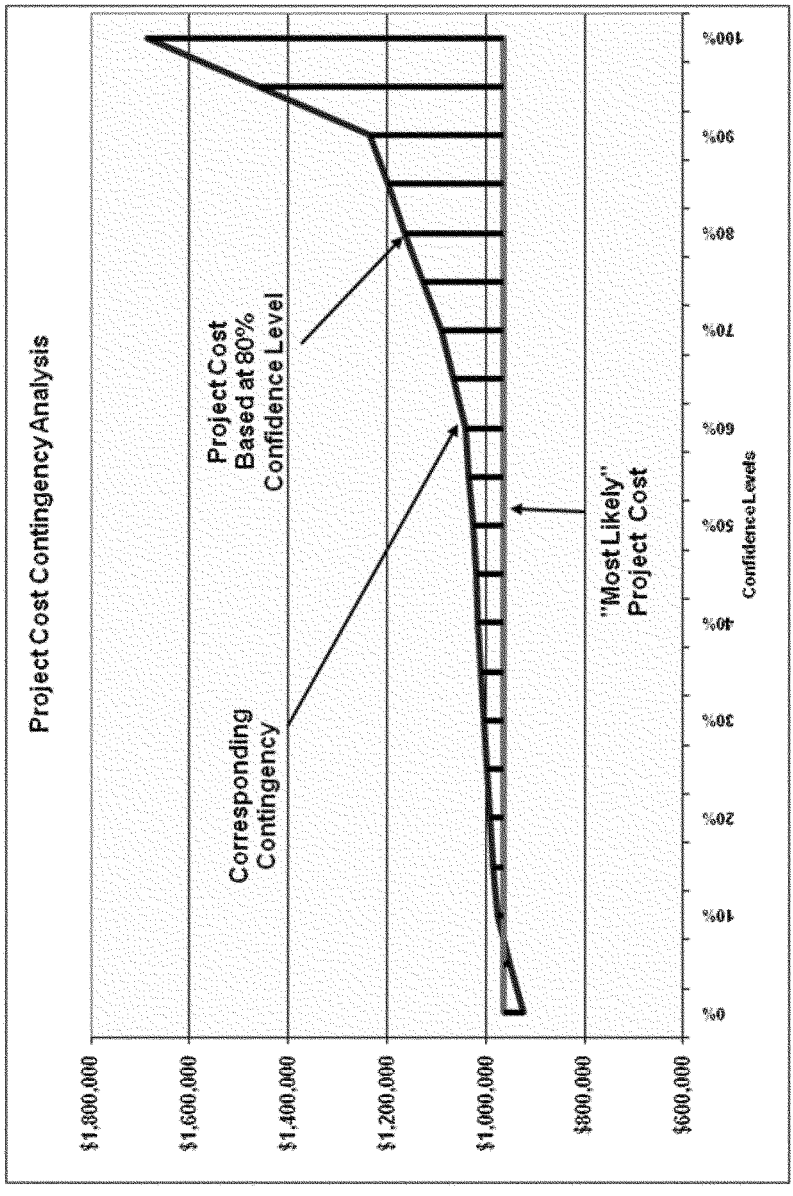


Figure 4. Project Cost Summary (LPP)

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

1. Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

2. Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

****** SUMMARY OF TOTAL PROJECT ANNUAL COST****** August 25, 2010

PROJECT: NATOMAS PACR, NED
LOCATION: CALIFORNIA
INTEREST RATE: 4.375%

U. S. ARMY CORPS OF ENGINEER
SACRAMENTO DISTRICT

ITEM	COST ($)
Effective Price Level (EPL): 1-Oct-2010	
A. INVESTMENT COST	
1. FEDERAL	
TOTAL	733,107,000
2. NON-FEDERAL	
TOTAL	530,466,000
TOTAL PROJECT INVESTMENT	**$1,263,573,000**
B. ANNUAL COSTS	
1. FEDERAL	
TOTAL	36,345,000
2. NON-FEDERAL	
TOTAL	31,479,000
TOTAL ANNUAL COST	**$67,824,000**

DETAILED ESTIMATE OF ANNUAL COST

ITEM			COST ($)
	Effective Price Level (EPL): 1-Oct-2010		
A.	**INVESTMENT COST**		
1.	FEDERAL		
	a. First Cost		657,760,000
	Less 18. Cultural Resources Preservation (-)		6,578,000
	b. Interest During Construction (+)		81,925,000
	TOTAL		$733,107,000
2.	NON-FEDERAL		
	a. First Cost		453,800,000
	b. Interest During Construction		76,666,000
	TOTAL		$530,466,000
	TOTAL PROJECT INVESTMENT		**$1,263,573,000**
B.	**ANNUAL COSTS**		
1.	FEDERAL		
	a. Interest and Amortization:		
	Interest @	4.375%	32,073,000
	Amortization @	0.583%	4,272,000
	Amortization Period	50	
	TOTAL		$36,345,000
2.	NON-FEDERAL		
	a. Interest and Amortization:		
	Interest @	4.375%	23,208,000
	Amortization @	0.583%	3,091,000
	Amortization Period	50	
	c. Maintenance And Operation:		5,180,000
	02--- Relocations	953,000	
	06--- Fish & Wildlife Facil.	160,000	
	11--- Levees	3,163,000	
	13--- Pumping Plants	904,000	
	TOTAL		$31,479,000
	TOTAL ANNUAL COST		**$67,824,000**

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

PROJECT: NATOMAS PACR, NED
LOCATION: CALIFORNIA
INTEREST RATE: 4.375%

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2010					
	FEDERAL COSTS					
1	LANDS AND DAMAGES, Administration	4,127,000				169,402
	Reach A	765,000	Oct-11	Apr-12	Oct-13	59,552
	Reach B	945,000	Oct-12	Apr-13	Oct-13	30,870
	Reach C	295,000	Oct-15	Apr-16	Oct-16	9,655
	Reach D	98,000	Oct-15	Apr-16	Oct-16	3,207
	Reach E	397,000	Oct-14	Apr-15	Oct-15	12,999
	Reach F	321,000	Oct-13	Apr-14	Oct-14	10,486
	Reach G	241,000	Oct-14	Apr-15	Oct-15	7,873
	Reach H	902,000	Oct-13	Apr-14	Oct-14	29,465
	Reach I	163,000	Oct-12	Apr-13	Oct-13	5,325
1	LANDS AND DAMAGES, Real Estate	14,365,000				573,924
	Reach A	2,312,000	Oct-11	Apr-12	Oct-13	179,979
	Reach B	5,848,000	Oct-12	Apr-13	Oct-13	191,034
	Reach C	1,027,000	Oct-15	Apr-16	Oct-16	33,611
	Reach D	2,512,000	Oct-15	Apr-16	Oct-16	82,211
	Reach E	1,074,000	Oct-14	Apr-15	Oct-15	35,084
	Reach H	1,592,000	Oct-13	Apr-14	Oct-14	52,005
6	FISH & WILDLIFE FACILITIES	18,869,000				1,111,404
3--	WILDLIFE FACILITIES & SANCTUARIES					
	Reach B					
	FEDERAL	1,635,000	Apr-13	Apr-13	Oct-13	35,481
	NON-FEDERAL - Section 104					
		14,000	Oct-08	Oct-09	Oct-13	2,977
		150,000	Oct-09	Oct-10	Oct-13	24,273
		78,000	Apr-11	Oct-11	Oct-13	7,901
	Reach C					
	FEDERAL	225,000	Oct-07	Oct-08	Oct-16	98,877
	NON-FEDERAL - Section 104					
		1,139,000	Oct-06	Oct-07	Oct-16	572,367
		498,000	Oct-07	Oct-08	Oct-16	218,848
		64,000	Oct-09	Oct-10	Oct-16	20,559
	Reach E	6,717,000	Apr-15	Nov-15	Oct-15	61,416
	Reach H	8,349,000	Apr-14	Nov-14	Oct-14	68,705
11	LEVEES AND FLOODWALLS	388,083,000				31,854,047
	Reach A	72,593,000	Apr-12	Oct-13	Oct-13	2,270,341
	Reach B					
	FEDERAL	25,077,000	Apr-13	Oct-13	Oct-13	259,298
	NON-FEDERAL - Section 104					
		199,000	Oct-08	Oct-09	Oct-13	42,317
		5,176,000	Oct-09	Oct-10	Oct-13	837,578
		17,788,000	Oct-08	Oct-09	Oct-13	3,782,602
		25,044,000	Apr-11	Oct-11	Oct-13	2,536,967
	Reach C					
	FEDERAL	908,000	Apr-16	Oct-16	Oct-16	9,011
	NON-FEDERAL - Section 104					
		1,189,000	Oct-08	Oct-09	Oct-16	450,674
		63,000	Oct-08	Oct-09	Oct-16	23,879
		2,568,000	Oct-08	Oct-09	Oct-16	973,364
		2,568,000	Oct-09	Oct-10	Oct-16	824,924
		1,407,000	Oct-09	Oct-10	Oct-16	451,973
		3,537,000	Oct-09	Oct-10	Oct-16	1,136,198
		3,537,000	Oct-09	Oct-10	Oct-16	1,136,198
		2,488,000	Oct-09	Oct-10	Oct-16	799,225
		3,964,000	Oct-09	Oct-10	Oct-16	1,273,364
	Reach D					
	FEDERAL	3,254,000	Apr-16	Nov-16	Oct-16	27,231
	NON-FEDERAL - Section 104					
		3,111,000	Oct-08	Oct-09	Oct-16	1,179,181
		13,835,000	Oct-08	Oct-09	Oct-16	5,243,962
		12,876,000	Oct-08	Oct-09	Oct-16	4,880,466
		3,289,000	Oct-08	Oct-09	Oct-16	1,246,649
		1,856,000	Oct-08	Oct-09	Oct-16	703,491
	Reach E	42,307,000	Apr-15	Nov-15	Oct-15	385,828
	Reach F	46,506,000	Apr-14	Oct-14	Oct-14	480,876
	Reach G	35,015,000	Apr-15	Oct-15	Oct-15	375,833
	Reach H	40,401,000	Apr-14	Nov-14	Oct-14	332,463
	Reach I	17,527,000	Apr-13	Oct-13	Oct-13	189,154

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2010					
13	PUMPING PLANT	56,135,000				684,592
	Reach A	6,003,000	Apr-12	Oct-13	Oct-13	187,743
	Reach B	17,215,000	Apr-13	Oct-13	Oct-13	178,004
	Reach C	21,496,000	Apr-16	Oct-16	Oct-16	213,334
	Reach D	4,207,000	Apr-16	Nov-16	Oct-16	35,206
	Reach G	2,823,000	Apr-15	Oct-15	Oct-15	30,301
	Reach H	2,881,000	Apr-14	Nov-14	Oct-14	23,708
	Reach I	1,510,000	Apr-13	Oct-13	Oct-13	16,296
18	CULTURAL RESOURCE PRES. (NO IDC)	6,578,000				
30	PLANNING, ENGR. & DESIGN	129,097,000				27,408,098
	Reach A					
	FEDERAL					
		124,000	Oct-08	Oct-09	Oct-13	26,368
		488,000	Oct-09	Oct-10	Oct-13	78,968
		10,202,000	Oct-11	Oct-13	Oct-13	434,551
	NON-FEDERAL - Section 104					
		43,000	Oct-06	Oct-07	Oct-13	13,813
		56,000	Oct-07	Oct-08	Oct-13	14,884
		764,000	Oct-08	Oct-09	Oct-13	162,464
		2,486,000	Oct-09	Oct-10	Oct-13	402,283
	Reach B					
	FEDERAL					
		310,000	Oct-08	Oct-09	Oct-13	65,921
		1,220,000	Oct-09	Oct-10	Oct-13	197,420
		7,464,000	Oct-11	Oct-13	Oct-13	325,240
	NON-FEDERAL - Section 104					
		53,000	Oct-05	Oct-06	Oct-13	20,088
		507,000	Oct-06	Oct-07	Oct-13	162,865
		5,620,000	Oct-07	Oct-08	Oct-13	1,493,688
		12,757,000	Oct-08	Oct-09	Oct-13	2,712,765
		13,816,000	Oct-09	Oct-10	Oct-13	2,235,698
		2,256,000	Oct-10	Oct-11	Oct-13	255,200
	Reach C					
	FEDERAL					
		163,000	Oct-08	Oct-09	Oct-16	61,783
		642,000	Oct-09	Oct-10	Oct-16	206,231
		2,685,000	Oct-14	Oct-16	Oct-16	115,744
	NON-FEDERAL - Section 104					
		613,000	Oct-05	Oct-06	Oct-16	348,339
		4,083,000	Oct-06	Oct-07	Oct-16	2,051,778
		9,647,000	Oct-07	Oct-08	Oct-16	4,239,410
		7,137,000	Oct-08	Oct-09	Oct-16	2,705,179
		1,397,000	Oct-09	Oct-10	Oct-16	448,761
	Reach D					
	FEDERAL					
		179,000	Oct-08	Oct-09	Oct-16	67,847
		707,000	Oct-09	Oct-10	Oct-16	227,111
		1,158,000	Oct-14	Nov-16	Oct-16	47,563
	NON-FEDERAL - Section 104					
		839,000	Oct-05	Oct-06	Oct-16	476,764
		1,604,000	Oct-06	Oct-07	Oct-16	805,038
		2,457,000	Oct-07	Oct-09	Oct-16	1,005,616
		3,361,000	Oct-08	Oct-09	Oct-16	1,273,940
		541,000	Oct-09	Oct-10	Oct-16	173,787
	Reach E					
	FEDERAL					
		108,000	Oct-08	Oct-09	Oct-15	34,676
		424,000	Oct-09	Oct-10	Oct-15	112,658
		5,067,000	Oct-13	Nov-15	Oct-15	213,253
	NON-FEDERAL - Section 104					
		193,000	Oct-06	Oct-07	Oct-15	84,798
		1,470,000	Oct-07	Oct-08	Oct-15	557,065
		1,294,000	Oct-08	Oct-09	Oct-15	415,474
		493,000	Oct-09	Oct-10	Oct-15	130,991
	Reach F					
	FEDERAL	4,806,000	Oct-12	Oct-14	Oct-14	209,120
	NON-FEDERAL - Section 104					
		98,000	Oct-06	Oct-07	Oct-14	37,146
		829,000	Oct-07	Oct-08	Oct-14	266,238
		1,116,000	Oct-08	Oct-09	Oct-14	296,524
		697,000	Oct-09	Oct-10	Oct-14	148,216
	Reach G					
	FEDERAL	3,493,000	Oct-13	Oct-15	Oct-15	153,444
	Reach H					
	FEDERAL					

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2010					
		147,000	Oct-08	Oct-09	Oct-14	39,058
		578,000	Oct-09	Oct-10	Oct-14	122,911
		5,334,000	Oct-12	Nov-14	Oct-14	217,645
	NON-FEDERAL - Section 104					
		3,000	Oct-05	Oct-06	Oct-14	1,318
		101,000	Oct-06	Oct-07	Oct-14	38,283
		1,567,000	Oct-07	Oct-08	Oct-14	503,250
		1,263,000	Oct-08	Oct-09	Oct-14	335,582
		485,000	Oct-09	Oct-10	Oct-14	103,985
	Reach I					
	FEDERAL	2,044,000	Oct-11	Oct-13	Oct-13	90,041
	NON-FEDERAL - Section 104					
		29,000	Oct-05	Oct-06	Oct-13	10,992
		128,000	Oct-06	Oct-07	Oct-13	41,118
		354,000	Oct-07	Oct-08	Oct-13	94,085
		676,000	Oct-08	Oct-09	Oct-13	143,751
		917,000	Oct-09	Oct-10	Oct-13	148,388
31	CONSTRUCTION MANAGEMENT	151,033,000				39,012,376
	Reach A					
	FEDERAL	6,288,000	Apr-12	Oct-13	Oct-13	196,657
	Reach B					
	FEDERAL	3,383,000	Apr-13	Oct-13	Oct-13	34,980
	NON-FEDERAL - Section 104					
		4,000	Oct-06	Oct-07	Oct-13	1,285
		2,000	Oct-07	Oct-08	Oct-13	532
		2,642,000	Oct-08	Oct-09	Oct-13	561,819
		34,125,000	Oct-09	Oct-10	Oct-13	5,522,091
		2,026,000	Apr-11	Oct-11	Oct-13	205,235
	Reach C					
	FEDERAL	1,792,000	Apr-16	Oct-16	Oct-16	17,784
	NON-FEDERAL - Section 104					
		779,000	Oct-06	Oct-07	Oct-16	391,461
		2,675,000	Oct-07	Oct-08	Oct-16	1,175,539
		5,568,000	Oct-08	Oct-09	Oct-16	2,118,053
		27,519,000	Oct-09	Oct-10	Oct-16	6,839,953
	Reach D					
	FEDERAL	597,000	Apr-16	Nov-16	Oct-16	4,996
	NON-FEDERAL - Section 104					
		13,395,000	Oct-06	Oct-07	Oct-16	6,731,220
		9,061,000	Oct-07	Oct-08	Oct-16	3,981,891
		18,143,000	Oct-08	Oct-09	Oct-16	6,876,848
		6,916,000	Oct-09	Oct-10	Oct-16	2,222,283
	Reach E	3,922,000	Apr-15	Nov-15	Oct-15	35,860
	Reach F	3,721,000	Apr-14	Oct-15	Oct-14	13,386
	Reach G	2,799,000	Apr-15	Oct-15	Oct-15	30,043
	Reach H	4,131,000	Apr-14	Nov-14	Oct-14	33,994
	Reach I	1,523,000	Apr-13	Oct-13	Oct-13	16,436
	CASH CONTRIBUTION (-)	55,276,000	Apr-12		Oct-16	5,662,155
	SECTION 104 (-)	55,249,000	Oct-11	Oct-11	Oct-16	13,206,567
	TOTAL FEDERAL COST	**$657,760,000**				**$81,925,121**
	NON-FEDERAL COSTS					
1	LANDS AND DAMAGES	205,338,000				9,538,509
	Reach A					
		369,000	Oct-09	Oct-10	Oct-13	59,711
		19,000	Oct-09	Oct-10	Oct-13	3,075
		6,000	Oct-09	Oct-10	Oct-13	971
		23,000	Oct-09	Oct-10	Oct-13	3,722
		28,542,000	Oct-11	Apr-12	Oct-13	2,221,872
	Reach B					
		1,869,000	Oct-09	Oct-10	Oct-13	302,441
		849,000	Oct-09	Oct-10	Oct-13	137,385
		283,000	Oct-09	Oct-10	Oct-13	45,795
		12,000	Oct-09	Oct-10	Oct-13	1,942
		490,000	Oct-09	Oct-10	Oct-13	79,292
		51,574,000	Oct-12	Apr-13	Oct-13	1,684,744
	Reach C					
		1,014,000	Oct-09	Oct-10	Oct-16	325,729
		578,000	Oct-09	Oct-10	Oct-16	185,672
		193,000	Oct-09	Oct-10	Oct-16	61,998
		213,000	Oct-09	Oct-10	Oct-16	68,422
		13,183,000	Oct-15	Apr-16	Oct-16	431,442

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2010					
	Reach D					
		515,000	Oct-09	Oct-10	Oct-16	165,434
		306,000	Oct-09	Oct-10	Oct-16	98,297
		102,000	Oct-09	Oct-10	Oct-16	32,766
		7,000	Oct-09	Oct-10	Oct-16	2,249
		91,000	Oct-09	Oct-10	Oct-16	29,232
		4,144,000	Oct-15	Apr-16	Oct-16	135,621
	Reach E					
		195,000	Oct-09	Oct-10	Oct-15	51,812
		61,000	Oct-09	Oct-10	Oct-15	16,208
		20,000	Oct-09	Oct-10	Oct-15	5,314
		102,000	Oct-09	Oct-10	Oct-15	27,102
		32,873,000	Oct-14	Apr-15	Oct-15	1,073,847
	Reach F					
		82,000	Oct-09	Oct-10	Oct-14	17,437
		7,000	Oct-09	Oct-10	Oct-14	1,489
		2,000	Oct-09	Oct-10	Oct-14	425
		1,000	Oct-09	Oct-10	Oct-14	213
		7,000	Oct-09	Oct-10	Oct-14	1,489
		13,668,000	Oct-13	Apr-14	Oct-14	446,486
	Reach G	18,340,000	Oct-14	Apr-15	Oct-15	599,104
	Reach H					
		140,000	Oct-09	Oct-10	Oct-14	29,771
		21,000	Oct-09	Oct-10	Oct-14	4,466
		7,000	Oct-09	Oct-10	Oct-14	1,489
		47,000	Oct-09	Oct-10	Oct-14	9,995
		31,790,000	Oct-13	Apr-14	Oct-14	1,038,469
	Reach I					
		70,000	Oct-09	Oct-10	Oct-13	11,327
		15,000	Oct-09	Oct-10	Oct-13	2,427
		5,000	Oct-09	Oct-10	Oct-13	809
		51,000	Oct-09	Oct-10	Oct-13	8,253
		3,452,000	Oct-12	Apr-13	Oct-13	112,765
2	RELOCATIONS	110,766,000				3,720,395
	Constr. Activities	110,766,000				3,720,395
3--	CEMETERIES, UTILITIES, & STRUCTURES					
	Reach A	13,608,000	Apr-12	Oct-13	Oct-13	425,589
	Reach B					
		280,000	Oct-09	Oct-10	Oct-13	45,309
		1,766,000	Oct-09	Oct-10	Oct-13	285,773
		1,206,000	Oct-09	Oct-10	Oct-13	195,154
		318,000	Oct-09	Oct-10	Oct-13	51,459
		2,000	Oct-09	Oct-10	Oct-13	324
		5,000	Oct-09	Oct-10	Oct-13	809
		19,332,000	Apr-13	Oct-13	Oct-13	199,894
	Reach C					
		296,000	Oct-08	Oct-09	Oct-16	112,195
		16,000	Oct-09	Oct-10	Oct-16	5,140
		87,000	Oct-08	Oct-09	Oct-16	32,976
		348,000	Oct-09	Oct-10	Oct-16	111,789
		360,000	Oct-09	Oct-10	Oct-16	115,644
		262,000	Oct-09	Oct-10	Oct-16	84,163
		14,000	Oct-08	Oct-09	Oct-16	5,307
		832,000	Oct-09	Oct-10	Oct-16	267,265
		6,000	Oct-08	Oct-09	Oct-16	2,274
		1,911,000	Oct-09	Oct-10	Oct-16	613,874
		8,058,000	Apr-16	Oct-16	Oct-16	79,970
	Reach D					
		778,000	Oct-08	Oct-09	Oct-16	294,890
		562,000	Oct-08	Oct-09	Oct-16	213,018
		17,000	Oct-08	Oct-09	Oct-16	6,444
		10,966,000	Apr-16	Nov-16	Oct-16	91,768
	Reach E	10,951,000	Apr-15	Nov-15	Oct-15	100,129
	Reach F	11,945,000	Apr-14	Oct-14	Oct-14	123,512
	Reach G	10,676,000	Apr-15	Oct-15	Oct-15	114,591
	Reach H	12,996,000	Apr-14	Nov-14	Oct-14	105,945
	Reach I	3,168,000	Apr-13	Oct-13	Oct-13	34,190
	SECTION 215	311,069,000				66,126,418
		311,069,000	Apr-12	Apr-12	Oct-16	66,126,418
30	PLANNING, ENGR. & DESIGN	19,614,000				3,045,817
		3,000	Oct-09	Oct-10	Oct-13	485
		2,042,000	Oct-11	Oct-13	Oct-13	86,978
		406,000	Oct-07	Oct-08	Oct-13	107,906
		1,444,000	Oct-08	Oct-09	Oct-13	307,065

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END DATE	PLANT USAGE DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2010					
		2,240,000	Oct-09	Oct-10	Oct-13	362,476
		535,000	Oct-11	Oct-13	Oct-13	23,312
		211,000	Oct-05	Oct-06	Oct-16	119,901
		697,000	Oct-06	Oct-07	Oct-16	350,255
		1,073,000	Oct-07	Oct-08	Oct-16	471,534
		1,214,000	Oct-08	Oct-09	Oct-16	460,150
		701,000	Oct-09	Oct-10	Oct-16	225,184
		967,000	Oct-14	Oct-16	Oct-16	41,685
		170,000	Oct-08	Oct-09	Oct-16	64,436
		102,000	Oct-09	Oct-10	Oct-16	32,766
		1,174,000	Oct-13	Oct-15	Oct-16	105,341
	Reach E	1,643,000	Oct-13	Nov-15	Oct-15	69,148
	Reach F	1,433,000	Oct-12	Oct-14	Oct-14	62,353
		8,000	Oct-09	Oct-10	Oct-15	2,126
		1,601,000	Oct-13	Oct-15	Oct-15	70,390
		5,000	Oct-09	Oct-10	Oct-14	1,063
		1,559,000	Oct-12	Nov-14	Oct-14	63,612
		6,000	Oct-09	Oct-10	Oct-13	971
		380,000	Oct-11	Oct-13	Oct-13	16,740
31	CONSTRUCTION MANAGEMENT	7,555,000				297,795
	Reach A	1,089,000	Apr-12	Oct-13	Oct-13	34,058
		74,000	Oct-08	Oct-09	Oct-13	15,736
		456,000	Oct-09	Oct-10	Oct-13	73,790
		286,000	Apr-11	Oct-11	Oct-13	28,972
		22,000	Oct-08	Oct-09	Oct-16	8,339
		8,000	Oct-09	Oct-10	Oct-16	2,570
		645,000	Apr-16	Oct-16	Oct-16	6,401
		782,000	Apr-16	Nov-16	Oct-16	6,544
	Reach E	876,000	Apr-15	Nov-15	Oct-16	46,514
	Reach F	956,000	Apr-14	Oct-14	Oct-15	52,120
	Reach G	1,068,000	Apr-15	Oct-15	Oct-15	11,463
	Reach H	1,040,000	Apr-14	Nov-14	Oct-14	8,568
	Reach I	253,000	Apr-13	Oct-13	Oct-13	2,730
	CASH CONTRIBUTION (+)	55,278,000	Apr-12		Oct-16	5,682,155
	SECTION 104 (-)	255,820,000	Apr-12	Apr-12	Oct-16	54,381,697
	TOTAL NON-FEDERAL	**$453,800,000**				**$76,666,368**
	TOTAL	**$1,111,560,000**				**$158,591,489**

DETAILED ESTIMATE OF M & O COSTS & REPLACEMENT COSTS

Price level %Increase	1.00	1.5083	Factor
Price Level of M&O costs	Oct-10	2620	
Effective Price Date (EPD)	Oct-10	2620	

ACCOUNT NUMBER	ITEM	ANNUAL COST ($)	FACTOR (%)	M&O COST ($)	PROJECT LIFE YRS	ITEM LIFE YRS	FACTOR (%)	REPLACEMENT COST ($)
			Effective Price Level (EPL): 1-Oct-2010					
02---	Relocations							
	Reach A, Pumps	100000	1.5	150625				
	Reach B, Pumps	150000	1.5	225938				
	Reach C, Pumps	75000	1.5	112969				
	Reach D, Pumps	100000	1.5	150625				
	Reach E, Pumps	35000	1.5	52719				
	Reach G, Pumps	35000	1.5	52719				
	Reach H, Pumps	70000	1.5	105438				
	Reach I, Pumps	35000	1.5	52719				
	Reach A, Drainage Swale and Storm Drainage I	7500	1.5	11297				
	Reach B, Drainage Swale and Storm Drainage I	12500	1.5	18828				
	Reach C, Drainage Swale and Storm Drainage I	12500	1.5	18828				
	Relocations			952703				0
06---	Fish & Wildlife Facil.							
	Reach A	13137	1.5	19788				
	Reach B	39370	1.5	59301				
	Reach C	26683	1.5	40191				
	Reach D	6808	1.5	10255				
	Reach E	11852	1.5	17852				
	Reach F	1773	1.5	2671				
	Reach G	1346	1.5	2027				
	Reach H	2362	1.5	3558				
	Reach I	2698	1.5	4064				
	Fish & Wildlife Facil.			159706				0
11---	Levees							
	Reach A	265000	1.5	399156				
	Reach B	610000	1.5	918813				
	Reach C	325000	1.5	489531				
	Reach D	300000	1.5	451875				
	Reach E	100000	1.5	150625				
	Reach F	150000	1.5	225938				
	Reach G	100000	1.5	150625				
	Reach H	150000	1.5	225938				
	Reach I	100000	1.5	150625				
	Levees			3163125				0
13---	Pumping Plants							
	Reach A, Pumps	100000	1.5	150625				
	Reach B, Pumps	150000	1.5	225938				
	Reach C, Pumps	75000	1.5	112969				
	Reach D, Pumps	100000	1.5	150625				
	Reach E, Pumps	35000	1.5	52719				
	Reach G, Pumps	35000	1.5	52719				
	Reach H, Pumps	70000	1.5	105438				
	Reach I, Pumps	35000	1.5	52719				
	Pumping Plants			903750				0
	SUMMARY							
02---	Relocations			952703				0
06---	Fish & Wildlife Facil.			159706				0
11---	Levees			3163125				0
13---	Pumping Plants			903750				0
	TOTAL			**$5,179,284**				**$0**

****** SUMMARY OF TOTAL PROJECT ANNUAL COST****** August 25, 2010

PROJECT: NATOMAS PACR, LPP
LOCATION: CALIFORNIA
INTEREST RATE: 4.375%

U. S. ARMY CORPS OF ENGINEER
SACRAMENTO DISTRICT

ITEM	COST ($)
Effective Price Level (EPL): 1-Oct-2010	
A. INVESTMENT COST	
1. FEDERAL	
TOTAL	734,698,000
2. NON-FEDERAL	
TOTAL	587,901,000
TOTAL PROJECT INVESTMENT	**$1,322,599,000**
B. ANNUAL COSTS	
1. FEDERAL	
TOTAL	36,424,000
2. NON-FEDERAL	
TOTAL	34,327,000
TOTAL ANNUAL COST	**$70,751,000**

DETAILED ESTIMATE OF ANNUAL COST

ITEM			COST ($)
	Effective Price Level (EPL): 1-Oct-2010		
A.	**INVESTMENT COST**		
1.	FEDERAL		
a.	First Cost		657,760,000
	Less 18. Cultural Resources Preservation (-)		6,578,000
b.	Interest During Construction (+)		83,516,000
	TOTAL		$734,698,000
2.	NON-FEDERAL		
a.	First Cost		506,340,000
b.	Interest During Construction		81,561,000
	TOTAL		$587,901,000
	TOTAL PROJECT INVESTMENT		**$1,322,599,000**
B.	**ANNUAL COSTS**		
1.	FEDERAL		
a.	Interest and Amortization:		
	Interest @	4.375%	32,143,000
	Amortization @	0.583%	4,281,000
	Amortization Period	50	
	TOTAL		$36,424,000
2.	NON-FEDERAL		
a.	Interest and Amortization:		
	Interest @	4.375%	25,721,000
	Amortization @	0.583%	3,426,000
	Amortization Period	50	
c.	Maintenance And Operation:		5,180,000
02---	Relocations	953,000	
06---	Fish & Wildlife Facil.	160,000	
11---	Levees	3,163,000	
13---	Pumping Plants	904,000	
	TOTAL		$34,327,000
	TOTAL ANNUAL COST		**$70,751,000**

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION

PROJECT: NATOMAS PACR, LPP
LOCATION: CALIFORNIA
INTEREST RATE: 4.375%

ACCOUNT NUMBER	DESCRIPTION	AMOUNT CONTRACT ($)	START DATE	END USAGE DATE	PLANT DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2010					
	FEDERAL COSTS					
1	LANDS AND DAMAGES, Administration	4,127,000				169,402
	Reach A	765,000	Oct-11	Apr-12	Oct-13	59,552
	Reach B	945,000	Oct-12	Apr-13	Oct-13	30,870
	Reach C	295,000	Oct-15	Apr-16	Oct-16	9,655
	Reach D	98,000	Oct-15	Apr-16	Oct-16	3,207
	Reach E	397,000	Oct-14	Apr-15	Oct-15	12,999
	Reach F	321,000	Oct-13	Apr-14	Oct-14	10,486
	Reach G	241,000	Oct-14	Apr-15	Oct-15	7,873
	Reach H	902,000	Oct-13	Apr-14	Oct-14	29,465
	Reach I	163,000	Oct-12	Apr-13	Oct-13	5,325
1	LANDS AND DAMAGES, Real Estate	14,365,000				573,924
	Reach A	2,312,000	Oct-11	Apr-12	Oct-13	179,979
	Reach B	5,848,000	Oct-12	Apr-13	Oct-13	191,034
	Reach C	1,027,000	Oct-15	Apr-16	Oct-16	33,611
	Reach D	2,512,000	Oct-15	Apr-16	Oct-16	82,211
	Reach E	1,074,000	Oct-14	Apr-15	Oct-15	35,084
	Reach H	1,592,000	Oct-13	Apr-14	Oct-14	52,005
6	FISH & WILDLIFE FACILITIES	18,869,000				1,111,404
3--	WILDLIFE FACILITIES & SANCTUARIES					
	Reach B					
	FEDERAL	1,635,000	Apr-13	Apr-13	Oct-13	35,481
	NON-FEDERAL - Section 104					
		14,000	Oct-08	Oct-09	Oct-13	2,977
		150,000	Oct-09	Oct-10	Oct-13	24,273
		78,000	Apr-11	Oct-11	Oct-13	7,901
	Reach C					
	FEDERAL	225,000	Oct-07	Oct-08	Oct-16	98,877
	NON-FEDERAL - Section 104					
		1,139,000	Oct-06	Oct-07	Oct-16	572,367
		498,000	Oct-07	Oct-08	Oct-16	218,848
		64,000	Oct-09	Oct-10	Oct-16	20,559
	Reach E	6,717,000	Apr-15	Nov-15	Oct-15	61,416
	Reach H	8,349,000	Apr-14	Nov-14	Oct-14	68,705
11	LEVEES AND FLOODWALLS	417,350,000				36,556,947
	Reach A	72,593,000	Apr-12	Oct-13	Oct-13	2,270,341
	Reach B					
	FEDERAL	25,077,000	Apr-13	Oct-13	Oct-13	259,298
	NON-FEDERAL - Section 104					
		199,000	Oct-08	Oct-09	Oct-13	42,317
		5,176,000	Oct-09	Oct-10	Oct-13	837,578
		20,913,000	Oct-08	Oct-09	Oct-13	4,447,131
		34,737,000	Apr-11	Oct-11	Oct-13	3,518,872
	Reach C					
	FEDERAL	908,000	Apr-16	Oct-16	Oct-16	9,011
	NON-FEDERAL - Section 104					
		1,611,000	Oct-08	Oct-09	Oct-16	610,627
		85,000	Oct-08	Oct-09	Oct-16	32,218
		2,882,000	Oct-08	Oct-09	Oct-16	1,092,381
		2,881,000	Oct-09	Oct-10	Oct-16	925,469
		1,564,000	Oct-09	Oct-10	Oct-16	502,407
		4,499,000	Oct-09	Oct-10	Oct-16	1,445,223
		4,498,000	Oct-09	Oct-10	Oct-16	1,444,902
		3,308,000	Oct-09	Oct-10	Oct-16	1,062,635
		3,964,000	Oct-09	Oct-10	Oct-16	1,273,364
	Reach D					
	FEDERAL	3,553,000	Apr-16	Nov-16	Oct-16	29,733
	NON-FEDERAL - Section 104					
		3,679,000	Oct-08	Oct-09	Oct-16	1,394,473
		14,272,000	Oct-08	Oct-09	Oct-16	5,409,600
		13,317,000	Oct-08	Oct-09	Oct-16	5,047,621
		5,918,000	Oct-08	Oct-09	Oct-16	2,243,513
		2,154,000	Oct-08	Oct-09	Oct-16	816,443
	Reach E	46,281,000	Apr-15	Nov-15	Oct-15	423,164
	Reach F	48,589,000	Apr-14	Oct-14	Oct-14	502,414
	Reach G	36,763,000	Apr-15	Oct-15	Oct-15	394,595
	Reach H	40,401,000	Apr-14	Nov-14	Oct-14	332,463
	Reach I	17,527,000	Apr-13	Oct-13	Oct-13	189,154

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END USAGE DATE	PLANT DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2010					
13	PUMPING PLANT	56,135,000				684,592
	Reach A	6,003,000	Apr-12	Oct-13	Oct-13	187,743
	Reach B	17,215,000	Apr-13	Oct-13	Oct-13	178,004
	Reach C	21,496,000	Apr-16	Oct-16	Oct-16	213,334
	Reach D	4,207,000	Apr-16	Nov-16	Oct-16	35,206
	Reach G	2,823,000	Apr-15	Oct-15	Oct-15	30,301
	Reach H	2,881,000	Apr-14	Nov-14	Oct-14	23,708
	Reach I	1,510,000	Apr-13	Oct-13	Oct-13	16,296
18	CULTURAL RESOURCE PRES. (NO IDC)	6,578,000				
30	PLANNING, ENGR. & DESIGN	130,834,000				27,545,634
	Reach A					
	FEDERAL					
		124,000	Oct-08	Oct-09	Oct-13	26,368
		488,000	Oct-09	Oct-10	Oct-13	78,968
		10,202,000	Oct-11	Oct-13	Oct-13	434,551
	NON-FEDERAL - Section 104					
		43,000	Oct-06	Oct-07	Oct-13	13,813
		56,000	Oct-07	Oct-08	Oct-13	14,884
		764,000	Oct-08	Oct-09	Oct-13	162,464
		2,486,000	Oct-09	Oct-10	Oct-13	402,283
	Reach B					
	FEDERAL					
		310,000	Oct-08	Oct-09	Oct-13	65,921
		1,220,000	Oct-09	Oct-10	Oct-13	197,420
		7,464,000	Oct-11	Oct-13	Oct-13	325,240
	NON-FEDERAL - Section 104					
		53,000	Oct-05	Oct-06	Oct-13	20,089
		507,000	Oct-06	Oct-07	Oct-13	162,865
		5,620,000	Oct-07	Oct-08	Oct-13	1,493,668
		12,757,000	Oct-08	Oct-09	Oct-13	2,712,765
		13,816,000	Oct-09	Oct-10	Oct-13	2,235,698
		3,155,000	Oct-10	Oct-11	Oct-13	356,895
	Reach C					
	FEDERAL					
		163,000	Oct-08	Oct-09	Oct-16	61,783
		642,000	Oct-09	Oct-10	Oct-16	206,231
		2,685,000	Oct-14	Oct-16	Oct-16	115,744
	NON-FEDERAL - Section 104					
		613,000	Oct-05	Oct-06	Oct-16	348,339
		4,083,000	Oct-06	Oct-07	Oct-16	2,051,778
		9,647,000	Oct-07	Oct-08	Oct-16	4,239,410
		7,137,000	Oct-08	Oct-09	Oct-16	2,705,179
		1,397,000	Oct-09	Oct-10	Oct-16	448,761
	Reach D					
	FEDERAL					
		179,000	Oct-08	Oct-09	Oct-16	67,847
		707,000	Oct-09	Oct-10	Oct-16	227,111
		1,206,000	Oct-14	Nov-16	Oct-16	49,534
	NON-FEDERAL - Section 104					
		839,000	Oct-05	Oct-06	Oct-16	476,764
		1,604,000	Oct-06	Oct-07	Oct-16	805,038
		2,457,000	Oct-07	Oct-09	Oct-16	1,005,616
		3,361,000	Oct-08	Oct-09	Oct-16	1,273,940
		541,000	Oct-09	Oct-10	Oct-16	173,787
	Reach E					
	FEDERAL					
		108,000	Oct-08	Oct-09	Oct-15	34,676
		424,000	Oct-09	Oct-10	Oct-15	112,658
		5,471,000	Oct-13	Nov-15	Oct-15	230,256
	NON-FEDERAL - Section 104					
		193,000	Oct-06	Oct-07	Oct-15	84,798
		1,470,000	Oct-07	Oct-08	Oct-15	557,065
		1,294,000	Oct-08	Oct-09	Oct-15	415,474
		493,000	Oct-09	Oct-10	Oct-15	130,991
	Reach F					
	FEDERAL	5,021,000	Oct-12	Oct-14	Oct-14	218,475
	NON-FEDERAL - Section 104					
		98,000	Oct-06	Oct-07	Oct-14	37,146
		829,000	Oct-07	Oct-08	Oct-14	266,238
		1,116,000	Oct-08	Oct-09	Oct-14	296,524
		697,000	Oct-09	Oct-10	Oct-14	148,216
	Reach G					
	FEDERAL	3,664,000	Oct-13	Oct-15	Oct-15	160,956
	Reach H					
	FEDERAL					

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END USAGE DATE	PLANT DATE	INTEREST DURING CONSTRUCTION
	Effective Price Level (EPL): 1-Oct-2010					
		147,000	Oct-08	Oct-09	Oct-14	39,058
		576,000	Oct-09	Oct-10	Oct-14	122,911
		5,334,000	Oct-12	Nov-14	Oct-14	217,645
	NON-FEDERAL - Section 104					
		3,000	Oct-05	Oct-06	Oct-14	1,318
		101,000	Oct-06	Oct-07	Oct-14	38,283
		1,567,000	Oct-07	Oct-08	Oct-14	503,250
		1,263,000	Oct-08	Oct-09	Oct-14	335,582
		489,000	Oct-09	Oct-10	Oct-14	103,985
	Reach I					
	FEDERAL	2,044,000	Oct-11	Oct-13	Oct-13	90,041
	NON-FEDERAL - Section 104					
		29,000	Oct-05	Oct-06	Oct-13	10,992
		128,000	Oct-06	Oct-07	Oct-13	41,118
		354,000	Oct-07	Oct-08	Oct-13	94,085
		676,000	Oct-08	Oct-09	Oct-13	143,751
		917,000	Oct-09	Oct-10	Oct-13	148,388
31	CONSTRUCTION MANAGEMENT	152,434,000				39,093,807
	Reach A					
	FEDERAL	6,268,000	Apr-12	Oct-13	Oct-13	196,657
	Reach B					
	FEDERAL	3,383,000	Apr-13	Oct-13	Oct-13	34,980
	NON-FEDERAL - Section 104					
		4,000	Oct-06	Oct-07	Oct-13	1,285
		2,000	Oct-07	Oct-08	Oct-13	532
		2,642,000	Oct-08	Oct-09	Oct-13	561,819
		34,125,000	Oct-09	Oct-10	Oct-13	5,522,091
		2,779,000	Apr-11	Oct-11	Oct-13	281,514
	Reach C					
	FEDERAL	1,792,000	Apr-16	Oct-16	Oct-16	17,784
	NON-FEDERAL - Section 104					
		779,000	Oct-06	Oct-07	Oct-16	391,461
		2,675,000	Oct-07	Oct-08	Oct-16	1,175,539
		5,567,000	Oct-08	Oct-09	Oct-16	2,117,674
		27,520,000	Oct-09	Oct-10	Oct-16	6,840,305
	Reach D					
	FEDERAL	621,000	Apr-16	Nov-16	Oct-16	5,197
	NON-FEDERAL - Section 104					
		13,395,000	Oct-06	Oct-07	Oct-16	6,731,220
		9,061,000	Oct-07	Oct-08	Oct-16	3,961,891
		18,143,000	Oct-08	Oct-09	Oct-16	6,876,846
		6,918,000	Oct-09	Oct-10	Oct-16	2,222,283
	Reach E	4,240,000	Apr-15	Nov-15	Oct-15	38,768
	Reach F	3,867,000	Apr-14	Oct-15	Oct-14	13,983
	Reach G	2,939,000	Apr-15	Oct-15	Oct-15	31,546
	Reach H	4,131,000	Apr-14	Nov-14	Oct-14	33,994
	Reach I	1,523,000	Apr-13	Oct-13	Oct-13	16,436
	CASH CONTRIBUTION (-)	87,683,000	Apr-12		Oct-16	9,013,140
	SECTION 104 (-)	55,249,000	Oct-11	Oct-11	Oct-16	13,206,567
	TOTAL FEDERAL COST	**$657,760,000**				**$83,516,003**
	NON-FEDERAL COSTS					
1	LANDS AND DAMAGES	205,338,000				9,538,509
	Reach A					
		369,000	Oct-09	Oct-10	Oct-13	59,711
		19,000	Oct-09	Oct-10	Oct-13	3,075
		6,000	Oct-09	Oct-10	Oct-13	971
		23,000	Oct-09	Oct-10	Oct-13	3,722
		28,542,000	Oct-11	Apr-12	Oct-13	2,221,872
	Reach B					
		1,869,000	Oct-09	Oct-10	Oct-13	302,441
		849,000	Oct-09	Oct-10	Oct-13	137,385
		283,000	Oct-09	Oct-10	Oct-13	45,795
		12,000	Oct-09	Oct-10	Oct-13	1,942
		490,000	Oct-09	Oct-10	Oct-13	79,292
		51,574,000	Oct-12	Apr-13	Oct-13	1,684,744
	Reach C					
		1,014,000	Oct-09	Oct-10	Oct-16	325,729
		578,000	Oct-09	Oct-10	Oct-16	185,672
		193,000	Oct-09	Oct-10	Oct-16	61,998
		213,000	Oct-09	Oct-10	Oct-16	68,422
		13,183,000	Oct-15	Apr-16	Oct-16	431,442

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END USAGE DATE	PLANT DATE	INTEREST DURING CONSTRUCTION
		Effective Price Level (EPL): 1-Oct-2010				
	Reach D					
		515,000	Oct-09	Oct-10	Oct-16	165,434
		306,000	Oct-09	Oct-10	Oct-16	98,297
		102,000	Oct-09	Oct-10	Oct-16	32,766
		7,000	Oct-09	Oct-10	Oct-16	2,249
		91,000	Oct-09	Oct-10	Oct-16	29,232
		4,144,000	Oct-15	Apr-16	Oct-16	135,621
	Reach E					
		195,000	Oct-09	Oct-10	Oct-15	51,812
		61,000	Oct-09	Oct-10	Oct-15	16,208
		20,000	Oct-09	Oct-10	Oct-15	5,314
		102,000	Oct-09	Oct-10	Oct-15	27,102
		32,873,000	Oct-14	Apr-15	Oct-15	1,073,847
	Reach F					
		82,000	Oct-09	Oct-10	Oct-14	17,437
		7,000	Oct-09	Oct-10	Oct-14	1,489
		2,000	Oct-09	Oct-10	Oct-14	425
		1,000	Oct-09	Oct-10	Oct-14	213
		7,000	Oct-09	Oct-10	Oct-14	1,489
		13,668,000	Oct-13	Apr-14	Oct-14	446,486
	Reach G	18,340,000	Oct-14	Apr-15	Oct-15	599,104
	Reach H					
		140,000	Oct-09	Oct-10	Oct-14	29,771
		21,000	Oct-09	Oct-10	Oct-14	4,466
		7,000	Oct-09	Oct-10	Oct-14	1,489
		47,000	Oct-09	Oct-10	Oct-14	9,995
		31,790,000	Oct-13	Apr-14	Oct-14	1,038,469
	Reach I					
		70,000	Oct-09	Oct-10	Oct-13	11,327
		15,000	Oct-09	Oct-10	Oct-13	2,427
		5,000	Oct-09	Oct-10	Oct-13	809
		51,000	Oct-09	Oct-10	Oct-13	8,253
		3,452,000	Oct-12	Apr-13	Oct-13	112,765
2	RELOCATIONS	127,700,000				5,133,696
	Constr. Activities	127,700,000				5,133,696
3--	CEMETERIES, UTILITIES, & STRUCTURES					
	Reach A	13,608,000	Apr-12	Oct-13	Oct-13	425,589
	Reach B					
		512,000	Oct-09	Oct-09	Oct-13	95,725
		1,766,000	Oct-09	Oct-09	Oct-13	330,175
		1,206,000	Oct-09	Oct-09	Oct-13	225,476
		318,000	Oct-09	Oct-09	Oct-13	59,454
		2,000	Oct-09	Oct-09	Oct-13	374
		5,000	Oct-09	Oct-09	Oct-13	935
		22,309,000	Apr-13	Apr-13	Oct-13	484,123
	Reach C					
		603,000	Oct-08	Oct-09	Oct-16	228,559
		32,000	Oct-09	Oct-10	Oct-16	10,279
		129,000	Oct-08	Oct-09	Oct-16	48,896
		514,000	Oct-09	Oct-10	Oct-16	165,113
		789,000	Oct-09	Oct-10	Oct-16	253,452
		262,000	Oct-09	Oct-10	Oct-16	84,163
		14,000	Oct-08	Oct-09	Oct-16	5,307
		833,000	Oct-09	Oct-10	Oct-16	267,586
		6,000	Oct-08	Oct-09	Oct-16	2,274
		1,910,000	Oct-09	Oct-10	Oct-16	613,553
		8,059,000	Apr-16	Oct-16	Oct-16	79,960
	Reach D					
		220,000	Oct-08	Oct-09	Oct-16	83,388
		778,000	Oct-08	Oct-09	Oct-16	294,890
		562,000	Oct-08	Oct-09	Oct-16	213,018
		1,263,000	Oct-08	Oct-09	Oct-16	478,722
		11,077,000	Apr-16	Nov-16	Oct-16	92,697
	Reach E	16,050,000	Apr-15	Nov-15	Oct-15	148,751
	Reach F	15,419,000	Apr-14	Oct-14	Oct-14	159,434
	Reach G	13,290,000	Apr-15	Oct-15	Oct-15	142,648
	Reach H	12,996,000	Apr-14	Nov-14	Oct-14	106,945
	Reach I	3,168,000	Apr-13	Oct-13	Oct-13	34,190
	SECTION 215	311,069,000				66,126,418
		311,069,000	Apr-12	Apr-12	Oct-16	66,126,418
30	PLANNING, ENGR. & DESIGN	21,630,000				3,133,148
		3,000	Oct-09	Oct-10	Oct-13	485
		2,042,000	Oct-11	Oct-13	Oct-13	86,978
		406,000	Oct-07	Oct-08	Oct-13	107,906

DETAILED ESTIMATE OF INTEREST DURING CONSTRUCTION(CONT'ED)

ACCOUNT NUMBER	DESCRIPTION	AMOUNT ($)	CONTRACT START DATE	CONTRACT END USAGE DATE	PLANT DATE	INTEREST DURING CONSTRUCTION
		Effective Price Level (EPL): 1-Oct-2010				
		1,444,000	Oct-08	Oct-09	Oct-13	307,065
		2,240,000	Oct-09	Oct-10	Oct-13	362,476
		966,000	Oct-11	Oct-13	Oct-13	42,093
		211,000	Oct-05	Oct-06	Oct-16	119,901
		697,000	Oct-06	Oct-07	Oct-16	350,255
		1,073,000	Oct-07	Oct-08	Oct-16	471,534
		1,214,000	Oct-08	Oct-09	Oct-16	460,150
		701,000	Oct-09	Oct-10	Oct-16	225,184
		967,000	Oct-14	Oct-16	Oct-16	41,685
		170,000	Oct-08	Oct-09	Oct-16	64,436
		102,000	Oct-09	Oct-10	Oct-16	32,766
		1,185,000	Oct-13	Oct-15	Oct-16	106,326
	Reach E	2,408,000	Oct-13	Nov-15	Oct-15	101,345
	Reach F	1,850,000	Oct-12	Oct-14	Oct-14	80,498
		8,000	Oct-09	Oct-10	Oct-15	2,126
		1,993,000	Oct-13	Oct-15	Oct-15	87,551
		5,000	Oct-09	Oct-10	Oct-14	1,063
		1,559,000	Oct-12	Nov-14	Oct-14	63,612
		6,000	Oct-09	Oct-10	Oct-13	971
		380,000	Oct-11	Oct-13	Oct-13	16,740
31	CONSTRUCTION MANAGEMENT	8,740,000				360,783
	Reach A	1,089,000	Apr-12	Oct-13	Oct-13	34,058
		74,000	Oct-08	Oct-09	Oct-13	15,736
		456,000	Oct-09	Oct-10	Oct-13	73,790
		516,000	Apr-11	Oct-11	Oct-13	52,271
		22,000	Oct-08	Oct-09	Oct-16	8,339
		8,000	Oct-09	Oct-10	Oct-16	2,570
		645,000	Apr-16	Oct-16	Oct-16	6,401
		790,000	Apr-16	Nov-16	Oct-16	6,611
	Reach E	1,284,000	Apr-15	Nov-15	Oct-16	68,177
	Reach F	1,234,000	Apr-14	Oct-14	Oct-15	67,277
	Reach G	1,329,000	Apr-15	Oct-15	Oct-15	14,265
	Reach H	1,040,000	Apr-14	Nov-14	Oct-14	8,558
	Reach I	253,000	Apr-13	Oct-13	Oct-13	2,730
	CASH CONTRIBUTION (+)	87,683,000	Apr-12		Oct-16	9,013,140
	SECTION 104 (-)	255,820,000	Apr-12	Apr-12	Oct-16	54,381,697
	TOTAL NON-FEDERAL	**$506,340,000**				**$81,560,973**
	TOTAL	**$1,164,100,000**				**$165,076,976**

DETAILED ESTIMATE OF M & O COSTS & REPLACEMENT COSTS

Price level %Increase	1.00	1.5083	Factor
Price Level of M&O costs	Oct-10	2620	
Effective Price Date (EPD)	Oct-10	2620	

ACCOUNT NUMBER	ITEM	ANNUAL COST ($)	FACTOR (%)	M&O COST ($)	PROJECT LIFE YRS	ITEM LIFE YRS	FACTOR (%)	REPLACEMENT COST ($)
			Effective Price Level (EPL): 1-Oct-2010					
02---	Relocations							
	Reach A, Pumps	100000	1.5	150625				
	Reach B, Pumps	150000	1.5	225938				
	Reach C, Pumps	75000	1.5	112969				
	Reach D, Pumps	100000	1.5	150625				
	Reach E, Pumps	35000	1.5	52719				
	Reach G, Pumps	35000	1.5	52719				
	Reach H, Pumps	70000	1.5	105438				
	Reach I, Pumps	35000	1.5	52719				
	Reach A, Drainage Swale and Storm Drainage I	7500	1.5	11297				
	Reach B, Drainage Swale and Storm Drainage I	12500	1.5	18828				
	Reach C, Drainage Swale and Storm Drainage I	12500	1.5	18828				
	Relocations			952703				0
06---	Fish & Wildlife Facil.							
	Reach A	13137	1.5	19788				
	Reach B	39370	1.5	59301				
	Reach C	26683	1.5	40191				
	Reach D	6808	1.5	10255				
	Reach E	11852	1.5	17852				
	Reach F	1773	1.5	2671				
	Reach G	1346	1.5	2027				
	Reach H	2362	1.5	3558				
	Reach I	2698	1.5	4064				
	Fish & Wildlife Facil.			159706				0
11---	Levees							
	Reach A	265000	1.5	399156				
	Reach B	610000	1.5	918813				
	Reach C	325000	1.5	489531				
	Reach D	300000	1.5	451875				
	Reach E	100000	1.5	150625				
	Reach F	150000	1.5	225938				
	Reach G	100000	1.5	150625				
	Reach H	150000	1.5	225938				
	Reach I	100000	1.5	150625				
	Levees			3163125				0
13---	Pumping Plants							
	Reach A, Pumps	100000	1.5	150625				
	Reach B, Pumps	150000	1.5	225938				
	Reach C, Pumps	75000	1.5	112969				
	Reach D, Pumps	100000	1.5	150625				
	Reach E, Pumps	35000	1.5	52719				
	Reach G, Pumps	35000	1.5	52719				
	Reach H, Pumps	70000	1.5	105438				
	Reach I, Pumps	35000	1.5	52719				
	Pumping Plants			903750				0
	SUMMARY							
02---	Relocations			952703				0
06---	Fish & Wildlife Facil.			159706				0
11---	Levees			3163125				0
13---	Pumping Plants			903750				0
	TOTAL			**$5,179,284**				**$0**

PROJECT: NATOMAS PACR, NED PLAN
LOCATION: CALIFORNIA
PROJECT COST ESTIMATE(PCE) SUMMARY

DATE PREPARED: 25-Aug-2010
PRICE LEVEL: 1-Oct-2010

CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)		SUNK COST THRU 30-Sep-2010	FIRST COST: PREVIOUS 1-Oct-2009	FIRST COST: COST CHANGES		FIRST COST: CURRENT				FULLY FUNDED (3: PREVIOUS 1-Oct-2009	CHANGE IN INFLAT - ION	FULLY FUNDED (3: CURRENT		
					PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN- GENCY	COST EST 5+6+7	EST		DIRECT COST	CONTIN- GENCY	COST EST 12+6+7+13
(1)	(2)	(3)	AMOUNT (4)($K)	COST EST (5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	FEDERAL														
1	LANDS AND DAMAGES, Admin		0	0	0	4127	3590		537	4127	0	463	3993	597	4590
1	LANDS AND DAMAGES, Real Estate		0	0	0	14365	10301		4064	14365	0	671	10769	4267	15036
6	FISH AND WILDLIFE FACILITIES		1865	0	0	18869	15175		3694	18869	0	1072	15996	3945	19941
11	LEVEES AND FLOODWALLS		79451	0	0	388083	313225		74858	388083	0	15739	325017	78805	403822
13	PUMPING PLANT		0	0	0	56135	42044		14091	56135	0	3775	44793	15117	59910
18	CULTURAL RESOURCES PRESERV.		0	0	0	6578	5660		918	6578	0	261	5885	954	6839
30	PLANNING/ENGINEERING/DESIGN		84588	0	0	129097	123807		5290	129097	0	4640	127870	5867	133737
31	CONSTRUCTION MANAGEMENT		120851	0	0	151033	143678		7355	151033	0	4113	146740	8406	155146
	TOTAL COST (FEDERAL FUNDS & NON-FEDERAL CASH CONTRIBUTION)		286755	0	0	768287	657460		110807	768287	0	30734	681063	117958	799021
	NON-FEDERAL CASH CONTRIBUTION (-)		3077	0	29	55249	45741		9537	55278	0	2340	47521	10097	57618
	SECTION 104 (-)		253974	0	0	55249	45741		9508	55249	0	2354	47521	10082	57603
	TOTAL FEDERAL COST		**29704**	**0**	**-29**	**657789**	**565998**		**91762**	**657760**	**0**	**26040**	**586021**	**97779**	**683800**
	NON-FEDERAL COST														
1	LANDS AND DAMAGES		7772	0	0	205338	155431		49907	205338	0	9304	162311	52331	214642
2	RELOCATIONS		9066	0	0	110766	85183		25583	110766	0	6280	89786	27260	117046
	SECTION 104		281665	0	0	311069	305202		5867	311069	0	236	305391	5914	311305
30	PLANNING/ENGINEERING/DESIGN		8280	0	0	19614	16670		2944	19614	0	573	17088	3099	20187
31	CONSTRUCTION MANAGEMENT		560	0	0	7555	5723		1832	7555	0	449	6050	1954	8004
	TOTAL NON-FEDERAL LERRD		307343	0	0	654342	568209		86133	654342	0	16842	580626	90558	671184
	NON-FEDERAL CASH CONTRIBUTION (+)		3077	0	29	55249	45741		9537	55278	0	2340	47521	10097	57618
	SECTION 104 (-), Remaining Allowable		27691	0	0	255820	259461		-3641	255820	0	-2118	257870	-4168	253702
	TOTAL NON-FEDERAL COST		**282729**	**0**	**29**	**453771**	**354489**		**99311**	**453800**	**0**	**21300**	**370277**	**104823**	**475100**
	TOTAL NED COST		**312433**	**0**	**0**	**1111560**	**920487**		**191073**	**1111560**	**0**	**47340**	**956298**	**202602**	**1158900**
	SUMMARY OF ESTIMATED COSTS														
	FEDERAL COST (CORPS OF ENGINEERS)		29704	0	-29	657789	565998		91762	657760	0	26040	586021	97779	683800
	REQUIRED NON-FEDERAL COST (+)		282729	0	29	453771	354489		99311	453800	0	21300	370277	104823	475100
	CASH CONTRIBUTION		3077	0	29	55249	45741		9537	55278	0	2340	47521	10097	57618

PROJECT: NATOMAS PACR, NED PLAN
LOCATION: CALIFORNIA
PROJECT COST ESTIMATE(PCE) SUMMARY

DATE PREPARED: 25-Aug-2010
PRICE LEVEL: 1-Oct-2010

CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	(3)	SUNK COST THRU 30-Sep-2010	FIRST COST						FULLY FUNDED (3				
				PREVIOUS 1-Oct-2009	COST CHANGES		CURRENT				PREVIOUS 1-Oct-2009	CHANGE IN	CURRENT		
			AMOUNT	COST EST	PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN-GENCY	COST EST 5+6+7	EST	INFLAT - ION	DIRECT COST	CONTIN-GENCY	COST EST 12+6+7+13
(1)	(2)		(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	OTHER COSTS		279652	0	0	398522	308748		89774	398522	0	18960	322756	94726	417482
	TOTAL FEDERAL AND REQUIRED NON-FEDERAL COSTS		**312433**	**0**	**0**	**1111560**	**920487**		**191073**	**1111560**	**0**	**47340**	**956298**	**202602**	**1158900**
	PROJECT EXECUTIVE SUMMARY														
1	LANDS AND DAMAGES		7772	0	0	223830	169322		54508	223830	0	10438	177073	57195	234268
2	RELOCATIONS		9066	0	0	110766	85183		25583	110766	0	6280	89786	27260	117046
6	FISH AND WILDLIFE FACILITIES		1865	0	0	18869	15175		3694	18869	0	1072	15996	3945	19941
11	LEVEES AND FLOODWALLS		79451	0	0	388083	313225		74858	388083	0	15739	325017	78805	403822
13	PUMPING PLANT		0	0	0	56135	42044		14091	56135	0	3775	44793	15117	59910
18	CULTURAL RESOURCES PRESERV.		0	0	0	6578	5660		918	6578	0	261	5885	954	6839
30	PLANNING, ENGINEERING AND DESIGN		92868	0	0	148711	140477		8234	148711	0	5213	144958	8966	153924
31	CONSTRUCTION MANAGEMENT		121411	0	0	158588	149401		9187	158588	0	4562	152790	10360	163150
	TOTAL NED COST		**312433**	**0**	**0**	**1111560**	**920487**		**191073**	**1111560**	**0**	**47340**	**956298**	**202602**	**1158900**
	FEDERAL COST		**29704**	**0**	**-29**	**657789**	**565998**		**91762**	**657760**	**0**	**26040**	**586021**	**97779**	**683800**
	NON-FEDERAL COST		**282729**	**0**	**29**	**453771**	**354489**		**99311**	**453800**	**0**	**21300**	**370277**	**104823**	**475100**

PROJECT: NATOMAS PACR, NED PLAN
LOCATION: CALIFORNIA
PROJECT COST ESTIMATE(PCE)

DATE PREPARED: 25-Aug-2010
PRICE LEVEL: 1-Oct-2010

CODE: 0 - no esc. applied, A - for administration, C - for combined indexes, All other Codes used coincides with the Code of Accounts.

CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	CODE	SUNK COST THRU 30-Sep-2010 AMOUNT	PREVIOUS 1-Oct-2009 COST EST	FIRST COST: COST CHANGES PRICE LEVEL	FIRST COST: COST CHANGES OTHER (SEE NOTE)	FIRST COST: CURRENT DIRECT COST	FIRST COST: CURRENT CONT RATE	FIRST COST: CURRENT CONTIN-GENCY	FIRST COST: CURRENT COST EST 5+6+7	FULLY FUNDED (3: PREVIOUS 1-Oct-2009 EST	FULLY FUNDED (3: CHANGE IN INFLAT - ION	FULLY FUNDED (3: CURRENT DIRECT COST	FULLY FUNDED (3: CURRENT CONTIN-GENCY	FULLY FUNDED (3: CURRENT COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	FEDERAL															
1	LANDS AND DAMAGES, Admin.	(2		0	0	0	4127	3590	0	537	4127	0	463	3993	597	4590
	Reach A		A	0	0	0	765	666	14.95	99	765	0	30	692	103	795
			A	**Expenditure Allocations** FY2012		**Start** 1-Oct-2011	**End** 2-Apr-2012	**Midpoint** 1-Jan-2012	**Period(YRS)** 1.25	**Expend.** 765				**Inflation Amt** 30	**Fully Funded** 795	
	Reach B		A	0	0	0	945	821	15.1	124	945	0	72	884	133	1017
			A	**Expenditure Allocations** FY2013		**Start** 1-Oct-2012	**End** 1-Apr-2013	**Midpoint** 31-Dec-2012	**Period(YRS)** 2.25	**Expend.** 945				**Inflation Amt** 72	**Fully Funded** 1017	
	Reach C		A	0	0	0	295	256	15.1	39	295	0	66	314	47	361
			A	**Expenditure Allocations** FY2016		**Start** 1-Oct-2015	**End** 1-Apr-2016	**Midpoint** 31-Dec-2015	**Period(YRS)** 5.25	**Expend.** 295				**Inflation Amt** 66	**Fully Funded** 361	
	Reach D		A	0	0	0	98	85	15	13	98	0	22	104	16	120
			A	**Expenditure Allocations** FY2016		**Start** 1-Oct-2015	**End** 1-Apr-2016	**Midpoint** 31-Dec-2015	**Period(YRS)** 5.25	**Expend.** 98				**Inflation Amt** 22	**Fully Funded** 120	
	Reach E		A	0	0	0	397	346	14.9	51	397	0	68	405	60	465
			A	**Expenditure Allocations** FY2015		**Start** 1-Oct-2014	**End** 1-Apr-2015	**Midpoint** 31-Dec-2014	**Period(YRS)** 4.25	**Expend.** 397				**Inflation Amt** 68	**Fully Funded** 465	
	Reach F		A	0	0	0	321	279	14.9	42	321	0	40	314	47	361
			A	**Expenditure Allocations** FY2014		**Start** 1-Oct-2013	**End** 1-Apr-2014	**Midpoint** 31-Dec-2013	**Period(YRS)** 3.25	**Expend.** 321				**Inflation Amt** 40	**Fully Funded** 361	
	Reach G		A	0	0	0	241	210	14.9	31	241	0	42	246	37	283
			A	**Expenditure Allocations** FY2015		**Start** 1-Oct-2014	**End** 1-Apr-2015	**Midpoint** 31-Dec-2014	**Period(YRS)** 4.25	**Expend.** 241				**Inflation Amt** 42	**Fully Funded** 283	
	Reach H		A	0	0	0	902	785	14.9	117	902	0	111	882	131	1013
			A	**Expenditure Allocations** FY2014		**Start** 1-Oct-2013	**End** 1-Apr-2014	**Midpoint** 31-Dec-2013	**Period(YRS)** 3.25	**Expend.** 902				**Inflation Amt** 111	**Fully Funded** 1013	
	Reach I		A	0	0	0	163	142	14.9	21	163	0	12	152	23	175
			A	**Expenditure Allocations** FY2013		**Start** 1-Oct-2012	**End** 1-Apr-2013	**Midpoint** 31-Dec-2012	**Period(YRS)** 2.25	**Expend.** 163				**Inflation Amt** 12	**Fully Funded** 175	

PROJECT: NATOMAS PACR, NED PLAN — DATE PREPARED: 25-Aug-2010

LOCATION: CALIFORNIA — PRICE LEVEL: 1-Oct-2010

PROJECT COST ESTIMATE(PCE)

CODE: 0 - no esc. applied, A - for administration, C - for combined indexes, All other Codes used coincides with the Code of Accounts.

CODE OF ACCT. NO. (1)	FEATURE/SUBFEATURE (NOTE) (2)	NOTES	COD E (3)	SUNK COST THRU 30-Sep-2010 AMOUNT (4)($K)	PREVIOUS 1-Oct-2009 COST EST (5)($K)	FIRST COST COST CHANGES PRICE LEVEL (6)($K)	FIRST COST COST CHANGES OTHER (SEE NOTE) (7)($K)	FIRST COST CURRENT DIRECT COST (8)($K)	FIRST COST CURRENT CONT RATE (9)(%)	FIRST COST CURRENT CONTIN-GENCY (10)($K)	FIRST COST CURRENT COST EST 5+6+7 (11)($K)	FULLY FUNDED (3 PREVIOUS 1-Oct-2009 EST (12)($K)	CHANGE IN INFLAT - ION (13)($K)	FULLY FUNDED (3 CURRENT DIRECT COST (14)($K)	FULLY FUNDED (3 CURRENT CONTIN-GENCY (15)($K)	FULLY FUNDED (3 CURRENT COST EST 12+6+7+13 (16)($K)
1	LANDS AND DAMAGES, Real Estate			0	0	0	14365	10301	0	4064	14365	0	671	10769	4267	15036
	Reach A		C	0	0	0	2,312	1792	29	520	2312	0	35	1819	528	2347
			C	**Expenditure Allocations** FY2012		**Start** 1-Oct-2011	**End** 2-Apr-2012	**Midpoint** 1-Jan-2012	**Period(YRS)** 1.25	**Expend.** 2312				**Inflation Amt** 35	**Fully Funded** 2347	
	Reach B		C	0	0	0	5,848	4147	41.01	1701	5848	0	185	4278	1755	6033
			C	**Expenditure Allocations** FY2013		**Start** 1-Oct-2012	**End** 1-Apr-2013	**Midpoint** 31-Dec-2012	**Period(YRS)** 2.25	**Expend.** 5848				**Inflation Amt** 185	**Fully Funded** 6033	
	Reach C		C	0	0	0	1,027	709	44.9	318	1027	0	87	769	345	1114
			C	**Expenditure Allocations** FY2016		**Start** 1-Oct-2015	**End** 1-Apr-2016	**Midpoint** 31-Dec-2015	**Period(YRS)** 5.25	**Expend.** 1027				**Inflation Amt** 87	**Fully Funded** 1114	
	Reach D		C	0	0	0	2,512	1580	59	932	2512	0	214	1714	1012	2726
			C	**Expenditure Allocations** FY2016		**Start** 1-Oct-2015	**End** 1-Apr-2016	**Midpoint** 31-Dec-2015	**Period(YRS)** 5.25	**Expend.** 2512				**Inflation Amt** 214	**Fully Funded** 2726	
	Reach E		C	0	0	0	1,074	790	36	284	1074	0	72	843	303	1146
			C	**Expenditure Allocations** FY2015		**Start** 1-Oct-2014	**End** 1-Apr-2015	**Midpoint** 31-Dec-2014	**Period(YRS)** 4.25	**Expend.** 1074				**Inflation Amt** 72	**Fully Funded** 1146	
	Reach H		C	0	0	0	1,592	1283	24.1	309	1592	0	78	1346	324	1670
			C	**Expenditure Allocations** FY2014		**Start** 1-Oct-2013	**End** 1-Apr-2014	**Midpoint** 31-Dec-2013	**Period(YRS)** 3.25	**Expend.** 1592				**Inflation Amt** 78	**Fully Funded** 1670	
6	FISH & WILDLIFE FACILITIES		6	1865	0	0	18869	15175		3694	18869	0	1072	15996	3945	19941
	Reach B		6	164	0	0	1877	1862		15	1877	0	80	1922	15	1937
	FEDERAL		6	0	0	0	1,635	1635	0	0	1635	0	59	1694	0	1694
			6	**Expenditure Allocations** FY2013		**Start** 1-Apr-2013	**End** 1-Apr-2013	**Midpoint** 1-Apr-2013	**Period(YRS)** 2.50	**Expend.** 1635				**Inflation Amt** 59	**Fully Funded** 1694	
	NON-FEDERAL - Section 104		6	164	0	0	242	227	24	15	242	0	1	228	15	243
			6	**Expenditure Allocations** FY2009		**Start** 1-Oct-2008	**End** 1-Oct-2009	**Midpoint** 1-Apr-2009	**Period(YRS)** 0.00	**Expend.** 14				**Inflation Amt** 0	**Fully Funded** 14	
			6	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	150				0	150	
			6	FY2011		1-Apr-2011	1-Oct-2011	1-Jul-2011	0.75	78				1	79	
	Reach C		6	1701	0	0	1926	1926		0	1926	0	0	1926	0	1926
	FEDERAL		O	0	0	0	225	225	0	0	225	0	0	225	0	225
			O	**Expenditure Allocations** FY2016		**Start** 1-Apr-2016	**End** 1-Apr-2016	**Midpoint** 1-Apr-2016	**Period(YRS)** 5.50	**Expend.** 225				**Inflation Amt** 0	**Fully Funded** 225	

PROJECT: NATOMAS PACR, NED PLAN — **DATE PREPARED: 25-Aug-2010**

LOCATION: CALIFORNIA — **PRICE LEVEL: 1-Oct-2010**

PROJECT COST ESTIMATE(PCE) — CODE: 0 - no esc. applied, A - for administration, C - for combined indexes, All other Codes used coincides with the Code of Accounts.

CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COD E	SUNK COST THRU 30-Sep-2010	PREVIOUS 1-Oct-2009	COST CHANGES		FIRST COST	CURRENT			PREVIOUS 1-Oct-2009	CHANGE IN	FULLY FUNDED (3 CURRENT		
				AMOUNT	COST EST	PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN-GENCY	COST EST 5+6+7	EST	INFLAT - ION	DIRECT COST	CONTIN-GENCY	COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	NON-FEDERAL - Section 104		6	1701	0	0	1,701	1701	0	0	1701	0	0	1701	0	1701
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			6	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	1139				0	1139	
			6	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	498				0	498	
			6	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	64				0	64	
	Reach E		6	0	0	0	6,717	4907	36.9	1810	6717	0	516	5283	1950	7233
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			6	FY2015		1-Apr-2015	3-Nov-2015	18-Jul-2015	4.80	6717				516	7233	
	Reach H		6	0	0	0	8,349	6480	28.84	1869	8349	0	496	6865	1980	8845
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			6	FY2014		1-Apr-2014	27-Nov-2014	30-Jul-2014	3.83	8349				496	8845	
11	LEVEES & FLOODWALLS		11	79451	0	0	388083	313225		74858	388083	0	15739	325017	78805	403822
	Reach A		11	0	0	0	72,593	55084	31.785	17509	72593	0	2337	56858	18072	74930
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2013		2-Apr-2012	26-Oct-2013	13-Jan-2013	2.29	72593				2337	74930	
	Reach B		11	23163	0	0	73284	63286		9998	73284	0	1284	64320	10248	74568
	FEDERAL		11	0	0	0	25,077	20245	23.87	4832	25077	0	1078	21115	5040	26155
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2013		1-Apr-2013	9-Oct-2013	5-Jul-2013	2.76	25077				1078	26155	
	NON-FEDERAL - Section 104		11	23163	0	0	48,207	43041	25.988	5166	48207	0	206	43205	5208	48413
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Demo, Structure Demo, Tree Removal, Contract 4047 May 2010 Sep 31 2010 FY10 Complete		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	199				0	199	
	GGS Drainage Canal, Schoolhouse Rd Pipeline & Teal Bend Pipeline, Contract 4046 May 2010 Sep 31 2010 FY10 Complete		11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	5176				0	5176	
	Levees, Contract 4046 May 2010 May 2010 Sep 31 2010 FY10 Complete		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	17788				0	17788	
			11	FY2011		1-Apr-2011	1-Oct-2011	1-Jul-2011	0.75	25044				206	25250	
	Reach C		11	21321	0	0	22229	21972		257	22229	0	86	22034	281	22315
	FEDERAL		11	0	0	0	908	651	39.5	257	908	0	86	713	281	994
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2016		1-Apr-2016	17-Oct-2016	9-Jul-2016	5.78	908				86	994	

PROJECT: NATOMAS PACR, NED PLAN — DATE PREPARED: 25-Aug-2010
LOCATION: CALIFORNIA — PRICE LEVEL: 1-Oct-2010
PROJECT COST ESTIMATE(PCE)

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COD E	SUNK COST THRU 30-Sep-2010 AMOUNT ($K)	SUNK COST THRU 30-Sep-2010 COST EST ($K)	FIRST COST: PREVIOUS 1-Oct-2009 COST EST ($K)	FIRST COST: COST CHANGES PRICE LEVEL ($K)	FIRST COST: COST CHANGES OTHER (SEE NOTE) ($K)	CURRENT: DIRECT COST ($K)	CURRENT: CONT RATE (%)	CURRENT: CONTIN-GENCY ($K)	CURRENT: COST EST 5+6+7 ($K)	FULLY FUNDED (3: PREVIOUS 1-Oct-2009 EST ($K)	CHANGE IN INFLAT-ION ($K)	FULLY FUNDED (3: CURRENT DIRECT COST ($K)	FULLY FUNDED (3: CURRENT CONTIN-GENCY ($K)	FULLY FUNDED (3: CURRENT COST EST 12+6+7+13 ($K)
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	
	NON-FEDERAL - Section 104		11	21321	0	0	21321	21321	0	0	21321	0	0	21321	0	21321	
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Levees, Contract 3980 5/09 -7/10 95% in FY09		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1189				0	1189	
	Levees, Contract 4032 8/15/09 - 9/30/10		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	63				0	63	
	Levees, Borrow Sites, Contract 4032 8/15/09 - 9/30/10		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	2568				0	2568	
	Levees, Contract 3980 5% in FY10		11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2568				0	2568	
	Levees, Contract 4032 8/15/09 - 9/30/10		11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1407				0	1407	
	Levees_2, Contract 4032 5/1/10 - 9/30/10		11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	3537				0	3537	
	Levees, Borrow Sites, Contract 4032 8/15/09 - 9/30/10		11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	3537				0	3537	
	Levees, Contract 4046 (portion within Reach C) May 2010 Sep 31 2010 FY10 Complete		11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2488				0	2488	
	Levees, Borrow Sites, Contract 4046 (for portion supplying borrow to Reach C) May 2010 Sep 31 2010 FY10 Complete		11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	3964				0	3964	
	Reach D		11	34967	0	0	38221	37232		989	38221	0	311	37449	1083	38532
	FEDERAL		11	0	0	0	3,254	2265	43.65	989	3254	0	311	2482	1083	3565
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2016		1-Apr-2016	23-Nov-2016	28-Jul-2016	5.83	3254				311	3565	
	NON-FEDERAL - Section 104		11	34967	0	0	34,967	34967	0	0	34967	0	0	34967	0	34967
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Levees, C4006		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	3111				0	3111	
	Levees, C3947		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	13835				0	13835	
	Levees, C3960		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	12876				0	12876	
	Levees, Borrow Sites, C3980		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	3289				0	3289	
	Levees, C4046		11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1856				0	1856	
	Reach E		11	0	0	0	42,307	30569	38.4	11738	42307	0	3249	32916	12640	45556
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2015		1-Apr-2015	3-Nov-2015	18-Jul-2015	4.80	42307				3249	45556	
	Reach F		11	0	0	0	46,506	35245	31.95	11261	46506	0	2706	37296	11916	49212
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2014		1-Apr-2014	9-Oct-2014	5-Jul-2014	3.76	46506				2706	49212	
	Reach G		11	0	0	0	35,015	25543	37.08	9472	35015	0	2661	27485	10191	37676
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2015		1-Apr-2015	2-Oct-2015	2-Jul-2015	4.75	35015				2661	37676	
	Reach H		11	0	0	0	40,401	30435	32.745	9966	40401	0	2399	32242	10558	42800

PROJECT: NATOMAS PACR, NED PLAN — **DATE PREPARED: 25-Aug-2010**

LOCATION: CALIFORNIA — **PRICE LEVEL: 1-Oct-2010**

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CODE OF ACCT. NO. (1)	FEATURE/SUBFEATURE (NOTE) (2)	NOTES	COD E (3)	SUNK COST THRU 30-Sep-2010 AMOUNT (4)($K)	SUNK COST THRU 30-Sep-2010 COST EST (5)($K)	FIRST COST PREVIOUS 1-Oct-2009	COST CHANGES PRICE LEVEL (6)($K)	COST CHANGES OTHER (SEE NOTE) (7)($K)	FIRST COST CURRENT DIRECT COST (8)($K)	CURRENT CONT RATE (9)(%)	CURRENT CONTIN-GENCY (10)($K)	CURRENT COST EST 5+6+7 (11)($K)	FULLY FUNDED (3 PREVIOUS 1-Oct-2009 EST (12)($K)	CHANGE IN INFLAT - ION (13)($K)	FULLY FUNDED (3 CURRENT DIRECT COST (14)($K)	FULLY FUNDED (3 CURRENT CONTIN-GENCY (15)($K)	FULLY FUNDED (3 CURRENT COST EST 12+6+7+13 (16)($K)
			11	**Expenditure Allocations** FY2014			**Start** 1-Apr-2014	**End** 27-Nov-2014	**Midpoint** 30-Jul-2014	**Period(YRS)** 3.83	**Expend.** 40401				**Inflation Amt** 2399	**Fully Funded** 42800	
	Reach I		11	0	0	0	17,527	13859	26.47	3668	17527	0	706	14417	3816	18233	
			11	**Expenditure Allocations** FY2013			**Start** 1-Apr-2013	**End** 1-Oct-2013	**Midpoint** 1-Jul-2013	**Period(YRS)** 2.75	**Expend.** 17527				**Inflation Amt** 706	**Fully Funded** 18233	
13	PUMPING PLANT		13	0	0	0	56135	42044			14091	56135	0	3775	44793	15117	59910
	Reach A		13	0	0	0	6,003	4818	24.59	1185	6003	0	193	4973	1223	6196	
			13	**Expenditure Allocations** FY2013			**Start** 2-Apr-2012	**End** 26-Oct-2013	**Midpoint** 13-Jan-2013	**Period(YRS)** 2.29	**Expend.** 6003				**Inflation Amt** 193	**Fully Funded** 6196	
	Reach B		13	0	0	0	17,215	13840	24.39	3375	17215	0	697	14400	3512	17912	
			13	**Expenditure Allocations** FY2013			**Start** 1-Apr-2013	**End** 9-Oct-2013	**Midpoint** 5-Jul-2013	**Period(YRS)** 2.76	**Expend.** 17215				**Inflation Amt** 697	**Fully Funded** 17912	
	Reach C		13	0	0	0	21,496	15066	42.68	6430	21496	0	2036	16493	7039	23532	
			13	**Expenditure Allocations** FY2016			**Start** 1-Apr-2016	**End** 17-Oct-2016	**Midpoint** 9-Jul-2016	**Period(YRS)** 5.78	**Expend.** 21496				**Inflation Amt** 2036	**Fully Funded** 23532	
	Reach D		13	0	0	0	4,207	2820	49.2	1387	4207	0	402	3089	1520	4609	
			13	**Expenditure Allocations** FY2016			**Start** 1-Apr-2016	**End** 23-Nov-2016	**Midpoint** 28-Jul-2016	**Period(YRS)** 5.83	**Expend.** 4207				**Inflation Amt** 402	**Fully Funded** 4609	
	Reach G		13	0	0	0	2,823	2078	35.85	745	2823	0	215	2236	802	3038	
			13	**Expenditure Allocations** FY2015			**Start** 1-Apr-2015	**End** 2-Oct-2015	**Midpoint** 2-Jul-2015	**Period(YRS)** 4.75	**Expend.** 2823				**Inflation Amt** 215	**Fully Funded** 3038	
	Reach H		13	0	0	0	2,881	2227	29.35	654	2881	0	171	2359	693	3052	
			13	**Expenditure Allocations** FY2014			**Start** 1-Apr-2014	**End** 27-Nov-2014	**Midpoint** 30-Jul-2014	**Period(YRS)** 3.83	**Expend.** 2881				**Inflation Amt** 171	**Fully Funded** 3052	
	Reach I		13	0	0	0	1,510	1195	26.35	315	1510	0	61	1243	328	1571	
			13	**Expenditure Allocations** FY2013			**Start** 1-Apr-2013	**End** 1-Oct-2013	**Midpoint** 1-Jul-2013	**Period(YRS)** 2.75	**Expend.** 1510				**Inflation Amt** 61	**Fully Funded** 1571	
18	CULTURAL RESOURCES PRESERV.	(1		0	0	0	6578	5660	16.21	918	6578	0	261	5685	954	6839	
30	PLANNING/ENGINEERING/DESIGN			84588	0	0	129097	123807	0	5290	129097	0	4640	127870	5867	133737	
	Reach A		A	3961	0	0	14163	12946		1217	14163	0	870	13536	1297	14833	

PROJECT: NATOMAS PACR, NED PLAN — DATE PREPARED: 25-Aug-2010

LOCATION: CALIFORNIA — PRICE LEVEL: 1-Oct-2010

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COO	SUNK COST THRU 30-Sep-2010	FIRST COST: PREVIOUS 1-Oct-2009	COST CHANGES: PRICE LEVEL	COST CHANGES: OTHER (SEE NOTE)	CURRENT: DIRECT COST	CURRENT: CONT RATE	CURRENT: CONTIN-GENCY	CURRENT: COST EST 5+6+7	PREVIOUS 1-Oct-2009	CHANGE IN INFLAT - ION	FULLY FUNDED (3 CURRENT: DIRECT COST	CURRENT: CONTIN-GENCY	CURRENT: COST EST 12+6+7+13
(1)	(2)		(3)	AMOUNT (4)($K)	COST EST (5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	EST (12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	FEDERAL		A	612	0	0	10,814	9597	13.55	1217	10814	0	670	10187	1297	11484
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	124				0	124	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	488				0	488	
			A	FY2012		1-Oct-2011	26-Oct-2013	13-Oct-2012	2.04	10202				670	10872	
	NON-FEDERAL - Section 104		C	3349	0	0	3,349	3349	0	0	3349	0	0	3349	0	3349
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	43				0	43	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	56				0	56	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	764				0	764	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2486				0	2486	
	Reach B		A	34283	0	0	44003	43088		915	44003	0	494	43538	959	44497
	FEDERAL		A	1530	0	0	8,994	8347	9.49	647	8994	0	482	8787	689	9476
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	310				0	310	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1220				0	1220	
			A	FY2012		1-Oct-2011	9-Oct-2013	4-Oct-2012	2.01	7464				482	7946	
	NON-FEDERAL - Section 104		C	32753	0	0	35,009	34741	13.5	268	35009	0	12	34751	270	35021
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	53				0	53	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	507				0	507	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	5620				0	5620	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	12757				0	12757	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	13816				0	13816	
			C	FY2011		1-Oct-2010	1-Oct-2011	1-Apr-2011	0.50	2256				12	2268	
	Reach C		A	23682	0	0	26367	26040		327	26367	0	569	26540	396	26936
	FEDERAL		A	805	0	0	3,490	3163	13.85	327	3490	0	569	3663	396	4059
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	163				0	163	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	642				0	642	
			A	FY2015		1-Oct-2014	17-Oct-2016	9-Oct-2015	5.03	2685				569	3254	
	NON-FEDERAL - Section 104		C	22877	0	0	22,877	22877	0	0	22877	0	0	22877	0	22877
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	613				0	613	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	4083				0	4083	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	9647				0	9647	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	7137				0	7137	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1397				0	1397	
	Reach D		A	9688	0	0	10846	10705		141	10846	0	249	10923	172	11095
	FEDERAL		A	886	0	0	2,044	1903	13.9	141	2044	0	249	2121	172	2293

PROJECT: NATOMAS PACR, NED PLAN
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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	CODE	SUNK COST THRU 30-Sep-2010 AMOUNT	SUNK COST THRU 30-Sep-2010 COST EST	FIRST COST PREVIOUS 1-Oct-2009 PRICE LEVEL	FIRST COST COST CHANGES OTHER (SEE NOTE)	FIRST COST CURRENT DIRECT COST	FIRST COST CURRENT CONT RATE	FIRST COST CURRENT CONTIN-GENCY	FIRST COST CURRENT COST EST 5+6+7	FULLY FUNDED (3 PREVIOUS 1-Oct-2009 EST	FULLY FUNDED (3 CHANGE IN INFLAT - ION	FULLY FUNDED (3 CURRENT DIRECT COST	FULLY FUNDED (3 CURRENT CONTIN-GENCY	FULLY FUNDED (3 CURRENT COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	179				0	179	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	707				0	707	
			A	FY2015		1-Oct-2014	23-Nov-2016	28-Oct-2015	5.08	1158				249	1407	
	NON-FEDERAL - Section 104		C	8802	0	0	8,802	8802	0	0	8802	0	0	8802	0	8802
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	839				0	839	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	1604				0	1604	
			C	FY2008		1-Oct-2007	1-Oct-2008	30-Sep-2008	0.00	2457				0	2457	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	3361				0	3361	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	541				0	541	
	Reach E		A	3982	0	0	9049	8239		810	9049	0	821	8928	942	9870
	FEDERAL		A	532	0	0	5,599	4789	19.04	810	5599	0	821	5478	942	6420
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	108				0	108	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	424				0	424	
			A	FY2014		1-Oct-2013	3-Nov-2015	17-Oct-2014	4.05	5067				821	5888	
	NON-FEDERAL - Section 104		C	3450	0	0	3,450	3450	0	0	3450	0	0	3450	0	3450
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	193				0	193	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	1470				0	1470	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1294				0	1294	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	493				0	493	
	Reach F		A	2740	0	0	7546	6969		577	7546	0	536	7440	642	8082
	FEDERAL		A	0	0	0	4,806	4229	13.65	577	4806	0	536	4700	642	5342
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2013		1-Oct-2012	9-Oct-2014	5-Oct-2013	3.01	4806				536	5342	
	NON-FEDERAL - Section 104		C	2740	0	0	2,740	2740	0	0	2740	0	0	2740	0	2740
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	98				0	98	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	829				0	829	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1116				0	1116	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	697				0	697	
	Reach G		A	0	0	0	3493	3065		428	3493	0	558	3555	496	4051
	FEDERAL		A	0	0	0	3,493	3065	13.95	428	3493	0	558	3555	496	4051
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2014		1-Oct-2013	2-Oct-2015	1-Oct-2014	4.00	3493				558	4051	

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COD E	SUNK COST THRU 30-Sep-2010 AMOUNT	SUNK COST THRU 30-Sep-2010 COST EST	FIRST COST PREVIOUS 1-Oct-2009	COST CHANGES PRICE LEVEL	COST CHANGES OTHER (SEE NOTE)	CURRENT DIRECT COST	CURRENT CONT RATE	CURRENT CONTIN-GENCY	CURRENT COST EST 5+6+7	FULLY FUNDED (3 PREVIOUS 1-Oct-2009 EST	CHANGE IN INFLAT - ION	CURRENT DIRECT COST	CURRENT CONTIN-GENCY	CURRENT COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)	
	Reach H	A		4148	0	0	9482	8845		637	9482	0	612	9384	710	10094	
	FEDERAL	A		725	0	0	6,059	5422	13.55	637	6059	0	612	5961	710	6671	
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**		
		A		FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	147				0	147		
		A		FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	578				0	578		
		A		FY2013		1-Oct-2012	27-Nov-2014	29-Oct-2013	3.08	5334				612	5946		
	NON-FEDERAL - Section 104	C		3423	0	0	3,423	3423	0	0	3423	0	0	3423	0	3423	
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**		
		C		FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	3				0	3		
		C		FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	101				0	101		
		C		FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	1567				0	1567		
		C		FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1263				0	1263		
		C		FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	489				0	489		
	Reach I	A		2104	0	0	4148	3910		238	4148	0	131	4026	253	4279	
	FEDERAL	A		0	0	0	2,044	1806	13.15	238	2044	0	131	1922	253	2175	
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**		
		A		FY2012		1-Oct-2011	1-Oct-2013	30-Sep-2012	2.00	2044				131	2175		
	NON-FEDERAL - Section 104	C		2104	0	0	2,104	2104	0	0	2104	0	0	2104	0	2104	
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**		
		C		FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	29				0	29		
		C		FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	128				0	128		
		C		FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	354				0	354		
		C		FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	676				0	676		
		C		FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	917				0	917		
31	CONSTRUCTION MANAGEMENT			120851	0	0	151033	143678	0	7355	151033	0	4113	146740	8406	155146	
	Reach A	A		0	0	0	6,288	4792	31.23	1496	6288	0	487	5163	1612	6775	
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**		
		A		FY2013		2-Apr-2012	26-Oct-2013	13-Jan-2013	2.29	6288				487	6775		
	Reach B	A		36773	0	0	42182	41108		1074	42182	0	354	41394	1142	42536	
	FEDERAL	A		0	0	0	3,383	2727	24.05	656	3383	0	337	2999	721	3720	
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**		
		A		FY2013		1-Apr-2013	9-Oct-2013	5-Jul-2013	2.76	3383				337	3720		
	NON-FEDERAL - Section 104	C		36773	0	0	38,799	38381	25.98	418	38799	0	17	38395	421	38816	
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**		
		C		FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	4				0	4		
		C		FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	2				0	2		
		C		FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	2642				0	2642		
		C		FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	34125				0	34125		
		C		FY2011		1-Apr-2011	1-Oct-2011	1-Jul-2011	0.75	2026				17	2043		

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(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	Reach C		A	36561	0	0	38353	37818		535	38353	0	452	38135	670	38805
	FEDERAL		A	0	0	0	1,792	1257	42.53	535	1792	0	452	1574	670	2244
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2016		1-Apr-2016	17-Oct-2016	9-Jul-2016	5.78	1792				452	2244	
	NON-FEDERAL - Section 104		C	36561	0	0	36,561	36561	0	0	36561	0	0	36561	0	36561
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	779				0	779	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	2675				0	2675	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	5588				0	5588	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	27519				0	27519	
	Reach D		A	47517	0	0	48114	47924		190	48114	0	152	48028	238	48266
	FEDERAL		A	0	0	0	597	407	46.7	190	597	0	152	511	238	749
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2016		1-Apr-2016	23-Nov-2016	28-Jul-2016	5.83	597				152	749	
	NON-FEDERAL - Section 104		C	47517	0	0	47,517	47517	0	0	47517	0	0	47517	0	47517
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	13395				0	13395	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	9061				0	9061	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	18143				0	18143	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	6918				0	6918	
	Reach E		A	0	0	0	3,922	2838	38.2	1084	3922	0	786	3407	1301	4708
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2015		1-Apr-2015	3-Nov-2015	18-Jul-2015	4.80	3922				786	4708	
	Reach F		A	0	0	0	3,721	2820	31.95	901	3721	0	551	3238	1034	4272
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2014		1-Apr-2014	9-Oct-2014	5-Jul-2014	3.76	3721				551	4272	
	Reach G		A	0	0	0	2,799	2043	37	756	2799	0	555	2448	906	3354
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2015		1-Apr-2015	2-Oct-2015	2-Jul-2015	4.75	2799				555	3354	
	Reach H		A	0	0	0	4,131	3131	31.95	1000	4131	0	625	3604	1152	4756
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2014		1-Apr-2014	27-Nov-2014	30-Jul-2014	3.83	4131				625	4756	

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(1)	(2)	(3)		(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	Reach I		A	0	0	0	1,523	1204	26.5	319	1523	0	151	1323	351	1674
			A	**Expenditure Allocations** FY2013		**Start** 1-Apr-2013	**End** 1-Oct-2013	**Midpoint** 1-Jul-2013	**Period(YRS)** 2.75	**Expend.** 1523				**Inflation Amt** 151	**Fully Funded** 1674	
	TOTAL COST (FEDERAL FUNDS & NON-FEDERAL CASH CONTRIBUTION)			286755	0	0	768287	657480		110807	768287	0	30734	681063	117958	799021
	NON-FEDERAL CASH CONTRIBUTION (-)			3077	0	29	55249	45741		9537	55278	0	2340	47521	10097	57618
	SECTION 104 (-)			253974	0	0	55249	45741		9508	55249	0	2354	47521	10082	57603
	TOTAL FEDERAL COST			**29704**	**0**	**-29**	**657789**	**565998**		**91762**	**657760**	**0**	**26040**	**586021**	**97779**	**683800**
	NON-FEDERAL COST															
1	LANDS AND DAMAGES			7772	0	0	205338	155431	0	49907	205338	0	9304	162311	52331	214642
	Reach A		C	417	0	0	28,959	23347	24.473	5612	28959	0	430	23693	5696	29389
			C	**Expenditure Allocations** FY2010 Projected Sunk Cost		**Start** 1-Oct-2009	**End** 1-Oct-2010	**Midpoint** 1-Apr-2010	**Period(YRS)** 0.00	**Expend.** 369				**Inflation Amt** 0	**Fully Funded** 369	
	Acquisition		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	19				0	19	
	Condemnation		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	6				0	6	
	Appraisal		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	23				0	23	
	Rights of Entry		C	FY2012		1-Oct-2011	2-Apr-2012	1-Jan-2012	1.25	28542				430	28972	
	Reach B		C	3503	0	0	55,077	40931	37.794	14146	55077	0	1629	42114	14592	56706
			C	**Expenditure Allocations** FY2010 Projected Sunk Cost		**Start** 1-Oct-2009	**End** 1-Oct-2010	**Midpoint** 1-Apr-2010	**Period(YRS)** 0.00	**Expend.** 1869				**Inflation Amt** 0	**Fully Funded** 1869	
	Acquisition		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	849				0	849	
	Condemnation		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	283				0	283	
	Appraisal		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	12				0	12	
	Reloc Assist		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	490				0	490	
	Rights of Entry		C	FY2013		1-Oct-2012	1-Apr-2013	31-Dec-2012	2.25	51574				1629	53203	
	Reach C		C	1998	0	0	15,181	11207	43.15	3974	15181	0	1122	11991	4312	16303
			C	**Expenditure Allocations** FY2010 Projected Sunk Cost		**Start** 1-Oct-2009	**End** 1-Oct-2010	**Midpoint** 1-Apr-2010	**Period(YRS)** 0.00	**Expend.** 1014				**Inflation Amt** 0	**Fully Funded** 1014	
	Acquisition		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	578				0	578	
	Condemnation		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	193				0	193	
	Appraisal		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	213				0	213	
	Rights of Entry		C	FY2016		1-Oct-2015	1-Apr-2016	31-Dec-2015	5.25	13183				1122	14305	
	Reach D		C	1021	0	0	5,165	3633	58.65	1532	5165	0	353	3856	1662	5518
			C	**Expenditure Allocations** FY2010 Projected Sunk Cost		**Start** 1-Oct-2009	**End** 1-Oct-2010	**Midpoint** 1-Apr-2010	**Period(YRS)** 0.00	**Expend.** 515				**Inflation Amt** 0	**Fully Funded** 515	
	Acquisition		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	306				0	306	
	Condemnation		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	102				0	102	
	Appraisal		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	7				0	7	
	Reloc Assist		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	91				0	91	
	Rights of Entry		C	FY2016		1-Oct-2015	1-Apr-2016	31-Dec-2015	5.25	4144				353	4497	

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(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	Reach E		C	378	0	0	33,251	25076	33.1	8175	33251	0	2201	26730	8722	35452
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Acquisition		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	195				0	195	
	Condemnation		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	61				0	61	
	Appraisal		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	20				0	20	
	Rights of Entry		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	102				0	102	
			C	FY2015		1-Oct-2014	1-Apr-2015	31-Dec-2014	4.25	32873				2201	35074	
	Reach F		C	99	0	0	13,767	9220	49.86	4547	13767	0	671	9687	4771	14438
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Acquisition		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	82				0	82	
	Condemnation		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	7				0	7	
	Appraisal		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2				0	2	
	Reloc Assist		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1				0	1	
	Rights of Entry		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	7				0	7	
			C	FY2014		1-Oct-2013	1-Apr-2014	31-Dec-2013	3.25	13668				671	14339	
	Reach G		C	0	0	0	18,340	13118	39.81	5222	18340	0	1228	13996	5572	19568
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2015		1-Oct-2014	1-Apr-2015	31-Dec-2014	4.25	18340				1228	19568	
	Reach H		C	215	0	0	32,005	26842	20.293	5383	32005	0	1561	27940	5626	33566
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Acquisition		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	140				0	140	
	Condemnation		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	21				0	21	
	Appraisal		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	7				0	7	
	Rights of Entry		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	47				0	47	
			C	FY2014		1-Oct-2013	1-Apr-2014	31-Dec-2013	3.25	31790				1561	33351	
	Reach I		C	141	0	0	3,593	2257	63.1	1336	3593	0	109	2324	1378	3702
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Acquisition		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	70				0	70	
	Condemnation		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	15				0	15	
	Appraisal		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	5				0	5	
	Rights of Entry		C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	51				0	51	
			C	FY2013		1-Oct-2012	1-Apr-2013	31-Dec-2012	2.25	3452				109	3561	
2	RELOCATIONS		2	9066	0	0	110798	85183		25583	110766	0	6280	89766	27260	117046
	Reach A		2	0	0	0	13,608	10851	25.41	2757	13608	0	438	11200	2846	14046
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2013		2-Apr-2012	26-Oct-2013	13-Jan-2013	2.29	13608				438	14046	
	Reach B		2	3577	0	0	22,909	19164	24.03	3745	22909	0	783	19795	3897	23692

PROJECT: NATOMAS PACR, NED PLAN — DATE PREPARED: 25-Aug-2010
LOCATION: CALIFORNIA — PRICE LEVEL: 1-Oct-2010
PROJECT COST ESTIMATE(PCE)

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	CODES	SUNK COST THRU 30-Sep-2010		FIRST COST: PREVIOUS 1-Oct-2009	FIRST COST: COST CHANGES		FIRST COST: CURRENT				FULLY FUNDED (3: PREVIOUS 1-Oct-2009	FULLY FUNDED (3: CHANGE IN INFLAT - ION	FULLY FUNDED (3: CURRENT		
				AMOUNT	COST EST		PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN-GENCY	COST EST 5+6+7	EST		DIRECT COST	CONTIN-GENCY	COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)		(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
				Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Relocations, Roads, Contract 4046 May 2010 Sep 31 2010 FY10 Complete		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	280				0	280	
	Elkhorn Irr Canal, Phase 2A, Contract 4047 May 2010 Sep 31 2010 FY10 Complete		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1766				0	1766	
	Relocations, Private Irr Fac, Contract 4047 May 2010 Sep 31 2010 FY10 Complete		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1206				0	1206	
	Gas Line Relocation, Calpine Gas, at Garden Highway Contract 4046 May 2010 Sep 31 2010 FY10 Complete		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	318				0	318	
	Underground Electrical Conduit for Street Light Contract 4046 May 2010 Sep 31 2010 FY10 Complete		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2				0	2	
	Relocate Street Light Contract 4046 May 2010 Sep 31 2010 FY10 Complete		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	5				0	5	
			2	FY2013			1-Apr-2013	9-Oct-2013	5-Jul-2013	2.76	19332				783	20115	
	Reach C		2	4132	0		0	12,190	9625	46.7	2565	12190	0	763	10145	2808	12953
				Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Relocations, Roadways, Contract 3980 5/09 - 7/10 95% in FY09		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	296				0	296	
	Relocations, Roadways, Contract 4032 8/15/09 - 9/30/10 20% for FY09		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	16				0	16	
	Relocations, Private Irr Fac, Contract 3980 95% in FY09		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	87				0	87	
	Relocations, Private Irr Fac, Contract 4032 8/15/09 - 9/30/10 20% for FY09		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	348				0	348	
	Relocations, Roadways, Contract 3980 5/09 -7/10 5% in FY10		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	360				0	360	
	Relocations, Roadways, Contract 4032 8/15/09 - 9/30/10 80% for FY10		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	262				0	262	
	Relocations, Roadways, Contract 4046 (portion within Reach C) May 2010 Sep 31 2010 FY10 Complete		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	14				0	14	
	Relocations, Private Irr Fac, Contract 3980 5% in FY10		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	832				0	832	
	Relocations, Private Irr Fac, Contract 4032 8/15/09 - 9/30/10 80% for FY10		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	6				0	6	
	Relocations, Private River Diversion Replacement, Contract 4053 5/1/10-9/30/10		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1911				0	1911	
			2	FY2016			1-Apr-2016	17-Oct-2016	9-Jul-2016	5.78	8058				783	8821	
	Reach D		2	1357	0		0	12,323	8903	45.33	3420	12323	0	1049	9624	3748	13372
				Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Road Relocations, C3947		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	778				0	778	
	Road Relocations, C3980		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	562				0	562	
	Utility Relocations, C3980		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	17				0	17	
			2	FY2016			1-Apr-2016	23-Nov-2016	28-Jul-2016	5.83	10966				1049	12015	

PROJECT: NATOMAS PACR, NED PLAN — **DATE PREPARED: 25-Aug-2010**

LOCATION: CALIFORNIA — **PRICE LEVEL: 1-Oct-2010**

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				AMOUNT		PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN-GENCY	COST EST 5+6+7	EST		DIRECT COST	CONTIN-GENCY	COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	Reach E		2	0	0	0	10,951	7801	40.38	3150	10951	0	841	8400	3392	11792
			2	Expenditure Allocations FY2015		Start 1-Apr-2015	End 3-Nov-2015	Midpoint 18-Jul-2015	Period(YRS) 4.80	Expend. 10951				Inflation Amt 841	Fully Funded 11792	
	Reach F		2	0	0	0	11,945	9006	32.63	2939	11945	0	695	9530	3110	12640
			2	Expenditure Allocations FY2014		Start 1-Apr-2014	End 9-Oct-2014	Midpoint 5-Jul-2014	Period(YRS) 3.76	Expend. 11945				Inflation Amt 695	Fully Funded 12640	
	Reach G		2	0	0	0	10,676	7795	36.96	2881	10676	0	811	8387	3100	11487
			2	Expenditure Allocations FY2015		Start 1-Apr-2015	End 2-Oct-2015	Midpoint 2-Jul-2015	Period(YRS) 4.75	Expend. 10676				Inflation Amt 811	Fully Funded 11487	
	Reach H		2	0	0	0	12,996	9537	36.27	3459	12996	0	772	10103	3665	13768
			2	Expenditure Allocations FY2014		Start 1-Apr-2014	End 27-Nov-2014	Midpoint 30-Jul-2014	Period(YRS) 3.83	Expend. 12996				Inflation Amt 772	Fully Funded 13768	
	Reach I		2	0	0	0	3,168	2501	26.65	667	3168	0	128	2602	694	3296
			2	Expenditure Allocations FY2013		Start 1-Apr-2013	End 1-Oct-2013	Midpoint 1-Jul-2013	Period(YRS) 2.75	Expend. 3168				Inflation Amt 128	Fully Funded 3296	
	SECTION 104		0	281665	0	0	311069	305202		5867	311069	0	236	305391	5914	311305
	Reach A		0	3349	0	0	3349	3349		0	3349	0	0	3349	0	3349
	Reach B		0	92853	0	0	122257	116390		5867	122257	0	236	116579	5914	122493
	Reach C		0	82460	0	0	82460	82460		0	82460	0	0	82460	0	82460
	Reach D		0	91286	0	0	91286	91286		0	91286	0	0	91286	0	91286
	Reach E		0	3450	0	0	3450	3450		0	3450	0	0	3450	0	3450
	Reach F		0	2740	0	0	2740	2740		0	2740	0	0	2740	0	2740
	Reach H		0	3423	0	0	3423	3423		0	3423	0	0	3423	0	3423
	Reach I		0	2104	0	0	2104	2104		0	2104	0	0	2104	0	2104
30	PLANNING/ENGINEERING/DESIGN		2	8280	0	0	19614	16670		2944	19614	0	573	17088	3099	20187
	Reach A		2	3	0	0	2,045	1631	25.41	414	2045	0	57	1677	425	2102
			2	Expenditure Allocations FY2010 Projected Sunk Cost		Start 1-Oct-2009	End 1-Oct-2010	Midpoint 1-Apr-2010	Period(YRS) 0.00	Expend. 3				Inflation Amt 0	Fully Funded 3	
			2	FY2012		1-Oct-2011	26-Oct-2013	13-Oct-2012	2.04	2042				57	2099	
	Reach B		2	4090	0	0	4,625	4521	24	104	4625	0	15	4534	106	4640
				Expenditure Allocations		Start	End	Midpoint	Period(YRS)	Expend.				Inflation Amt	Fully Funded	

PROJECT: NATOMAS PACR, NED PLAN — **DATE PREPARED: 25-Aug-2010**

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COD E	SUNK COST THRU 30-Sep-2010 AMOUNT	SUNK COST THRU 30-Sep-2010 COST EST	FIRST COST PREVIOUS 1-Oct-2009 COST CHANGES PRICE LEVEL	FIRST COST PREVIOUS 1-Oct-2009 COST CHANGES OTHER (SEE NOTE)	FIRST COST CURRENT DIRECT COST	FIRST COST CURRENT CONT RATE	FIRST COST CURRENT CONTIN-GENCY	FIRST COST CURRENT COST EST 5+6+7	FULLY FUNDED (3 PREVIOUS 1-Oct-2009 EST	FULLY FUNDED (3 CHANGE IN INFLAT - ION	FULLY FUNDED (3 CURRENT DIRECT COST	FULLY FUNDED (3 CURRENT CONTIN-GENCY	FULLY FUNDED (3 CURRENT COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
		2	FY2008			1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	406				0	406	
		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1444				0	1444	
		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2240				0	2240	
		2	FY2012			1-Oct-2011	9-Oct-2013	4-Oct-2012	2.01	535				15	550	
	Reach C	2		3896	0	0	4,863	4555	46.7	308	4863	0	78	4608	333	4941
			Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2006			1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	211				0	211	
		2	FY2007			1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	697				0	697	
		2	FY2008			1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	1073				0	1073	
		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1214				0	1214	
		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	701				0	701	
		2	FY2015			1-Oct-2014	17-Oct-2016	9-Oct-2015	5.03	967				78	1045	
	Reach D	2		272	0	0	1,446	1080	45.33	366	1446	0	73	1130	389	1519
			Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2009			1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	170				0	170	
		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	102				0	102	
		2	FY2014			1-Oct-2013	2-Oct-2015	1-Oct-2014	4.00	1174				73	1247	
	Reach E	2		0	0	0	1,843	1170	40.38	473	1643	0	104	1244	503	1747
			Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2014			1-Oct-2013	3-Nov-2015	17-Oct-2014	4.05	1643				104	1747	
	Reach F	2		0	0	0	1,433	1081	32.61	352	1433	0	64	1129	368	1497
			Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2013			1-Oct-2012	9-Oct-2014	5-Oct-2013	3.01	1433				64	1497	
	Reach G	2		8	0	0	1,609	1177	37	432	1609	0	100	1250	459	1709
			Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	8				0	8	
		2	FY2014			1-Oct-2013	2-Oct-2015	1-Oct-2014	4.00	1601				100	1701	
	Reach H	2		5	0	0	1,564	1149	36.3	415	1564	0	72	1202	434	1636
			Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	5				0	5	
		2	FY2013			1-Oct-2012	27-Nov-2014	29-Oct-2013	3.08	1559				72	1631	
	Reach I	2		6	0	0	386	306	26.8	80	386	0	10	314	82	396
			Expenditure Allocations			**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2010 Projected Sunk Cost			1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	6				0	6	
		2	FY2012			1-Oct-2011	1-Oct-2013	30-Sep-2012	2.00	380				10	390	

PROJECT: NATOMAS PACR, NED PLAN
LOCATION: CALIFORNIA
PROJECT COST ESTIMATE(PCE)

DATE PREPARED: 25-Aug-2010
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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COD E	SUNK COST THRU 30-Sep-2010	FIRST COST: PREVIOUS 1-Oct-2009	FIRST COST: COST CHANGES		FIRST COST: CURRENT				FULLY FUNDED (3: PREVIOUS 1-Oct-2009	CHANGE IN INFLAT - ION	FULLY FUNDED (3: CURRENT		
				AMOUNT	COST EST	PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN- GENCY	COST EST 5+6+7	EST		DIRECT COST	CONTIN- GENCY	COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
31	CONSTRUCTION MANAGEMENT		2	560	0	0	7555	5723		1832	7555	0	449	6050	1954	8004
	Reach A		2	0	0	0	1,089	868	25.41	221	1089	0	35	896	228	1124
			2	Expenditure Allocations FY2013		Start 2-Apr-2012	End 26-Oct-2013	Midpoint 13-Jan-2013	Period(YRS) 2.29	Expend. 1089				Inflation Amt 35	Fully Funded 1124	
	Reach B		2	530	0	0	816	760	24.1	56	816	0	2	762	56	818
			2	Expenditure Allocations FY2009		Start 1-Oct-2008	End 1-Oct-2009	Midpoint 1-Apr-2009	Period(YRS) 0.00	Expend. 74				Inflation Amt 0	Fully Funded 74	
			2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	456				0	456	
			2	FY2011		1-Apr-2011	1-Oct-2011	1-Jul-2011	0.75	286				2	288	
	Reach C		2	30	0	0	675	470	46.6	205	675	0	61	512	224	736
			2	Expenditure Allocations FY2009		Start 1-Oct-2008	End 1-Oct-2009	Midpoint 1-Apr-2009	Period(YRS) 0.00	Expend. 22				Inflation Amt 0	Fully Funded 22	
			2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	8				0	8	
			2	FY2016		1-Apr-2016	17-Oct-2016	9-Jul-2016	5.78	645				61	706	
	Reach D		2	0	0	0	782	538	45.33	244	782	0	75	590	267	857
			2	Expenditure Allocations FY2016		Start 1-Apr-2016	End 23-Nov-2016	Midpoint 28-Jul-2016	Period(YRS) 5.83	Expend. 782				Inflation Amt 75	Fully Funded 857	
	Reach E		2	0	0	0	876	624	40.38	252	876	0	67	672	271	943
			2	Expenditure Allocations FY2015		Start 1-Apr-2015	End 3-Nov-2015	Midpoint 18-Jul-2015	Period(YRS) 4.80	Expend. 676				Inflation Amt 67	Fully Funded 943	
	Reach F		2	0	0	0	956	721	32.51	235	956	0	56	764	248	1012
			2	Expenditure Allocations FY2014		Start 1-Apr-2014	End 9-Oct-2014	Midpoint 5-Jul-2014	Period(YRS) 3.76	Expend. 956				Inflation Amt 56	Fully Funded 1012	
	Reach G		2	0	0	0	1,068	779	37.1	289	1068	0	81	838	311	1149
			2	Expenditure Allocations FY2015		Start 1-Apr-2015	End 2-Oct-2015	Midpoint 2-Jul-2015	Period(YRS) 4.75	Expend. 1068				Inflation Amt 81	Fully Funded 1149	
	Reach H		2	0	0	0	1,040	763	36.3	277	1040	0	62	809	293	1102
			2	Expenditure Allocations FY2014		Start 1-Apr-2014	End 27-Nov-2014	Midpoint 30-Jul-2014	Period(YRS) 3.83	Expend. 1040				Inflation Amt 62	Fully Funded 1102	
	Reach I		2	0	0	0	253	200	26.8	53	253	0	10	207	56	263
			2	Expenditure Allocations FY2013		Start 1-Apr-2013	End 1-Oct-2013	Midpoint 1-Jul-2013	Period(YRS) 2.75	Expend. 253				Inflation Amt 10	Fully Funded 263	

PROJECT: NATOMAS PACR, NED PLAN — **DATE PREPARED: 25-Aug-2010**

LOCATION: CALIFORNIA — **PRICE LEVEL: 1-Oct-2010**

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(1)	(2)		(3)	AMOUNT (4)($K)	COST EST (5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	EST (12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	TOTAL NON-FEDERAL LERRD			307343	0	0	654342	568209		86133	654342	0	16842	580626	90558	671184
	NON-FEDERAL CASH CONTRIBUTION (+)			3077	0	29	55249	45741		9537	55278	0	2340	47521	10097	57618
	SECTION 104 (-), Remaining Allowable			27691	0	0	255820	259461		-3641	255820	0	-2118	257870	-4168	253702
	TOTAL NON-FEDERAL COST			**282729**	**0**	**29**	**453771**	**354489**		**99311**	**453800**	**0**	**21300**	**370277**	**104823**	**475100**
	TOTAL NED COST			**312433**	**0**	**0**	**1111560**	**920487**		**191073**	**1111560**	**0**	**47340**	**956298**	**202602**	**1158900**

BASIS OF ESTIMATE:

(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.

(2 Federal administrative costs for Non-federal land acquisition

(3 The Fully Funded cost estimate was prepared in compliance with OMB INDEXES EC-11-2-199, published on MAR. 31, 2010..

(4 CWCCIS indexes from 10/01/2009 to 10/01/2010, are projected rates for Lands and Constructions. OMB escalation rates are actual for PED & CM and Real Estate Admin.

(5 The Project Cost Estimate was prepared based on the Natoms PCR report Dated Oct 1 2010.

PROJECT: NATOMAS PACR, LPP PLAN — DATE PREPARED: 25-Aug-2010
LOCATION: CALIFORNIA — PRICE LEVEL: 1-Oct-2010
PROJECT COST ESTIMATE(PCE) SUMMARY OF COST

CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)		SUNK COST THRU 30-Sep-2010	FIRST COST: PREVIOUS 1-Oct-2009	FIRST COST: COST CHANGES		FIRST COST: CURRENT				FULLY FUNDED ($				
					PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN-GENCY	COST EST 5+6+7	PREVIOUS 1-Oct-2009	CHANGE IN INFLAT - ION	CURRENT: DIRECT COST	CONTIN-GENCY	COST EST 12+6+7+13
(1)	(2)	(3)	AMOUNT (4)($K)	COST EST (5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	EST (12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	FEDERAL														
1	LANDS AND DAMAGES, Admin		0	0	0	4127	3590		537	4127	0	463	3993	597	4590
1	LANDS AND DAMAGES, Real Estate		0	0	0	14365	10301		4064	14365	0	671	10769	4267	15036
6	FISH AND WILDLIFE FACILITIES		1865	0	0	18869	15175		3694	18869	0	1072	15996	3945	19941
11	LEVEES AND FLOODWALLS		90921	0	0	417350	338254		79096	417350	0	18338	350477	83211	433688
13	PUMPING PLANT		0	0	0	56135	42044		14091	56135	0	3775	44793	15117	59910
18	CULTURAL RESOURCES PRESERV.		0	0	0	6578	5660		918	6578	0	261	5885	954	6839
30	PLANNING/ENGINEERING/DESIGN		84588	0	0	130834	125320		5514	130834	0	4773	129501	6106	135607
31	CONSTRUCTION MANAGEMENT		120851	0	0	152434	144745		7689	152434	0	4241	147897	8778	156675
	TOTAL COST (FEDERAL FUNDS & NON-FEDERAL CASH CONTRIBUTION)		298225	0	0	800692	685089		115603	800692	0	31594	709311	122975	832285
	NON-FEDERAL CASH CONTRIBUTION (-)		14547	0	29	87654	73350		14333	87683	0	3200	75769	15114	90883
	SECTION 104 (-)		253974	0	0	55249	45741		9508	55249	0	2354	47521	10082	57603
	TOTAL FEDERAL COST		**29704**	**0**	**-29**	**657789**	**565998**		**91762**	**657760**	**0**	**26040**	**586021**	**97779**	**683800**
	NON-FEDERAL COST														
1	LANDS AND DAMAGES		7772	0	0	205338	155431		49907	205338	0	9304	162311	52331	214642
2	RELOCATIONS		11724	0	0	127700	98315		29385	127700	0	7205	103589	31316	134905
	SECTION 104		281965	0	0	311069	305202		5867	311069	0	236	305391	5914	311305
30	PLANNING/ENGINEERING/DESIGN		8280	0	0	21630	18152		3478	21630	0	677	18645	3662	22307
31	CONSTRUCTION MANAGEMENT		560	0	0	8740	6593		2147	8740	0	520	6968	2292	9260
	TOTAL NON-FEDERAL LERRD		310001	0	0	674477	583693		90784	674477	0	17942	596904	95515	692419
	NON-FEDERAL CASH CONTRIBUTION (+)		14547	0	29	87654	73350		14333	87683	0	3200	75769	15114	90883
	Cost Above NED		11470	0	0	32405	27609		4796	32405	0	860	28248	5017	33265
	SECTION 104 (-)		27691	0	0	255820	259461		-3641	255820	0	-2118	257870	-4168	253702
	TOTAL NON-FEDERAL COST		**296857**	**0**	**29**	**506311**	**397582**		**108758**	**506340**	**0**	**23260**	**414803**	**114797**	**529600**
	TOTAL LPP COST		**326561**	**0**	**0**	**1164100**	**963580**		**200520**	**1164100**	**0**	**49300**	**1000824**	**212576**	**1213400**
	SUMMARY OF ESTIMATED COSTS														
	FEDERAL COST (CORPS OF ENGINEERS)		29704	0	-29	657789	565998		91762	657760	0	26040	586021	97779	683800

PROJECT: NATOMAS PACR, LPP PLAN
LOCATION: CALIFORNIA
PROJECT COST ESTIMATE(PCE) SUMMARY OF COST

DATE PREPARED: 25-Aug-2010
PRICE LEVEL: 1-Oct-2010

CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)		SUNK COST THRU 30-Sep-2010	FIRST COST						FULLY FUNDED (3				
				PREVIOUS 1-Oct-2009	COST CHANGES		CURRENT				PREVIOUS 1-Oct-2009	CHANGE IN	CURRENT		
					PRICE	OTHER	DIRECT	CONT	CONTIN-	COST EST		INFLAT -	DIRECT	CONTIN-	COST EST
			AMOUNT	COST EST	LEVEL	(SEE NOTE)	COST	RATE	GENCY	5+6+7	EST	ION	COST	GENCY	12+6+7+13
(1)	(2)	(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	REQUIRED NON-FEDERAL COST (+)		296857	0	29	506311	397582		108758	506340	0	23260	414803	114797	529600
	CASH CONTRIBUTION		14547	0	29	87654	73350		14333	87683	0	3200	75769	15114	90883
	OTHER COSTS		282310	0	0	418657	324232		94425	418657	0	20060	339034	99683	438717
	TOTAL FEDERAL AND REQUIRED NON-FEDERAL COSTS		**326561**	**0**	**0**	**1164100**	**963580**		**200520**	**1164100**	**0**	**49300**	**1000824**	**212576**	**1213400**
	PROJECT EXECUTIVE SUMMARY														
1	LANDS AND DAMAGES		7772	0	0	223830	169322		54508	223830	0	10438	177073	57195	234268
2	RELOCATIONS		11724	0	0	127700	98315		29385	127700	0	7205	103589	31316	134905
6	FISH AND WILDLIFE FACILITIES		1865	0	0	18869	15175		3694	18869	0	1072	15996	3945	19941
11	LEVEES AND FLOODWALLS		90921	0	0	417350	338254		79096	417350	0	16338	350477	83211	433688
13	PUMPING PLANT		0	0	0	56135	42044		14091	56135	0	3775	44793	15117	59910
18	CULTURAL RESOURCES PRESERV.		0	0	0	6578	5660		918	6578	0	261	5885	954	6839
30	PLANNING, ENGINEERING AND DESIGN		92868	0	0	152464	143472		8992	152464	0	5450	148146	9768	157914
31	CONSTRUCTION MANAGEMENT		121411	0	0	161174	151338		9836	161174	0	4761	154865	11070	165935
	TOTAL LPP COST		**326561**	**0**	**0**	**1164100**	**963580**		**200520**	**1164100**	**0**	**49300**	**1000824**	**212576**	**1213400**
	FEDERAL COST		**29704**	**0**	**-29**	**657789**	**565998**		**91762**	**657760**	**0**	**26040**	**586021**	**97779**	**683800**
	NON-FEDERAL COST		**296857**	**0**	**29**	**506311**	**397582**		**108758**	**506340**	**0**	**23260**	**414803**	**114797**	**529600**

PROJECT: NATOMAS PACR, LPP PLAN — **DATE PREPARED: 25-Aug-2010**

LOCATION: CALIFORNIA — **PRICE LEVEL: 1-Oct-2010**

PROJECT COST ESTIMATE(PCE)

CODE: 0 - no esc. applied, A - for administration, C - for combined indexes, All other Codes used coincides with the Code of Accounts.

CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	CODE	SUNK COST THRU 30-Sep-2010 AMOUNT	FIRST COST: PREVIOUS 1-Oct-2009 COST EST	COST CHANGES: PRICE LEVEL	COST CHANGES: OTHER (SEE NOTE)	CURRENT: DIRECT COST	CURRENT: CONT RATE	CURRENT: CONTINGENCY	CURRENT: COST EST 5+6+7	FULLY FUNDED (3: PREVIOUS 1-Oct-2009 EST	CHANGE IN INFLAT - ION	CURRENT: DIRECT COST	CURRENT: CONTINGENCY	CURRENT: COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	FEDERAL															
1	LANDS AND DAMAGES, Admin.	(2		0	0	0	4127	3590	0	537	4127	0	463	3993	597	4590
	Reach A		A	0	0	0	765	666	14.95	99	765	0	30	692	103	795
			A	**Expenditure Allocations** FY2012		**Start** 1-Oct-2011	**End** 2-Apr-2012	**Midpoint** 1-Jan-2012	**Period(YRS)** 1.25	**Expend.** 765				**Inflation Amt** 30	**Fully Funded** 795	
	Reach B		A	0	0	0	945	821	15.1	124	945	0	72	884	133	1017
			A	**Expenditure Allocations** FY2013		**Start** 1-Oct-2012	**End** 1-Apr-2013	**Midpoint** 31-Dec-2012	**Period(YRS)** 2.25	**Expend.** 945				**Inflation Amt** 72	**Fully Funded** 1017	
	Reach C		A	0	0	0	295	256	15.1	39	295	0	66	314	47	361
			A	**Expenditure Allocations** FY2016		**Start** 1-Oct-2015	**End** 1-Apr-2016	**Midpoint** 31-Dec-2015	**Period(YRS)** 5.25	**Expend.** 295				**Inflation Amt** 66	**Fully Funded** 361	
	Reach D		A	0	0	0	98	85	15	13	98	0	22	104	16	120
			A	**Expenditure Allocations** FY2016		**Start** 1-Oct-2015	**End** 1-Apr-2016	**Midpoint** 31-Dec-2015	**Period(YRS)** 5.25	**Expend.** 98				**Inflation Amt** 22	**Fully Funded** 120	
	Reach E		A	0	0	0	397	346	14.9	51	397	0	68	405	60	465
			A	**Expenditure Allocations** FY2015		**Start** 1-Oct-2014	**End** 1-Apr-2015	**Midpoint** 31-Dec-2014	**Period(YRS)** 4.25	**Expend.** 397				**Inflation Amt** 68	**Fully Funded** 465	
	Reach F		A	0	0	0	321	279	14.9	42	321	0	40	314	47	361
			A	**Expenditure Allocations** FY2014		**Start** 1-Oct-2013	**End** 1-Apr-2014	**Midpoint** 31-Dec-2013	**Period(YRS)** 3.25	**Expend.** 321				**Inflation Amt** 40	**Fully Funded** 361	
	Reach G		A	0	0	0	241	210	14.9	31	241	0	42	246	37	283
			A	**Expenditure Allocations** FY2015		**Start** 1-Oct-2014	**End** 1-Apr-2015	**Midpoint** 31-Dec-2014	**Period(YRS)** 4.25	**Expend.** 241				**Inflation Amt** 42	**Fully Funded** 283	
	Reach H		A	0	0	0	902	785	14.9	117	902	0	111	882	131	1013
			A	**Expenditure Allocations** FY2014		**Start** 1-Oct-2013	**End** 1-Apr-2014	**Midpoint** 31-Dec-2013	**Period(YRS)** 3.25	**Expend.** 902				**Inflation Amt** 111	**Fully Funded** 1013	
	Reach I		A	0	0	0	163	142	14.9	21	163	0	12	152	23	175
			A	**Expenditure Allocations** FY2013		**Start** 1-Oct-2012	**End** 1-Apr-2013	**Midpoint** 31-Dec-2012	**Period(YRS)** 2.25	**Expend.** 163				**Inflation Amt** 12	**Fully Funded** 175	

PROJECT: NATOMAS PACR, LPP PLAN — **DATE PREPARED: 25-Aug-2010**

LOCATION: CALIFORNIA — **PRICE LEVEL: 1-Oct-2010**

PROJECT COST ESTIMATE(PCE)

CODE: 0 - no esc. applied, A - for administration, C - for combined indexes, All other Codes used coincides with the Code of Accounts.

CODE OF ACCT. NO. (1)	FEATURE/SUBFEATURE (NOTE) (2)	NOTES	COD E (3)	SUNK COST THRU 30-Sep-2010 AMOUNT (4)($K)	SUNK COST THRU 30-Sep-2010 COST EST (5)($K)	FIRST COST PREVIOUS 1-Oct-2009	COST CHANGES PRICE LEVEL (6)($K)	COST CHANGES OTHER (SEE NOTE) (7)($K)	CURRENT DIRECT COST (8)($K)	CURRENT CONT RATE (9)(%)	CURRENT CONTIN-GENCY (10)($K)	CURRENT COST EST 5+6+7 (11)($K)	FULLY FUNDED (3 PREVIOUS 1-Oct-2009 EST (12)($K)	CHANGE IN INFLAT - ION (13)($K)	FULLY FUNDED (3 CURRENT DIRECT COST (14)($K)	FULLY FUNDED (3 CURRENT CONTIN-GENCY (15)($K)	FULLY FUNDED (3 CURRENT COST EST 12+6+7+13 (16)($K)
1	LANDS AND DAMAGES, Real Estate			0	0	0	14365	10301	0	4064	14365	0	671	10769	4267	15036
	Reach A		C	0	0	0	2312	1792	29	520	2312	0	35	1819	528	2347
			C	Expenditure Allocations FY2012		Start 1-Oct-2011	End 2-Apr-2012	Midpoint 1-Jan-2012	Period(YRS) 1.25	Expend. 2312				Inflation Amt 35	Fully Funded 2347	
	Reach B		C	0	0	0	5848	4147	41.01	1701	5848	0	185	4278	1755	6033
			C	Expenditure Allocations FY2013		Start 1-Oct-2012	End 1-Apr-2013	Midpoint 31-Dec-2012	Period(YRS) 2.25	Expend. 5848				Inflation Amt 185	Fully Funded 6033	
	Reach C		C	0	0	0	1027	709	44.9	318	1027	0	87	769	345	1114
			C	Expenditure Allocations FY2016		Start 1-Oct-2015	End 1-Apr-2016	Midpoint 31-Dec-2015	Period(YRS) 5.25	Expend. 1027				Inflation Amt 87	Fully Funded 1114	
	Reach D		C	0	0	0	2512	1580	59	932	2512	0	214	1714	1012	2726
			C	Expenditure Allocations FY2016		Start 1-Oct-2015	End 1-Apr-2016	Midpoint 31-Dec-2015	Period(YRS) 5.25	Expend. 2512				Inflation Amt 214	Fully Funded 2726	
	Reach E		C	0	0	0	1074	790	36	284	1074	0	72	843	303	1146
			C	Expenditure Allocations FY2015		Start 1-Oct-2014	End 1-Apr-2015	Midpoint 31-Dec-2014	Period(YRS) 4.25	Expend. 1074				Inflation Amt 72	Fully Funded 1146	
	Reach H		C	0	0	0	1592	1283	24.1	309	1592	0	78	1346	324	1670
			C	Expenditure Allocations FY2014		Start 1-Oct-2013	End 1-Apr-2014	Midpoint 31-Dec-2013	Period(YRS) 3.25	Expend. 1592				Inflation Amt 78	Fully Funded 1670	
6	FISH & WILDLIFE FACILITIES		6	1865	0	0	18869	15175		3694	18869	0	1072	15996	3945	19941
	Reach B		6	164	0	0	1877	1862		15	1877	0	60	1922	15	1937
	FEDERAL		6	0	0	0	1635	1635	0	0	1635	0	59	1694	0	1694
			6	Expenditure Allocations FY2013		Start 1-Apr-2013	End 1-Apr-2013	Midpoint 1-Apr-2013	Period(YRS) 2.50	Expend. 1635				Inflation Amt 59	Fully Funded 1694	
	NON-FEDERAL - Section 104		6	164	0	0	242	227	24	15	242	0	1	228	15	243
			6	Expenditure Allocations FY2009		Start 1-Oct-2008	End 1-Oct-2009	Midpoint 1-Apr-2009	Period(YRS) 0.00	Expend. 14				Inflation Amt 0	Fully Funded 14	
			6	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	150				0	150	
			6	FY2011		1-Apr-2011	1-Oct-2011	1-Jul-2011	0.75	78				1	79	
	Reach C		6	1701	0	0	1926	1926		0	1926	0	0	1926	0	1926
	FEDERAL		O	0	0	0	225	225	0	0	225	0	0	225	0	225
			O	Expenditure Allocations FY2016		Start 1-Apr-2016	End 1-Apr-2016	Midpoint 1-Apr-2016	Period(YRS) 5.50	Expend. 225				Inflation Amt 0	Fully Funded 225	

PROJECT: NATOMAS PACR, LPP PLAN — **DATE PREPARED: 25-Aug-2010**

LOCATION: CALIFORNIA — **PRICE LEVEL: 1-Oct-2010**

PROJECT COST ESTIMATE(PCE) — CODE: 0 - no esc. applied, A - for administration, C - for combined indexes, All other Codes used coincides with the Code of Accounts.

CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTE	COD E	SUNK COST THRU 30-Sep-2010 AMOUNT (4)($K)	PREVIOUS 1-Oct-2009 COST EST (5)($K)	COST CHANGES PRICE LEVEL (6)($K)	COST CHANGES OTHER (SEE NOTE) (7)($K)	FIRST COST / CURRENT DIRECT COST (8)($K)	CONT RATE (9)(%)	CONTIN-GENCY (10)($K)	COST EST 5+6+7 (11)($K)	PREVIOUS 1-Oct-2009 EST (12)($K)	CHANGE IN INFLAT - ION (13)($K)	FULLY FUNDED (3 CURRENT DIRECT COST (14)($K)	CONTIN-GENCY (15)($K)	COST EST 12+6+7+13 (16)($K)
(1)	(2)		(3)													
	NON-FEDERAL - Section 104	6		1701	0	0	1701	1701	0	0	1701	0	0	1701	0	1701
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		6		FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	1139				0	1139	
		6		FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	498				0	498	
		6		FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	64				0	64	
	Reach E	6		0	0	0	6717	4907	36.9	1810	6717	0	516	5283	1950	7233
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		6		FY2015		1-Apr-2015	3-Nov-2015	18-Jul-2015	4.80	6717				516	7233	
	Reach H	6		0	0	0	8349	6480	28.84	1869	8349	0	496	6865	1980	8845
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		6		FY2014		1-Apr-2014	27-Nov-2014	30-Jul-2014	3.83	8349				496	8845	
11	LEVEES & FLOODWALLS	11		90921	0	0	417350	338254		79096	417350	0	16338	350477	83211	433688
	Reach A	11		0	0	0	72593	55084	31.785	17509	72593	0	2337	56858	18072	74930
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		11		FY2013		2-Apr-2012	26-Oct-2013	13-Jan-2013	2.29	72593				2337	74930	
	Reach B	11		26288	0	0	86102	74105		11997	86102	0	1295	75147	12250	87397
	FEDERAL	11		0	0	0	25077	20245	23.865	4832	25077	0	1009	21060	5026	26086
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		11		FY2013		1-Apr-2013	9-Oct-2013	5-Jul-2013	2.76	25077				1009	26086	
	NON-FEDERAL - Section 104	11		26288	0	0	61025	53860	25.985	7165	61025	0	286	54087	7224	61311
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Demo, Structure Demo, Tree Removal, Contract 4047 May 2010 Sep 31 2010 FY10 Complete	11		FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	199				0	199	
	GGS Drainage Canal, Schoolhouse Rd Pipeline & Teal Bend Pipeline, Contract 4046 May 2010 Sep 31 2010 FY10 Complete	11		FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	5176				0	5176	
	Levees, Contract 4046 May 2010 May 2010 Sep 31 2010 FY10 Complete	11		FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	20913				0	20913	
		11		FY2011		1-Apr-2011	1-Oct-2011	1-Jul-2011	0.75	34737				286	35023	
	Reach C	11		25292	0	0	26200	25943		257	26200	0	86	26005	281	26286
	FEDERAL	11		0	0	0	908	651	39.5	257	908	0	86	713	281	994
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		11		FY2016		1-Apr-2016	17-Oct-2016	9-Jul-2016	5.78	908				86	994	

PROJECT: NATOMAS PACR, LPP PLAN — **DATE PREPARED: 25-Aug-2010**

LOCATION: CALIFORNIA — **PRICE LEVEL: 1-Oct-2010**

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COD E	SUNK COST THRU 30-Sep-2010		FIRST COST						FULLY FUNDED (3			
				PREVIOUS 1-Oct-2009		COST CHANGES		CURRENT				PREVIOUS 1-Oct-2009	CHANGE IN	CURRENT		
				AMOUNT	COST EST	PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN-GENCY	COST EST 5+6+7	EST	INFLAT - ION	DIRECT COST	CONTIN-GENCY	COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	NON-FEDERAL - Section 104		11	25292	0	0	25292	25292	0	0	25292	0	0	25292	0	25292
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1611				0	1611	
			11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	85				0	85	
			11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	2882				0	2882	
			11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2881				0	2881	
			11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1564				0	1564	
			11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	4499				0	4499	
			11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	4498				0	4498	
			11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	3308				0	3308	
			11	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	3964				0	3964	
	Reach D		11	39341	0	0	42894	41814		1080	42894	0	340	42050	1184	43234
	FEDERAL		11	0	0	0	3553	2473	43.7	1080	3553	0	340	2709	1184	3893
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2016		1-Apr-2016	23-Nov-2016	28-Jul-2016	5.83	3553				340	3893	
	NON-FEDERAL - Section 104		11	39341	0	0	39341	39341	0	0	39341	0	0	39341	0	39341
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	3679				0	3679	
			11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	14272				0	14272	
			11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	13317				0	13317	
			11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	5919				0	5919	
			11	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	2154				0	2154	
	Reach E		11	0	0	0	46281	33402	38.558	12879	46281	0	3554	35967	13868	49835
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2015		1-Apr-2015	3-Nov-2015	18-Jul-2015	4.80	46281				3554	49835	
	Reach F		11	0	0	0	48589	36823	31.952	11766	48589	0	2827	38966	12450	51416
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2014		1-Apr-2014	9-Oct-2014	5-Jul-2014	3.76	48589				2827	51416	
	Reach G		11	0	0	0	36763	26789	37.23	9974	36763	0	2794	28825	10732	39557
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2015		1-Apr-2015	2-Oct-2015	2-Jul-2015	4.75	36763				2794	39557	
	Reach H		11	0	0	0	40401	30435	32.745	9966	40401	0	2399	32242	10558	42800
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			11	FY2014		1-Apr-2014	27-Nov-2014	30-Jul-2014	3.83	40401				2399	42800	
	Reach I		11	0	0	0	17527	13859	26.465	3668	17527	0	706	14417	3816	18233
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	

PROJECT: NATOMAS PACR, LPP PLAN — **DATE PREPARED: 25-Aug-2010**

LOCATION: CALIFORNIA — **PRICE LEVEL: 1-Oct-2010**

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COD E	SUNK COST THRU 30-Sep-2010	PREVIOUS 1-Oct-2009	FIRST COST: COST CHANGES		FIRST COST: CURRENT				PREVIOUS 1-Oct-2009	CHANGE IN INFLAT - ION	FULLY FUNDED (3 CURRENT		
				AMOUNT	COST EST	PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN- GENCY	COST EST 5+6+7	EST		DIRECT COST	CONTIN- GENCY	COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
			11	FY2013		1-Apr-2013	1-Oct-2013	1-Jul-2013	2.75	17527				706	18233	
13	PUMPING PLANT		13	0	0	0	56135	42044		14091	56135	0	3775	44793	15117	59910
	Reach A		13	0	0	0	6003	4818	24.6	1185	6003	0	193	4973	1223	6196
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			13	FY2013		2-Apr-2012	26-Oct-2013	13-Jan-2013	2.29	6003				193	6196	
	Reach B		13	0	0	0	17215	13840	24.39	3375	17215	0	697	14400	3512	17912
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			13	FY2013		1-Apr-2013	9-Oct-2013	5-Jul-2013	2.76	17215				697	17912	
	Reach C		13	0	0	0	21496	15066	42.68	6430	21496	0	2036	16493	7039	23532
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			13	FY2016		1-Apr-2016	17-Oct-2016	9-Jul-2016	5.78	21496				2036	23532	
	Reach D		13	0	0	0	4207	2820	49.2	1387	4207	0	402	3089	1520	4609
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			13	FY2016		1-Apr-2016	23-Nov-2016	28-Jul-2016	5.83	4207				402	4609	
	Reach G		13	0	0	0	2823	2078	35.85	745	2823	0	215	2236	802	3038
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			13	FY2015		1-Apr-2015	2-Oct-2015	2-Jul-2015	4.75	2823				215	3038	
	Reach H		13	0	0	0	2881	2227	29.35	654	2881	0	171	2359	693	3052
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			13	FY2014		1-Apr-2014	27-Nov-2014	30-Jul-2014	3.83	2881				171	3052	
	Reach I		13	0	0	0	1510	1195	26.4	315	1510	0	61	1243	328	1571
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			13	FY2013		1-Apr-2013	1-Oct-2013	1-Jul-2013	2.75	1510				61	1571	
18	CULTURAL RESOURCES PRESERV.			0	0	0	6578	5660		918	6578	0	261	5885	954	6839
30	PLANNING/ENGINEERING/DESIGN			84588	0	0	130834	125320	0	5514	130834	0	4773	129501	6106	135607
	Reach A		A	3961	0	0	14163	12946		1217	14163	0	670	13536	1297	14833
	FEDERAL		A	612	0	0	10814	9597	13.55	1217	10814	0	670	10187	1297	11484
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	124				0	124	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	488				0	488	
			A	FY2012		1-Oct-2011	26-Oct-2013	13-Oct-2012	2.04	10202				670	10872	

PROJECT: NATOMAS PACR, LPP PLAN — **DATE PREPARED: 25-Aug-2010**

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COD E	SUNK COST THRU 30-Sep-2010	FIRST COST: PREVIOUS 1-Oct-2009	FIRST COST: COST CHANGES		FIRST COST: CURRENT				FULLY FUNDED (3: PREVIOUS 1-Oct-2009	FULLY FUNDED (3: CHANGE IN INFLAT - ION	FULLY FUNDED (3: CURRENT		
				AMOUNT	COST EST	PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN-GENCY	COST EST 5+6+7	EST		DIRECT COST	CONTIN-GENCY	COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	NON-FEDERAL - Section 104		C	3349	0	0	3349	3349	0	0	3349	0	0	3349	0	3349
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	43				0	43	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	56				0	56	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	764				0	764	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2486				0	2486	
	Reach B		A	34283	0	0	44902	43680		1022	44902	0	499	44335	1066	45401
	FEDERAL		A	1530	0	0	8994	8347	9.49	647	8994	0	482	8787	689	9476
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	310				0	310	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1220				0	1220	
			A	FY2012		1-Oct-2011	9-Oct-2013	4-Oct-2012	2.01	7464				482	7946	
	NON-FEDERAL - Section 104		C	32753	0	0	35908	35533	13.5	375	35908	0	17	35548	377	35925
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	53				0	53	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	507				0	507	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	5620				0	5620	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	12757				0	12757	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	13816				0	13816	
			C	FY2011		1-Oct-2010	1-Oct-2011	1-Apr-2011	0.50	3155				17	3172	
	Reach C		A	23682	0	0	26367	26040		327	26367	0	569	26540	396	26936
	FEDERAL		A	805	0	0	3490	3163	13.85	327	3490	0	569	3663	396	4059
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	163				0	163	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	642				0	642	
			A	FY2015		1-Oct-2014	17-Oct-2016	9-Oct-2015	5.03	2685				569	3254	
	NON-FEDERAL - Section 104		C	22877	0	0	22877	22877	0	0	22877	0	0	22877	0	22877
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	613				0	613	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	4083				0	4083	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	9647				0	9647	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	7137				0	7137	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1397				0	1397	
	Reach D		A	9688	0	0	10894	10746		148	10894	0	259	10973	180	11153
	FEDERAL		A	886	0	0	2092	1944	14	148	2092	0	259	2171	180	2351
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	179				0	179	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	707				0	707	
			A	FY2015		1-Oct-2014	23-Nov-2016	28-Oct-2015	5.08	1206				259	1465	
	NON-FEDERAL - Section 104		C	8802	0	0	8802	8802	0	0	8802	0	0	8802	0	8802

PROJECT: NATOMAS PACR, LPP PLAN — **DATE PREPARED: 25-Aug-2010**

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	CODE	SUNK COST THRU 30-Sep-2010		FIRST COST: PREVIOUS 1-Oct-2009	FIRST COST: CURRENT					PREVIOUS 1-Oct-2009	CHANGE IN INFLAT - ION	FULLY FUNDED (3 CURRENT		
				AMOUNT	COST EST	PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN-GENCY	COST EST 5+6+7	EST		DIRECT COST	CONTIN-GENCY	COST EST 12+6+7+13
(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	839				0	839	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	1604				0	1604	
			C	FY2008		1-Oct-2007	1-Oct-2009	30-Sep-2008	0.00	2457				0	2457	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	3361				0	3361	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	541				0	541	
	Reach E		A	3982	0	0	9453	8579		874	9453	0	887	9325	1015	10340
	FEDERAL		A	532	0	0	6003	5129	19	874	6003	0	887	5875	1015	6890
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	108				0	108	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	424				0	424	
			A	FY2014		1-Oct-2013	3-Nov-2015	17-Oct-2014	4.05	5471				687	6358	
	NON-FEDERAL - Section 104		C	3450	0	0	3450	3450	0	0	3450	0	0	3450	0	3450
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	193				0	193	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	1470				0	1470	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1294				0	1294	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	493				0	493	
	Reach F		A	2740	0	0	7761	7159		602	7761	0	560	7652	669	8321
	FEDERAL		A	0	0	0	5021	4419	13.63	602	5021	0	560	4912	669	5581
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2013		1-Oct-2012	9-Oct-2014	5-Oct-2013	3.01	5021				560	5581	
	NON-FEDERAL - Section 104		C	2740	0	0	2740	2740	0	0	2740	0	0	2740	0	2740
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	98				0	98	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	829				0	829	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1116				0	1116	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	697				0	697	
	Reach G		A	0	0	0	3684	3215		449	3664	0	586	3730	520	4250
	FEDERAL		A	0	0	0	3684	3215	13.95	449	3664	0	586	3730	520	4250
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2014		1-Oct-2013	2-Oct-2015	1-Oct-2014	4.00	3664				586	4250	
	Reach H		A	4148	0	0	9482	8845		637	9482	0	612	9384	710	10094
	FEDERAL		A	725	0	0	6059	5422	13.55	637	6059	0	612	5961	710	6671
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	147				0	147	
			A	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	578				0	578	
			A	FY2013		1-Oct-2012	27-Nov-2014	29-Oct-2013	3.08	5334				612	5946	

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	C O D E	SUNK COST THRU 30-Sep-2010 AMOUNT	PREVIOUS 1-Oct-2009 COST EST	COST CHANGES PRICE LEVEL	COST CHANGES OTHER (SEE NOTE)	FIRST COST DIRECT COST	CURRENT CONT RATE	CURRENT CONTIN-GENCY	CURRENT COST EST 5+6+7	PREVIOUS 1-Oct-2009 EST	CHANGE IN INFLAT-ION	FULLY FUNDED (3 CURRENT DIRECT COST	FULLY FUNDED (3 CURRENT CONTIN-GENCY	FULLY FUNDED (3 CURRENT COST EST 12+6+7+13
(1)	(2)	(3)		(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	NON-FEDERAL - Section 104		C	3423	0	0	3423	3423	0	0	3423	0	0	3423	0	3423
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	3				0	3	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	101				0	101	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	1567				0	1567	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1263				0	1263	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	469				0	469	
	Reach I		A	2104	0	0	4148	3910		238	4148	0	131	4026	253	4279
	FEDERAL		A	0	0	0	2044	1806	13.15	238	2044	0	131	1922	253	2175
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2012		1-Oct-2011	1-Oct-2013	30-Sep-2012	2.00	2044				131	2175	
	NON-FEDERAL - Section 104		C	2104	0	0	2104	2104	0	0	2104	0	0	2104	0	2104
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	29				0	29	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	128				0	128	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	354				0	354	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	676				0	676	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	917				0	917	
31	CONSTRUCTION MANAGEMENT			120651	0	0	152434	144745	0	7689	152434	0	4241	147897	8778	156675
	Reach A		A	0	0	0	6288	4792	31.23	1496	6288	0	487	5163	1612	6775
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2013		2-Apr-2012	26-Oct-2013	13-Jan-2013	2.29	6288				487	6775	
	Reach B		A	36773	0	0	42935	41706		1229	42935	0	360	41996	1299	43295
	FEDERAL		A	0	0	0	3383	2727	24.05	656	3383	0	337	2999	721	3720
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2013		1-Apr-2013	9-Oct-2013	5-Jul-2013	2.76	3383				337	3720	
	NON-FEDERAL - Section 104		C	36773	0	0	39552	38979	26	573	39552	0	23	38997	578	39575
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	4				0	4	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	2				0	2	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	2642				0	2642	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	34125				0	34125	
			C	FY2011		1-Apr-2011	1-Oct-2011	1-Jul-2011	0.75	2779				23	2802	
	Reach C		A	36581	0	0	38353	37818		535	38353	0	452	38135	670	38805
	FEDERAL		A	0	0	0	1792	1257	42.6	535	1792	0	452	1574	670	2244
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2016		1-Apr-2016	17-Oct-2016	9-Jul-2016	5.78	1792				452	2244	

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(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
	NON-FEDERAL - Section 104		C	36561	0	0	36561	36561	0	0	36561	0	0	36561	0	36561
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	779				0	779	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	2675				0	2675	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	5587				0	5587	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	27520				0	27520	
	Reach D		A	47517	0	0	48138	47940		198	48138	0	158	48047	249	48296
	FEDERAL		A	0	0	0	621	423	46.9	198	621	0	158	530	249	779
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2016		1-Apr-2016	23-Nov-2016	28-Jul-2016	5.83	621				158	779	
	NON-FEDERAL - Section 104		C	47517	0	0	47517	47517	0	0	47517	0	0	47517	0	47517
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	13395				0	13395	
			C	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	9061				0	9061	
			C	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	18143				0	18143	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	6918				0	6918	
	Reach E		A	0	0	0	4240	3065	38.32	1175	4240	0	850	3680	1410	5090
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2015		1-Apr-2015	3-Nov-2015	18-Jul-2015	4.80	4240				850	5090	
	Reach F		A	0	0	0	3887	2946	31.95	941	3887	0	576	3382	1081	4463
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2014		1-Apr-2014	9-Oct-2014	5-Jul-2014	3.76	3887				576	4463	
	Reach G		A	0	0	0	2939	2143	37.15	796	2939	0	582	2567	954	3521
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2015		1-Apr-2015	2-Oct-2015	2-Jul-2015	4.75	2939				582	3521	
	Reach H		A	0	0	0	4131	3131	31.95	1000	4131	0	625	3604	1152	4756
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2014		1-Apr-2014	27-Nov-2014	30-Jul-2014	3.83	4131				625	4756	
	Reach I		A	0	0	0	1523	1204	26.5	319	1523	0	151	1323	351	1674
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			A	FY2013		1-Apr-2013	1-Oct-2013	1-Jul-2013	2.75	1523				151	1674	
	TOTAL COST (FEDERAL FUNDS & NON-FEDERAL CASH CONTRIBUTION)			298225	0	0	800692	685089		115603	800692	0	31594	709311	122975	832286

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	NON-FEDERAL CASH CONTRIBUTION (-)			14547	0	29	87654	73350		14333	87683	0	3200	75769	15114	90883
	SECTION 104 (-)			253974	0	0	55249	45741		9508	55249	0	2354	47521	10082	57603
	TOTAL FEDERAL COST			**29704**	**0**	**-29**	**657789**	**565998**		**91762**	**657760**	**0**	**26040**	**586021**	**-5065**	**683800**
	NON-FEDERAL COST															
1	LANDS AND DAMAGES			7772	0	0	205338	155431	0	49907	205338	0	9304	162311	52331	214642
	Reach A		C	417	0	0	28959	23347	24.473	5612	28959	0	430	23693	5696	29389
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	369				0	369	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	19				0	19	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	6				0	6	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	23				0	23	
			C	FY2012		1-Oct-2011	2-Apr-2012	1-Jan-2012	1.25	28542				430	28972	
	Reach B		C	3503	0	0	55077	40931	37.794	14146	55077	0	1629	42114	14592	56706
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1869				0	1869	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	849				0	849	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	283				0	283	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	12				0	12	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	490				0	490	
			C	FY2013		1-Oct-2012	1-Apr-2013	31-Dec-2012	2.25	51574				1629	53203	
	Reach C		C	1998	0	0	15181	11207	43.15	3974	15181	0	1122	11991	4312	16303
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1014				0	1014	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	578				0	578	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	193				0	193	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	213				0	213	
			C	FY2016		1-Oct-2015	1-Apr-2016	31-Dec-2015	5.25	13183				1122	14305	
	Reach D		C	1021	0	0	5165	3633	58.65	1532	5165	0	353	3856	1662	5518
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	515				0	515	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	306				0	306	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	102				0	102	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	7				0	7	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	91				0	91	
			C	FY2016		1-Oct-2015	1-Apr-2016	31-Dec-2015	5.25	4144				353	4497	
	Reach E		C	378	0	0	33251	25076	33.1	8175	33251	0	2201	26730	8722	35452
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	195				0	195	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	61				0	61	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	20				0	20	

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(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	102				0	102	
			C	FY2015		1-Oct-2014	1-Apr-2015	31-Dec-2014	4.25	32873				2201	35074	
	Reach F		C	99	0	0	13767	9220	49.86	4547	13767	0	671	9667	4771	14438
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	82				0	82	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	7				0	7	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2				0	2	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1				0	1	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	7				0	7	
			C	FY2014		1-Oct-2013	1-Apr-2014	31-Dec-2013	3.25	13668				671	14339	
	Reach G		C	0	0	0	18340	13118	39.81	5222	18340	0	1228	13996	5572	19568
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2015		1-Oct-2014	1-Apr-2015	31-Dec-2014	4.25	18340				1228	19568	
	Reach H		C	215	0	0	32005	26642	20.293	5363	32005	0	1561	27940	5626	33566
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	140				0	140	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	21				0	21	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	7				0	7	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	47				0	47	
			C	FY2014		1-Oct-2013	1-Apr-2014	31-Dec-2013	3.25	31790				1561	33351	
	Reach I		C	141	0	0	3593	2257	63.1	1336	3593	0	109	2324	1378	3702
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	70				0	70	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	15				0	15	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	5				0	5	
			C	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	51				0	51	
			C	FY2013		1-Oct-2012	1-Apr-2013	31-Dec-2012	2.25	3452				109	3561	
2	RELOCATIONS		2	11724	0	0	127700	98315		29385	127700	0	7205	103589	31316	134905
	Reach A		2	0	0	0	13808	10851	25.41	2757	13808	0	438	11200	2846	14046
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2013		2-Apr-2012	26-Oct-2013	13-Jan-2013	2.29	13808				438	14046	
	Reach B		2	3809	0	0	26118	21796	24.03	4322	26118	0	904	22525	4497	27022
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
	Relocations, Roads, Contract 4046 May 2010 Sep 31 2010 FY10 Complete		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	512				0	512	
	Elkhorn Irr Canal, Phase 2A, Contract 4047 May 2010 Sep 31 2010 FY10 Complete		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1766				0	1766	
	Relocations, Private Irr Fec, Contract 4047 May 2010 Sep 31 2010 FY10 Complete		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1206				0	1206	

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(1)	(2)		(3)													
	Gas Line Relocation, Calpine Gas, at Garden Highway Contract 4046 May 2010 Sep 31 2010 FY10 Complete	2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	318				0	318	
	Underground Electrical Conduit for Street Light Contract 4046 May 2010 Sep 31 2010 FY10 Complete	2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2				0	2	
	Relocate Street Light Contract 4046 May 2010 Sep 31 2010 FY10 Complete	2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	5				0	5	
		2	FY2013		1-Apr-2013	9-Oct-2013	5-Jul-2013	2.76	22309				904	23213	
	Reach C	2	5092	0	0	13151	10585	46.72	2568	13151	0	763	11105	2809	13914
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	603				0	603	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	32				0	32	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	129				0	129	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	514				0	514	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	789				0	789	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	262				0	262	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	14				0	14	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	833				0	833	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	6				0	6	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	1910				0	1910	
		2	FY2016		1-Apr-2016	17-Oct-2016	9-Jul-2016	5.78	8059				763	8822	
	Reach D	2	2823	0	0	13900	10369	46.8	3531	13900	0	1060	11091	3869	14960
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	220				0	220	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	778				0	778	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	562				0	562	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1263				0	1263	
		2	FY2016		1-Apr-2016	23-Nov-2016	28-Jul-2016	5.83	11077				1060	12137	
	Reach E	2	0	0	0	16050	11433	40.38	4617	16050	0	1233	12312	4971	17283
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2015		1-Apr-2015	3-Nov-2015	18-Jul-2015	4.80	16050				1233	17283	
	Reach F	2	0	0	0	15419	11584	33.11	3835	15419	0	897	12258	4058	16316
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2014		1-Apr-2014	9-Oct-2014	5-Jul-2014	3.76	15419				897	16316	
	Reach G	2	0	0	0	13290	9659	37.588	3631	13290	0	1010	10393	3907	14300
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2015		1-Apr-2015	2-Oct-2015	2-Jul-2015	4.75	13290				1010	14300	
	Reach H	2	0	0	0	12996	9537	36.27	3459	12996	0	772	10103	3665	13768
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	

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(1)	(2)		(3)	(4)($K)	(5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
		2	FY2014		1-Apr-2014	27-Nov-2014	30-Jul-2014	3.83	12996					772	13768	
	Reach I	2	0	0	0	3,168	2501	26.68	667	3168	0	128	2602	694	3296
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2013		1-Apr-2013	1-Oct-2013	1-Jul-2013	2.75	3168				128	3296	
	SECTION 104		281665	0	0	311069	305202		5867	311069	0	236	305391	5914	311305
30	PLANNING/ENGINEERING/DESIGN	2	8280	0	0	21630	18152		3478	21630	0	577	18645	3662	22307
	Reach A	2	3	0	0	2045	1631	25.41	414	2045	0	57	1677	425	2102
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	3				0	3	
		2	FY2012		1-Oct-2011	26-Oct-2013	13-Oct-2012	2.04	2042				57	2099	
	Reach B	2	4090	0	0	5056	4869	24	187	5056	0	26	4890	192	5082
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	406				0	406	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1444				0	1444	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	2240				0	2240	
		2	FY2012		1-Oct-2011	9-Oct-2013	4-Oct-2012	2.01	966				26	992	
	Reach C	2	3896	0	0	4863	4555	46.8	308	4863	0	78	4608	333	4941
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2006		1-Oct-2005	1-Oct-2006	1-Apr-2006	0.00	211				0	211	
		2	FY2007		1-Oct-2006	1-Oct-2007	1-Apr-2007	0.00	697				0	697	
		2	FY2008		1-Oct-2007	1-Oct-2008	1-Apr-2008	0.00	1073				0	1073	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	1214				0	1214	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	701				0	701	
		2	FY2015		1-Oct-2014	17-Oct-2016	9-Oct-2015	5.03	967				78	1045	
	Reach D	2	272	0	0	1457	1080	46.7	377	1457	0	74	1130	401	1531
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	170				0	170	
		2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	102				0	102	
		2	FY2014		1-Oct-2013	2-Oct-2015	1-Oct-2014	4.00	1185				74	1259	
	Reach E	2	0	0	0	2408	1715	40.38	693	2408	0	152	1824	736	2560
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2014		1-Oct-2013	3-Nov-2015	17-Oct-2014	4.05	2408				152	2560	
	Reach F	2	0	0	0	1850	1390	33.1	460	1850	0	83	1452	481	1933
			Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
		2	FY2013		1-Oct-2012	9-Oct-2014	5-Oct-2013	3.01	1850				83	1933	

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	COD E	SUNK COST THRU 30-Sep-2010 AMOUNT (4)($K)	SUNK COST THRU 1-Oct-2009 COST EST (5)($K)	FIRST COST COST CHANGES PRICE LEVEL (6)($K)	FIRST COST COST CHANGES OTHER (SEE NOTE) (7)($K)	FIRST COST CURRENT DIRECT COST (8)($K)	FIRST COST CURRENT CONT RATE (9)(%)	FIRST COST CURRENT CONTIN-GENCY (10)($K)	FIRST COST CURRENT COST EST 5+6+7 (11)($K)	FULLY FUNDED (3 PREVIOUS 1-Oct-2009 EST (12)($K)	FULLY FUNDED (3 CHANGE IN INFLAT - ION (13)($K)	FULLY FUNDED (3 CURRENT DIRECT COST (14)($K)	FULLY FUNDED (3 CURRENT CONTIN-GENCY (15)($K)	FULLY FUNDED (3 CURRENT COST EST 12+6+7+13 (16)($K)
	(1)	(2)	(3)													
	Reach G		2	8	0	0	2001	1457	37.55	544	2001	0	125	1548	578	2126
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	8				0	8	
			2	FY2014		1-Oct-2013	2-Oct-2015	1-Oct-2014	4.00	1993				125	2118	
	Reach H		2	5	0	0	1564	1149	36.25	415	1564	0	72	1202	434	1636
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	5				0	5	
			2	FY2013		1-Oct-2012	27-Nov-2014	29-Oct-2013	3.08	1559				72	1631	
	Reach I		2	6	0	0	386	306	26.7	80	386	0	10	314	82	396
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	6				0	6	
			2	FY2012		1-Oct-2011	1-Oct-2013	30-Sep-2012	2.00	380				10	390	
31	CONSTRUCTION MANAGEMENT		2	560	0	0	8740	6593		2147	8740	0	520	6968	2292	9260
	Reach A		2	0	0	0	1089	868	25.41	221	1089	0	35	896	228	1124
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2013		2-Apr-2012	26-Oct-2013	13-Jan-2013	2.29	1089				35	1124	
	Reach B		2	530	0	0	1046	946	24	100	1046	0	4	949	101	1050
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	74				0	74	
			2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	456				0	456	
			2	FY2011		1-Apr-2011	1-Oct-2011	1-Jul-2011	0.75	516				4	520	
	Reach C		2	30	0	0	675	470	46.7	205	675	0	61	511	225	736
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2009		1-Oct-2008	1-Oct-2009	1-Apr-2009	0.00	22				0	22	
			2	FY2010 Projected Sunk Cost		1-Oct-2009	1-Oct-2010	1-Apr-2010	0.00	8				0	8	
			2	FY2016		1-Apr-2016	17-Oct-2016	9-Jul-2016	5.78	645				61	706	
	Reach D		2	0	0	0	790	538	46.9	252	790	0	76	590	276	866
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2016		1-Apr-2016	23-Nov-2016	28-Jul-2016	5.83	790				76	866	
	Reach E		2	0	0	0	1284	915	40.3	369	1284	0	99	986	397	1383
				Expenditure Allocations		**Start**	**End**	**Midpoint**	**Period(YRS)**	**Expend.**				**Inflation Amt**	**Fully Funded**	
			2	FY2015		1-Apr-2015	3-Nov-2015	18-Jul-2015	4.80	1284				99	1383	
	Reach F		2	0	0	0	1234	927	33.1	307	1234	0	72	961	325	1306

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CODE OF ACCT. NO.	FEATURE/SUBFEATURE (NOTE)	NOTES	CODES	SUNK COST THRU 30-Sep-2010	FIRST COST: PREVIOUS 1-Oct-2009	FIRST COST: COST CHANGES		FIRST COST: CURRENT				PREVIOUS 1-Oct-2009	CHANGE IN INFLAT - ION	FULLY FUNDED (3 CURRENT		
						PRICE LEVEL	OTHER (SEE NOTE)	DIRECT COST	CONT RATE	CONTIN- GENCY	COST EST 5+6+7	EST		DIRECT COST	CONTIN- GENCY	COST EST 12+6+7+13
(1)	(2)		(3)	AMOUNT (4)($K)	COST EST (5)($K)	(6)($K)	(7)($K)	(8)($K)	(9)(%)	(10)($K)	(11)($K)	(12)($K)	(13)($K)	(14)($K)	(15)($K)	(16)($K)
		2		Expenditure Allocations FY2014		Start 1-Apr-2014	End 9-Oct-2014	Midpoint 5-Jul-2014	Period(YRS) 3.76	Expend. 1234				Inflation Amt 72	Fully Funded 1306	
	Reach G	2		0	0	0	1329	966	37.6	363	1329	0	101	1039	391	1430
		2		Expenditure Allocations FY2015		Start 1-Apr-2015	End 2-Oct-2015	Midpoint 2-Jul-2015	Period(YRS) 4.75	Expend. 1329				Inflation Amt 101	Fully Funded 1430	
	Reach H	2		0	0	0	1040	763	36.3	277	1040	0	62	809	293	1102
		2		Expenditure Allocations FY2014		Start 1-Apr-2014	End 27-Nov-2014	Midpoint 30-Jul-2014	Period(YRS) 3.83	Expend. 1040				Inflation Amt 62	Fully Funded 1102	
	Reach I	2		0	0	0	253	200	26.8	53	253	0	10	207	56	263
		2		Expenditure Allocations FY2013		Start 1-Apr-2013	End 1-Oct-2013	Midpoint 1-Jul-2013	Period(YRS) 2.75	Expend. 253				Inflation Amt 10	Fully Funded 263	
	TOTAL NON-FEDERAL LERRD			310001	0	0	674477	583693		90784	674477	0	17942	596904	95515	692419
	NON-FEDERAL CASH CONTRIBUTION (+)			14547	0	29	87654	73350		14333	87683	0	3200	75769	15114	90883
	NED Construction Share			3077	0	29	55249	45741		9537	55278	0	2340	47521	10097	57618
	Cost Above NED			11470	0	0	32405	27609		4796	32405	0	860	28248	5017	33265
	SECTION 104 (-), Remaining Allowable			27691	0	0	255820	259461		-3641	255820	0	-2118	257870	-4168	253702
	TOTAL NON-FEDERAL COST			**296857**	**0**	**29**	**506311**	**397582**		**108758**	**506340**	**0**	**23260**	**414803**	**114797**	**529600**
	TOTAL LPP COST			**326561**	**0**	**0**	**1164100**	**963580**		**200520**	**1164100**	**0**	**49300**	**1000824**	**212576**	**1213400**

BASIS OF ESTIMATE:

(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.

(2 Federal administrative costs for Non-federal land acquisition.

(3 The Fully Funded cost estimate was prepared in compliance with OMB INDEXES EC-11-2-199, published on MAR. 31, 2010..

(4 CWCCIS indexes from 10/01/2009 to 10/01/2010, are projected rates for Lands and Constructions. OMB escalation rates are actual for PED & CM and Real Estate Admin.

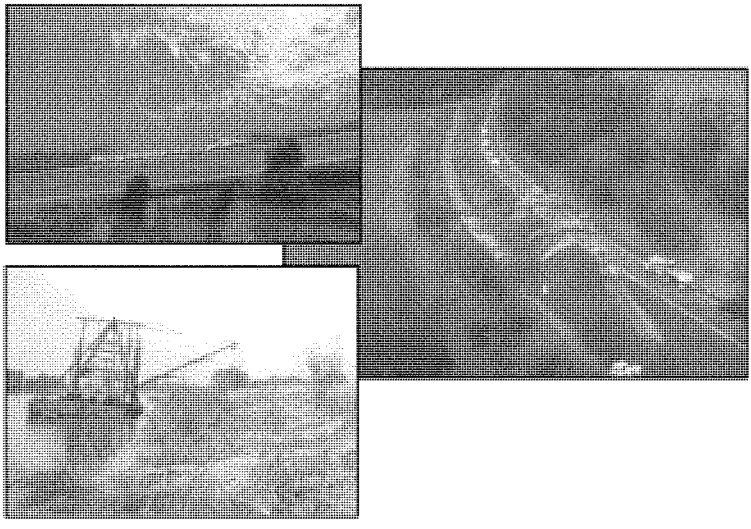
Post-Authorization Change Report

American River Watershed

Common Features Project

Natomas Basin

Sacramento and Sutter Counties, California



SAFCA
Sacramento
Area Flood
Control
Agency

US Army Corps
of Engineers ®
Sacramento District

APPENDIX H - ECONOMICS

October 2010

EXECUTIVE SUMMARY

FOREWORD

This Appendix presents the economic analysis for the Natomas Post-Authorization Change, Interim Reevaluation Report. The study area is the Natomas Basin in the city of Sacramento. This Basin is surrounded by levees and is a "closed" ring levee system. The Interim National Economic Development (NED) Plan has been identified as one which includes making improvements to the entire levee system, which, for analytical and technical purposes, is comprised of nine geotechnical levee reaches (NAT A, NAT B, NAT C on the Sacramento River; NAT D on the Natomas Cross Canal; NAT E on the Pleasant Grove Canal; NAT F, NAT G, and NAT H on the Natomas East Main Drainage Canal; and NAT I on the American River). The Interim NED Plan produces average annual benefits of approximately $443 million, has a benefit-to-cost ratio of 6.5 to 1, and reduces flood risk from about a 1 in 5 chance of flooding to about a 1 in 67 chance of flooding in any given year.

It is important to point out that the cumulative reach-by-reach analysis presented in the following chapters has its limitations, mostly related to the modeling tools and the assumed engineering data used to perform the economic analysis. Significant limitations are:

- HEC-FDA was the economic model used to perform the analysis. While HEC-FDA is an approved Corps of Engineers planning model, it was not developed for and does not have the inherent functionality to analyze flooding within a systems context. Currently, the Corps does not have a certified model that addresses dependent inter-relational performance throughout a system. The economic analysis presented herein, however, does attempt to use a systems approach to characterize the flood risk in the Basin by manipulating data outside of HEC-FDA and applying this data within HEC-FDA. This analytical process is described in detail in Chapter 6, *With-Project Analysis*. A main objective of the approach was to perform a cumulative reach-by-reach analysis in order to show the reduction in flood risk to the Basin with each additional levee reach improvement; however, it does not go unrecognized that the reach-by-reach results presented in Chapters 6, 7a, and 7b may differ from those results that may be obtained from a model developed specifically to analyze flooding problems from a systems perspective. While the analytical approach described in this Appendix was necessitated by the lack of availability of a systems model, it is important to note that the Corps of Engineers is currently developing a model (FRM) that will be able to evaluate flood risk (probability of flooding and consequences of flooding) based on a systems approach.

- The economic analysis was completed prior to datum conversion from NGVD 29 to NAVD 88. Within the context of HEC-FDA modeling, this may have introduced additional uncertainty in terms of levee height deficiency and the true impact (or non-

impact) of overtopping, which in turn could have affected the cumulative reach-by-reach analysis presented in Chapter 6. In particular, the methodical approach relies partly on HEC-FDA-computed annual exceedance probability (AEP) values, which is the chance of flooding in any given year, to determine the order of levee reach improvements; AEP for each reach and under different conditions is computed based on water surface elevation data that may be more uncertain in some reaches than in others. In instances where the AEP of reaches are particularly close, changes to one of the uncertainty drivers could alter the "order" of levee reach improvements.

The data and modeling tools used to perform the economic analysis may well have affected the order of reach improvements or the grouping of fixes presented in Table ES-7 of this Executive Summary and in Chapters 6, 7a, and 7b of this Appendix. It does not, however, affect the reality that the Natomas Basin is a "closed" ring levee system, whereby flood protection is only as good as its weakest link.

Chapter 6 describes the analytical approach and methodically depicts how flood risk in the Basin is improved as segments of the ring levee surrounding the Basin are improved, until finally the complete ring levee is improved; Chapter 7a introduces costs and shows the net benefit and benefit-to-cost analyses of improvements to the ring levee; Chapter 7b shows the net benefit and benefit-to-cost analyses using the Natomas @Risk Model (N@RM), which expands on the HEC-FDA analysis by incorporating additional assumptions regarding human behavior factors.

ES.1 OVERVIEW

Previous project delivery team (PDT) study efforts for the Natomas Basin area were conducted under a Natomas General Reevaluation Report (GRR). Initial findings (e.g., increased costs and scope of levee improvements for the Natomas Basin) from some of these efforts coupled with findings (e.g., potential through- and under seepage issues with the Sacramento River east levees downstream of the American River, which could lead to failure and major flooding in the city of Sacramento) from other hydraulic and geotechnical studies resulted in the Natomas Basin study efforts being included in a broader American River Watershed Common Features GRR so that potential FRM issues could be more fully addressed from a system approach and to reduce flood risk to the entire city of Sacramento (including the Natomas Basin). An ARWCF GRR document was completed in 2009; an F3 Conference was held in March of 2009.

Subsequent to the F3 Conference, it was decided that work for the Natomas Basin would be fast-tracked and the Basin area would be studied separately from the rest of the ARWCF project area. The study would be conducted under a Post-Authorization Change (PAC) and would be documented in a Natomas Post-Authorization Change Report (NPACR).

This Economic Appendix to the Natomas Post-Authorization Change Report (NPACR) documents the economic analysis performed for the Natomas Basin economic impact area (EIA). The analysis documented in this appendix addresses flood risk (probability of flooding and consequences of flooding) in the Natomas Basin, expected benefits associated with potential flood risk management (FRM) alternatives, and residual risk associated with these potential alternatives.

ES.2 PURPOSE AND SCOPE OF ECONOMIC ANALYSIS

The purpose of this Economic Appendix to the NPACR is to present the economic analysis performed for the Natomas Basin economic impact area. This appendix describes the methodologies, assumptions, data and results of the analysis, and summarizes the flood risk under the without-project condition, the residual flood risk associated with potential alternatives, and the economic benefits associated with these alternatives. This appendix also describes the benefit-to-cost and net benefit analyses performed to determine feasibility and optimization of various alternatives, respectively.

This Economic Appendix is intended to:

- Document the current hydrologic data used in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the current hydraulic floodplains and HEC-FDA hydraulic input data used in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the current geotechnical HEC-FDA input data (i.e., geotechnical levee functions which show the relationship between water surface on the river versus the probability of levee failure, or "geotechnical risk and uncertainty curves" (GRU) as they

are referred to throughout this appendix) used in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions

- Document the economic methodologies, major assumptions, models, and data used in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the economic damage/benefit categories considered in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the results (detailed HEC-FDA output files and EAD/AEP results) of the HEC-FDA model runs for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the screening-level cost estimates used to perform the net benefit and benefit-to-cost analyses
- Describe the approach used to perform the with-project benefits analysis and document the results of the net benefit and benefit-to-cost analyses used to determine plan optimization and feasibility
- Describe additional analyses that will be conducted for future studies and which were not considered in this NPACR

ES.3 WITHOUT-PROJECT DAMAGES

The Natomas Basin encompasses parts of both Sutter and Sacramento counties in California. The impact area is bounded by the Natomas Cross Canal to the north, the Natomas East Main Drainage Canal (NEMDC) to the east, the American River to the south, and the Sacramento River to the west.

For the NPACR, without-project damages and with-project benefits were based on potential damages to residential structures and contents, non-residential (commercial, industrial, public, and farm) structures and contents, and automobiles. Other damage/benefit categories, including agricultural/crops, traffic disruption, and emergency costs, will be addressed in the upcoming GRR.

There are approximately 23,000 structures in the Natomas Basin. Structure counts are presented in Table ES-1. Total value of damageable property (structures and contents) is displayed in Table ES-2 and is approximately $8.5 billion.

Table ES-1
Structure Count
Natomas Basin

STRUCTURE COUNT BY DAMAGE CATEGORY	
Damage Category	**Structure Count**
Commercial	303
Farm	21
Industrial	156
Public	85
Residential	22,265
TOTAL	**22,830**

Table ES-2
Total Value of Damageable Property by Category
Structures and Contents
Values in $Millions, October 2010 Price Level

CATEGORY	VALUE OF DAMAGEABLE PROPERTY		
	Structures	**Contents**	**Total**
Commercial	681	308	989
Farm	6	7	13
Industrial	458	249	707
Public	440	275	715
Residential	4,076	2,038	6,114
TOTAL	**5,661**	**2,877**	**8,538**

Single-event damages for the 2-, 10-, 25-, 50-, 100-, 200-, and 500-year flood events were computed in the economic model (HEC-FDA) and are presented in Table ES-3. The damages shown are based on flooding from a levee breach along the Natomas Cross Canal (NCC). The consequences from a breach are greatest from a breach on the NCC than from any of the other water sources (Sacramento River, Pleasant Grove Creek Canal, Natomas East Main Drainage Canal, and American River).[1] Potential damages from a breach on the NCC range from $6.3 billion for the 2-yr event to close to $7.0 billion for the 500-year event; Figure ES-1 displays the event floodplains from a breach on the NCC. There is extremely deep (darkest blue indicates greater than 20 feet of flooding) and extensive flooding in the Basin from a breach on the NCC.

[1] Nine geotechnical reaches (economic index points) were delineated for the analysis. A levee breach from any of these nine index points produced a unique suite of floodplains (2-yr to 500-yr). Single-event damages from a breach on the NCC were the greatest for all events, while damages from a breach on the Natomas East Main Drainage Canal (NEMDC) were the lowest.

Table ES-3
Without-Project Single-Event Damages
Damages Based on Levee Breach from Natomas Cross Canal (NCC)
Values in $Millions, October 2010 Price Level

DAMAGE CATEGORY	NATOMAS REACH D SINGLE-EVENT WITHOUT-PROJECT FLOOD DAMAGES						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	4,133	4,386	4,444	4,495	4,513	4,519	4,520
Commercial	760	814	832	849	857	868	875
Industrial	530	585	596	609	619	627	637
Public	537	597	604	639	647	650	651
Farm	9	10	11	11	11	11	12
Auto Losses	333	339	339	339	339	339	339
TOTAL	**6,302**	**6,731**	**6,826**	**6,942**	**6,986**	**7,014**	**7,034**

Figure ES-1

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Without-project EAD is estimated to be approximately $462 million and is shown in Table ES-4 below.

Table ES-4
Without-Project Expected Annual Damages (EAD) by Category
Values in $Millions, October 2010 Price Level

STRUCTURE & CONTENTS	WITHOUT-PROJECT EAD
Total	462

ES.4 WITH-PROJECT DAMAGES AND DAMAGES REDUCED

A with-project benefit analysis was performed based on levee improvement (by geotechnical reach) around the basin; these improvements included fixing levees in place as well as levee raises in reaches where necessary. The levee reach improvements are:

- No Improvement -- Without-Project
- Fix Reach D
- Fix Reach D+A
- Fix Reach D+A+E
- Fix Reach D+A+E+B
- Fix Reach D+A+E+B+C
- Fix Reach D+A+E+B+C+H
- Fix Reach D+A+E+B+C+H+G
- Fix Reach D+A+E+B+C+H+G+F
- Fix Reach D+A+E+B+C+H+G+F+I
- Fix All + Raise D,B,E,F
- Fix All + Raise D,B,E,F,A,C,I,G
- Fix All + Raise All

Table ES-5 displays the with-project residual damages and benefits for each alternative. Each alternative is comprised of specific methods of fixes (measures) for each reach. Additionally, two categories of alternatives were identified for plan formulation purposes – a "fix-in-place" and "adjacent levee" alternative. Generally speaking, each measure can be part of both a "fix-in-place" and "adjacent levee" alternative as the salient factor that determines how a measure is categorized is dictated mostly by where the measure is physically located. From a geotechnical performance point of view, whether a measure is labeled "fix-in-place" or "adjacent levee" does not change its geotechnical performance (i.e., a measure has the same geotechnical performance no matter how it's categorized), and therefore, benefits for each measure (method of fix) and benefits between the two categories of alternative evaluated, are the same. This can be seen in Table ES-5.

Table ES-5
With-Project Residual Damages and Benefits by Levee Reach Improvement
Damages/Benefits in $Millions, October 2010 Price Level

LEVEE REACH IMPROVEMENT	ALTERNATIVE TYPE	EXPECTED ANNUAL DAMAGES	RESIDUAL DAMAGES	DAMAGES REDUCED (BENEFITS)
Without-Project	Adjacent Levee	462	--	--
	Fix-in-Place			
Fix D	Adjacent Levee	--	341	121
	Fix-in-Place			
Fix D+A	Adjacent Levee	--	330	132
	Fix-in-Place			
Fix D+A+E	Adjacent Levee	--	299	163
	Fix-in-Place			
Fix D+A+E+B	Adjacent Levee	--	101	361
	Fix-in-Place			
Fix D+A+E+B+C	Adjacent Levee	--	60	402
	Fix-in-Place			
Fix D+A+E+B+C+H	Adjacent Levee	--	32	430
	Fix-in-Place			
Fix D+A+E+B+C+H+G	Adjacent Levee	--	24	438
	Fix-in-Place			
Fix D+A+E+B+C+H+G+F	Adjacent Levee	--	19	443
	Fix-in-Place			
Fix D+A+E+B+C+H+G+F+I	Adjacent Levee	--	19	443
	Fix-in-Place			
Fix All + Raise D,B,E,& F	Adjacent Levee	--	10	452
	Fix-in-Place			
Fix All + Raise D,B,E,F, A,C,I,& G	Adjacent Levee	--	8	454
	Fix-in-Place			
Fix All + Raise All	Adjacent Levee	--	2	460
	Fix-in-Place			

It can be seen from Table ES-5 that Fix all reaches – D, A, E, B, C, H, G, F, and I) does not provide any additional benefit. Any additional benefit of fixing I is only achieved when levees in other reaches are raised. This is because fixing NAT I without raising levees in other reaches at the same time does not improve the probability of flooding in the Basin.

ES.5 PROJECT PERFORMANCE

Project performance can be measured by annual exceedance probability (AEP), long-term risk, and conditional non-exceedance probability (CNP). These were computed in HEC-FDA using hydrologic, hydraulic, and geotechnical engineering data. Table ES-6 presents the AEP results for each alternative.

Table ES-6
Project Performance Statistics by Levee Reach Improvement

GROUP	AEP
Without-Project	.21
Fix D	.21
Fix D+A	.18
Fix D+A+E	.12
Fix D+A+E+B	.04
Fix D+A+E+B+C	.04
Fix D+A+E+B+C+H	.015
Fix D+A+E+B+C+H+G	.015
Fix D+A+E+B+C+H+G+F	.015
Fix D+A+E+B+C+H+G+F+I	.015
Fix All + Raise D,B,E,& F	.008
Fix All + Raise D,B,E,F, A,C,I,& G	.006
Fix All + Raise All	.001

Table ES-6 shows that Basin-wide AEP is reduced with each improvement. Fixing all levees (no raises) around the Basin results in an AEP of about .015. Additional levee raises throughout the Basin improves AEP correspondingly.

ES.6 NET BENEFIT ANALYSIS

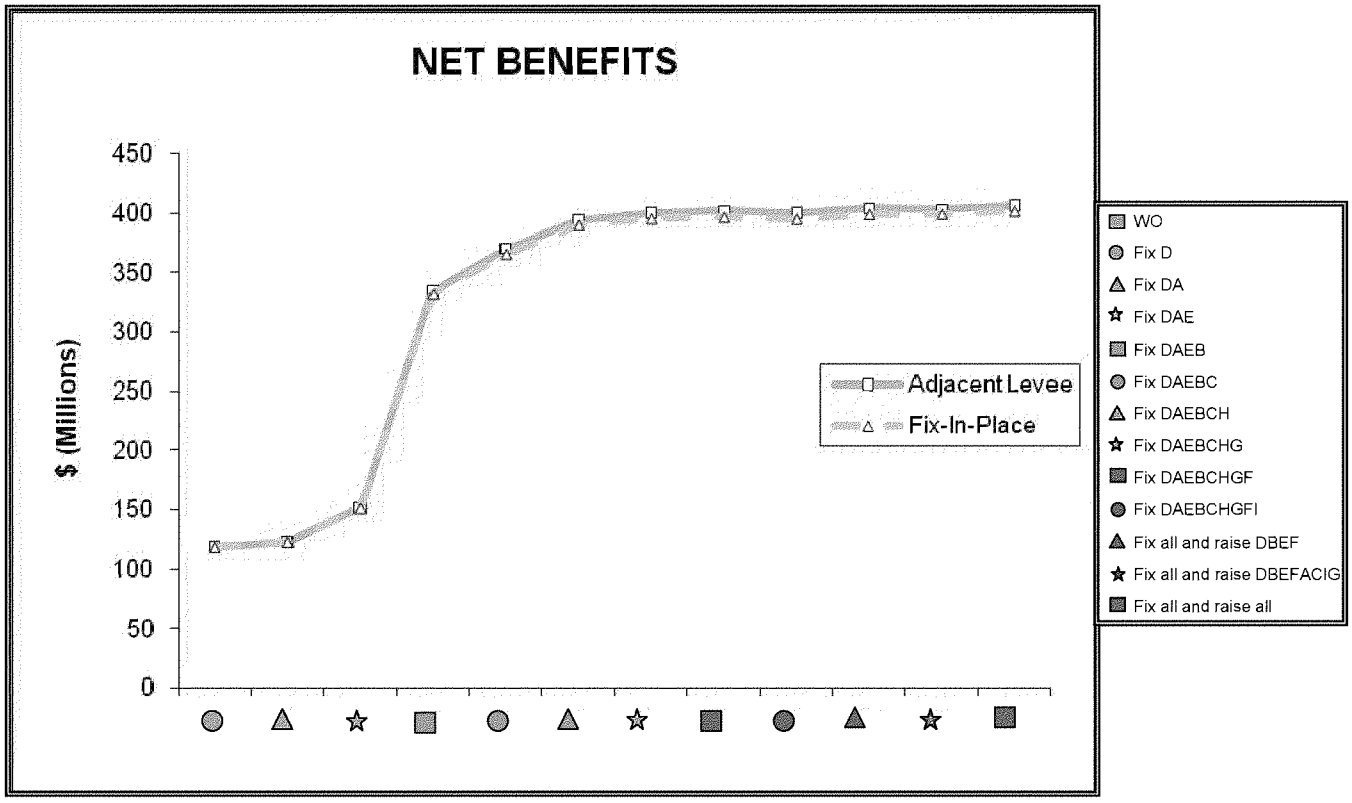
Average annual benefits for each levee reach improvement were determined by taking the difference between without-project EAD and with-project EAD (Table ES-5). Net benefits were determined by taking the difference between average annual benefits and average annual costs.

For purposes of preliminarily screening of improvements, total project first costs and interest during construction (IDC) were estimated for the various measures (methods of fixes) in each reach and by alternative type ("fix-in-place" or "adjacent levee"). First costs and IDC were added together to derive total investment costs. Investment costs were then amortized assuming a 50-year period of analysis and an interest rate of 4.375%.

Table ES-7 displays the average annual benefits and average annual costs, benefit-to-cost ratios by levee reach improvement. Figure ES-2 visually displays the net benefits of each improvement

in graphical form, and shows that net benefits continue to increase until the 11th levee reach improvement, where the cost of improving the levee are greater than the additional benefits; The 11th improvement includes levee raises in A, C, I, and G in addition to levee raises in D, B, E, and F. It should be noted that net benefits do increase from the first set of levee raises to the final raises, where levee raises occur in all reaches.

Figure ES-1
October 2010 Price Level



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Table ES-7
Net Benefits and Benefit-to-Cost Ratio
October 2010 Price Level

Levee Reach Improvement	ALTERNATIVE TYPE	EXPECTED ANNUAL DAMAGES	ANNUAL BENEFITS	ANNUAL COST	NET BENEFITS	B/C RATIO
WITHOUT-PROJECT	-	462	-	-	-	-
FIX D	Adjacent Levee	341	121	2.0	119	61.7
	Fix-in-Place			2.0	119	61.7
FIX D, A	Adjacent Levee	330	132	8.3	124	15.9
	Fix-in-Place			8.6	123	15.4
FIX D, A, E	Adjacent Levee	299	163	11.5	152	14.2
	Fix-in-Place			12.0	151	13.6
FIX D, A, E, B	Adjacent Levee	101	361	26.7	334	13.5
	Fix-in-Place			29.2	332	12.4
FIX D, A, E, B, C	Adjacent Levee	60	402	31.7	370	12.7
	Fix-in-Place			36.0	366	11.2
FIX D, A, E, B, C, H	Adjacent Levee	32	430	35.6	394	12.1
	Fix-in-Place			39.9	390	10.8
FIX D, A, E, B, C, H, G	Adjacent Levee	24	438	37.8	400	11.6
	Fix-in-Place			42.4	396	10.3
FIX D, A, E, B, C, H, G, F	Adjacent Levee	19	443	41.3	402	10.7
	Fix-in-Place			46.1	397	9.6
FIX D, A, E, B, C, H, G, F, I	Adjacent Levee	19	443	42.7	400	10.4
	Fix-in-Place			47.6	395	9.3
FIX ALL + RAISE D, B, E, F	Adjacent Levee	10	452	48.1	404	9.4
	Fix-in-Place			52.7	399	8.6
FIX ALL + RAISE D, B, E-2, F, G, I, A, C	Adjacent Levee	8	454	51.1	403	8.9
	Fix-in-Place			54.6	399	8.3
FIX ALL + RAISE ALL	Adjacent Levee	2	460	53.5	407	8.6
	Fix-in-Place			58.1	402	7.9

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ES.7 CONCLUSION

The Natomas Basin is considered a "closed" ring levee system, whereby flood protection is only as good as its weakest link. Table ES-8 is a condensed version of Table ES-7. Table ES-8 displays the risk remaining after improvements to groups of specific levee reaches. The purpose of the table is to highlight the notion that the Natomas Basin is a "closed" ring levee system as well as to show the reduction in flood risk with each levee reach improvement in terms of the chance of flooding and the consequences of flooding.

Table ES-8
Residual Risk and Unit of Measurement
October 2010 Price Level

Unit of Measurement	Improvement	Expected Annual Damages (EAD) In $Millions	Residual Damages In $Millions	Annual Exceedance Probability (AEP)
N/A	No fixes	462	--	.21
3 of 9 reaches	Fix D, A, E	--	299	.12
6 of 9 reaches	Fix D, A, E, B, C, H	--	32	.015
COMPLETE SYSTEM	Fix All Reaches	--	19	.015
COMPLETE SYSTEM	Fix all and raise some	--	10	.008
COMPLETE SYSTEM	Fix all and raise some	--	8	.006
COMPLETE SYSTEM	Fix all and raise all	--	2	.001

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LIST OF ABBREVIATIONS AND ACRONYMS

AEP	Annual Exceedance Probability
AR	American River
ARWCF	American River Watershed Common Features
ARN	AR North Basin
ARS	AR South Basin
C&I	Commercial and Industrial
CIP	Controlling Index Point
CF	Common Features
cfs	cubic feet per second
CNP	Conditional Non-Exceedance Probability
CVP	Central Valley Project
EA	Environmental Assessment
EAD	Expected Annual Damages
Appendix	Economic Appendix
EGM	Economic Guidance Memorandum
EIA	Economic Impact Area
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EQ	Environmental Quality
ERR	Economic Reevaluation Report
FDR	Floor Damage Reduction
FEMA	Federal Emergency Management Agency
FIA	Federal Insurance Administration
FRM	Flood Risk Management
GIS	Geographic Information Systems
GRR	General Reevaluation Report
GRU	Geotechnical Risk & Uncertainty
HEC-FDA	Hydrologic Engineering Center Flood Damage Analysis model
H&H	Hydrology and Hydraulics
I-5	Interstate 5
IDC	Interest During Construction
IP	Index Point
IWR	Institute for Water Resources
JFP	Joint Federal Project
LRR	Limited Reevaluation Report
MFR	Multiple-Family Residence
MH	Mobile Home
NA1	No Action 1 Condition
NA2	No Action 2 Condition
NA3	No Action 3 Condition
NADA	National Auto Dealer Association
Natomas	A suburb within the Sacramento city limits, just north of downtown Sacramento and in the Natomas Basin.
NCC	Natomas Cross Canal
NED	National Economic Development
NEMDC	Natomas East Main Drainage Canal
NPACR	Natomas Post-Authorization Change Report
OSE	Other Social Effects
PAC	Post Authorization Change Report
PDT	Project Delivery Team
PMF	Probable Maximum Flood
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RED	Regional Economic Development
RM	River Mile
ROI	Region of Influence
SAFCA	Sacramento Area Flood Control Agency
SFR	Single-Family Residence
SIR	Supplemental Information Report
SP	Selected Plan
SR	Sacramento River
TOL	Top of Levee
USACE	U.S. Army Corps of Engineers
WO1	Without-Project Condition 1
WO2	Without-Project Condition 2
WO3	Without-Project Condition 3
WOPC	Without-Project Condition
WRDA	Water Resources Development Act
WSE	Water Surface Elevation
WSP	Water Surface Profile

CHAPTER 1
INTRODUCTION

1.1 NATOMAS POST-AUTHORIZATION CHANGE REPORT (NPACR)

Previous project delivery team (PDT) study efforts for the Natomas Basin area were conducted under a Natomas General Reevaluation Report (GRR). Initial findings (e.g., increased costs and scope of levee improvements for the Natomas Basin) from some of these efforts coupled with findings (e.g., potential through- and under seepage issues with the Sacramento River east levees downstream of the American River, which could lead to failure and major flooding in the city of Sacramento) from other hydraulic and geotechnical studies resulted in the Natomas Basin study efforts being included in a broader American River Watershed Common Features GRR so that potential FRM issues could be more fully addressed from a system approach and to reduce flood risk to the entire city of Sacramento (including the Natomas Basin). An interim ARWCF GRR document evaluating without-project conditions was completed in 2009; an F3 Conference was held in March of 2009.

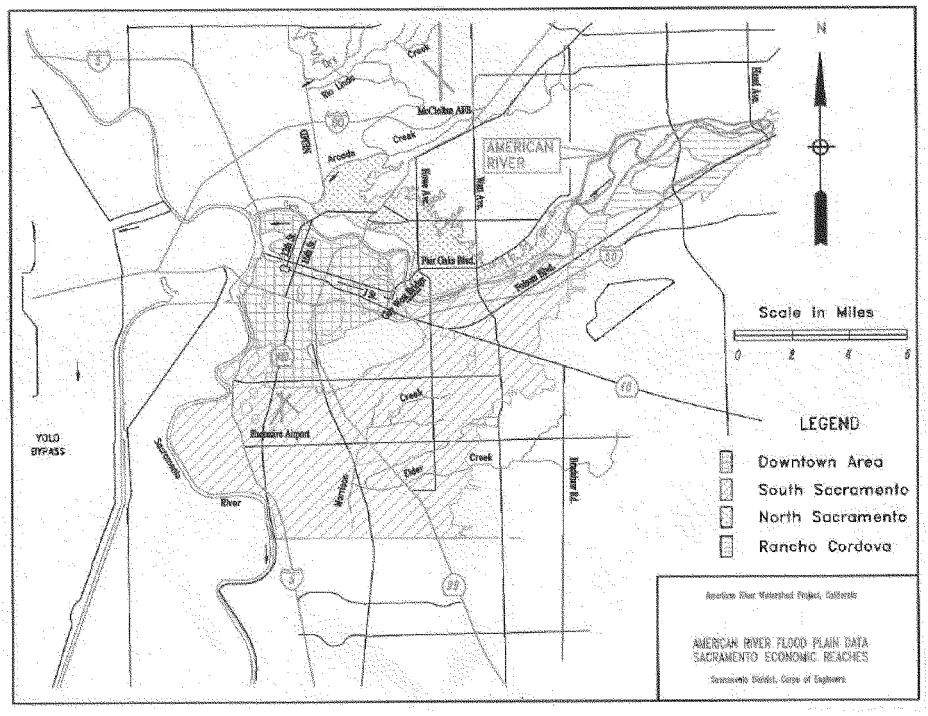
Subsequent to the F3 Conference, it was decided that work for the Natomas Basin would be fast-tracked and the Basin area would be studied separately from the rest of the ARWCF project area. The study would be conducted under a Post-Authorization Change (PAC) and would be documented in a Natomas Post-Authorization Change Report (NPACR).

This Economic Appendix to the Natomas Post-Authorization Change Report (NPACR) documents the economic analysis performed for the Natomas Basin economic impact area (EIA). The analysis documented in this appendix addresses flood risk (probability of flooding and consequences of flooding) in the Natomas Basin, expected benefits associated with potential flood risk management (FRM) alternatives, and residual risk associated with these potential alternatives.

1.2 BACKGROUND – AMERICAN RIVER WATERSHED

In order to provide a broader picture of the flood-related issues facing the Sacramento metropolitan area as well as to provide a more complete context in which to understand the flooding issues associated with the Natomas Basin, a brief background and flooding history of the entire ARWCF study area is described in the following paragraphs. For reference purposes, Figure 1-1 shows the ARWCF study area, including the Natomas Basin area.

Figure 1-1
MAP OF ENTIRE ARWCF STUDY AREA



The American River Watershed drains about 2,100 square miles northeast of Sacramento and includes portions of Placer, El Dorado, and Sacramento counties. Runoff from this basin flows through Folsom Reservoir and passes through Sacramento within a system of levees. Folsom Dam and Reservoir, located on the American River about 25 miles east of the city of Sacramento, form a multipurpose water project. The project was constructed by the U.S. Army Corps of Engineers (USACE) and is operated by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) as part of the Central Valley Project (CVP). The reservoir has a normal full-pool storage capacity of 975,000 acre-feet with a minimum seasonally designated flood control storage space of 400,000 acre-feet.

In February 1986, major storms in Northern California caused record flood flows in the American River Watershed. Outflows from Folsom Reservoir, together with high flows in the Sacramento River, caused water levels to rise above the safety margin on levees protecting the Sacramento area. The effects of the 1986 storms raised concerns over the adequacy of the existing flood control system. This in turn led to a series of study authorizations and investigations into the need to provide additional flood protection to the Sacramento area. The major reports documenting completed investigations are summarized in Section 2. Some of the key milestones in this process included:

- **1986** – Severe storms in Northern California raise concern over level of flood protection in watershed
- **1988** – Continuing Appropriations Act funds American River Watershed Investigation
- **1989** – Sacramento Area Flood Control Agency (SAFCA) is formed
- **1991** – American River Watershed Investigation Feasibility Report and Environmental Impact Statement/Environmental Impact Report (EIS/EIR) recommends levee improvements at Natomas and a detention dam at Auburn
- **1993** – Defense Appropriations Act authorized Natomas levee improvements proposed in the 1991 Feasibility Report and directs USACE to conduct new flood risk management (FRM) studies, including flood management at Folsom Dam, rejecting the proposed detention dam at Auburn
- **1996** – American River Watershed, California, Supplemental Information Report (SIR) and EIS/EIR identifies three plans to reduce flood risk: Folsom Dam Modifications, Stepped Release Plan, and Auburn Detention Dam Plan, which was identified as the National Economic Development (NED) Plan
- **1996** – Water Resources Development Act (WRDA) of 1996 again rejects proposed detention dam at Auburn but authorizes additional levee improvements that were common to all three plans (referred to as "Common Features") in the 1996 SIR
- **1997** – Severe storms again highlight flooding risk in the watershed
- **1998** – SAFCA releases Folsom Dam Modification Report, New Outlets Plan, that presents alternatives to lower the spillways under the Folsom Dam Modifications Plan from the 1996 SIR

- **1999** – WRDA of 1999 authorizes the Folsom Modification Project as identified in the 1996 SIR and as modified by SACFA and also directs the USACE to conduct further FRM studies
- **2001** – Common Features Limited Reevaluation Report (LRR) identifies improvements providing additional benefits and project performance to the Lower American River. Section 366 of WRDA 1999 further modifies the WRDA 1996 authorization in regard to Common Features with specific direction related to levee modifications. Work directed in this section of WRDA is important to the current effort because it would allow for Folsom Dam to increase outflows to 160,000 cubic feet per second (cfs) for a sustained time (currently being evaluated) without a high probability of levee failure along the Lower American River.
- **2002** – American River Watershed, California, Long-Term Study and EIS/EIR recommend raising Folsom Dam by 7 feet (referred to as "Folsom Modification Project").
- **2003** – Energy and Water Development Appropriations Act for 2004 authorizes a 7-foot raise of Folsom Dam
- **2003** – Folsom Dam Modification Project LRR and Environmental Assessment (EA)/EIS reconcile conflicts between the authorized Folsom Modification Project and recommendations in the 2002 Long-Term Study Feasibility Report
- **2005** – Energy and Water Development Appropriations Act for 2006 directs the USACE and Reclamation to collaborate on FRM planning by the USACE and dam safety efforts by Reclamation at Folsom Dam.
- **2005** – The limitations of the existing flood control system in the Sacramento area and the need to increase the level of flood protection receive increased public attention in the aftermath of the 2005 Gulf Coast hurricanes.
- **2007** – American River Watershed Project, California, Folsom Modification and Folsom Dam Raise Projects, Post Authorization Change (PAC) Report documents recommended changes to two authorized projects: the Folsom Modification Project and the Folsom Dam Raise Project, and evaluates a Joint Federal Project (JFP) that addresses both FRM and dam safety objectives.
- **2007** – American River Watershed Project, California; Folsom Modification and Folsom Dam Raise Projects; Economic Reevaluation Report (ERR) documents the analysis of potential damages associated with flood risk and the economic benefits and project performance statistics associated with alternative FRM alternatives at Folsom Dam for the American River Watershed. The analysis revised the PAC report with a current inventory and an increased emphasis on the Regional Economic Development (RED) and Other Social Effects (OSE) accounts.

The new floodplain inventory for the ERR analysis was a primary aspect of the update from the PAC analysis. (Another important difference between the PAC and ERR was that the ERR considered the RED and OSE accounts in addition to the NED account.) The revised inventory included an expanded floodplain area and additional economic impact areas. These allowed for

more precise and accurate economic modeling using the HEC-FDA program. Additionally, the economic modeling used for the 2007 ERR incorporated new non-residential content damage curves and new stage-damage curves, which were computed within the HEC-FDA program. Computing stage-damage curves directly within HEC-FDA eliminated the need to use additional, external software (@RISK) to compute stage-damage curves with uncertainty.

- **2009** – American River Watershed, Common Features GRR, Without-project (F3) Economic Appendix was completed for the larger Sacramento study area.

Unlike in the ERR, which only considered flooding from the American River, the GRR also considered flooding from the Sacramento River and therefore evaluated expected annual flood damages for the Natomas Basin impact area. The GRR also used updated hydrologic, hydraulic, and geotechnical data, a current version of the HEC-FDA program, and the same economic inventory developed for the 2007 ERR. The Economic Appendix to the GRR described the methodologies, data, assumptions, and results of the economic analysis and summarized the without-project flood risk (probability of flooding and consequences of flooding) for 18 economic impact areas and for multiple without-project conditions. These results were presented at an F3 conference in March 2009. The full ARCF GRR is being completed concurrently with this NPACR. The GRR, when completed, will include analysis of the flood risk for the three major areas within the Lower American River Watershed study area – the American River North and American River South areas, as well as the Natomas Basin area.

1.3 PURPOSE AND SCOPE

The purpose of this Economic Appendix to the NPACR is to present the economic analysis performed for the Natomas Basin economic impact area. This appendix describes the methodologies, assumptions, data and results of the analysis, and summarizes the flood risk under the without-project condition, the residual flood risk associated with potential alternatives, and the economic benefits associated with these alternatives. This appendix also describes the benefit-to-cost and net benefit analyses performed to determine feasibility and optimization of various alternatives, respectively.

This Economic Appendix is intended to:

- Document the current hydrologic data used in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the current hydraulic floodplains and HEC-FDA hydraulic input data used in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the current geotechnical HEC-FDA input data (i.e., geotechnical levee functions which show the relationship between water surface on the river versus the probability of levee failure, or "geotechnical risk and uncertainty curves" (GRU) as they are referred to throughout this appendix) used in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions

- Document the economic methodologies, major assumptions, models, and data used in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the economic damage/benefit categories considered in the economic analysis for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the results (detailed HEC-FDA output files and EAD/AEP results) of the HEC-FDA model runs for the Natomas Basin impact area under both the without-project and with-project conditions
- Document the screening-level cost estimates used to perform the net benefit and benefit-to-cost analyses
- Describe the approach used to perform the with-project benefits analysis and document the results of the with-project benefit, net benefit, and benefit-to-cost analyses used to determine plan optimization and feasibility
- Describe additional analyses that will be conducted for future studies and which were not considered in this NPACR

1.4 ORGANIZATION AND CONTENTS

Chapter 1 of this appendix provides an overview of the authorizations, investigations, and resulting reports leading up to the Natomas Post-Authorization Change Report (NPACR). The chapter also outlines the purpose and scope of the economic analysis, and provides an overview of the organization and contents of the NPACR Economic Appendix.

Chapter 2 provides background information on economic analyses documented in prior reports that evaluated FRM benefits on the American and Sacramento Rivers.

Chapter 3 describes the Natomas Basin impact area and provides a detailed compilation of the structure inventory and valuations (structures and contents) used as the base inventory for the economic analysis.

Chapter 4 describes the economic and risk analysis methodologies used in this NPACR, outlines the major assumptions used in the economic analysis, and summarizes the engineering data (hydrologic, hydraulic, and geotechnical) and economic data (e.g., economic uncertainties, depth-percent damage functions) used in the economic analysis; this chapter also outlines the NED damage/benefit categories considered in the analysis.

Chapter 5 provides a detailed report of the HEC-FDA results for each index point under the without-project condition; these results include expected annual damages (EAD), annual exceedance probability (AEP), and single-event damages, all of which were used to guide the subsequent with-project benefit analysis documented in Chapter 6; the delineation of the Natomas Basin impact area into two separate impact area (major and minor) is also explained.

Chapter 6 summarizes the HEC-FDA base model results (per reach/index point) for the various with-project geotechnical fixes, outlines the order of fixes (Levee Reach Improvements) selected based on the without-project and with-project HEC-FDA base model results, describes the conceptual approach used to perform the with-project benefit analysis, explains in detail the steps taken and factors considered to perform the with-project analysis, and reports the results of each levee reach improvement in terms of Basin-wide AEP, residual EAD, and annual benefits.

Chapter 7A presents the net benefit and benefit-to-cost analyses using the HEC-FDA results as documented in Chapters 5 and 6. Chapter 7a summarizes the costs used in the net benefit analysis and reports the net benefits and benefit-to-cost ratios for each levee reach improvement. **It is important to note that the net benefit and benefit-to-cost analyses and results reported in Chapter 7A are not the "final" results used as the basis for plan formulation. Chapter 7B presents the net benefits and benefit-to-cost analyses and results used for the basis for plan formulation.**

Chapter 7B presents the with-project net benefit, and benefit-to-cost analyses and results used as the basis for plan formulation; these results are also what are reported in the Executive Summary of this Appendix. The results documented in Chapter 7B were obtained through "post-processing" of the HEC-FDA output presented in Chapters 5, by repeating the steps of the with-project analysis as described in Chapter 6, and by taking the costs used in the net benefit and benefit-to-cost analyses documented in Chapter 7A. This "post-processing" of the HEC-FDA output was completed in order to adjust expected annual damages and benefits to account for rational human behavior. A model was developed to account for human behavior in the form of assumptions regarding a rebuild period and a loss of inventory stock in the floodplain after a flood event occurs in the Natomas Basin. The model was developed and the EAD and benefit adjustments were made in response to agency technical review (ATR) comments.

Chapter 8 describes the residual risk associated with future development in the Natomas Basin.

Chapter 9 describes any future analyses that will be conducted in the GRR, including those associated with additional NED benefit categories (e.g., emergency costs, traffic disruption costs, and airport-related transportation costs) as well as those related to the Regional Economic Development (RED) and Other Social Effects (OSE) accounts.

Chapter 10 lists any references used to write this economic appendix.

Enclosure 1 contains the without-project floodplain plates. Suites of floodplains comprising the 2-yr to 500-yr flood events are presented for each of the nine Natomas Basin index points used in the economic analysis.

Enclosure 2 includes the HEC-FDA input data used in the analysis as well as the more detailed HEC-FDA output results not contained within the main economic appendix.

Enclosure 3 includes the Economic Memorandum for Record (MFR) that documents the sensitivity analysis performed subsequent to the ARCF F3 Conference regarding upstream levee performance and human intervention assumptions and their effects on the economic analysis.

Enclosure 4 includes information on the utility program used to convert FLO-2D output data into an HEC-FDA-importable format.

Enclosure 5 includes an information paper that describes the technique used to incorporate additional hydraulic stage uncertainty within the HEC-FDA model when only exceedance probability-stage curves are used.

Enclosure 6 contains cost tables used for the preliminary screening of alternatives; these tables include more detailed cost information than what is presented in Chapter 7a, *Net Benefit and Benefit-to-Cost Analyses*.

Enclosure 7 contains the documentation provided to the USACE Planning Center of Expertise (PCX)/Model Certification for Flood Risk Management (FRM) in San Francisco. This documentation was created to obtain approval for use of the @Risk model.

Enclosure 8 contains information on the dollar-per-square foot values used as the basis to compute depreciated replacement values for both residential and non-residential structure types. These values were developed by Clark-Wolcott, Inc., Real Estate Analysts and Consultants.

CHAPTER 2
ECONOMIC ANALYSIS IN PRIOR REPORTS

Section 1.1 of this appendix provided a summary timeline of major study and project authorizations and investigations associated with the American River Watershed Study. Much of the economic data in previous American River Watershed planning reports trace their beginnings to the initial 1991 American River Watershed Investigation Feasibility Report. The following sections of this chapter describe changes in economic analysis methodologies, data, and conclusions from each study. Many of the studies described below did not evaluate the Natomas Basin area. However, general knowledge of the analyses, results, and recommendations associated with previous American River Watershed studies will help to place into perspective how the Natomas Basin flooding issues have come into play in relation to the flooding issues facing the Sacramento metropolitan region as a whole.

2.1 AMERICAN RIVER WATERSHED INVESTIGATION FEASIBILITY REPORT, 1991

The recommended plan in the 1991 feasibility report was a detention dam at Auburn providing more than 500,000 acre-feet of flood storage and reducing the probability of flooding in Sacramento to a 1-in-200 chance in any given year (using pre-risk based evaluation methodologies). This project was not authorized by Congress and two projects to follow were adopted to help reduce flood damages in the Sacramento Area. These were the SAFCA North Area Levee Project (Natomas) and Re-operation of Folsom Dam from 400,000 acre-foot fixed space to a variable 400,000/670,000 acre-feet. The basic floodplain and economic inventory data from this study was used for developing the economic databases for all subsequent studies up to but not including the ERR.

Only limited data developed for this 1991 Feasibility Report was used in the 2007 ERR, 2009 ARCF GRR, and this current NPACR analysis. The nonresidential structural depth-percent damage functions developed for the long duration flooding conditions from this 1991 study were used in modifying the Federal Emergency Management Agency (FEMA) curves in the 2007 ERR, 2009 GRR, and this NPACR. All other data was dropped in favor of either more detailed and/or current information.

2.2 AMERICAN RIVER WATERSHED SUPPLEMENTAL INFORMATION REPORT (SIR), 1996

The 1996 SIR was the first document to use risk analysis for determining economic benefits on the American River. The SIR identified three final alternatives: the Stepped Release, the Folsom Modifications, and the Detention Dam plans. The Detention Dam, which reduced the probability of flooding along the American River to less than a 1-in-500 chance of flooding in any given year, was determined to be the NED Plan but was not recommended in the Chief's report. Instead, the less controversial Common Features was authorized. This alternative included 'features' that were part of all three final alternatives and would not preclude selection of anyone of the three alternatives in the future. Completion of the Common Features was expected at the

time to provide Sacramento with '100-year protection,' terminology no longer used in the USACE guidance.

In 1999, the WRDA authorized additional levee improvements to supplement the 1996 Common Features and authorized a modified version of the Folsom Modifications Plan identified in the 1996 SIR. WRDA 99 also authorized additional study of FRM measures beyond the Folsom Modifications.

For economic analysis, three documents resulted from this authorization:

- Common Features LRR, completed in 2001
- American River Long-Term Study, completed in 2002
- Folsom Modifications LRR, revised November 2003

The Common Features was important in defining the future without-project condition for the ERR study. The levee failure probabilities are based on the completion of the ARCF project. Both the Long-Term Study and the Folsom Modifications are relevant in defining the final array of alternatives to include dam outlets and potential dam raises. But the economic, hydrologic, hydraulic, and geotechnical inputs applied in these prior studies were not used in the economic model for the ERR. In 2008, the need to reevaluate the ARCF due to changes in problem identification, and increasing scope and cost became apparent. Therefore, as a part of the 2009 ARCF GRR, the benefits and associated performance of the recommended plan for the ERR without the ARCF in place were analyzed.

2.3 AMERICAN RIVER WATERSHED COMMON FEATURES LRR, 2001

With completion of the Common Features Project, it is estimated that the outflows from Folsom Dam could be increased to as much as 160,000 cfs for a sustained time without a high probability of levee failure along the American River. The improvements include raising a small portion of the left-bank levee upstream of Mayhew Drain, raising a small portion of the right-bank levee downstream of Howe Avenue, installing gates and pumps to the Mayhew Drain area, and performing additional levee work to improve conditions in the Natomas Basin.

In the LRR, the analysis split the Common Features into two areas:

- The Lower American River levee improvements, which is functional, and enables the American River to pass the 100-year event
- The Natomas Basin area, which required significant reformulation and development of a GRR; the 2009 ARCF GRR was expanded to include the Natomas Basin area.

The Lower American River first costs were estimated in the 2001 LRR at $158 million, with $14.2 million in annual benefits and $12.7 million in annual costs. The additional net benefits for the Lower American area were $1.6 million, with a benefit-to-cost ratio of 1.1 to 1, and an annual exceedance probability (AEP) of 0.0099.

The 2001 LRR served as the basis for the levee performance assumptions in the ERR. But, because the economic, hydrologic, hydraulic, and geotechnical inputs are not the same, direct comparison of the damages, benefits, and project performance between the Common Features 2001 LRR, the 2007 ERR, and the still-to-be completed GRR is not practical.

2.4 AMERICAN RIVER WATERSHED LONG-TERM STUDY, 2002

The purpose of the Long-Term Study was to address the residual flood risk remaining once the Folsom Modifications was completed. The study looked at an array of FRM alternatives that include dam raises ranging from 3.5 feet to 12 feet. The Long-Term Study determined that a 7-foot raise of Folsom Dam, which would provide both additional FRM improvements and dam safety improvements by enabling the facility to pass 100 percent of the probable maximum flood (PMF), would be the optimal (non-Auburn Dam) economic solution.

Recommendations from the 2002 Long-Term Study that were authorized by Congress in the Energy and Water Development Appropriations Act for fiscal year 2004 included raising the dam by 7 feet (mini-raise), spillway modifications at L.L. Anderson Dam, a permanent bridge downstream from Folsom Dam, and modification of emergency release operations to permit surcharge. First costs for this project were estimated at around $249 million, with $128 million allocated to FRM. Annual FRM benefits of $19 million and annual FRM costs of $10 million provided a benefit-to-cost ratio of 1.9 to 1. This project was estimated at the time to reduce flooding to a 0.0057 AEP[2].

As with other studies before the ERR, the inputs used in the economic modeling for the Long-Term Study were not used in economic modeling for the ERR. Of relevance to the still-to be-completed ARCF GRR will be the two potential project components evaluated in the ERR, the 3.5-foot and the 7.0-foot dam raises. In the ARCF GRR, the 3.5-foot raise will be analyzed by comparing two separate without-project conditions.[3] The GRR will evaluate the benefits of the raise and will confirm whether or not the additional improvements are still justified under the changed without-project conditions.

2.5 AMERICAN RIVER WATERSHED FOLSOM MODIFICATIONS LRR, 2003

The 2003 LRR reconciled conflicts between the authorized Folsom Modifications Project elements and recommendations in the 2002 Long-Term Study. As directed by Congress in WRDA 1999, the plan identified in the 2002 Long-Term Study included raising Folsom Dam, modifying downstream levee improvements, and implementing other elements necessary to meet current Federal dam safety standards. These authorized features, which make up the Folsom Dam Raise Project, carry design implications for the previously authorized Folsom Modifications Project.

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[2] In the Long-Term Study, advanced forecast releases were evaluated as part of the alternatives that would have an impact on project performance. With the consideration of advance release, project performance (as measured by AEP) increased to 0.0047. Advance release was dropped as part of the evaluation for the ERR.

[3] In the upcoming ARCF GRR, a without-project condition, which assumes that the Authorized Common Features (ACF) and Folsom Modifications are in place, will be evaluated. This condition will be compared to a separate without-project condition, which assumes that the ACF, Folsom Modifications, and the 3.5 foot mini-raise are in place.

The 2003 LRR refined the elements related to increasing release capacity to be consistent with gate modifications in the 2002 Long-Term Study. These changes included the following:

- Construct two new upper-tier outlets
- Enlarge the four existing upper-tier outlets to 9 feet, 4 inches, by 14 feet, and the four existing lower-tier outlets to 9 feet, 4 inches, by 12 feet
- Modify the existing main spillway stilling basin

In addition, for the surcharge storage aspect of the project, the three emergency spillway tainter gates would be replaced with larger gates, as authorized, but the design would permit future expansion of these gates should the Folsom Dam Raise Project be authorized and implemented.

The Folsom Modifications revised economics report (November 2003) identified the recommended project as new and enlarged existing outlets capable of releases of 115,000 cubic feet per second (cfs) and improvements allowing for the use of surcharge storage up to Elevation 474 feet. First costs for this project were estimated at around $214 million with annual benefits of $32 million and annual costs of $16 million providing a benefit-to-cost ratio of 2.0 to 1. This project was estimated at the time to reduce the annual exceedance probability of flooding to 0.0071.

During the construction proposal process, the cost estimates exceeded the fully funded authorized costs (Section 902 limit). Consequently, dam operations and performance and alternate structural methods to achieve the FRM improvements provided by the outlet modifications were reexamined. Subsequent studies also found that modification of the two outboard lower-tier outlets was infeasible, and offered only a marginal increase in performance.

The ERR evaluated LRR construction measures (eight of the total 10 outlets described) that were included as alternatives evaluated in the ERR. The GRR will evaluate the additional benefits of the Folsom Dam modifications (outlined in the 2007 ERR) by comparing two separate without-project conditions.[4]

2.6 AMERICAN RIVER WATERSHED PAC REPORT, 2007

The purpose of the PAC report was to document changes to two authorized projects: the Folsom Modifications Project and the Folsom Dam Raise Project. Both projects share an objective of improving flood management on the Lower American River, primarily through structural modifications to the existing Folsom Dam.

In the PAC report, project elements from both the Folsom Modifications and the Long-Term Study were considered not only for the purpose of flood risk management but also for dam safety. During the design refinements for Folsom Modifications, it was believed that due to significant increases in the cost estimates that the authorized project may not be optimal or even economically feasible. During this preliminary analysis, it appeared that adding operational gates

[4] In order to evaluate the benefits of the Folsom Modifications, one without-project condition, which assumes that the ACF is in place, will be compared to another without-project condition, which assumes that the ACF and Folsom Modifications are in place.

to the proposed Reclamation dam safety auxiliary spillway may provide a more efficient way to meet two project purposes.

The Folsom Dam Joint Federal Project (JFP) was intended to meet not only the goals of the USACE but also the Bureau of Reclamation and the local sponsor as well; its analysis became one of the main focuses of the PAC. As mentioned, the PAC economic analysis included elements of three authorizations, the Folsom Modifications, the Dam Raise, and Reclamation's dam safety project. The combined project's objectives in terms of economic outputs and project performance were: (1) Reduce flood damages as effectively and efficiently as possible within a limited schedule and without complete reformulation, (2) safely pass the 200-year design flow event without levee failure (based on design non-risk-based criteria), and (3) pass the PMF without placing the dam structure in danger of failure.

The PAC and ERR evaluated a final array of four action alternatives. Alternative C, as described below, was the recommended plan from both studies. Alternative C included an auxiliary spillway containing six submerged tainter gates, a 3.5-foot dam raise, and three emergency spillway gate replacements. The recommended plan is summarized in Table 2-1 below.

Table 2-1
Benefits, Costs, and Project Performance In
The 2007 Post Authorization Change Report

SUMMARY CRITERIA	RECOMMENDED PLAN
Performance	
Passes PMF	Yes
Probability of Flooding AEP	0.0054
Design Flood Event (non-risked-based criteria)	240
First Cost (FRM only, $ millions)	788
Annual Cost (FRM only, $ millions)	40.0
Annual Benefits (FRM, $ millions)	107.1
Net Benefits (FRM, $ millions)	67.1
Benefit-Cost Ratio	2.7
Residual Damages ($ millions)	91.1
Percent Damage Reduction	54

Note: Values in October 2006 prices.
AEP = annual exceedance probability
FRM = flood risk management

2.7 AMERICAN RIVER WATERSHED ERR REPORT, 2007

The main purpose of the ERR was to affirm that the recommended plan from the PAC was economically feasible and was the most efficient among the array of alternatives considered. The focus of the ERR was to revise the economics and the HEC-FDA model (including hydrologic and hydraulic data) in hopes of obtaining a more accurate estimate of flood risk for the study area.

The 2007 ERR quantified NED benefits based on 2007 local conditions. Many factors contributed to the improvement of the economic analysis in the 2007 ERR as compared to previous analyses. These include more data, more precise data, improved methodologies, and additional analyses. Some of these are described below:

- The 2007 ERR HEC-FDA economic model contained a new economic inventory; the structures and contents of the new 2007 floodplain were inventoried and valued; locality-specific non-residential contents were valued; ground surveys were conducted for a sample of single-family residential (SFR) structures and a field survey was conducted for 100 percent of the multiple-family residential (MFR), public, commercial, and industrial structures; depreciation and building quality data were collected through numerous field visits; the total value of structures and contents potentially at risk was estimated at more than $58 billion while expected annual damages (EAD) for the without-project condition were estimated at $277 million. (This value does not include the Natomas Basin area.)

- Stage-damage curves with uncertainty were computed directly within the HEC-FDA model and utilized newly-developed non-residential content damage curves.

- Whereas in the 1991 American River Watershed Investigation Feasibility Report only one floodplain was used in the analysis, the analysis for the 2007 ERR used seven event-based floodplains.

- The 2007 ERR modeled 17 economic impact areas (Natomas Basin was not included); the increase in the number of impact areas allowed for more precise and accurate HEC-FDA modeling.

- A new methodology that allowed for the direct import of geo-referenced floodplain data originating from the hydraulic engineering models (HEC-RAS and FLO-2D) directly into the HEC-FDA model was used; this enabled the computation of stage-damage curves directly within HEC-FDA instead of using an external software program to compute stage-damage curves.

- For the ERR, an expert elicitation panel was convened to identify non-residential structure categories and estimate their content values. Nineteen non-residential categories were identified. Content values (dollar per square foot) were computed and depth-percent damage curves were developed for each structure category.

- A Regional Economic Development (RED) analysis was completed for the 2007 ERR, which provided detailed insights into the most likely regional impacts of the 200-yr and

500-yr flood events in the Sacramento region. The RED analysis was completed using the IMPLAN model.

- An Other Social Effects (OSE) analysis was completed for the 2007 ERR, which described the potential effects of the Selected Plan (SP) on the Sacramento County urban area as well as the potential effects of hypothetical 200-yr and 500-year flood events (from the American River) on the Sacramento County urban area.

The 2007 ERR evaluated the same four alternatives that were evaluated for the PAC. These are described in more detail below. The recommended plan for the ERR was Alternative C. Benefits are shown in Table 2-2 and Figure 2-1 below.

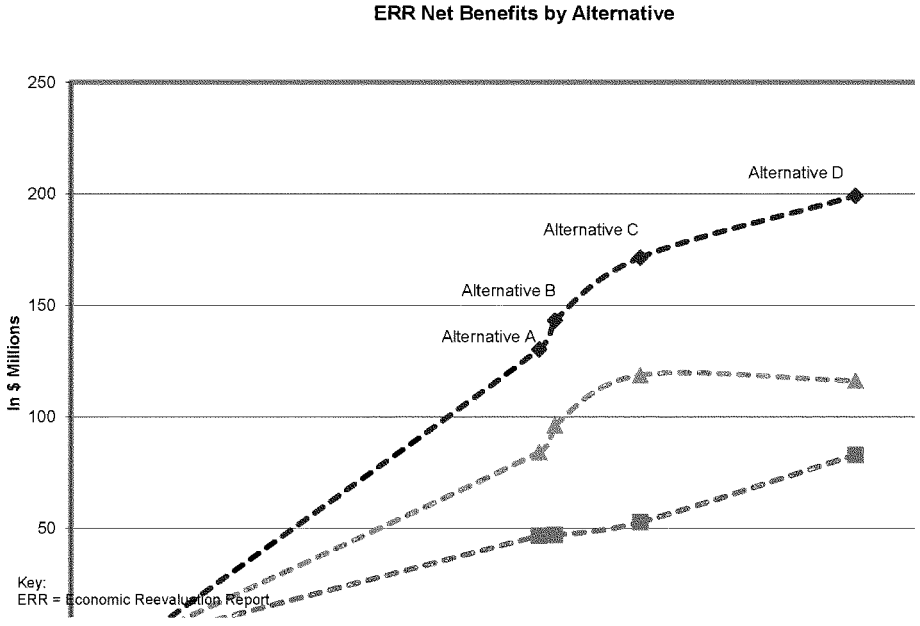
- Alternative A – Eight Main Dam Outlets and Fuseplug Spillway
- Alternative B – Six Submerged Tainter Gate Auxiliary Spillway
- Alternative C – Six Submerged Tainter Gate Auxiliary Spillway, 3.5-Foot Dam Raise, and Three Emergency Spillway Gate Replacements
- Alternative D – Six Submerged Tainter Gate Auxiliary Spillway, 7-Foot Dam Raise, and Eight Emergency and Service Spillway Gate Replacements

Table 2-2
ERR Benefit-to-Cost Analysis per Alternative

ITEM	ALT A	ALT B	ALT C	ALT D
Total Project First Costs	650.4	918.1	1,042.1	1,555.6
Annual Benefits (2018-2067)	98.1	116.3	143.8	172.2
Annual Benefits-During Construction (2012-2017)	32.6	26.9	29.9	26.9
Total Annual Flood Damage Reduction Benefits	130.7	143.2	173.7	199.1
Annual Costs	46.6	62.3	68.0	98.2
Savings in Avoided Dam Safety Annual Costs[1]	0	-15.3	-15.3	-15.3
Net Flood Damage Reduction Annual Costs	46.6	47.0	52.7	82.9
Net Benefits	84.1	96.2	121.0	116.2
Benefits to Cost Ratio	2.8	3.0	3.3	2.4

Notes:
1) Values are in millions and are based on October 2007 prices, a 50-year period of analysis, and a 4.875 percent interest rate
2) Alternatives B, C, and D will eliminate the need for construction of the dam safety only fuseplug as part of the future without-project condition. The $15.3 million reduction in dam safety annual costs was taken as a savings from the net flood risk management annual costs.

Figure 2-1
NET BENEFIT, ANNUAL BENEFIT, AND ANNUAL COST CURVES



2.8 AMERICAN RIVER WATERSHED GRR REPORT

The ARCF GRR Report is currently being completed as a separate document from the NPACR. The GRR, part of which was completed in March of 2009 to document the without-project condition(s), will continue to focus on the major areas within the Lower American River Watershed, including the American River North Basin, the American River South Basin, and the Natomas Basin, the focus of this report.

CHAPTER 3
NATOMAS BASIN AND ECONOMIC INVENTORY BASE DATA

3.1 AMERICAN RIVER COMMON FEATURES STUDY AREA

The without-project analysis completed in 2009 as part of the GRR included 18 economic impact areas (EIA) within three major basins: the American River – North (4 impact areas) basin, the American River – South (13 impact areas) basin, and the Natomas Basin (which is its own impact area). Table 3-1 below lists all of the impact areas included in the 2009 analysis and Figure 3-1 shows the entire ARCF study area delineated by the 18 impact areas.

Table 3-1
Economic Impact Areas by Basin

Economic Impact Area	Total Acres	Total Square Miles
AR-NORTH		
ARD 13: American River Drive	5,220	8.2
AE 14: Arden/Expo	6,080	9.5
NS 15: North Sacramento	3,750	5.8
DC 16 Dry Creek	9,290	14.5
Total Basin	**24,340**	**38.0**
AR-SOUTH		
PG 1: Pocket/Greenhaven	4,160	6.5
FM 2: Fruitridge/Meadowview	13,270	20.7
LP 3: Land Park	4,100	6.4
DS 4: Downtown Sacramento	3,830	6.0
ES 5: East Sacramento	3,800	5.9
RCA 6a: Rancho Cordova West	6,110	9.5
RCA 6b: Rancho Cordova East		
GR 7: Gold River	1,870	2.9
SF 8: South I-50/Florin/Watt	13,500	21.1
FS 9: Florin South	10,420	16.3
MA 10: Mather North	8,550	13.4
RMT 11: Rosemont	9,220	14.4
SM 17: South of Morisson Creek	67,540	105.5
Total Basin	**146,370**	**228.6**
NATOMAS		
Natomas	53,570	83.7
Total Basin	**53,570**	**83.7**
TOTAL AREA (All Basins)	**224,280**	**350.3**

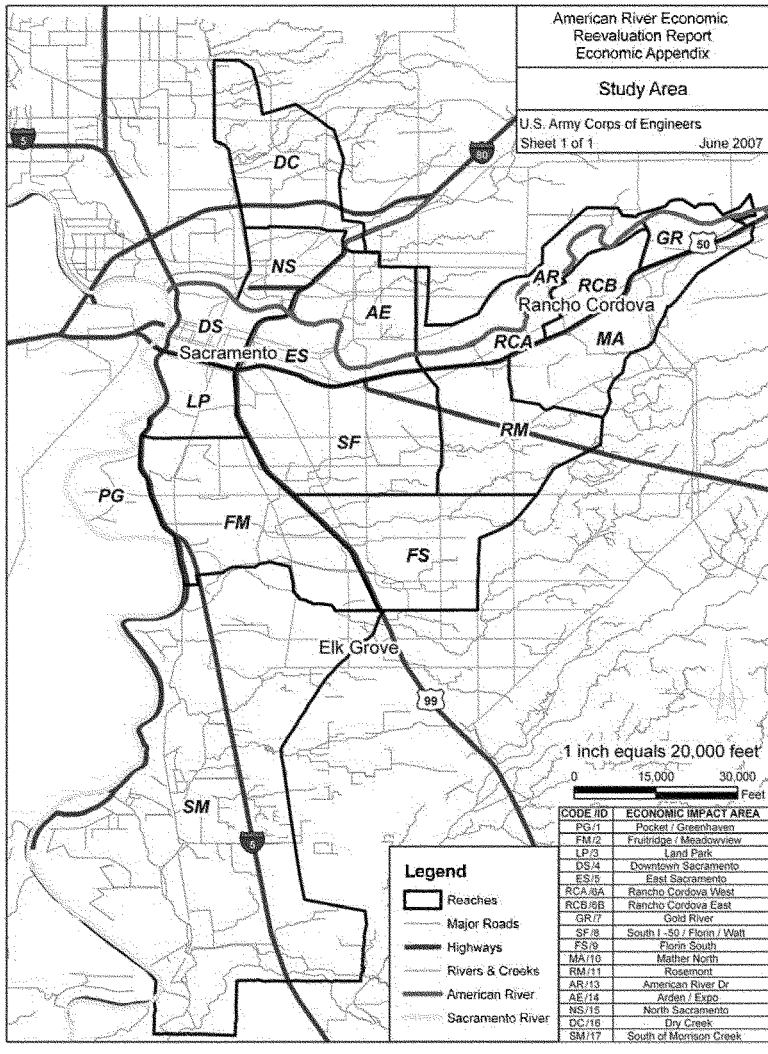


Figure 3-1
Economic Impact Areas

Together, Table 3-1 and Figure 3-1 allows for the comparison of size between impact areas and basins, especially as it pertains to the Natomas Basin area, which is the focus of this report. The data show that the Natomas Basin accounts for approximately 25% of the total ARCF study area. The sections that follow will describe in detail the economic inventory, structure and content valuations, and floodplains associated with the Natomas Basin impact area.

3.1.1 Natomas Basin Economic Impact Area

As was mentioned previously, the focus of this report is the Natomas Basin area. The other basins will be evaluated in a separate GRR.

Natomas Basin encompasses parts of both Sutter and Sacramento counties in California. The impact area is bounded by the Natomas Cross Canal to the north, the Natomas East Main Drainage Canal (NEMDC) to the east, the American River to the south, and the Sacramento River to the west. The area is currently not protected from the one percent chance event and therefore lies within the Federal Emergency Management Agency's (FEMA) 100-year flood plain. In 2008, the federal government issued a construction moratorium which effectively restricted development in the Basin until the levees are improved and the area can be re-mapped as being outside the 100-year floodplain.

Beginning around 1998, the area north of Interstate 80 experienced rapid development, including single-family residential (SFR) and multi-family residential (MFR) structures as well as commercial, industrial, and public structures. The area continued to experience significant development up until 2008 as more people moved to the area, which offered both relative housing affordability and convenience to employment centers.

Figure 3-2 shows a typical residential community in the North Natomas area.

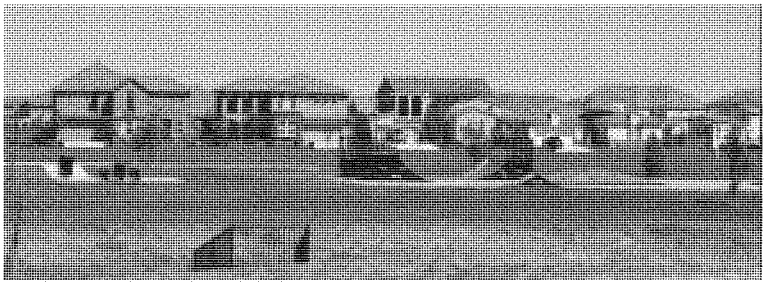


Figure 3-2
Photo of Typical North Natomas Neighborhood

3.2 ECONOMIC INVENTORY – COLLECTION OF BASE DATA

For the Natomas Basin impact area, a base geographic information system (GIS) inventory with parcel attribute data was provided by the local sponsor for both Sacramento and Sutter counties. Building attribute data were used to determine land use and valuation of structures and contents. Numerous field visits were taken to collect the base inventory data; data was collected using standard USACE practices. The following sections describe the data collection process in more detail.

3.2.1 Field Inventory Characteristics

Field sheets containing the base inventory data were taken to the field along with aerial maps for identification. Characteristics observed in the field were recorded on the field sheets, including:

A) ***Stories:*** The number of floors or stories found in the building.

B) ***Foundation:*** The estimated difference between the average ground elevation and the first floor of the structure.

C) ***Building Use:*** While the base data included a specification of land use, field verification was required to correlate building use to more specific residential and non-residential structure occupancy types. Under the more general residential, commercial, industrial, and public categories typically used in USACE studies, the following specific occupancy types were identified.

For residential structures:

1) ***SFR:*** This category may include detached single family homes, half-plexes, duplexes, and townhouses with four units or less per parcel.
2) ***MFR:*** This category may include apartments, townhouses, and attached multiple units.
3) ***MH:*** This category may include mobile homes and mobile home parks.

For non-residential structures:

4) ***COM-OFF:*** office buildings
5) ***COM-RET:*** typical retail stores
6) ***COM-FOOD:*** retail stores that sell perishable food items
7) ***COM-REST:*** restaurants, fast food establishments
8) ***COM-MED:*** medical, dental, hospitals, care facilities, veterinary
9) ***COM-SHOP:*** large shopping centers, box stores, shopping malls
10) ***COM-SERV:*** auto repair, service and maintenance shops
11) ***IND-WH:*** warehouses, storage, transportation centers
12) ***IND-LT:*** small tool shops, light manufacture
13) ***IND-HV:*** heavy manufacture, large plants

14) ***PUB-GOV:*** government buildings, county, city, state and federally owned offices
15) ***PUB-SCH:*** schools, elementary, middle, high, colleges and day care/pre-school facilities
16) ***PUB-CH:*** churches
17) ***PUB-REC:*** recreation, assembly- clubs theaters
18) ***FARM:*** nonresidential outbuildings and sheds, family farm residences and light production facilities.

D) ***Class:*** This characteristic corresponds with classifications from the Marshall and Swift (M&S) Valuation Service. Each of the five classifications corresponds to a grade of construction for use in the structure valuation.

1) ***A:*** primary characteristic- steel reinforced frame
2) ***B:*** reinforced concrete frame
3) ***C:*** Masonry
4) ***D:*** Wood Frame
5) ***S:*** Metal frame-prefabricated

E) ***Type:*** This characteristic represents the quality of construction for the observed structure. Different land use categories have slightly different groupings but can include the following:

1) ***Excellent***
2) ***Very Good***
3) ***Good***
4) ***Average***
5) ***Fair***
6) ***Low Cost***

F) ***Condition***: This characteristic is a subjective measure of the remaining life of the structure. This is not a measure of the actual age as many older structures may have been restored and may have had improvements made to extend its remaining life. The estimated percentage of remaining value was recorded to account for depreciation. The basic groupings for assignment of condition during the field observations included:

1) ***New:*** (no signs of deterioration, all new components) 100% remaining life
2) ***Excellent:*** around 95%
3) ***Very Good:*** basic wear and tear- move in condition- fully functional 90 to 95%
4) ***Good:*** some minor maintenance required 80 to 90 %
5) ***Fair:*** showing signs or wear 70 to 80 %
6) ***Poor:*** 50 to 70%
7) ***Other:*** abandoned or condemned

3.2.2 Assignment of Non-SFR Square Footage

For all residential structures classified as SFR, Sacramento County provided detailed information regarding square footage of the buildings. This included total square footage, basement square footage, 2nd-floor square footage, and garage square footage; this same data was not available for the non-residential and MFR categories. For many of the larger buildings and in some of the commercially dense areas, the county provided GIS data that included digitized building footprints. This GIS data was used to identify each structure's square footage. For those buildings not included in the GIS data, high-resolution aerial photographs were used in conjunction with GIS to measure the building footprint. In both cases, the measured first floor square footages were used along with the number of damageable floors (limited to no more than three floors) to estimate the maximum possible damageable square footage for structure valuation purposes.

3.3 VALUE OF DAMAGEABLE PROPERTY IN NATOMAS BASIN

The total value of damageable property (structures and contents) within the Natomas Basin impact area is estimated at $8.5 billion. Table 3-2 below displays the total value of damageable property by category.

Table 3-2
Total Value of Damageable Property by Category
Structures and Contents
Values in $Millions, October 2010 Price Level

CATEGORY	VALUE OF DAMAGEABLE PROPERTY		
	Structures	Contents	Total
Commercial	681	308	989
Farm	6	7	13
Industrial	458	249	707
Public	440	275	715
Residential	4,076	2,038	6,114
TOTAL	**5,661**	**2,877**	**8,538**

3.3.1 Structure Valuation

All structures were valued based upon a function of square footage, estimated cost per square foot (from the Marshall & Swift Valuation Handbook), and estimated depreciation. Values per square foot were based on building use, class, and type as outlined in Marshall and Swift Valuation Handbook[5]. Depreciated replacement values of structures are listed by category in Table 3-3 below.

Table 3-3
Total Value of Damageable Property – Structures
Values in $Millions, October 2010 Price Level

VALUE OF DAMAGEABLE PROPERTY (STRUCTURES) BY DAMAGE CATEGORY	
Damage Category	**Structure Value**
Commercial	681
Farm	6
Industrial	458
Public	440
Residential	4,076
TOTAL	**5,661**

[5] Structure valuations were based on replacement cost estimates developed by Clark-Walcott, Inc., Real Estate Analysts and Consultants specifically for structures in the Natomas Basin. Clark-Wolcott, Inc. developed replacement cost estimates on a dollar-per-square foot basis for 39 different residential and non-residential structure types using data and methods published by the Marshall and Swift Valuation Service. Base Clark-Walcott, Inc. dollar-per-square foot data were then adjusted by USACE SPK to account for depreciation, which was then applied to the square footage of a structure to derive structure value. The base Clark-Walcott, Inc. data is presented in Enclosure 8.

The total value of structures (excluding the value of their contents, which is presented in Sections 3.4 and 3.5) is approximately $ 5.7 billion or nearly 67% of the $8.5 billion total. These values represent all structures within the Natomas Basin impact area.

3.3.2 Content Valuation

Non-residential and residential content values are presented in Table 3-4 below. Sections 3.4.1 and 3.4.2 provide more details about non-residential and residential content valuation, respectively.

Table 3-4
Total Value of Damageable Property – Contents
Values in $Millions, October 2010 Price Level

CONTENT VALUE BY DAMAGE CATEGORY	
Damage Category	**Content Value**
Commercial	308
Farm	7
Industrial	249
Public	275
Residential	2,038
TOTAL	**2,877**

3.3.3 Non-Residential Content Valuation

An expert elicitation was performed to develop content values and content depth-percent damage curves for specific occupancy types (as listed in section 3.2.1 above) for the 2007 ERR. The results of that expert elicitation were used for the 2009 GRR as well as for this NPACR. The values and curves were developed specifically for structures in the American River Watershed study area. In total, there were 22 different occupancy types with values ranging from $22 to $235 per square foot with uncertainty.

In the 2009 GRR content values for non-residential structures were generated as a function of building use, damageable square footage, and content value per square footage (by the 22 different categories). These same values were carried forward to this NPACR analysis. Total non-residential content value is estimated to be approximately $839 million.

Additional information related to the depth-percent damage curves used for the NPACR analysis can be found in Chapter 5, *Without-Project Analysis*.

3.3.4 Residential Content Valuation

For SFR residential structures, depth-percent damage curves developed by the USACE Institute for Water Resources (IWR) and presented in Economic Guidance Memorandum (EGM) 04-01,

were used. Since the percentage damages in these generic depth-percent damage curves were developed as a function of structure value, it was unnecessary to explicitly derive content values for input into the HEC-FDA model; the model computes content damages by applying the percentages in the content-percent damage curves to structure values. For reporting purposes and to estimate content value for residential structures, a content-to-structure value ratio of 50% was used, which is consistent with the ratio used in prior American River studies. Total residential content value is estimated to be approximately $2.0 billion.

3.4 STRUCTURE COUNT

Table 3-5 below displays the total number of structures within the Natomas Basin impact area and which are at risk of flooding. Structure counts are broken down by major category. It is estimated that there is close to 23,000 structures in the Natomas Basin impact area.

Table 3-5
Total Structure Count

STRUCTURE COUNT BY DAMAGE CATEGORY	
Damage Category	**Structure Count**
Commercial	303
Farm	21
Industrial	156
Public	85
Residential	22,265
TOTAL	**22,830**

CHAPTER 4
ECONOMIC METHODOLOGIES AND MAJOR ASSUMPTIONS

4.1 CONSISTENCY WITH REGULATIONS AND POLICIES

This economic analysis was performed in accordance with standards, procedures, and guidance of the USACE. The *Planning Guidance Notebook* (ER 1105-2-100, April 2000, with emphasis on Appendix D, Economic and Social Considerations, Amendment No. 1, June 2004) serves as the primary source for evaluation methods of FRM studies and was used as reference for this analysis. Additional guidance for risk analysis was obtained from EM 1110-2-1619, *Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies* (August 1996) and ER 1105-2-101, *Planning Risk-Based Analysis for Flood Damage Reduction Studies* (Revised January 2006).

4.2 PRICE LEVEL, PERIOD OF ANALYSIS, AND DISCOUNT RATE

Unless otherwise noted, all values in this document are presented in October 2010 prices. Costs and benefits of the various alternatives were evaluated over a 50-year period of analysis. For common comparison, all costs and benefits over the period of analysis were converted to present values using the current federal discount rate of 4.375 percent. The base year of 2016 was identified as the year that all alternatives considered would be completed and fully functional, providing a full level of project benefits. The base year is important as it guides, at least conceptually during this phase of the study, the construction period and timing of project costs assumed for computation of interest during construction (IDC).

4.3 METHODOLOGIES

The following sections describe the methodologies and data application techniques used to perform the economic analysis. These include methodologies and techniques pertaining to the analysis framework (multiple index points, floodplain assignments), the application of modeling results and data (hydrologic, hydraulic, and geotechnical analyses) used for the economic analysis, and the application of economic data (uncertainties, depth-percent damage curves) used in the HEC-FDA model.

4.3.1 Using Multiple Index Points to Analyze Multiple-Source Flooding

In the 2009 GRR economic analysis, without-project expected annual damages for the Natomas Basin impact area was based on engineering data (HEC-FDA input data and floodplains) at one index point location, which was located on the Sacramento River at river mile 79. This was (and still is) known as the NAT C index point. For this NPACR analysis, nine index points were selected around the Basin with the intent to better facilitate the evaluation of a with-project analysis and to perform a more accurate net benefit analysis which identifies a plan that optimizes benefits from a national perspective.

4.3.1.1 Rationale for Methodology

The Natomas Basin can flood from four sources: the Natomas Cross Canal (NCC) to the north, the Natomas East Main Drainage Canal (NEMDC) to the east, the American River to the south, or the Sacramento River to the west, each with varying probabilities depending on the source. Multiple sources of flooding in the Basin make it difficult to estimate expected annual damages (EAD) and annual exceedance probability (AEP) on a basin-wide basis using currently available computer models. Additional analytical complexity is introduced if one considers the probability of flooding along a particular flooding source also varies (i.e., not only is the probability of flooding between various water sources not uniform but the probability of flooding along a specific water source is also not uniform), and that the same area is flooded from levee breaches at different locations but at varying magnitudes (i.e., different floodplains) depending on the location of the breach.

In the past and in similar studies with multiple-source flooding, EAD for an economic impact area was computed based either on 1) composite floodplains using one index point or 2) weighted averages of separate EAD results using multiple index points. These methods have tended to overstate without-project damages. In addition, using a single index point, as was done for the 2009 GRR (F3 without-project analysis for the Natomas Basin), produces a less accurate net benefit analysis of an array of alternatives as net benefits would be based on engineering improvements at only one representative index point, instead of engineering improvements at a representative sample of index points around the entire Basin based on improvements along all sources of flooding.

4.3.1.2 Natomas Basin Index Points

In order to better estimate without-project damages and to facilitate a more accurate analysis of potential alternatives, nine index points (reaches) around the Basin were identified by the project delivery team (PDT) and used in the economic analysis. Figure 4-1 displays the general location of each index point around the Basin. Table 4-1 below describes the location of the nine index points.

Figure 4-1 General Location of Natomas Basin Index Points

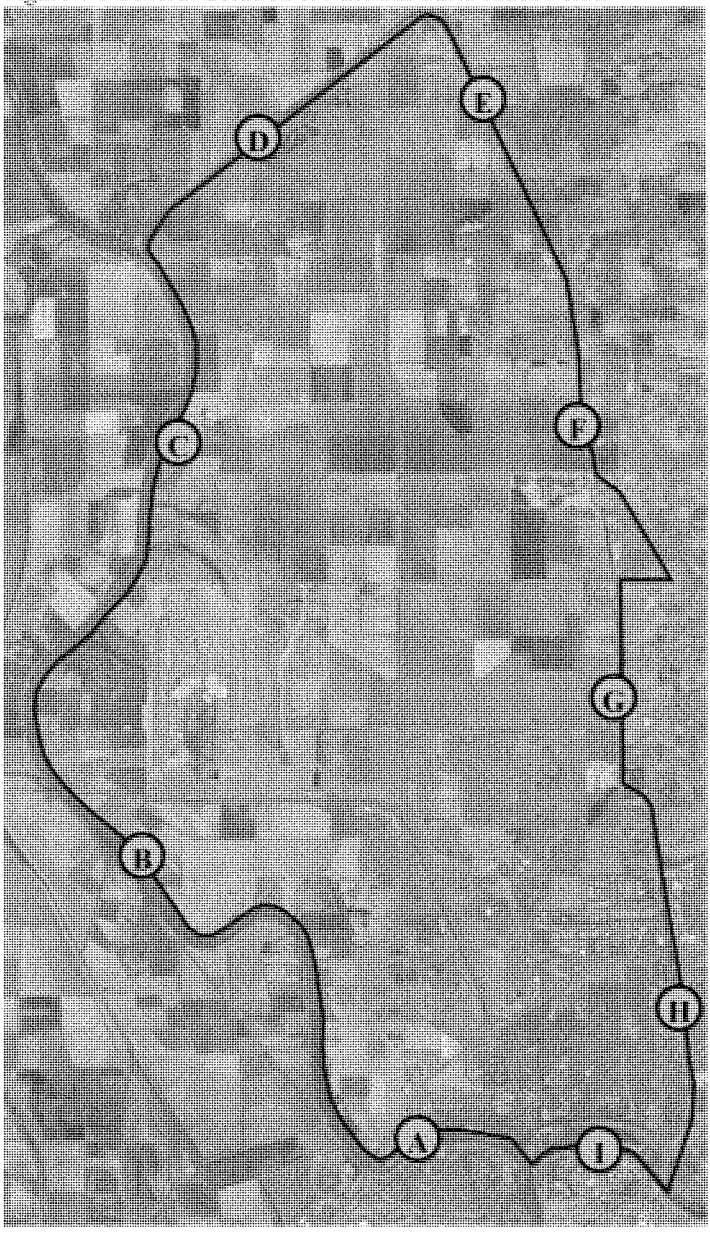


Table 4-1
Natomas Basin Index Points

INDEX POINT	WATERWAY	RIVER MILE (RM)
A	Sacramento River	62.75
B	Sacramento River	69.25
C	Sacramento River	79.00
D	Natomas Cross Canal (NCC)	2.63
E	Natomas East Main Drainage Canal (NEMDC)	Pleasant Grove Canal (PGCC)
F	Natomas East Main Drainage Canal (NEMDC)	12.62
G	Natomas East Main Drainage Canal (NEMDC)	8.59
H	Natomas East Main Drainage Canal (NEMDC)	4.32
I	American River	1.00

More detail on how the nine index points were applied in the economic analysis is provided in Chapter 5, *Without-Project Analysis -- HEC-FDA Base Modeling Results*, and Chapter 6, *With-Project Analysis.*

4.3.2 Application of Engineering Data in the Economic Analysis

The following sub-sections describe briefly the engineering model and data used for input into the economic analysis and HEC-FDA economic model. More details can be found in the appropriate engineering appendix (Appendix B – Hydrology, Appendix C – Hydraulics, and Appendix F – Geotechnical).

4.3.2.1 Hydrologic Engineering Data and Application in HEC-FDA

The Sacramento District Water Management Section provided all hydrologic data used in the HEC-FDA modeling. This includes the equivalent record length for each index point (A through I) and frequency-discharge curves for index points B, C, and I. For index points A, D, E, F, G, and H, only frequency-stage curves (and not frequency-discharge curves) were provided; only frequency-stage curves were developed due to backwater effects in these areas, which made it difficult to model discharges along these reaches. (The hydrologic data was provided to the Hydraulic Design Section for use in channel modeling using the HEC-RAS program; frequency-stage curves were then developed and provided to the Economics & Risk Analysis Section by the SPK Hydraulic Design Section for use in the HEC-FDA models.) Data and curves for each index point and for both without-project and with-project conditions were provided. These data and curves can be found in Enclosure 1, *HEC-FDA Input Data and Output Results.*

4.3.2.2 Hydraulic Engineering Data and Application in HEC-FDA

The SPK Hydraulic Design Section used the HEC-RAS model to determine stages in the channel, to model levee breakout locations, and to develop breakout hydrographs; the Hydraulic Design Section used the FLO-2D model to determine water surface elevations in the floodplain (i.e., develop suites of floodplains). More details about the data and assumptions used by the Hydraulic Design Section for their HEC-RAS and FLO-2D modeling efforts can be found in Appendix C.

In the 2009 GRR without-project (F3) analysis for the Natomas Basin impact area, a suite of floodplains was generated for only one index point (NAT C); for this NPACR analysis, a suite of floodplains was generated for each of the nine index points. For each index point, the Hydraulic Design Section provided data for input into the HEC-FDA model. These datasets that were used in the HEC-FDA modeling include:

- Frequency-discharge-stage curves (with uncertainty) for the without-project condition (WOPC); the WOPC assumed in this analysis is described in this chapter under the section entitled, *Major Assumptions.*

- Frequency-discharge-stage curves (with uncertainty) for the with-project condition, including levee raises within the project area.

- Frequency-stage curves that were used for the floodplain analysis; these curves were used in HEC-FDA for computation of the stage-damage curves. Section 4.3.3 describes in more detail the process of using this frequency-stage data to compute stage-damage curves in HEC-FDA.

- Formatted FLO-2D data for direct import into HEC-FDA as a water surface profile (or suite of floodplains). These floodplains and the process used to generate and format them for direct import into HEC-FDA are described in more detail in Section 4.3.3.

4.3.2.3 Hydraulic Engineering Stage Uncertainty Data and Application in HEC-FDA

As was discussed in section 4.3.2.1, exceedance probability-stage curves (instead of exceedance probability-discharge and stage-discharge curves) were developed for most of the nine index points due to the effects on discharges backwater has at these index point locations. These effects on discharges, which result in non-monotonic stage-discharge curves (flows don't increase with increasing stages), would make it impossible to use these curves in the HEC-FDA model, which requires monotonic stage-discharge curves. Exceedance probability-stage curves were developed for index points NAT A on the Sacramento River, NAT D on the Natomas Cross Canal (NCC), and NAT E, NAT F, G, and H on the Natomas East Main Drainage Canal (NEMDC)[6].

Using only exceedance probability-stage curves in HEC-FDA resolves the issue of non-monotonic stage-discharge curves, but this approach only captures hydrologic uncertainty (via equivalent record length) and neglects to explicitly capture typical hydraulic in-channel stage uncertainty (e.g., channel roughness) within HEC-FDA. In order to explicitly address hydraulic stage uncertainty within HEC-FDA, several non-standard techniques were applied in HEC-FDA using exceedance probability-stage curves and stage uncertainty data provided by the SPK Hydraulic Design Section.

A methodology paper describing these non-standard techniques is provided as Enclosure 5 in this Economic Appendix. While this methodology paper was developed specifically to address downstream stage uncertainty as it relates to upstream levee performance assumptions, the same general approach can be used to account for stage uncertainty related to other hydraulic factors. Therefore, it is important to note that Enclosure 5 is included mainly as a reference and to inform potential readers of this document that there exists a non-standard technique that can be applied in HEC-FDA to reasonably account for additional stage uncertainty; this NPACR economic analysis applied the same technique described in Enclosure 5 to capture typical stage uncertainties which cannot be captured by using only frequency-stage curves; for this NPACR analysis, this technique was not applied to account for uncertainty in stages due to potential upstream levee failures.

To account for additional hydraulic stage uncertainty within HEC-FDA using only the exceedance probability-stage curves and stage uncertainty data (i.e., standard deviation of stages per frequency event) provided by the Hydraulic Design Section, the following techniques were used in HEC-FDA:

- All three available discharge and stage relationships (exceedance probability-discharge, stage-discharge, and transform flow curves) in HEC-FDA were used but defined only in terms of stage.
- Exceedance probability-stage curves were entered using the graphical option set for discharge but stages were entered in place of flow.
- The transform flow option was used to explicitly address stage uncertainty by entering stage standard deviations by probability event instead of inflow-outflow.

[6] NAT E is technically located on the Pleaseant Grove Canal, which is essentially connected to the Natomas East Main Drainage Canal (NEMDC) in the north. Only for reporting purposes in this Appendix, references made to the location of the NAT E index point will be to the NEMDC.

- The stage-discharge curve was entered in HEC-FDA as a "dummy" curve, where stage would equal stage.

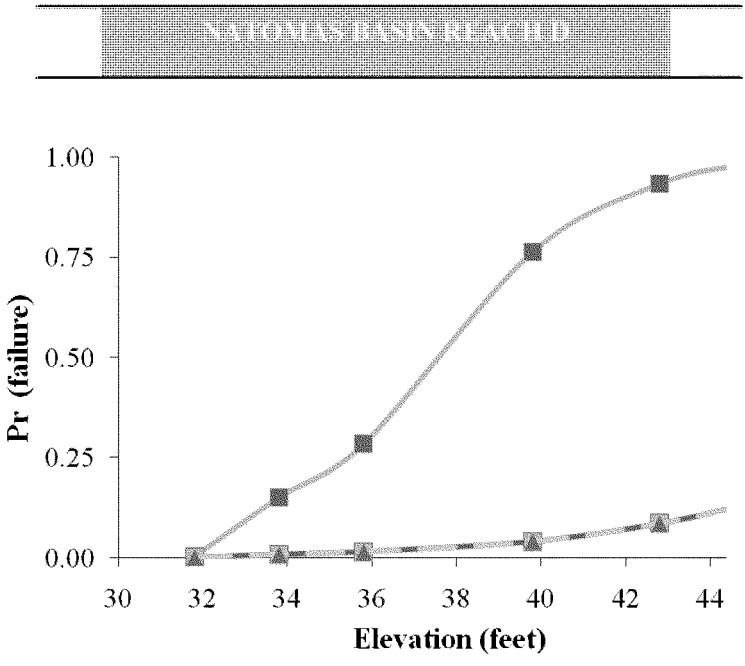
More details about this technique and a description of HEC-FDA sensitivity runs completed to validate this technique can be found in Enclosure 5.

4.3.2.4 Geotechnical Engineering Data and Application

As explained in previous sections of this report, for the 2009 GRR F3 Natomas Basin economic analysis only one index point was used (NAT C) and only one geotechnical risk and uncertainty curve (GRU) was entered into the HEC-FDA model as part of the AEP and EAD computations. For this NPACR, nine index points were used in the analysis resulting in nine without-project GRU curves and 18 with-project GRU curves. (There were between one and three with-project GRU curves for each geotechnical reach/index point.) Figure 4-2 below is one example of the GRU curves (without-project and with-project) used for the NAT D reach/index point. Enclosure 2 presents the complete set of GRU curves used in the economic analysis; Appendix F describes in detail the development of these GRU curves; and Chapter 6, *With-Project Analysis*, lists by index point and water source the method of geotechnical fix, with each fix represented by a unique GRU curve.

Figure 4-2

Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve



Elevation	Probability of Failure		
	WO	SB/SCB CWP IE	SB/SCB CWP
31.8	0.001069	0.000000	0.000000
33.8	0.015000	0.000736	0.000736
35.8	0.285324	0.001401	0.001401
39.8	0.762297	0.003982	0.003982
42.8	0.931273	0.008504	0.008504
44.8	0.981961	0.013115	0.013115

One reason for including nine index points/reaches in the NPACR analysis was to better facilitate the with-project benefits analysis and to address the reality that the Basin is at risk from flooding from multiple sources, but to different degrees. In fact, the without-project GRU curves, on first glance, reveal that the levee reaches around the Basin do differ in terms of existing conditions and the flood protection provided. Once the without-project GRU curves are applied in the economic analysis and integrated with the hydrologic and hydraulic data, HEC-FDA results highlight the differences in expected performance of the levee reaches around the Basin. The without-project HEC-FDA modeling results for each reach/index point are presented in Chapter 5, *Without-Project Analysis*.

4.3.3 Economic HEC-FDA Model and Application of Floodplain Data

The Hydrologic Engineering Center's HEC-FDA model (version 1.2.4) was used to perform the economic damage and benefits analyses. More detailed descriptions about the capabilities of HEC-FDA model and how it was used are provided in the following sub-sections.

4.3.3.1 The HEC-FDA Economic Model

The HEC-FDA model was used to integrate the engineering data (hydrologic, hydraulic, and geotechnical), compute stage-damage curves using specially-formatted hydraulic FLO-2D output data, and compute initial AEP and EAD results under both without-project and with-project conditions. The HEC-FDA model was also used to conduct the with-project benefits analysis using the information provided by the initial HEC-FDA modeling results.

4.3.3.2 Application of Floodplain Data

Floodplains were developed by the SPK Hydraulic Design Section using the FLO-2D model, which produces interior water surface elevations by grid cell; the Hydraulic Design Section used a 400 foot by 400 ft grid cell size. Suites of FLO-2D floodplains (2-year to 500-year frequency events) were developed for use in the without-project condition for each of the nine index points. The Hydraulic Design Section developed the Natomas Basin floodplains assuming certain project components on the American River would be constructed and operational, including the Authorized Common Features, Joint Federal Project, and Folsom Dam mini-raise; development of floodplains also assumed that the American River could safely pass 160,000 cubic feet per second.

Importing the FLO-2D data into the HEC-FDA models required file modification. The FLO-2D files were modified so that the HEC-FDA program could import them as a HEC-RAS water surface profile (WSP) output file. Instead of using river station numbers like in a typical HEC-RAS WSP, assignment of water surface elevations by frequency event were completed using grid cell numbers (output of FLO-2D); the grid cell assignments represent actual floodplain water surface elevations by frequency event rather than in-channel water surface elevations. Once the formatted FLO-2D floodplains (WSP) were imported into HEC-FDA, a row was inserted at the top of the WSP which included the in-channel (HEC-RAS) stages associated with the index point (for a particular reach). This step allowed for the linkage between the two-dimensional floodplain data (FLO-2D data imported into HEC-FDA) and the in-channel

HEC-RAS stages. Importing formatted FLO-2D data and assigning water surface elevations to grid cells eliminated the need for creating interior-exterior relationships, which is another way to link exterior (river) stages to interior (floodplain) stages within HEC-FDA.[7]

Additionally, since structures and depths of flooding (water surface elevations) in the WSPs are linked by grid cell number, this technique allowed for the computation of stage-damage curves within HEC-FDA and eliminated the need to use other models (e.g., @Risk) to compute stage-damage curves. Once computed, stages in the stage-damage curves are scaled by HEC-FDA using the in-channel (exterior) stages at the index point (first row of data inserted into WSP). The index point, then, links the floodplain data (via stage-damage curves) to the channel hydrology, hydraulic, and geotechnical data in the HEC-FDA model.[8] The process of inserting data into the first row of the WSP for computation of stage-damage curves is explained in the following sub-section.

4.3.3.3 Computation of Stage-Damage Curves within the HEC-FDA Model

For each of the nine suites of floodplains (one at each index point), the Sacramento District's Hydraulic Design Section formatted the FLO-2D floodplain output data so that the floodplains could be directly imported into the HEC-FDA model as a water surface profile. The Hydraulic Design Section used the HECFDA utility (not to be confused with the HEC-FDA model) to format the FLO-2D data; this utility was developed by a consultant specifically to allow FLO-2D output data to be imported into the HEC-FDA model.[9] The formatted files contained every grid cell that contained a structure and the water surface elevations in each grid cell for each frequency event. The suite of floodplains (one for each index point) was used in HEC-FDA to compute stage-damage curves.

An example of the FLO-2D-formatted floodplain data that was imported into HEC-FDA for the NAT A index point is shown in Figure 4-3 below. As explained in sub-section 4.3.3.2, once the formatted data is imported, stage data is inserted into the first row of the water surface profile representing the HEC-RAS exterior stages (per frequency event) at the index point that were used by the Hydraulic Design Section to develop the floodplains. The first row of data is

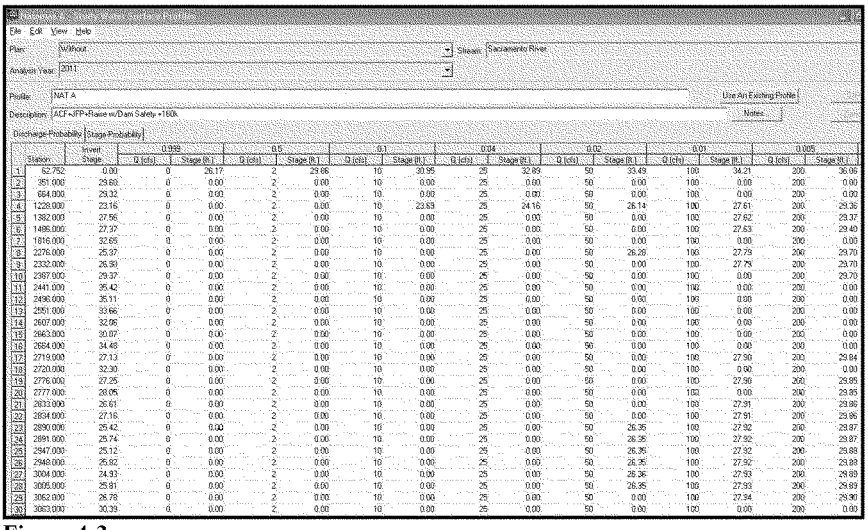
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[7] Since the floodplains used in the NPACR economic analysis were developed assuming that the American River could safely pass 160,000 flow, two sets of frequency-stage curves were entered into HEC-FDA to address the fact that the without-project condition for this NPACR does not make this same 160,000 flow assumption. This adjustment was made even though floodplains for the Natomas Basin impact area do not differ significantly under each scenario. This difference in assumptions was accounted for in HEC-FDA by using one set of HEC-RAS-developed frequency-stage curves (those used to develop the floodplains) to compute stage-damage curves in HEC-FDA and using another set of HEC-RAS-developed frequency-stage curves (those reflecting the without-project condition without assuming the safe passage of the 160,000 flow) to compute AEP/EAD in HEC-FDA at the index point. In effect, using two sets of frequency-stage curves in HEC-FDA shifts the frequencies at specific stages to account for the different underlying assumptions and scales the stages in the stage-damage curves to reflect the stages associated with the correct without-project condition being assumed for this NPACR. (The without-project condition assumed for this NPACR analysis is described in more detail under Section 4.4, *Major Assumptions*.)

[8] Note: The FLO-2D-based WSPs are used only to compute stage-damage curves within HEC-FDA. None of the exceedance probability-discharge functions or stage-discharge functions were retrieved from the WSP.

[9] The HECFDA utility is a stand-alone FORTRAN program used specifically to format FLO-2D model output data (grid element ground elevation and water surface elevation) into the HEC-FDA file format. The HECFDA user guidelines, which explains in more detail the steps involved in formatting the FLO-2D output data, is provided as Enclosure 4 to this Economic Appendix.

required in order to be able to 1) properly scale stages in association with the computation of the stage stage-damage curves in HEC-FDA and 2) link exterior (river) stages to damages in the floodplain for expected annual damage (EAD) calculations in HEC-FDA. It is important to note that the discharge values listed under each frequency event in the WSP/FLO-2D data are placeholder ("dummy") values only and are not used by the HEC-FDA program in its computation of stage-damage curves.



Station	Invert Stage	0.999 Q (cfs)	0.999 Stage (ft.)	0.5 Q (cfs)	0.5 Stage (ft.)	0.1 Q (cfs)	0.1 Stage (ft.)	0.04 Q (cfs)	0.04 Stage (ft.)	0.02 Q (cfs)	0.02 Stage (ft.)	0.01 Q (cfs)	0.01 Stage (ft.)	0.005 Q (cfs)	0.005 Stage (ft.)
62.752	0.00	0	26.17	2	29.66	10	30.95	25	32.89	50	33.49	100	34.21	200	36.06
351.000	29.60	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
664.000	29.32	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
1229.000	23.16	0	0.00	2	0.00	10	22.83	25	24.16	50	26.14	100	27.61	200	29.36
1382.000	27.56	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	27.62	200	29.37
1486.000	27.37	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	27.63	200	29.40
1816.000	32.65	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
2276.000	25.37	0	0.00	2	0.00	10	0.00	25	0.00	50	26.28	100	27.79	200	29.70
2332.000	26.50	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	27.75	200	29.70
2387.000	29.37	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	29.70
2441.000	35.42	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
2496.000	35.11	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
2551.000	33.66	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
2607.000	32.06	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
2663.000	30.07	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
2684.000	34.48	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
2719.000	27.13	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	27.56	200	29.84
2720.000	32.30	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00
2776.000	27.25	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	27.56	200	29.85
2777.000	28.05	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	29.85
2833.000	26.61	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	27.91	200	29.86
2834.000	27.16	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	27.91	200	29.86
2890.000	25.42	0	0.00	2	0.00	10	0.00	25	0.00	50	26.35	100	27.92	200	29.87
2891.000	25.74	0	0.00	2	0.00	10	0.00	25	0.00	50	26.35	100	27.92	200	29.87
2947.000	25.12	0	0.00	2	0.00	10	0.00	25	0.00	50	26.35	100	27.92	200	29.88
2948.000	25.62	0	0.00	2	0.00	10	0.00	25	0.00	50	26.35	100	27.92	200	29.88
3004.000	24.93	0	0.00	2	0.00	10	0.00	25	0.00	50	26.36	100	27.93	200	29.89
3005.000	25.81	0	0.00	2	0.00	10	0.00	25	0.00	50	26.35	100	27.93	200	29.89
3062.000	26.78	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	27.94	200	29.90
3063.000	30.39	0	0.00	2	0.00	10	0.00	25	0.00	50	0.00	100	0.00	200	0.00

Figure 4-3
FLO-2D Output Data Formatted and Imported into HEC-FDA, NAT A Index Point

4.4 MAJOR ASSUMPTIONS

Some of the major, fundamental assumptions used throughout this NPACR economic analysis are described in the following sub-sections. Major assumptions, generally those that may have a significant impact on the Natomas Basin economic analysis, include those made in regard to the without-project condition, upstream levee performance, potential for human intervention in the project area, index point locations and derivation of floodplains based on these index points, future hydrologic, hydraulic, and geotechnical levee conditions, and future development in the Natomas Basin.

4.4.1 Without-Project Condition – 2009 GRR and 2010 NPACR

Six conditions were developed to analyze the American River South, American River North, and Natomas Basins in the 2009 GRR; for this NPACR, only one without-project condition was used to evaluate the Natomas Basin since, for the most part, the Natomas Basin area is not affected by changes on the American River associated with assumptions pertaining to completed project components. The conditions used for the 2009 GRR are re-visited in sub-section 4.4.1.1 below;

the without-project condition assumed for this NPACR analysis is described in sub-section 4.4.1.2.

4.4.1.1 2009 GRR Conditions

For the 2009 GRR, three without-project conditions and three no-action conditions were developed for the analysis. They were labeled as follows: WO1, WO2, and WO3 for the without-project conditions and NA1, NA2, and NA3 for the no-action conditions. These conditions were delineated based on the complex and long history of the American River Watershed projects and with the intent to reveal, through the changing flood protection level and expected consequences associated with each condition, the nature of the authorized flood risk management solutions associated with the Watershed. The analysis of additional conditions was also necessary in order to properly formulate projects for the on-going GRR. The conditions delineated for the GRR were:

- **Without Project Conditions**: The without-project conditions (WOPC) all assume that none of the components of the Common Features (CF) project has been implemented. The differences between the WOPCs are:
  - WO1: Conditions as they would be in 2010 if there were no CF components in place (most of which are constructed). Folsom operational storage would remain the current 400,000/670,000 cfs variable.
  - WO2: Same as above with the addition of the Joint Federal Project which addresses both dam safety and flood risk management issues through Folsom Dam modifications (described as alternative B in the PAC and ERR.) It is projected that the JFP will be completed by 2014.The WO2 condition shows how the ERR recommended plan would perform with a different without project condition (no Common Features) as its analysis base.
  - WO3: Same as above with the addition of the 3.5 foot Folsom Dam and Reservoir raise. It is projected that the 3.5 foot raise will be completed by 2016.This condition shows how the raise would perform with a different without-project condition as its analysis base. The comparison of this condition to WO1 gives the change in performance and benefits associated with all of the current plans to change Folsom Dam and Reservoir (without the Common Features components in place).

- **No-Action Conditions**: These conditions assume that the CF components that have been completed or are anticipated to be completed and which require no additional federal authorization are in place.
  - NA1: Conditions as they would be in 2010 with all (WRDA 96/99) CF components in place that can be completed without additional authorization.
  - NA2: Same as NA1 with the addition of the JFP from the ERR.
  - NA3: Same as NA2 with the addition of the 3.5 foot Folsom Dam and Reservoir raise. This condition is comparable to the ERR recommended plan. The comparison of this condition to NA1 gives the change in performance and benefits associated with all of the current plans to change Folsom Dam and Reservoir. The comparison of any with-project alternatives to this condition will provide the remaining benefits possible, the change in residual flood damages, and the change in expected performance that the Sacramento metropolitan area can expect to experience with additional improvements above those already authorized on the Lower American River.

As it turns out, only the WO1, WO3, and NA3 conditions ended up being analyzed in the 2009 GRR. For the on-going GRR, only the WO1, NA1, NA2 (with and without dam safety), and NA3 conditions will be carried forward.

4.4.1.2 2010 NPACR Without-Project Condition

In both the 2009 GRR the only without-project condition assumed for the Natomas Basin impact area was the NA3 condition. This without-project condition, which assumes that the authorized Common Features components, the JFP, and the mini-raise are in place, is also assumed for this NPACR.

4.4.2 Upstream Levee Performance

In the 2009 GRR, the assumption of no upstream levee breaches, commonly used in USACE engineering analyses, was made; hence, only levee overtopping, and no levee breaches, was considered upstream of the project area.

Subsequent to the GRR F3 conference in March 2009, and in association with addressing the relatively high AEP and EAD values that were being reported for the Natomas Basin impact area associated with the NAT C index point (Sacramento River, river mile 79), additional sensitivity analyses pertaining to upstream levee breaches were conducted to see its effect on AEP and EAD values. In these sensitivity analyses, the hydraulic frequency-stage curves were adjusted based on historical flood events to account for possible upstream levee breaches; these modified curves were then used in HEC-FDA to see its effects on AEP and EAD. The analysis found that adjustments to the frequency-stage curves produced only relatively minimal changes to AEP and EAD results. The Economic Memorandum for Record that describes the sensitivity analyses is provided as Enclosure 3 in this Economic Appendix. Further details concerning upstream levee performance assumptions can also be found in Appendix C, Hydraulics.

For this NPACR, no upstream levee breaches were assumed in the hydraulic engineering analysis and are not reflected in the exceedance-probability-stage curves used in the economic analysis.

4.4.3 Potential for Human Intervention and the GRU Curves

As mentioned in sub-section 4.4.2, the 2009 GRR analysis brought into question the reasonableness of the high AEP and EAD results that were being reported for the Natomas Basin impact area. Directly related to this were the effects the GRU curves were having on the AEP and EAD results. Subsequent to the F3 conference, economic sensitivity analyses were performed using modified GRU curves to see the effect these curves would have on AEP and EAD. The GRU curves were modified by the SPK Geotechnical Sciences Section to reflect the possibility of human intervention during the smaller exceedance probability events, where the assumption of human intervention on the levees can be considered reasonable as there is historical precedent whereby efforts to stabilize levees have occurred during past flood events in the Natomas Basin impact area.

Based on the modifications made to the GRU curves to reflect the potential for human intervention, the economic sensitivity analyses suggested that only a relatively minimal effect to AEP and EAD could be attributable to these GRU curve modifications. More detail about how the GRU curves were modified to account for potential human intervention can be found in Appendix F, *Geotechnical*; more detail about the economic sensitivity analyses can be found in Enclosure 3 of this Appendix.

For this NPACR, GRU curves (without-project and with-project) used in the economic analysis do not account for the potential for human intervention.

4.4.3 Index Point Locations and Derivation of Floodplains

The Natomas Basin impact area is at risk of flooding from the American River, the Sacramento River, the Natomas Cross Canal, and the Natomas East Main Drainage Canal. For the 2009 GRR economic analysis, floodplains were developed based on breakouts from only one index point (NAT C) on the Sacramento River, a location that had been previously selected for prior Natomas Basin studies. For this NPACR analysis, suites of floodplains were developed based on nine index points located on each of the flooding sources in order to better characterize the without-project condition and facilitate the formulation and evaluation of with-project alternatives.

4.4.4 Future Development in Natomas Basin

In the Natomas Basin impact area significant residential and non-residential construction occurred up until the area was re-mapped (and considered to be within the 100-year floodplain) and a 2008 construction moratorium came into effect. Significant development is expected to continue within the Basin over the next few decades if FRM improvements are made which will remove the area from the FEMA 100-year floodplain and lift the existing building moratorium.

To be consistent with the WRDA 90 Section 308 guidance, none of the growth expected to occur once the 2008 construction moratorium is lifted will be considered in the damage/benefit analysis (future without-project condition). However, future development within the Natomas Basin impact area will be considered in terms of describing future residual risk. This residual risk will be characterized in this NPACR analysis by describing additional event damages and population at risk associated with each alternative.

4.4.6 Future Conditions for Hydrology, Hydraulics, and Geotechnical

For the NPACR the basic assumption is that the hydrology, hydraulics, and geotechnical would remain the same between the existing and future without-project conditions. Future hydrologic, hydraulics, and geotechnical engineering HEC-FDA data inputs were assumed to be the same as existing base conditions. For HEC-FDA modeling purposes, these relationships were set equal under both existing and future without-project conditions.

CHAPTER 5
WITHOUT-PROJECT ANALYSIS – HEC-FDA BASE MODELING RESULTS

Chapter 5 presents the HEC-FDA base modeling results used to inform and guide the with-project analysis documented in Chapter 6; the HEC-FDA modeling completed for each reach and documented in this chapter "sets the stage" for the with-project analysis. Analyzing expected annual damages (EAD) and annual exceedance probability (AEP) for each reach/index point was a necessary step in the analytical process in order to gain information (e.g., EAD, AEP, single-event damages) regarding the overall risk (probability of flooding and consequences of flooding) associated with each reach independently of one another; the results also allowed for the determination of the risk of flooding associated with each reach on a relative basis, that is, which reaches consists of levees that provide the least protection from flooding (or has the greatest risk of flooding) and which reaches consists of levees that provide the most protection from flooding. This initial analysis provided sufficient information to establish the baseline without-project condition (EAD and AEP) used for the with-project analysis documented in Chapter 6. This baseline without-project condition used for the with-project analysis is presented at the end of this chapter.

5.1 MULTIPLE INDEX POINTS AND SINGLE IMPACT AREA

In the without-project economic analysis conducted as part of the 2009 ARWCF GRR, only one index point (NAT C on the Sacramento River near the confluence with the Natomas Cross Canal) was used to evaluate the without-project condition. For this NPACR, nine economic index points, which represent nine different geotechnical reaches, were selected around the Basin in order to better facilitate the evaluation of alternatives and support the economic with-project analysis. The locations of the nine index points were presented in Chapter 4, *Economic Methodologies and Major Assumptions.*

The use of nine index points for economic evaluation purposes necessarily resulted in nine sets of without-project hydrologic/hydraulic HEC-FDA input data, nine suites of without-project floodplains, and nine without-project GRU curves. What did not change between the 2009 analysis and this NPACR, at least during the initial stages of this current economic analysis, was that the entire Basin was considered as one impact area having the same economic structure inventory.[10] Having nine different index points and only one impact area resulted in reach/index point-specific without-project AEP and EAD results, which are presented in the following subsections. Nine HEC-FDA models were set-up to model each reach/index point. Evaluation of the AEP and EAD results from this initial HEC-FDA modeling showed the risk associated with flooding on a reach-by-reach basis; this initial, "building block" modeling was a necessary step

[10]The Basin was eventually split into two impact areas based on the results of the initial HEC-FDA without-project modeling for each reach/index point. The delineation of two impact areas is described later in this chapter.

and provided valuable information for making decisions associated with the Basin-wide with-project analysis, which is presented in Chapter 6, *With-Project Analysis*.

5.2 WITHOUT-PROJECT FLOODPLAINS

Floodplains were developed by the Sacramento District's Hydraulic Design Section using the FLO-2D hydraulic model, which provides interior water surface elevations by grid cell. Without-project floodplains were developed for the 2-, 10-, 25-, 50-, 100-, 200-, and 500-year probability events for each index point. The suites of floodplains associated with each index point are presented in Enclosure 1; these plates show the extent and depths of flooding associated with levee breaches at each index point for each event. Additional details regarding the floodplains and their development can be found in Appendix C, *Hydraulics*.

5.3 HYDROLOGIC, HYDRAULIC, AND GEOTECHNICAL DATA

As described in Chapter 4, *Economic Methodologies and Major Assumptions*, key engineering relationships used in the economic analysis include exceedance probability-stage functions (NAT A, NAT D, NAT E, NAT F, NAT G, NAT H) or exceedance probability-discharge and stage-discharge functions (NAT B, NAT C, NAT I); geotechnical risk and uncertainty (GRU) curves were developed for all reaches/index points. All of the HEC-FDA input data can be found in Enclosure 2 of this Appendix.

5.4 ECONOMIC INVENTORY VALUATION BY EVENT FLOODPLAIN

Chapter 4 presented the structure count and total value of damageable property within the Natomas Basin impact area. For each index point, Table 5-1 displays the total number of structures and the total value of these structures that fall within a specific event floodplain. The data in Table 5-1 show that most of the structures in the Natomas Basin are at risk from flooding. The table also allows for the comparison of the flooding risk (in terms of the number of structures affected and the value of property at risk) associated with a breach at one reach/index point versus a breach at another reach/index point. It can be clearly seen from this table that the number of structures and value of property at risk from a levee breach at NAT F or NAT G are significantly lower than from a breach at the other reaches/index points.

Table 5-1
Number of Structures and Value of Property at Risk
October 2010 Price Level

REACH/ INDEX PT	EVENT FLOODPLAIN	NUMBER OF STRUCTURES	STRUCTURE VALUE	CONTENT VALUE	TOTAL VALUE
A	25-yr	20,964	5,255,941	2,649,709	7,905,650
	100-yr	22,313	5,619,278	2,854,929	8,474,207
	500-yr	22,543	5,658,982	2,876,400	8,535,382
B	25-yr	21,229	5,304,540	2,686,974	7,991,514
	100-yr	22,574	5,617,342	2,853,797	8,471,139
	500-yr	22,828	5,659,545	2,876,682	8,536,227
C	25-yr	22,706	5,644,853	2,869,222	8,514,075
	100-yr	22,828	5,659,633	2,876,726	8,536,359
	500-yr	22,830	5,660,504	2,877,154	8,537,658
D	25-yr	22,828	5,660,504	2,877,154	8,537,658
	100-yr	22,830	5,660,504	2,877,154	8,537,658
	500-yr	22,830	5,660,504	2,877,154	8,537,658
E	25-yr	16,184	4,075,581	1,992,676	6,068,257
	100-yr	17,453	4,291,210	2,104,792	6,396,002
	500-yr	19,594	4,765,657	2,347,633	7,113,290
F	25-yr	1,096	213,063	105,249	318,312
	100-yr	5,969	1,884,830	919,943	2,804,773
	500-yr	16,043	3,863,171	1,890,689	5,753,860
G	25-yr	3,141	973,369	477,315	1,450,684
	100-yr	9,279	2,431,106	1,187,646	3,618,752
	500-yr	16,313	3,947,895	1,933,051	5,880,946
H	25-yr	14,292	3,552,158	1,728,885	5,281,043
	100-yr	17,931	4,402,568	2,157,145	6,559,713
	500-yr	20,995	5,260,235	2,652,132	7,912,367
I	25-yr	21,335	5,335,584	2,696,741	8,032,325
	100-yr	22,412	5,642,219	2,867,606	8,509,825
	500-yr	22,551	5,659,545	2,876,682	8,536,227

5.5 DEPTH-PERCENT DAMAGE FUNCTIONS

The depth of flooding is the primary factor in determining potential damages to structures, contents, and automobiles. Depth-percent damage functions were used in the HEC-FDA model to estimate the percent of value lost for these categories. Residential depth-damage curves (structures and contents) were taken from Economic Guidance Memorandum (EGM) 04-01, *Generic Depth-Damage Relationships for Residential Structures,* for use on both single-family and multi-family residential structures. Structures were identified as 1-story, 2-story, or split-

level. Mobile home curves were taken from the May 1997 Final Report, *Depth Damage Relationships in Support of Morganza to the Gulf, Louisiana Feasibility Study*. Non-residential curves (structures) were based on the same 1997 Morganza study (USACE New Orleans District) and were used for the Natomas Basin, where inundation depths are deep and flooding durations are long (greater than three days). In 2007 non-residential content depth-percent damage curves were developed based on the expert elicitation for each of the 22 categories outlined in Chapter 3; these curves were developed specifically for building types in the Sacramento Metropolitan area and were used for this NPACR analysis.

The complete set of depth- percent damage functions with their corresponding uncertainties can be found in Enclosure 2. Tables 5-2 to 5-7 show the depths-percent damage functions for residential and non-residential damage categories (without uncertainty).

Table 5-2
Residential Curves

CATEGORY		DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET							
		-4.0	-1.0	0.0	1	3	5	10	15
1 Story	Structure	0%	3%	13%	23%	40%	53%	73%	80%
	Content	0%	2%	8%	13%	22%	29%	38%	40%
2 Story	Structure	0%	3%	9%	15%	26%	36%	56%	68%
	Content	0%	1%	5%	9%	16%	21%	32%	37%
Split	Structure	0%	6%	7%	9%	17%	29%	63%	84%
	Content	0%	2%	3%	5%	11%	20%	46%	61%
1 Story w/base	Structure	5%	19%	26%	32%	46%	59%	80%	81%
	Content	6%	13%	16%	19%	25%	30%	39%	39%
2 Story w/base	Structure	5%	14%	18%	22%	32%	42%	65%	76%
	Content	5%	10%	12%	14%	18%	22%	34%	49%
Split w/base	Structure	5%	14%	19%	23%	33%	44%	65%	69%
	Content	4%	9%	12%	14%	18%	22%	26%	26%
Mobile Home-Short Duration	Structure	0%	6%	10%	45%	46%	66%	66%	66%
	Content	0%	0%	0%	38%	69%	90%	90%	90%
Mobile Home-Long Duration	Structure	0%	6%	10%	45%	96%	96%	96%	96%
	Content	0%	0%	0%	85%	99%	99%	99%	99%

Table 5-3
Non Residential Structure Curves

CATEGORY	DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET						
	-1.0	0	1	3	5	10	15
1 Story Short Duration	0	7	16	28	31	46	50
2 Story Short Duration	0	5	10	18	22	38	38
1 Story Long Duration	0	7	22	31	32	54	86
2 Story Long Duration	0	5	15	22	23	46	80

Table 5-4
Non Residential Content Curves – 1 Story – Short Duration

CATEGORY	DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET						
	-1.0	0	1	3	5	10	15
Food Stores	0	0	29	96	100	100	100
Furniture-Retail	0	0	80	96	100	100	100
Grocery Store	0	0	32	89	100	100	100
Hotel-Full Service	0	0	23	90	100	100	100
Medical	0	0	33	89	100	100	100
Office	0	0	35	90	100	100	100
Restaurant	0	0	30	96	100	100	100
Rest-Fast Food	0	0	23	90	100	100	100
Retail	0	0	80	96	100	100	100
Service-Auto	9	10	23	67	100	100	100
Shopping Centers	0	0	33	72	100	100	100
Heavy	0	0	16	56	92	100	100
Light	0	0	35	75	96	100	100
Warehouse	0	0	23	69	96	100	100
Churches	0	0	33	85	99	99	100
Government	0	0	35	90	100	100	100
Recreation	0	0	38	95	100	100	100
Schools	0	0	22	67	88	100	100
Farms	0	0	30	76	100	100	100

Table 5-5
Non Residential Content Curves – 2 Story – Short Duration

CATEGORY	DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET						
	-1.0	0	1	3	5	10	15
Food Stores	0	0	25	50	50	50	100
Furniture-Retail	0	0	42	50	50	50	100
Grocery Store	0	0	27	49	50	50	100
Hotel-Full Service	0	0	20	50	50	50	100
Medical	0	0	28	49	50	50	100
Office	0	0	29	50	50	50	100
Restaurant	0	0	25	50	50	50	100
Rest-Fast Food	0	0	20	50	50	50	100
Retail	0	0	19	36	50	50	100
Service-Auto	8	8	19	37	50	50	100
Shopping Centers	0	0	28	40	50	50	100
Heavy	0	0	14	31	46	50	100
Light	0	0	30	41	48	50	100
Warehouse	0	0	20	38	48	50	100
Churches	0	0	28	47	49	50	100
Government	0	0	30	50	50	50	100
Recreation	0	0	32	49	50	50	100
Schools	0	0	18	37	44	50	100

Table 5-6
Non Residential Content Curves – 1 Story – Long Duration

CATEGORY	DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET						
	-1.0	0	1	3	5	10	15
Food Stores	0	0	78	100	100	100	100
Furniture-Retail	0	0	98	100	100	100	100
Grocery Store	0	0	87	100	100	100	100
Hotel-Full Service	0	0	88	100	100	100	100
Medical	0	0	75	100	100	100	100
Office	0	0	97	100	100	100	100
Restaurant	0	0	91	100	100	100	100
Rest-Fast Food	0	0	88	100	100	100	100
Retail	0	0	80	100	100	100	100
Service-Auto	10	10	74	100	100	100	100
Shopping Centers	0	0	96	100	100	100	100
Heavy	0	0	33	77	100	100	100
Light	0	0	88	99	100	100	100
Warehouse	0	0	84	100	100	100	100
Churches	0	0	73	99	99	99	100
Government	0	0	97	100	100	100	100
Recreation	0	0	98	100	100	100	100
Schools	0	0	88	100	100	100	100
Farms	0	0	56	100	100	100	100

Table 5-7
Non Residential Content Curves – 2 Story – Long Duration

CATEGORY	DEPTH OF FLOODING ABOVE THE FIRST FLOOR IN FEET						
	-1.0	0	1	3	5	10	15
Food Stores	0	0	38	56	56	67	100
Furniture-Retail	0	0	47	56	56	67	100
Grocery Store	0	0	42	56	56	67	100
Hotel-Full Service	0	0	42	56	56	67	100
Medical	0	0	36	56	56	67	100
Office	0	0	46	56	56	67	100
Restaurant	0	0	44	56	56	67	100
Rest-Fast Food	0	0	42	56	56	67	100
Retail	0	0	38	56	56	67	100
Service-Auto	5	5	35	56	56	67	100
Shopping Centers	0	0	46	56	56	67	100
Heavy	0	0	40	56	56	67	100
Light	0	0	42	56	56	67	100
Warehouse	0	0	40	56	56	67	100
Churches	0	0	35	55	55	66	100
Government	0	0	45	56	56	68	100
Recreation	0	0	47	56	56	67	100
Schools	0	0	42	56	56	67	100
Farms	0	0	27	56	56	67	100

5.6 AUTOMOBILE LOSSES

Damages to automobiles were developed based on a function of average value, number of vehicles, estimated evacuation rate, depth of flooding, and depth-percent damages loss. Values were determined for average used cars ($14,925)[11] and new cars ($28,500) based on information from the National Auto Dealer Association (NADA). The number of cars per residential unit (1.93) was based on the total number of automobiles and trucks registered in the Sacramento Area (source: California Department of Finance) divided by the number of households. Automobile counts for car dealerships were based on discussions with local dealers (who also verified values were within a reasonable range) and comparisons with spot inventories from aerial photos. New car values were used to determine value of vehicles at risk at full service new car dealerships and used car values for both residential units and small used car dealerships. It

[11] For the analysis and results documented in Chapters 5, 6, and 7a, the values used to compute vehicle damages is $14,925. However, comments received through agency technical review recommended using a lesser value of $7,988, which is the value published by the Bureau of Transportation Statistics, unless regional vehicle data supported the higher value of $14,925. For the analysis presented in Chapter 7b, damages are based on the lower value of $7,988; the damages and benefits results reported in Chapter 7b serve as the "final" economic results used for the net benefit and benefit-to-cost analyses and for plan formulation purposes.

was assumed that, based on short evacuation time[12], about 50% of residential-based vehicles will be removed from the flood area prior to the event and only 20% will be removed from dealerships. Depth-percent damage functions for automobiles were based on averages from curves developed by the Institute for Water Resources (IWR) and provided in EGM 09-04, *Generic Depth-Damage Relationships for Vehicles*. These curves were developed for five vehicle categories (sedans, pickups, SUV, sports, and mini-vans) and are displayed in Table 5-8 below. The curve used for this analysis is displayed in the last column.

[12] The 50% assumption (percentage of antos moved out of the floodplain) used for automobiles was made based on the potential short warning time, the large number of people who live in the Basin, the relatively small number of major routes (highways) for evacuation, and EGM 09-04 which recommends a removal rate of 50.6% for areas where the warning time is less than 6 hours.

Table 5-8
Vehicle Depth-Percent Damage Curve

	PERCENT DAMAGE TO VEHICLES											
	Sedans		Pickups		SUVs		Sports		Mini Vans		HEC-FDA	
Depth Above Grnd	Percent Dam	Std Dev	Percent Dam	Std Dev	Percent Dam	Std Dev	Percent Dam	Std Dev	Percent Dam	Std Dev	Percent Dam	Std Dev
.5	7.60%	2.42%	5.20%	3.02%	0.00%	11.28%	1.40%	19.22%	0.00%	9.11%	2.80%	9.00%
1	28.00%	1.84%	20.30%	2.53%	13.80%	8.76%	29.20%	16.81%	17.80%	6.82%	21.80%	7.40%
2	46.20%	1.51%	34.40%	2.33%	30.60%	6.67%	52.80%	13.17%	38.30%	5.33%	40.50%	5.80%
3	62.20%	1.45%	47.50%	2.38%	45.80%	5.24%	72.20%	8.47%	56.80%	4.88%	56.90%	4.50%
4	76.00%	1.57%	59.60%	2.57%	59.40%	4.78%	87.40%	3.61%	73.30%	5.34%	71.10%	3.60%
5	87.60%	1.74%	70.70%	2.81%	71.40%	5.36%	98.40%	6.12%	87.80%	6.23%	83.20%	4.50%
6	97.00%	1.92%	80.80%	3.04%	81.80%	6.61%	100%	13.80%	100%	7.20%	91.90%	6.50%
7	100%	2.06%	89.90%	3.21%	90.60%	8.17%	100%	13.80%	100%	7.20%	96.10%	6.90%
8	100%	2.06%	98.00%	3.32%	97.80%	9.88%	100%	13.80%	100%	7.20%	99.20%	7.30%
9	100%	2.06%	100%	3.36%	100%	11.70%	100%	13.80%	100%	7.20%	100%	7.60%
10	100%	2.06%	100%	3.36%	100%	11.70%	100%	13.80%	100%	7.20%	100%	7.60%

5.7 ECONOMIC UNCERTAINTIES

The valuation of residential and non-residential structures and contents along with automobile losses were estimated with uncertainty. In the estimation of structure value, three variables were considered to have a possible range of values: $ per square foot, building square footage, and percent of estimated depreciation. Using a triangular distribution to describe the range of these three variables, a Monte Carlo simulation was run on typical structures by category and the mean and standard deviations were compared to derive coefficients of variation (COV) for structure values by category. Content value uncertainties were based on data from the aforementioned expert elicitation. The program Best Fit was used to determine what would be a reasonable distribution, and using the model data, a normal distribution best described uncertainty in structure and content valuation. These uncertainty parameters for valuation were imported into the HEC-FDA program. The uncertainties for structure and content values by category are shown in Table 5-9 below.

Table 5-9
UNCERTAINTY IN STRUCTURE AND CONTENT VALUE

USE CATEGORY	UNCERTAINTY IN VALUE (INPUT TO HEC-FDA)	
	Structure SD/Mean	Content SD/Mean
Residential (SFR & MFR)	17%	12%
Mobile Homes	14%	12%
Office 2-Story	17%	14%
Office 1-Story	17%	16%
Retail	17%	18%
Retail-Furniture	17%	20%
Auto Dealerships	12%	12%
Hotel	12%	16%
Food Stores	21%	27%
Restaurants	19%	3%
Restaurants-Fast Food	19%	13%
Medical	13%	46%
Hospitals	21%	46%
Shopping Centers	20%	23%
Large Grocery Stores	20%	4%
Service (Auto)	17%	4%
Warehouse	17%	31%
Light Ind.	21%	19%
Heavy Ind.	21%	31%
Government	31%	16%
Schools	15%	33%
Religious	19%	40%
Recreation	19%	13%
Farms	20%	8%
Automobiles	15%	N/A

Several factors contributed to the uncertainty associated with automobile damages. These factors include the average unit value, the number of vehicles per residence/dealership assumed, and the evacuation rate. It was assumed that the average number or automobiles per residential unit was 2 and the evacuation rate was 50%. An average value of an automobile was calculated to be $14,930. (As was previously noted, this value was reduced to $7,988.) While uncertainty in these variables was not considered, uncertainty in the percent damage (Table 5-9) by depth (as reflected in the depth-percent damage curve) was taken into account.

Uncertainty in first floor elevation was also included in the model. During the field inventory, first floor estimations were made by visual inspection and assigned to structures in one half-foot increases. For example, the average SFR built on slab without any fill might be listed as ground elevation + 0.5 foot to 1.0 foot; raised foundations either 1.5, 2 or 2.5 feet. Based on this level of

precision, it was assumed that 0.5 foot standard error would capture the potential uncertainty in this first floor elevation adjustment.

The uncertainty associated with the percent damages at specific depths of flooding for automobiles and structures/contents were entered into the HEC-FDA model. Residential structure and content depth-percent damage curves are normally distributed and include standard deviations of percent damages by depth of flooding. Non-residential content depth-percent damage curves are triangularly distributed and include a minimum, most likely, and maximum percent damage by depth of flooding. These curves with their corresponding uncertainties are shown in section 5.5 above.

5.8 WITHOUT-PROJECT SINGLE-EVENT DAMAGES

Single-event without-project damages for the 2-, 10-, 25-, 50-, 100-, 200-, and 500-year events were computed in HEC-FDA using the economic inventory, flooding depths, and depth-percent damage functions. Table 5-10 displays damages by event on a reach/index point-specific basis. Tables 5-11 through 5-19 display the damages by event and damage category for each reach/index point. It is important to note that the values in these tables represent single-event damages based on flooding the same impact area (the entire Natomas Basin) and structure inventory but from different sources (index points); damages, therefore, cannot be summed across reaches/index point as this would result in double counting.

Single-event damages for structures and contents and for both residential and non-residential categories were calculated with uncertainty in HEC-FDA. Single-event automobile damages with uncertainty were also estimated. The single-event damage results indicate that flooding from NAT D for all frequency events results in the most severe consequences with damages ranging from $6.9 billion for a 2-year event to $7.0 billion for a 500-year event.

Table 5-10
Single-Event Without-Project Damages by Reach/Index Point

REACH/INDEX POINT	NATOMAS BASIN SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVELS)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
NAT A	3,815	4,983	5,122	5,739	6,196	6,502	6,739
NAT B	3,733	5,176	5,199	5,673	6,113	6,408	6,775
NAT C	5,194	6,386	6,540	6,759	6,836	6,954	7,010
NAT D	6,302	6,731	6,826	6,942	6,986	7,014	7,034
NAT E	2,002	2,955	3,384	3,587	3,743	3,913	4,261
NAT F	0	44	78	134	191	259	3,049
NAT G	222	573	615	1,054	1,616	1,971	3,068
NAT H	36	904	2,773	3,388	3,923	4,524	5,098
NAT I	3,806	5,163	5,389	5,998	6,427	6,671	6,813

Table 5-11
Single-Event Without-Project Damages
NAT A

DAMAGE CATEGORY	NAT A SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	2,573	3,279	3,373	3,752	4,062	4,246	4,388
Commercial	492	598	615	697	757	794	825
Industrial	338	404	420	483	523	563	590
Public	170	409	414	486	515	553	588
Farm	1	3	3	5	8	9	10
Auto Losses	241	291	296	316	331	336	339
TOTAL	**3,815**	**4,983**	**5,122**	**5,739**	**6,196**	**6,502**	**6,739**

Table 5-12
Siugle-Event Without-Project Damages
NAT B

DAMAGE CATEGORY	NAT B SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	2,371	3,384	3,398	3,702	4,008	4,197	4,411
Commercial	453	614	619	685	734	774	824
Industrial	317	421	423	476	515	551	591
Public	361	456	457	489	518	543	600
Farm	2	4	5	6	7	9	10
Auto Losses	229	297	298	314	330	334	339
TOTAL	**3,733**	**5,176**	**5,199**	**5,673**	**6,113**	**6,408**	**6,775**

Table 5-13
Single-Event Without-Project Damages
NAT C

DAMAGE CATEGORY	NAT C SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	3,628	4,183	4,277	4,402	4,451	4,499	4,519
Commercial	668	770	788	820	833	851	866
Industrial	460	548	565	588	597	611	626
Public	482	542	564	600	605	643	649
Farm	5	9	10	10	11	11	11
Auto Losses	311	334	336	339	339	339	339
TOTAL	**5,194**	**6,386**	**6,540**	**6,759**	**6,836**	**6,954**	**7,010**

Table 5-14
Single-Event Without-Project Damages
NAT D

DAMAGE CATEGORY	NAT D SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	4,133	4,386	4,444	4,495	4,513	4,519	4,520
Commercial	760	814	832	849	857	868	875
Industrial	530	585	596	609	619	627	637
Public	537	597	604	639	647	650	651
Farm	9	10	11	11	11	11	12
Auto Losses	333	339	339	339	339	339	339
TOTAL	**6,302**	**6,731**	**6,826**	**6,942**	**6,986**	**7,014**	**7,034**

Table 5-15
Single-Event Without-Project Damages
NAT E

DAMAGE CATEGORY	NAT E SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	1,172	1,915	2,250	2,409	2,521	2,651	2,875
Commercial	325	409	449	464	479	497	551
Industrial	260	301	317	327	336	343	368
Public	122	139	152	155	169	173	199
Farm	0	0	1	2	2	2	2
Auto Losses	123	190	216	229	237	247	265
TOTAL	**2,002**	**2,955**	**3,384**	**3,587**	**3,743**	**3,913**	**4,261**

Table 5-16
Single-Event Without-Project Damages
NAT F

DAMAGE CATEGORY	NAT F SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	0	41	68	118	164	225	1,903
Commercial	0	0	0	0	0	0	448
Industrial	0	0	0	0	0	0	347
Public	0	0	4	4	10	10	150
Farm	0	0	0	0	0	0	1
Auto Losses	0	3	6	11	17	24	200
TOTAL	**0**	**44**	**78**	**134**	**191**	**259**	**3,049**

Table 5-17
Single-Event Without-Project Damages
NAT G

DAMAGE CATEGORY	NAT G SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	192	316	319	560	909	1,150	1,990
Commercial	0	99	129	247	283	321	434
Industrial	0	106	109	159	243	258	302
Public	10	19	24	32	90	121	140
Farm	0	0	0	0	0	0	0
Auto Losses	20	33	34	55	90	121	202
TOTAL	**222**	**573**	**615**	**1,054**	**1,616**	**1,971**	**3,068**

Table 5-18
Single-Event Without-Project Damages
NAT H

DAMAGE CATEGORY	NAT H SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	28	435	1,735	2,239	2,641	3,066	3,346
Commercial	3	216	416	459	511	576	616
Industrial	0	147	302	321	350	391	425
Public	0	54	140	152	174	213	414
Farm	0	0	0	1	1	2	3
Auto Losses	5	53	179	217	246	277	296
TOTAL	**36**	**904**	**2,773**	**3,388**	**3,923**	**4,524**	**5,098**

Table 5-19
Single-Event Without-Project Damages
NAT I

DAMAGE CATEGORY	NAT I SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	2,555	3,400	3,547	3,928	4,201	4,347	4,430
Commercial	499	621	655	732	787	815	836
Industrial	334	424	441	507	557	584	598
Public	170	416	436	498	540	578	600
Farm	1	3	3	6	9	10	10
Auto Losses	246	299	307	327	335	338	339
TOTAL	**3,806**	**5,163**	**5,389**	**5,998**	**6,427**	**6,671**	**6,813**

5.9 HEC-FDA MODEL RESULTS BY REACH/INDEX POINT

The following subsections present the without-project expected annual damages (EAD) and annual exceedance probability (AEP) results. Without-project EAD was computed on a reach/index point-specific basis using the HEC-FDA model. The HEC-FDA model integrates the hydrologic, hydraulic, geotechnical and economic relationships with uncertainty to create exceedance probability-damage functions with uncertainty. Without-project EAD for each reach/index point is shown in Table 5-20; the EAD results for each reach/index point broken down by category are displayed in Table 5-21.

Depending on where the levee breach occurs, EAD ranges between $26 million and over one billion. The HEC-FDA results indicate that risk of flooding from NAT D (Natomas Cross Canal) is the worst: over one billion dollars in expected damages and a one-in-five chance of flooding in any given year. On the other hand, risk of flooding from NAT I is the lowest in terms of probability: about a 1 in 67 chance of flooding in any given year; the risk of flooding from NAT F is the lowest in terms of consequences: about $26 million in expected annual damages.

5.9.1 Expected Annual Damages (EAD)

Table 5-20 and 5-21 show the without-project expected annual damages results for each reach/index point. Table 5-20 shows total damages while Table 5-21 shows damages by category.

Table 5-20
Expected Annual Damages by Reach/Index Point (Oct 2010 Price Level)

PLAN	EXPECTED ANNUAL DAMAGES (EAD) IN $MILLIONS								
	Reach/Index Point								
	SR			NCC	PGCC/NEMDC				AR
	A	B	C	D	E	F	G	H	I
Without-Project	747	351	265	1,167	789	26	67	122	95

Notes: SR = Sacramento River, NCC = Natomas Cross Canal; PGCC = Pleasant Grove Creek Canal; NEMDC = Natomas East Main Drainage Canal; AR = American River

Table 5-21
EAD by Reach/Index Point and Damage Category (Oct 2010 Price Level)
Without-Project Condition (Per Reach/Index Point)

ECONOMIC REACH/INDEX POINT	EXPECTED ANNUAL DAMAGES (EAD) IN $MILLIONS								
	Reach/Index Point								
	SR			NCC	PGCC/NEMDC				AR
	A	B	C	D	E	F	G	H	I
Residential	468	227	172	758	518	20	41	77	62
Commercial	97	44	32	144	99	2	11	19	12
Industrial	65	30	23	102	69	1	8	12	8
Public	54	31	23	103	59	1	3	6	8
Farm	1	1	1	2	1	0	0	0	0
Automobiles	43	20	13	59	44	2	4	7	5
Total	747	351	265	1,167	789	26	67	122	95

Notes: SR = Sacramento River, NCC = Natomas Cross Canal; PGCC = Pleasant Grove Creek Canal; NEMDC = Natomas East Main Drainage Canal; AR = American River

5.9.2 Annual Exceedance Probability (AEP)

Table 5-22 below displays the AEP results on a reach-by-reach basis.

Table 5-22
Without-Project AEP by Reach/Index Point

PLAN	ANNUAL EXCEEDANCE PROBABILITY (AEP)								
	Natomas Basin Reach/Index Point								
	SR			NCC	PGCC/NEMDC				AR
	A	B	C	D	E	F	G	H	I
Without-Project	0.20	0.12	0.04	0.21	0.18	0.30	0.20	0.04	0.015

5.10 EVALUATION OF WITHOUT-PROJECT HEC-FDA RESULTS

Upon completion of the initial HEC-FDA modeling runs (per reach/index point) for the without-project condition, the results revealed that for index points NAT F and NAT G there was a relatively high probability of flooding but a relatively low consequence (EAD) of flooding as compared to the other index points. As shown in Tables 5-21 and 5-22, AEP and EAD for NAT F is .30 and approximately $26 million, respectively; AEP and EAD for NAT G is .20 and approximately $67 million, respectively.

The reach/index point-specific AEP and EAD results prompted a closer look at the underlying floodplain data, upon which damages are based on. Total single-event damages, which were computed in HEC-FDA, showed that on a relative basis (i.e., as compared to the other reaches/index points) damages resulting from levee breaches in NAT F or NAT G are significantly lower than damages resulting from levee reaches in the other reaches for all exceedance probability events. (See Tables 5-16 and 5-17.)

Evaluation of the without-project AEP, EAD, and single-event damages data together showed that even though NAT F and NAT G have relatively high AEPs, the consequences of flooding from breaches in those reaches do not become significant until the occurrence of bigger flood events. The main factors that explain the relatively low incurrence of damages up until the bigger flood events include a) relatively small floodplains up until the .01 to .005 probability events b) relatively low depths of flooding up until the .002 probability event and 3) relatively low number of structures affected by flooding up until about the .01 to .005 probability event. (See Enclosure 1 for NAT F and NAT G floodplains plates.)

The EAD and AEP results from the HEC-FDA "building block" models and subsequent evaluation of single-event damages for NAT F and NAT G helped to identify in more detail the flooding problem (risk and consequences) in the Natomas Basin impact area on a reach-by-reach (or index point-by-index point) basis and also provided valuable information in regard to the approach taken to perform the Basin-wide with-project benefit analysis. One of these approaches

involved splitting the Basin into two impact areas, each with its own economic inventory. This is explained in the next section.

5.10.1 Impact Areas: "Major" and "Minor"

Based on the initial HEC-FDA without-project modeling results for each reach/index point, the Basin was split up into two impact areas for purposes of conducting the with-project benefit analysis documented in Chapter 6. By splitting the Basin into two impact areas – a "Major" impact area and a "Minor" impact area[13] – levee reach improvements around the Basin could be ordered by balancing the main factors of risk: the probability of flooding (as measured by AEP) and the consequences of flooding (as measured by EAD and single-event damages). Figure 5-1 shows the two impact areas. Chapter 6, *With-Project Analysis*, provides more details regarding the delineation of the Major and Minor impact areas. Tables 5-23 to 5-25 in the subsections below display the single-event damages and EAD results for each area.

It should be pointed out that the terms "major" and "minor" are relative and were used mainly to associate the geographic areas tied to the two sets of index points. When performing the HEC-FDA analysis to compute initial EAD results for the separate impact areas (different economic inventories) at each index point, the "Major" area was tied to index points NAT A through NAT E, NAT H, and NAT I and the "Minor" area was tied to index points NAT F and NAT G. In terms of geographic extent, the "major" area is much larger than the "minor" area; in terms of single-event damages, the "major" area also shows much greater damages than the "minor" area. However, on an absolute basis, the "minor" area still shows significant damages. Tables 5-23 through 5-33 display the single-event damages for each index point after splitting the Basin inventory into two separate areas.

[13] The terms "Major" and "Minor" used to describe the impact areas are used as relative terms as well as to distinguish that one area was treated as the main area and the other as a secondary area (or "residual" area) in order to facilitate the with-project analysis described in Chapter 6 of this Appendix. On a relative basis and in terms of geographic area, the "Major" area is larger than the "Minor" area; as will be seen in the last section of this chapter, the without-project EAD value ($886 million) computed as the baseline without-project damages for the "Major" area is greater than the EAD value ($477 million) computed as the baseline without-project damages for the "Minor" area. However, on an absolute basis, without-project EAD used as the baseline for each respective area can actually be considered "major."

Figure 5-1 Minor impact area (shaded); major impact area (non-shaded)



5.10.2 Single-Event Damages: Two Impact Areas

Table 5-23
Single-Event Without-Project Damages
Index Points Tied to Inventory of Major Impact Area

ECONOMIC REACH/INDEX POINT	MAJOR IMPACT AREA SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $MILLIONS, OCTOBER 2010 PRICE LEVELS)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
NAT A	3,280	3,549	3,667	4,200	4,626	4,920	5,156
NAT B	2,466	3,718	3,738	4,139	4,550	4,827	5,192
NAT C	4,032	4,807	4,958	5,177	5,252	5,470	5,427
NAT D	4,724	5,148	5,242	5,359	5,402	5,431	5,451
NAT E	1,788	3,619	4,198	4,595	4,828	5,028	5,242
NAT H	0	709	1,585	2,110	2,684	3,087	3,517
NAT I	2,525	3,704	3,893	4,446	4,847	5,089	5,230

Table 5-24
Single-Event Without-Project Damages
Index Points Tied to Inventory of Minor Impact Area

ECONOMIC REACH/INDEX POINT	MINOR IMPACT AREA SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $MILLIONS, OCTOBER 2010 PRICE LEVELS)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
NAT F	0	43	77	134	191	259	1,024
NAT G	81	81	635	735	892	893	1,171

Table 5-25
Single-Event Without-Project Damages
NAT A (Tied to Inventory of Major Impact Area)

DAMAGE CATEGORY	NAT A SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	1,868	2,495	2,578	2,921	3,217	3,394	3,534
Commercial	195	268	278	326	378	412	443
Industrial	906	191	204	257	289	327	354
Public	131	364	370	438	466	505	539
Farm	1	3	3	5	8	9	10
Auto Losses	179	228	234	254	269	273	276
TOTAL	3,280	3,549	3,667	4,200	4,626	4,920	5,156

Table 5-26
Single-Event Without-Project Damages
NAT B (Tied to Inventory of Major Impact Area)

DAMAGE CATEGORY	NAT B SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	1,718	2,588	2,599	2,874	3,164	3,345	3,556
Commercial	170	276	281	315	358	392	442
Industrial	85	204	205	250	283	315	355
Public	323	411	412	442	469	494	552
Farm	2	4	5	6	7	9	10
Auto Losses	168	235	235	252	268	272	276
TOTAL	**2,466**	**3,718**	**3,738**	**4,139**	**4,550**	**4,827**	**5,192**

Table 5-27
Single-Event Without-Project Damages
NAT C (Tied to Inventory of Major Impact Area)

DAMAGE CATEGORY	NAT C SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	2,804	3,332	3,424	3,548	3,597	3,645	3,664
Commercial	302	388	406	438	451	569	484
Industrial	236	312	329	352	361	375	390
Public	436	493	516	552	556	594	600
Farm	5	9	10	10	10	11	11
Auto Losses	249	272	274	276	277	277	277
TOTAL	**4,032**	**4,807**	**4,958**	**5,177**	**5,252**	**5,470**	**5,427**

Table 5-28
Single-Event Without-Project Damages
NAT D (Tied to Inventory of Major Impact Area)

DAMAGE CATEGORY	NAT D SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	3,283	3,532	3,590	3,641	3,658	3,665	3,666
Commercial	378	432	450	467	475	486	493
Industrial	295	349	360	373	383	391	401
Public	489	548	555	590	598	601	603
Farm	9	10	10	11	11	11	12
Auto Losses	271	276	277	277	277	277	277
TOTAL	**4,724**	**5,148**	**5,242**	**5,359**	**5,402**	**5,431**	**5,451**

Table 5-29
Single-Event Without-Project Damages
NAT E (Tied to Inventory of Major Impact Area)

DAMAGE CATEGORY	NAT E SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	1,296	2,541	2,926	3,195	3,346	3,461	3,590
Commercial	135	270	316	361	393	415	450
Industrial	123	194	251	286	315	338	360
Public	102	379	443	475	494	531	555
Farm	0	3	6	9	9	10	10
Auto Losses	131	233	257	269	272	274	277
TOTAL	**1,788**	**3,619**	**4,198**	**4,595**	**4,828**	**5,028**	**5,242**

Table 5-30
Single-Event Without-Project Damages
NAT F (Tied to Inventory of Minor Impact Area)

DAMAGE CATEGORY	NAT F SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	0	41	68	118	164	225	592
Commercial	0	0	0	0	0	0	153
Industrial	0	0	0	0	0	0	183
Public	0	0	4	4	10	10	37
Farm	0	0	0	0	0	0	0
Auto Losses	0	3	6	11	17	24	58
TOTAL	**0**	**43**	**77**	**134**	**191**	**259**	**1,024**

Table 5-31
Single-Event Without-Project Damages
NAT G (Tied to Iuventory of Minor Impact Area)

DAMAGE CATEGORY	NAT G SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	71	71	317	368	437	437	611
Commercial	0	0	143	165	225	225	281
Industrial	0	0	118	133	152	152	183
Public	4	4	24	30	32	32	38
Farm	0	0	0	0	0	0	0
Auto Losses	6	6	33	40	47	47	59
TOTAL	**81**	**81**	**635**	**735**	**892**	**893**	**1,171**

Table 5-32
Single-Event Without-Project Damages
NAT H (Tied to Inventory of Major Impact Area)

DAMAGE CATEGORY	NATOMAS REACH H SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	0	530	1,105	1,539	1,983	2,271	2,451
Commercial	0	63	135	174	212	250	270
Industrial	0	15	124	136	159	185	203
Public	0	43	103	108	140	166	364
Farm	0	0	0	1	1	2	3
Auto Losses	0	58	117	152	189	212	227
TOTAL	**0**	**709**	**1,585**	**2,110**	**2,684**	**3,087**	**3,517**

Table 5-33
Single-Event Without-Project Damages
NAT I (Tied to Inventory of Major Impact Area)

DAMAGE CATEGORY	NAT I SINGLE-EVENT WITHOUT-PROJECT DAMAGES (VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Residential	1,860	2,605	2,735	3,091	3,349	3,493	3,576
Commercial	205	282	300	358	405	433	454
Industrial	143	206	220	277	321	348	362
Public	131	371	390	449	491	529	552
Farm	1	3	3	6	9	10	10
Auto Losses	185	237	245	265	272	276	276
TOTAL	**2,525**	**3,704**	**3,893**	**4,446**	**4,847**	**5,089**	**5,230**

5.10.3 Expected Annual Damages: Two Impact Areas, Post Basin Split

Tables 5-34 and 5-35 show the EAD results after the Basin was split into two impact areas – Major and Minor. These HEC-FDA results reflect the use of 1) reach-specific suite of floodplains 2) reach-specific HEC-FDA engineering input data (frequency-discharge-stage curves and GRU curves) and 3) a split Basin inventory where NAT A through E, NAT H, and NAT I damage results account for flooding to those structures in the non-shaded area of Figure 5-1; and NAT F and NAT G damage results account for flooding to those structures in the shaded area of Figure 5-1.

By comparing the EAD results in Tables 5-34 and 5-35 (two inventories, split Basin) to the EAD results in Table 5-20 (one inventory, whole Basin), it can be seen that, as expected, EAD results across all reaches decrease. For example, EAD for NAT D prior to splitting the Basin (i.e., damages based on inventory of whole Basin) is approximately $1.2 billion; EAD for NAT D decreases to approximately $900 million after splitting the Basin (i.e., damages based on a smaller inventory). Similarly, EAD for NAT F decreases from approximately $26 million to approximately $18 million, reflecting the reduced inventory tied to the NAT F index point after splitting up the Basin into two areas.

Table 5-34
Expected Annual Damages by Reach/Index Point (Oct 2010 Price Level)
Split Inventory: Index Points Tied to Inventory of Major Impact Area

PLAN	EXPECTED ANNUAL DAMAGES (EAD) IN $MILLIONS						
	Natomas Basin Reach/Index Point						
	SR			NCC	PGCC/NEMDC		AR
	A	B	C	D	E	H	I
Without-Project	552	593	215	894	563	76	68

Notes: SR = Sacramento River, NCC = Natomas Cross Canal; PGCC = Pleasant Grove Creek Canal; NEMDC = Natomas East Main Drainage Canal; AR = American River

Table 5-35
Expected Annual Damages by Reach/Index Point (Oct 2010 Price Level)
Split Inventory: Index Points Tied to Inventory of Minor Impact Area

PLAN	EXPECTED ANNUAL DAMAGES (EAD) IN $MILLIONS	
	Natomas Basin Reach/Index Point	
	NEMDC	
	F	G
Without-Project	18	60

Notes: NEMDC = Natomas East Main Drainage Canal

5.11 PURPOSE OF CHAPTER 5 RESULTS & ESTABLISHING THE BASIS FOR THE WITH-PROJECT ANALYSIS DOCUMENTED IN CHAPTER 6

As noted in previous sections of this report, this chapter is intended to show the steps that were taken and the analyses that were completed in order to obtain the data/information necessary to inform and guide the with-project, net benefit, and benefit-to-cost analyses, which are presented in Chapters 6, 7A, and 7B of this Appendix. In summary, the data/information presented in this chapter was used to:

- Determine that a re-delineation of the Basin was necessary in order to facilitate the with-project analysis; thus, two impact areas (Major and Minor) were created. (This decision was based on the EAD and AEP results pre-split.)
- Determine that NAT D on the Natomas Cross Canal (NCC) is the weakest link in terms of overall flood risk: the probability of flooding and the consequences of flooding. (This determination was based on the EAD and AEP results of the pre-split and post-split.)
- Determine that NAT D, all of its associated HEC-FDA engineering input data, and event floodplains would serve as the starting point (baseline) for the with-project benefit analysis for the Major impact area. (This determination was based on the reach-specific HEC-FDA EAD and AEP results post-split.)
- Determine that NAT F, all of its associated HEC-FDA engineering input data, and NAT D floodplains would serve as the starting point (baseline) for the with-project benefit analysis for the Minor impact area. (This determination was based on the reach-specific HEC-FDA and AEP results post-split.)
- Determine the order of fixes by reach for the with-project analysis for the Major and Minor impact areas. (This determination was based on the EAD and AEP results, post-split.)
- Determine the "floodplain assignments" for each levee reach improvement in the Major and Minor impact areas. (This determination was based on the reach-specific AEP results and single-event damages, post-split.)

A summary of the EAD results (and inputs these results are based on) thus far in the analytical process is provided in Table 5-36 below. The without-project EAD for each impact area used as the baseline for the with-project analysis presented in Chapter 6 is also displayed in Table 5-36. The information provided in the table is described in more detail in the bulleted points below:

- As displayed in the first section of the table, initial HEC-FDA base modeling runs (first step of the analysis) were completed for all reaches/index points around the Basin independent of each other; AEP and EAD results were obtained for each reach from these base model runs, which helped inform the next step on the way to performing the with-project analysis, which is documented in Chapter 6.
- The AEP and EAD information gained in the first step guided the next step of the analytical process. While the initial results indicated that, generally, a reach with a high AEP also had a high EAD, reaches NAT F and NAT G had relatively high AEPs and low EADs. From this information, it was determined that the Basin should be split into two areas with two separate economic inventories, each area tied to specific reaches/index points – one area tied to reaches NAT A, B, C, D, E, H, and I and the other area tied to

reaches NAT F and G; this decision was made in order to facilitate the with-project analysis. As in the initial modeling runs, the HEC-FDA modeling runs in this second step were completed for each reach around the Basin to obtain EAD results for each reach independent of each other (AEP for each reach, as expected, did not change from the initial model runs); the only difference between the modeling runs in this step and those in the first step is the economic inventory tied to each reach. This difference is reflected in the lower EAD values seen in section two of Table 5-36, as each reach is now tied to a smaller inventory (i.e., split-Basin inventory rather than a full-Basin inventory). This second step was necessary in order to split the economic inventory into two areas for with-project analysis purposes; the EAD results were not used as input into the with-project analysis.

- Finally, the third section of Table 5-36 displays the inputs and results used in the final step of the analytical process. This section shows the baseline without-project EAD (per impact area) used as the starting point in the with-project analysis (Chapter 6). As displayed in the table, NAT D was determined to be the without-project controlling index point (CIP) for the Major area since overall risk (probability and consequences) at this index point is the greatest; the without-project EAD for the Major impact area is the same as those EAD values for NAT D obtained in step two in the process since none of the HEC-FDA inputs (engineering data used in the AEP calculations, economic inventory, and flood depth data) has changed. In the Minor impact area, NAT F was determined to be the without-project CIP since NAT F's AEP is greater than NAT G's. Unlike in the Major impact area, the EAD value for the Minor impact area differs from the previous step (step two) – the without-project EAD value for the Minor area is not the same as the EAD for NAT F as shown in step two. This difference is purely the result of using different floodplain depth data ("floodplain assignments") for the Minor area: whereas in step two Nat F floodplain depth data were used to compute EAD at NAT F, in this step NAT D floodplain depth data were used. The flood depth data from the NAT D floodplains were used because, even though the structures in the Minor impact area are being tied to the NAT F index point, these structures are still at great risk of being flooded by a breakout at NAT D, which result in larger and deeper floodplains (compared to floodplains from breaches in any of the other reaches, including NAT F). Not using the depth data from NAT D would understate the possible consequences (damages) to those structures in the Minor impact area. The process of "floodplain assignments," which are really flood depth data taken from a respective floodplain (e.g., NAT D 500-year floodplain) assigned to structures in either the Major or Minor impact area, is explained further in Chapter 6, Section 6.7. In this section the with-project analysis and "floodplain assignments" used for each levee reach improvement and for each impact area is explained in more detail. At this point of the analysis, the without-project EAD values for each impact area have been established (last row of Table 5-36 below) for the with-project analysis presented in Chapter 6: without-project EAD for the Major impact area is $886 million and without-project EAD for the Minor impact area is $477 million.

Table 5-36
Summary of Steps Leading Up to the Establishment of Without-Project EAD for Purposes of the With-Project Analysis

ANALYTICAL STEP	ECONOMIC ANALYSIS INPUT/OUTPUT	INDEX POINTS TIED TO MAJOR AREA							INDEX POINTS TIED TO MINOR AREA	
1	Index Point	A	B	C	D	E	H	I	F	G
	Inventory	Entire Basin							Entire Basin	
	Floodplain Suite Used	A	B	C	D	E	H	I	F	G
	EAD ($Millions)	747	351	265	1,167	789	122	95	26	67
2	Index Point	A	B	C	D	E	H	I	F	G
	Inventory	Split Basin							Split Basin	
	Floodplain Suite Used	A	B	C	D	E	H	I	F	G
	EAD ($Millions)	552	228	215	886	563	76	68	18	60
3	Index Point	D							F	
	Inventory	Spit Basin							Split Basin	
	Floodplain Suite Used	D							D	
	Without-Project EAD ($Millions)	**886**							**477**	

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CHAPTER 6
WITH-PROJECT ANALYSIS

At the end of Chapter 5, the baseline without-project EADs for the Major ($886 million) and Minor ($477 million) impact areas were presented. These without-project EAD values are carried forward to this chapter and are used as the baseline without-project damages (per impact area) for the with-project benefit analysis.

It is important to note that the without-project EAD values and the with-project benefit analysis presented in this chapter, as it turns out, were only preliminary and are NOT used as the basis for plan formulation. Based on agency technical review, these EAD and benefit values were adjusted in order to account for aspects of human behavior that significantly reduce the EAD and benefit values. The revised with-project and net benefit analyses are presented in Chapter 7B.

This chapter is important in that it describes in detail the approach used to perform the with-project analysis; the exact same approach is also used in the analysis presented in Chapter 7B, where the adjustment to EAD and benefit values (as well as the net benefit analysis) are presented. So, while the numbers presented here are not the "final" numbers used to formulate plans, understanding the process used to derive these numbers will aid in understanding the analysis presented in Chapter 7B.

6.1 PURPOSE OF WITH-PROJECT REACH-BY-REACH ANALYSIS

This chapter, along with Chapters 7a and 7b, describe the economic analysis from a purely NED perspective, resulting in 1) a net benefit curve which shows the benefits associated with each successive levee reach improvement and 2) a project performance curve which shows the associated reduction in flood risk to the Basin with each successive levee reach improvement. These curves were developed by analyzing each of the nine levee reaches within the context that each reach has different problems or different combination of problems; that each reach has differing probability of failure and associated set of damage consequences; and that each reach has its own unique set of potential engineering solutions. A reach-by-reach analysis was necessary primarily to 1) show the residual risk remaining after each successive reach improvement and to 2) layout the potential order of fixes based on a comparative analysis of the overall risk associated with each of the nine reaches.

6.2 A LOOK AHEAD TO THE FINAL ARRAY OF ALTERNATIVES

The final array of alternatives was narrowed down to two action alternatives: strengthening the levees along the entire perimeter (all nine reaches) of the Natomas Basin through construction of adjacent levees, where practical, and fixing levees in place where that was most practical. The final array is the result of an iterative plan formulation/re-formulation process, which ultimately

considered more than just the NED account as presented in Chapters 6, 7a, and 7b. Additional discussion of the Interim NED Plan can be found in the Main Report.

6.3 OVERVIEW OF REACH-BY-REACH ANALYSIS

Flood risk management benefits are measured by comparing the without-project expected annual damages (EAD) to the with-project residual damages (with-project EAD) for various alternatives or in the case of this NPACR, various levee reach improvements based on ordered fixes by geotechnical reach (A through I) around the Natomas Basin. With-project conditions for various project measures/levee reach improvement were modeled in HEC-FDA; benefits of each measure/levee reach improvement equate to the difference between the without-project and with-project EAD. The following chapter explains the process of measuring the economic outputs of each project levee reach improvement. General steps include:

- Modeling in HEC-FDA specific with-project improvements and without-project conditions (explained in Chapter 5) on a reach-by-reach basis
- Evaluating the without-project and/or the with-project EAD and AEP results on a reach-by-reach basis.
- Using these reach-specific results to inform and guide the order of fixes (by reach) for the with-project analysis.
- Using the nine suites (one for each index point) of floodplains provided by the Hydraulic Design Section to compile a unique suite of floodplains for each levee reach; individual event floodplains are selected by taking into account any previous levee reach improvements and by determining the residual floodplains, or the ones still remaining in the "mix," that would likely remain once a fix is implemented[14].
- Modeling each levee reach improvement in HEC-FDA to compute AEP and EAD results on a basin-wide basis.

6.4 HYDROLOGIC, HYDRAULIC, AND GEOTECHNICAL DATA

The with-project hydrology and hydraulics (exceedance probability-discharge and stage-discharge functions for NAT B and NAT C; exceedance probability-stage functions for all other reaches/index points) differed slightly from the without-project hydrology and hydraulics. In the initial HEC-FDA base models for each reach/index point, two sets of curves were entered into HEC-FDA - one set to represent the without-project condition and another set to represent the with-project condition (fixes). Additionally, the GRU curves also differed between the without-project and with-project conditions. In the without-project condition one GRU curve for each reach/index point was entered into HEC-FDA; in the with-project condition, at least one GRU curve was entered into HEC-FDA, depending on the number of geotechnical fixes (as represented by a GRU curve) evaluated. The complete set of without-project and with-project

[14] Throughout the remainder of this chapter, the "unique suite of floodplains for each levee reach improvement" as explained in this bullet point will be referred to as the "floodplain assignment" for each respective levee reach improvement and impact area (Major or Minor). It should be noted that the term "floodplain assignment" as used to describe the suite of floodplains for each levee reach improvement actually means that the flood depth data from a respective event floodplain (e.g., the NAT D 500-year) were assigned to the structures in the respective impact area (Major or Minor).

hydrologic, hydraulic, and geotechnical engineering data used in HEC-FDA is presented in Enclosure 2 of this Appendix.

6.5 RE-DELINEATION OF IMPACT AREAS FOR WITH-PROJECT ANALYSIS PURPOSES

The without-project HEC-FDA base modeling results for each index point were presented in Chapter 5. For ease of comparison and discussion purposes, these results are also presented in subsection 6.2.1. The initial HEC-FDA modeling and results were used as "building blocks" to define a way forward to perform the with-project benefit analysis, which is the focus of this chapter.

6.5.1 AEP and EAD Results

As explained in Chapter 5, the NAT F and NAT G without-project AEP and EAD results seemed counterintuitive, as HEC-FDA results for these reaches/index points were showing a relatively high probability of flooding but relatively low expected damages as compared to the other reaches. A closer look at the underlying floodplain data revealed that although AEP (.30 for NAT F and .20 for NAT G) in these reaches were relatively high, levee breaches in these reaches from more frequent events (below 100-yr to 200-yr) did not cause significant damages, in expected annual terms. This can be explained by the relatively shallow depths of flooding and/or the non-existence of any significant amount of damageable property (i.e., higher frequency event floodplains consists of a large amount of vacant/agricultural land instead of structures) that result from potential levee breaches in these reaches.
Table 6-1 below displays the without-project EAD results for each reach/index point; Table 6-2 below displays the AEP results for each reach/index point. Both of these tables are reproduced from Chapter 5. Please refer to Chapter 5 to see the single-event without-project damages tables by reach/index point.

Table 6-1
Expected Annual Damages (EAD) by Reach/Index Point
October 2010 Price Level

PLAN	EXPECTED ANNUAL DAMAGES (EAD) IN $MILLIONS								
	Natomas Basin Reach/Index Point								
	SR			NCC	PGCC/NEMDC				AR
	A	B	C	D	E	F	G	H	I
Without-Project	747	351	265	1,167	789	26	67	122	95

Notes: SR = Sacramento River, NCC = Natomas Cross Canal; PGCC = Pleasant Grove Creek Canal; NEMDC = Natomas East Main Drainage Canal; AR = American River

Table 6-2
Annual Exceedance Probability (AEP) by Reach/Index Point

PLAN	ANNUAL EXCEEDANCE PROBABILITY (AEP)								
	Natomas Basin Reach/Index Point								
	SR			NCC	PGCC/NEMDC				AR
	A	B	C	D	E	F	G	H	I
Without-Project	0.20	0.12	0.04	0.21	0.18	0.30	0.20	0.04	0.015

Notes: SR = Sacramento River, NCC = Natomas Cross Canal; PGCC = Pleasant Grove Creek Canal; NEMDC = Natomas East Main Drainage Canal; AR = American River

6.5.2 Major and Minor Impact Areas

Upon further evaluation of the without-project HEC-FDA results, it was determined that in order to accurately reflect within the with-project analysis the order of fixes by reach, NAT F and NAT G were analyzed on their own by creating two structure inventories and two impact areas – a Major impact area and a Minor impact area. The structure inventory for the Major impact area is tied to index points/reaches NAT A, NAT B, NAT C, NAT D, NAT E, NAT H, and NAT I; the inventory for the Minor area, delineated as those structures that lay within the 100-yr floodplains of NAT F and NAT G, is tied to index points/reaches NAT F and G. This approach relies on two with-project analyses (one each for the Major and Minor impact areas) occurring concurrently.[15]

For each levee reach improvement, total damages (residual damages) would be computed by adding the results of the with-project analysis of each impact area[16]. Section 6.4.2 explains this process in more detail and in a step-by-step fashion. Figure 6-1 below displays the Minor impact area in color, whose structures are tied to the NAT F and NAT G index points. The non-shaded area is the Major impact area, whose structures are tied to the NAT A, NAT B, NAT C, NAT D, NAT E, NAT H, and NAT I index points.

[15] The primary reason for separating the Basin into two impact areas was to be able to perform a Basin-wide with-project analysis by balancing the factors of risk (probability and consequences of flooding), which drive the analysis; this proved to be a challenge when using only one impact area, since NAT F and NAT G were producing relatively high AEPs but relatively low EADs. Having only one impact area would result in NAT F and NAT G being fixed early on in the with-project analysis, even though the consequences (damages) of flooding from these reaches were the lowest. In reality, NAT F and NAT G should probably be fixed only after other reaches are fixed, where the risk is greater (in terms of damages).

[16] It is important to note that using this approach does not result in double counting of damages/benefits because the two impact areas have unique economic structure inventories.

Figure 6-1 Minor impact area (shaded green)



6.5.3 AEP, EAD, and Single-Event Damages by Major and Minor Areas

The following tables show the HEC-FDA-computed AEP, EAD, and single-event damages results for the major and minor impact areas. The tables include results for each reach/index point under the without-project, which repeats what was reported in Chapter 5. The tables also include the HEC-FDA results for each reach/index point under the with-project (geotechnical fixes) levee reach improvements. All of the numbers reflect the impact area/economic inventory split corresponding to the Major and Minor impact areas.

The tables show that for each reach/index point, without-project AEPs do not change after the inventory/impact area split; for each reach/index point, without-project EAD and single-event damage results do change, and now reflect flooding consequences based on the two separate inventories. The tables also show the residual EAD and AEP results for each reach/index point under the with-project fixes. It should be noted that not all measures listed in Table 6-3 through 6-6 were evaluated for each reach/index point since these are reach/location-specific fixes; therefore, not all cells in the tables are populated with results.

Table 6-3
Expected Annual Damages (EAD) by Reach/Index Point (Oct 2010 Price Level)
Without-Project and With-Project (Fixes)
Reaches/Index Points Tied to Inventory of Major Impact Area

PLAN	EAD IN $MILLIONS						
	NATOMAS REACH/INDEX POINT						
	SR			NCC	PGCC/NEMDC		AR
	A	B	C	D	E	H	I
Without-Project	552	230	215	894	563	76	68
SCB Cutoff Wall	29	25				13	38
CB Cutoff Wall	29						
Adjacent Levee w/SB Cutoff Wall		25	39				
Drained Seepage Berm		78					
Drained Seepage Berm + Cutoff Wall			91				
SB Cutoff Wall			53		37	13	38
SB Cutoff Wall (ditch filled)				81			
SCB Cutoff Wall (ditch filled)				81			
Drained Stability Berm							
Flattened Landside Levee Slope							
First Raise	15	24	24	28	31	2	8
Second Raise					9		

Notes: SR = Sacramento River, NCC = Natomas Cross Canal; PGCC = Pleasant Grove Creek Canal; NEMDC = Natomas East Main Drainage Canal; AR = American River

Table 6-4
Expected Annual Damages (EAD) by Reach/Index Point (Oct 2010 Price Level)
Without-Project and With-Project (Fixes)
Reaches/Index Points Tied to Inventory of Minor Impact Area

PLAN	EAD IN SMILLIONS	
	NATOMAS REACH/INDEX POINT	
	NEMDC	
	F	G
Without-Project	18	60
SCB Cutoff Wall		
CB Cutoff Wall		
Adjacent Levee w/SB Cutoff Wall		
Drained Seepage Berm		
Drained Seepage Berm + Cutoff Wall		
SB Cutoff Wall		6
SB Cutoff Wall (ditch filled)		
SCB Cutoff Wall (ditch filled)		
Drained Stability Berm	5	
Flattened Landside Levee Slope	9	
First Raise	2	5
Second Raise		

Notes: NEMDC = Natomas East Main Drainage Canal

Table 6-5
Annual Exceedance Probability by Reach/Index Point
Without-Project and With-Project (Fixes)
Reaches/Index Points Tied to Major Impact Area

PLAN	ANNUAL EXCEEDANCE PROBABILITY (AEP)						
	NATOMAS REACH/INDEX POINT						
	SR			NCC	PGCC/NEMDC		AR
	A	B	C	D	E	H	I
Without-Project	0.20	0.12	0.04	0.21	0.18	0.04	0.015
SCB Cutoff Wall	0.007	0.017					0.008
CB Cutoff Wall	0.007						
Adjacent Levee w/SB Cutoff Wall		0.017	0.007				
Drained Seepage Berm		0.036					
Drained Seepage Berm + Cutoff Wall			0.017				
SB Cutoff Wall			0.010		0.019	0.004	0.008
SB Cutoff Wall (ditch filled)				0.016			
SCB Cutoff Wall (ditch filled)				0.016			
Drained Stability Berm							
Flattened Landside Levee Slope							
First Raise	0.003	0.006	0.005	0.005	0.007	.001	0.002
Second Raise					0.002		

Notes: SR = Sacramento River, NCC = Natomas Cross Canal; PGCC = Pleasant Grove Creek Canal; NEMDC = Natomas East Main Drainage Canal; AR = American River

Table 6-6
Annual Exceedance Probability by Reach/Index Point
Without-Project and With-Project (Fixes)
Reaches/Index Points Tied to Minor Impact Area

PLAN	AEP	
	NATOMAS REACH/INDEX POINT	
	NEMDC	
	F	G
Without-Project	0.30	0.20
SCB Cutoff Wall		
CB Cutoff Wall		
Adjacent Levee w/SB Cutoff Wall		
Drained Seepage Berm		
Drained Seepage Berm + Cutoff Wall		
SB Cutoff Wall		0.006
SB Cutoff Wall (ditch filled)		
SCB Cutoff Wall (ditch filled)		
Drained Stability Berm	0.023	
Flattened Landside Levee Slope	0.045	
First Raise	0.002	0.004
Second Raise		

Notes: NEMDC = Natomas East Main Drainage Canal

The tables above show the geotechnical methods of fixes (measures) evaluated for each reach; a GRU curve was provided by the SPK Geotechnical Section to represent each method of fix. (Enclosure 2 includes the GRU curves for each fix and reach/index point.) The HEC-FDA results listed in Tables 6-3 to 6-6 above were used primarily to guide the with-project analysis. In other words, the "building block" AEP and EAD results shown above were used to select the order of fixes. As will be seen later on in subsection 6.4.2, *Mechanics of with-project Analysis*, the first nine levee reach improvements resulted in fixing individual reaches without any levee raises. For these improvements, an individual fix in a particular reach assumes that the method of fix is the one that provides the most protection/benefits – in most cases methods of fixes within a particular reach provide the same level of protection and benefits (refer to tables above). This assumption is not explicitly apparent in the mechanics of the with-project analysis, which shows that the reduction in damages (benefits) are realized mainly through the removal of vulnerable reaches and then moving to the next weakest point in the Basin; a method of fix is not explicitly stated and really does not come into play until the last three levee reach improvements when levee raises take place (i.e., which reaches' levees should be raised first based on with-project AEP/EAD results) and where there are differences between the performance of the methods of fixes within a particular reach.

It is also important to note that the following sections will refer to two general types of alternatives – "fix-in-place"-type alternatives and "adjacent levee"-type alternatives. These two

types of alternatives are basically differentiated by the location of the improvement, not the method of fix. So, for example, an alternative could be comprised of a Soil Bentonite (SB) Cutoff Wall in each reach, but this could be considered a "fix-in-place" alternative or an "adjacent levee" alternative, depending on the location of the fix. This clarification is important for two main reasons and will become more apparent in Chapter 7, *Net Benefit and Benefit-to-Cost Analyses*:

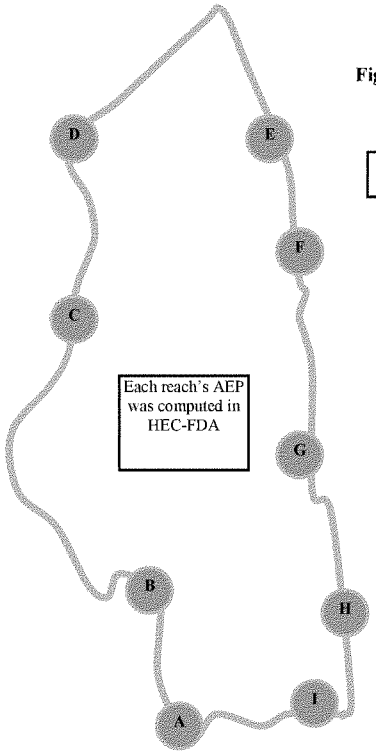
- From a geotechnical performance point of view, the performance of a specific method of fix (as represented by a GRU curve) is the same whether it's considered a "fix-in-place" or "adjacent levee" alternative; therefore with-project (with a fix) AEP and EAD computations were determined using the GRU curves representing specific methods of fixes.
- The differentiation between the two types of alternatives comes in the form of costs and not benefits.

6.6 GENERAL DESCRIPTION OF WITH-PROJECTAL ANALYSIS

A with-project benefit analysis was performed using the nine geotechnical reaches/index points to reasonably show, on a Basin-wide basis, the residual damages, expected benefits, and AEP after performing each levee reach improvement around the Natomas Basin. Based on the results of the with-project analysis, levee reach improvements were grouped together in order to develop alternatives that made logical sense from the perspective of reducing the probability of flooding and consequences around the Basin and from the perspective of capturing synergies between individual fixes (e.g., NAT A and NAT E should be fixed as one levee improvement because fixing only one does not provide significant benefits). The general approach taken to perform the with-project analysis is described conceptually in Figure 6-2 below.

With each levee reach improvement, it is assumed that the method of fix for a particular reach is the one that is the most cost-effective – that is, that the benefits of the protection it provides (as shown in Tables 6-3 and 6-4 above) are greater than the costs (as shown in Enclosure 6).

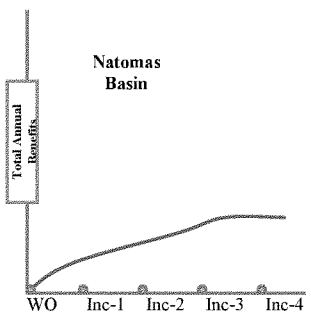
Figure 6-2

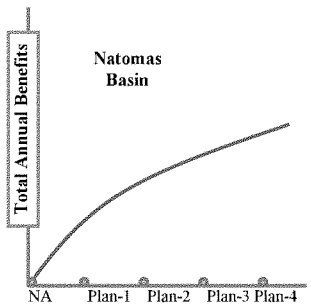


Each reach's AEP was computed in HEC-FDA

Fixes around basin

Reach	Without Project	Inc-1	Inc-2	Inc-3	Levee Raise
A					
B					
C					
D					
E					
F					
G					
H					
I					





Total Annual Benefits are based on fixes for each representative reach around the basin. A with-project benefit analysis entails fixing the weakest reach first.

Total annual benefits were first computed for each levee reach; improvements were then grouped together to create plans. Benefits increase with each successive improvement.

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6.7 NPACR WITH-PROJECT ANALYSIS – DETAILS

The following subsections will describe the details of the NPACR with-project benefit analysis by explaining how the HEC-FDA base modeling results were used to order levee reach improvements, how floodplains were selected for each levee reach improvement, and the mechanics of modeling each levee reach improvement in the HEC-FDA model.

6.7.1 Summary of Ordered Fixes Based on HEC-FDA Base Modeling Results

Levee reach improvements, or the order of fixes on a reach-by-reach basis, were selected using the information provided by the initial HEC-FDA base modeling results. Separate HEC-FDA models (one for the Major impact area and one for the Minor impact area) were created in order to evaluate each levee reach improvement for each area concurrently; these models serve as the final HEC-FDA models used to document the with-project benefit analysis results. Tables 6-7 and 6-8 below summarize the final order of levee reach improvements and show the controlling index point (CIP)[17] and floodplain assignments used for each improvement. Two tables are shown in order to properly display the CIP and floodplain assignments used for each impact area (Major and Minor) and which were used for the HEC-FDA modeling.

The order of improvement described in the following sections and used to perform the with-project analysis was based primarily on the EAD and AEP results reported in Chapter 5; these results informed/guided the order of improvements outlined in Tables 6-7 and 6-8. The order was based on a combination of AEP and EAD values for each reach. Generally, a reach with a high AEP also had high expected damages (e.g., NAT D); in the analysis, the reach with the highest AEP was fixed first. After this fix, the reach with the next highest AEP was considered the "weakest link" in the Basin and so was fixed next. The "floodplain assignments" (i.e., flood depths taken from the floodplain of the reach listed in the tables) displayed in Tables 6-7 and 6-8 show the progression (i.e., reduction in the number of floodplains from the total mix of floodplains) as each reach was fixed. Based on base modeling AEP and EAD results, the reaches in the Major area would be ordered as follows: D (AEP = .21), A (AEP = .20), E (AEP = .18), B (AEP = .12), C (AEP = .04), H (AEP = .04), and I (AEP = .015). In the case of reaches C and H, where AEP is the same, EAD was used to determine which reach would be fixed first. Here, reach C had a much greater EAD value than reach H ($215 million for C versus $76 million for H), so C was selected to be fixed before H. Based on base modeling AEP and EAD results and by comparing potential benefits between fixing these reaches and other reaches tied to the Major area, NAT F and NAT G (Minor area) was determined to be fixed after NAT H but before NAT I; fixing NAT F and G before fixing NAT H produced smaller with-project benefits than fixing NAT H before NAT F and NAT G, and fixing NAT I before NAT F and NAT G did not produce any additional with-project benefits (not only is AEP at NAT I significantly lower than the AEPs at NAT F and NAT G, but in order to gain any additional with-project benefit from fixing NAT I, levee raises in other reaches would have to occur.)

[17] The controlling index point (CIP) for a respective levee reach improvement is the index point/reach that will be fixed in the following improvement – this is the next "weakest link" of the Basin. In the Major area and for improvements 6-9, NAT I was selected as the index point, since this would be the next fix in the with-project analysis.

Table 6-7
Summary of Floodplain and Controlling Index Point Assignments by Levee Reach Improvement
Major Impact Area

LEVEE REACH IMPROVEMENT	CIP	FLOODPLAIN ASSIGNMENTS BY EVENT						
		2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
No fixes	D	D	D	D	D	D	D	D
D	A	B	B	C	C	D	D	D
D+A	E	B	B	C	C	D	D	D
D+A+E	B	B	B	C	C	D	D	D
D+A+E+B	C	--	--	C	C	D	D	D
D+A+E+B+C	H	--	--	H	E	D	D	D
D+A+E+B+C+H	I	--	--	--	E	D	D	D
D+A+E+B+C+H+G	I	--	--	--	E	D	D	D
D+A+E+B+C+H+G+F	I	--	--	--	E	D	D	D
D+A+E+B+C+H+F+G+I	I	--	--	--	E	D	D	D
Fix all and raise D, B, E, F	I	--	--	--	--	--	D	D
Fix all and raise D, B, E, F, A, C, I, G	I	--	--	--	--	--	--	D
Fix all and raise all to 500-yr WSEL	I	--	--	--	--	--	--	D

Table 6-8
Snmmary of Floodplain and Controlling Index Point Assignments by Levee Reach Improvement
Minor Impact Area

LEVEE REACH IMPROVEMENT	CIP	FLOODPLAIN ASSIGNMENTS BY EVENT						
		2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
No fixes	F	D	D	D	D	D	D	D
D	F	B	B	C	C	D	D	D
D+A	F	B	B	C	C	D	D	D
D+A+E	F	B	B	C	C	D	D	D
D+A+E+B	F	G	G	C	C	D	D	D
D+A+E+B+C	F	G	G	H	E	D	D	D
D+A+E+B+C+H	F	G	G	G	E	D	D	D
D+A+E+B+C+H+G	F	F	F	F	E	D	D	D
D+A+E+B+C+H+G+F	F	--	--	--	E	D	D	D
D+A+E+B+C+H+F+G+I	F	--	--	--	E	D	D	D
Fix all and raise D, B, E, F	F	--	--	--	--	--	D	D
Fix all and raise D, B, E, F, A, C, I, G	F	--	--	--	--	--	--	D
Fix all and raise all to 500-yr WSEL	F	--	--	--	--	--	--	D

The steps taken to perform each levee reach improvement (per Major and Minor impact areas) were:

- Selecting the controlling index point (CIP) for each levee reach improvement was based on several factors, including reach-specific AEP, reach-specific EAD, and the comparison of potential benefits of fixing one reach instead of another would provide.
- Once a levee reach/fix was determined, floodplain assignments for that levee reach were identified by evaluating the floodplains that were ultimately removed from the "mix" of floodplains (suites from each index point) due to previous fixes and the floodplains that still remain[18].

[18] For example, in the second levee reach improvement (fix D and A, with NAT E as the CIP), flood depths taken from NAT B (2-yr, 10yr), NAT C (25-yr, 50-yr), and NAT D (100-yr to 500-yr) floodplains were used. For the 2-year and 10-year events, the floodplains associated with NAT D and NAT A produce the most conseqnences (single-event damages); however these floodplains have, theoretically, been removed from the "mix" of floodplains since NAT D has already been fixed (first levee reach improvement) and NAT A is being fixed in this second levee reach improvement. While NAT E is the CIP for this second levee reach improvement and will be fixed in the third improvement, flood depths from NAT B (which also has not been fixed yet but will be in the fonrth levee reach improvement) were used for the 2-year and 10-year events as the consequences (single-event damages, see Tables 5-26 and 5-27) from NAT B are slightly higher than from NAT E. This same rationale was used for selecting NAT C flood depths for the 25-yr and 50-year events for this levee reach improvement and for assigning flood depth data for all of the other levee reaches and areas.

- Once floodplains for a levee reach were assigned, the suite was compiled (individual event floodplains taken from the nine suites of floodplains) and imported into HEC-FDA as a WSP.
- A row of stage data associated with the CIP was then inserted into the WSP.
- Stage-damage curves were computed in HEC-FDA using the newly-compiled suite of floodplains for that levee reach and the economic inventory (already imported into HEC-FDA).
- The HEC-FDA input data (exceedance probability-discharge-stage curves and GRU curves) associated with the CIP was entered into HEC-FDA.
- AEP and EAD computations were completed in HEC-FDA.

An important point to note, and which may be more clear once the results of the with-project analysis is explained using graphs (section 6.5), is that with each levee reach improvement a reduction in risk (either the probability of flooding using AEP as a measure, the consequences of flooding via smaller floodplains, or both) takes place. In Chapter 7, *Net Benefit and Benefit-to-Cost Analyses*, benefits will be compared to costs to determine the feasibility of each alternative and the optimal plan (i.e., the one with the most net benefits) amongst all of those evaluated.

More detailed explanations of each levee reach improvement are explained in Section 6.4.2 below.

6.7.2 Mechanics of Reach-by-Reach With-Project Analysis

For better understanding, the following discussion may require the reader to refer back to the tables in subsection 6.2.3 (AEP, EAD, single-event damages), the suites of floodplain plates located in Enclosure 1 of this Appendix, and Tables 6-7 and 6-8 above that show the floodplain assignments.

6.7.2.1 Establishing the Without-Project Condition for the Basis of the With-Project Analysis

An important first step was to identify the basis/starting point of the with-project analysis – or establishing the without-project condition for which all other levee reaches would be compared to. Evaluation of the reach/index point-specific without-project HEC-FDA results indicated that a levee breach at NAT D, from both a probability of flooding (measured using AEP) point of view and consequences of flooding (measured using EAD and single-event damages) point of view, could be considered the weakest link of the entire Natomas Basin. This determination is borne out by the AEP, EAD, and single-event damages results:

- AEP of .21
- EAD of over a billion dollars
- Single-event damages range from $6.3 billion (2-yr) to $7.0 billion (500yr)

NAT D was selected as the controlling index point (CIP) to represent the baseline without-project condition for the Major impact area; NAT F was selected as the CIP to represent the baseline without-project condition for the Minor impact area. The baseline without-project EAD

values used in the with-project analysis and taken from the results of the initial modeling documented in Chapter 5, are $886 million (Major area) and $477 million (Minor area). These values are also displayed in Tables 6-9, 6-10, and 6-11 below.

Individual event (2-yr to 500-yr) floodplains for the without-project (both Major and Minor impact areas) were selected exclusively from the suite of floodplains developed for NAT D, as the NAT D floodplains produced the greatest amount of damages than any other floodplains associated with the other reaches/index points. This suite of floodplains (shown in Tables 6-7 and 6-8 for both areas) was then imported into HEC-FDA and stage-damage curves were computed within HEC-FDA. (The economic structure inventory was also imported into HEC-FDA.) All of the engineering data (exceedance probability-stage, equivalent record length, and GRU curve) associated with the NAT D index point was entered into HEC-FDA, and EAD was computed.

Tables 6-9 and 6-10 below show the results by Major and Minor impact areas. Table 6-11 combines the results to show total EAD for the without-project. Considering both impact areas, baseline without-project EAD is $1.363 billion.

Table 6-9
Without-Project
Major Impact Area
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD	AEP	ANNUAL BENEFITS	% DAMAGE REDUCED
Without	886	.21	--	--

Table 6-10
Without-Project
Minor Impact Area
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD	AEP	ANNUAL BENEFITS	% DAMAGE REDUCED
Without	477	.30	--	--

Table 6-11
Without-Project
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

The remaining levee reach improvements will be explained in a similar way to this one, however only one combined table showing the results for both the Major and Minor impact areas will be displayed. The rationale for selecting the CIP and floodplains (both impact areas) will be explained for each levee reach.

6.7.2.2 Levee Reach Improvement– Fix NAT D

The first levee reach improvement selected was to fix NAT D. NAT A was selected as the CIP, which had the next highest AEP/damages (Major impact area); the CIP for the Minor impact area remained NAT F, and remained the CIP for all levee reach improvements. Holding the CIP constant at NAT F for all levee reach improvements enabled residual damages in the Minor impact area to be computed for each levee reach based solely on the removal of floodplains from the "mix" due to fixes that occurred in the Major impact area, until NAT F and NAT G were fixed. Once NAT F and NAT G were fixed, residual damages for the Minor impact area resulted from the removal of floodplains from the "mix" as well as a reduction in the probability of flooding.

For this levee reach improvement, the floodplains selected are shown in Tables 6-7 and 6-8 (2-yr = B, 10-yr = B, 25-yr = C, 50-yr = C, and 100-yr to 500-yr = D); they are the same for both impact areas. By fixing NAT D, the 2-, 10-, 25-, and 50-yr floodplains for NAT D were removed from the "mix" and were replaced by NAT B (2-yr and 10-yr) and NAT C (25-yr and 50-yr) floodplains. These were chosen because they represented the floodplains having the greatest consequences (damages) for a specific event and which were still in the "mix" of floodplains to choose from.

Table 6-12
First Levee Reach Improvement: Fix NAT D
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

The results in Table 6-12 show that fixing NAT D reduces damages significantly in the Major impact area. This can be explained by the substantial reduction in both the extent and depths of flooding when switching from NAT D floodplains (without; 2-yr and 10-yr) to NAT B floodplains (first levee reach improvement; 2-yr and 10-yr) and NAT C floodplains (25-yr and 50-year). On the other hand, damages are reduced only relatively minimally in the Minor impact area. This can be explained by the relatively minimal reduction in the extent and depths of flooding within this impact area when going from NAT D to NAT B/NAT C floodplains.

6.7.2.3 Levee Reach Improvement – Fix NAT A

The second levee reach improvement selected was to fix NAT A (and the previous fix, NAT D). NAT E was selected as the CIP, which had the next highest AEP/damages (Major impact area) once NAT A is fixed; the CIP for the Minor impact area remained NAT F.

For this levee reach improvement, the floodplains selected are shown in Tables 6-7 and 6-8 (2-yr = B, 10-yr = B, 25-yr = C, 50-yr = C, and 100-yr to 500-yr = D); the assignments are the same for both impact areas and do not change from the first levee reach improvement. This is because fixing NAT A does not remove any floodplains from the "mix" that effectively changes the assignments.[19]

Table 6-13
Second Levee Reach Improvement: Fix NAT A
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

[19] NAT A floodplains (2-yr through 100-yr) are removed, but other floodplains still exist that produce as much or more damages for these frequency events; in this case, NAT B (2-yr and 10-yr) and NAT C (25-yr and 50-yr) and NAT D (100-yr to 500yr) floodplains still exist.

The results in Table 6-13 show that fixing NAT A reduces damages minimally (about $6 million) in the Major impact area. The reduction in damages for this levee reach improvement can be attributed to a slight reduction in the probability of flooding (as measured by a lower AEP -- from .21 to .18) but cannot be attributed to a reduction in flooding consequences (as represented by event floodplains) because these were unchanged.

Fixing NAT A does not reduce damages in the Minor impact area. Here, both the probability of flooding (as measured by AEP) and consequences of flooding are unchanged from the previous levee reach improvement.

On first glance this levee reach improvement suggests that fixing NAT A as a second improvement does not result in a significant amount of additional benefits. However, it is not until the next levee reach improvement (3rd) is completed does it become apparent that fixing NAT A without fixing NAT E (or vice versa) would not make sense since full benefits are realized only when both are fixed; no benefits are realized when neither is fixed. It can be argued that NAT A and NAT E have a synergistic relationship.

6.7.2.4 Levee Reach Improvement – Fix NAT E

The third levee reach improvement selected was to fix NAT E (along with NAT D and NAT A). NAT B was selected as the CIP, which had the next highest AEP/damages (Major impact area) once NAT E is fixed; the CIP for the Minor impact area remained NAT F.

For this levee reach improvement, the floodplains selected are shown in Tables 6-7 and 6-8 (2-yr = B, 10-yr = B, 25-yr = C, 50-yr = C, and 100-yr to 500-yr = D); the assignments are the same for both impact areas and do not change from the first and second levee reach improvements. As in the second improvement, fixing NAT E does not remove any floodplains from the "mix" that effectively changes the assignments.[20]

Table 6-14
Third Levee Reach Improvement: Fix NAT E
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

[20] NAT A floodplains (2-yr through 100-yr) are removed, but other floodplains still exist that produce as much or more damages for these frequency events; in this case, NAT B (2-yr and 10-yr) and NAT C (25-yr and 50-yr) and NAT D (100-yr to 500yr) floodplains still exist.

The results in Table 6-14 show that fixing NAT E reduces damages significantly ($315 million for this levee reach improvement) in the Major impact area. The reduction in damages for this levee reach improvement can be attributed to a relatively significant reduction in the probability of flooding (as measured by a lower AEP -- from .18 to .12) but cannot be attributed to a reduction in flooding consequences (as represented by event floodplains) because these were unchanged.

Fixing NAT E does not reduce damages in the Minor impact area. Here, both the probability of flooding (as measured by AEP) and consequences of flooding are unchanged from the previous levee reach improvement.

6.7.2.5 Levee Reach Improvement – Fix NAT B

The fourth levee reach improvement selected was to fix NAT B (along with NAT D, NAT A, and NAT E). NAT C was selected as the CIP, which had the next highest AEP/damages (Major impact area) once NAT B is fixed; the CIP for the Minor impact area remained NAT F.

For this levee reach improvement, the floodplains selected are shown in Table 6-7 (25-yr = C, 50-yr = C, and 100-yr to 500-yr = D) for the Major impact area; this levee reach improvement finally removes several event floodplains from the "mix." Fixing NAT D, NAT A, NAT E, and NAT B reduces the probability of flooding (and levee breaches) from these reaches and effectively removes the 2-yr and 10-yr floodplains in the Major impact area. For the Minor impact area, the floodplain assignments change from the previous levee reach improvement (2-yr = G, 10-yr = G, 25-yr = C, 50-yr = C, 100-yr to 500-yr = D). There are still 2-yr and 10-yr floodplains in the Minor impact area because there is still a possibility of flooding from the smaller events (AEP = .30) in this area.

Table 6-15
Fourth Levee Reach Improvement: Fix NAT B
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%
Fix D+A+E+B	129	97	226	.04	.30	1,137	83%

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

The results in Table 6-15 show that fixing NAT B again reduces damages significantly in both the Major impact area ($132 million) and Minor impact area ($352 million) for combined reduction in damages of $484 million. The reduction in damages for this levee reach improvement can be attributed to a relatively significant reduction in the probability of flooding (as measured by a lower AEP -- from .12 to .04) and to the reduction in flooding consequences

(removal of event floodplains in the Major impact area) and a significant reduction in the extent and depths of flooding for the 2-yr and 10-yr events in the Minor impact area (refer to NAT G 2-yr and 10-yr floodplains in Enclosure 1).

6.7.2.6 Levee Reach Improvement– Fix NAT C

The fifth levee reach improvement selected was to fix NAT C (along with NAT D, NAT A, NAT E, and NAT B). NAT H was selected as the CIP, which had the highest AEP/damages (Major impact area) once NAT C is fixed; the CIP for the Minor impact area remained NAT F.

For this improvement, the floodplains selected are shown in Table 6-7 (25-yr = H, 50-yr = E, and 100-yr to 500-yr = D) for the Major impact area; this levee reach improvement removes additional event floodplains from the "mix." Fixing NAT D, NAT A, NAT E, NAT B and NAT C reduces the probability of flooding (and levee breaches) from these reaches and effectively removes the 2-yr and 10-yr floodplains (as in the fourth improvement). What also happens is that the 25-yr and 50-yr event floodplains change in the Major impact area, with the bigger NAT C floodplains being replaced by the smaller NAT H (25-yr) and slightly smaller NAT E (50-yr) floodplains. For the Minor impact area, the floodplain assignments change from the previous levee reach improvement (2-yr = G, 10-yr = G, 25-yr = H, 50-yr = E, 100-yr to 500-yr = D), with NAT H (25-yr) and NAT E (50-yr) floodplains replacing the bigger NAT C floodplains, as in the Major impact area.

Table 6-16
Fifth Levee Reach Improvement: Fix NAT C
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%
Fix D+A+E+B	129	97	226	.04	.30	1,137	83%
Fix D+A+E+B+C	101	95	196	.04	.30	1,167	86%

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

The results in Table 6-16 show that fixing NAT C reduces damages relatively slightly in both the Major impact area ($28 million) and Minor impact area ($2 million) for combined reduction in damages of $30 million. The reduction in damages for this improvement can be attributed solely to reduction in flooding consequences (replacement of event floodplains with slightly larger floodplains in both impact areas).

6.7.2.7 Levee Reach Improvement– Fix NAT H

The sixth levee reach improvement selected was to fix NAT H (along with NAT D, NAT A, NAT E, NAT B, and NAT C). NAT I was selected as the CIP, which had one of the highest remaining AEP/damages (Major impact area) once NAT H is fixed. Although HEC-FDA AEP results showed that post-fix NAT D (.016), post-fix NAT B (.017), post-fix NAT E (.019), and pre-fix NAT I (.015) all had very similar AEPs, NAT I was selected as the CIP not only because of its AEP, but also because of its relatively high EAD value; furthermore, NAT I was selected as the CIP because, in terms of engineering data, it had what could be considered the most reliable data (compared to NAT D, E, B) based on the period of record (NAT I = 87 years; NAT B = 71 years; NAT D and E = 25 years). The CIP for the Minor impact area remained NAT F.

For this improvement, the floodplains selected are shown in Table 6-7 (50-yr = E, and 100-yr to 500-yr = D) for the Major impact area; this levee reach improvement removes the 25-year event floodplain from the "mix." Fixing NAT D, NAT A, NAT E, NAT B, NAT C, and NAT H reduces the probability of flooding (and levee breaches) from these reaches and effectively removes the 25-yr floodplain. For the Minor impact area, the floodplain assignments change from the previous levee reach improvement (2-yr = G, 10-yr = G, 25-yr = G, 50-yr = E, 100-yr to 500-yr = D), with the slightly smaller NAT G (25-yr) floodplain replacing the NAT H (25-yr) floodplain. Again, in the Minor impact area no event floodplains have been removed yet (i.e., full suite of floodplains were used to compute EAD) as the probability of flooding in this area still remains high (NAT F AEP = .30).

Table 6-17
Sixth Levee Reach Improvement: Fix NAT H
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%
Fix D+A+E+B	129	97	226	.04	.30	1,137	83%
Fix D+A+E+B+C	101	95	196	.04	.30	1,167	86%
Fix D+A+E+B+C+H	28	94	122	.015	.30	1,241	91%

Notes ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

The results in Table 6-17 show that fixing NAT H reduces damages by $73 million in the Major impact area and only minimally ($1 million) in the Minor impact area for a combined reduction in damages of $74 million. The reduction in damages for this improvement can be attributed mostly to the reduction in the probability of flooding (AEP reduced from .04 to .015) and flooding consequences (removal of 25-yr event floodplain) in the Major impact area.

6.7.2.8 Levee Reach Improvement– Fix NAT G

The seventh levee reach improvement selected was to fix NAT G (along with NAT D, NAT A, NAT E, NAT B, NAT C, and NAT H). This is the improvement where the probability of flooding in the Minor impact area (breaches from NAT F and NAT G) is finally addressed – where the consequences of flooding warrants fixes to NAT F and NAT G. NAT I remained the CIP in the Major impact area (since this levee reach improvement only affects the Minor impact area). The CIP for the Minor impact area remained NAT F.

For this improvement, the floodplains selected are shown in Table 6-7 (50-yr = E, and 100-yr to 500-yr = D) for the Major impact area; they are exactly the same as the previous improvement. For the Minor impact area, the floodplain assignments changed from the previous improvement (2-yr =F, 10-yr = F, 25-yr = F, 50-yr = E, 100-yr to 500-yr = D), with the slightly smaller NAT F (2-yr to 25-yr) floodplains replacing the NAT G floodplains. Again, in the Minor impact area no event floodplains have been removed yet (i.e., full suite of floodplains were used to compute EAD) as the probability of flooding in this area still remains high (NAT F AEP = .30) until Fixes to both NAT F and NAT G are completed.

Table 6-18
Seventh Levee Reach Improvement: Fix NAT G
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%
Fix D+A+E+B	129	97	226	.04	.30	1,137	83%
Fix D+A+E+B+C	101	95	196	.04	.30	1,167	86%
Fix D+A+E+B+C+H	28	94	122	.015	.30	1,241	91%
Fix D+A+E+B+C+H+G	28	81	109	.015	.30	1,254	92%

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

The results in Table 6-18 show that fixing NAT G reduces damages by $13 million in the Minor impact area; damages in the Major impact area remain the same as none of the contributing factors (probability of flooding or floodplain assignments) have changed from the previous levee reach improvement. The reduction in damages for this improvementcan be attributed solely to the reduction in flooding consequences (smaller 2-yr, 10-yr, 25-yr floodplains) in the Minor impact area.

6.7.2.9 Levee Reach Improvement– Fix NAT F

The eighth levee reach improvement was to fix NAT F (along with NAT D, NAT A, NAT E, NAT B, NAT C, NAT H, and NAT G). As with the previous improvement, in this levee reach improvement the probability of flooding in the Minor impact area (breaches from NAT F and NAT G) is addressed. NAT I again remained the CIP in the Major impact area (since this improvement only affects the Minor impact area). The CIP for the Minor impact area remained NAT F.

For this levee reach improvement, the floodplains selected are shown in Tables 6-7 (50-yr = E, and 100-yr to 500-yr = D) for the Major impact area; they are exactly the same as the previous improvement. For the Minor impact area, the floodplain assignments changed from the previous improvement (50-yr = E, 100-yr to 500-yr = D), and floodplains (2-yr, 10-yr, 25-yr) are finally removed from this area as fixing both NAT G and NAT F reduced the probability of flooding from .30 to .023.

Table 6-19
Eighth Levee Reach Improvement: Fix NAT F
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%
Fix D+A+E+B	129	97	226	.04	.30	1,137	83%
Fix D+A+E+B+C	101	95	196	.04	.30	1,167	86%
Fix D+A+E+B+C+H	28	94	122	.015	.30	1,241	91%
Fix D+A+E+B+C+H+G	28	81	109	.015	.30	1,254	92%
Fix D+A+E+B+C+H+G+F	28	37	65	.015	.023	1,298	95%

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

The results in Table 6-19 show that fixing NAT F reduces damages by an added levee reach improvement of $44 million in the Minor impact area; damages in the Major impact area remain the same as none of the contributing factors (probability of flooding or floodplain assignments) have changed from the previous improvement. The reduction in damages for this levee reach improvement can be attributed to both the reduction in the probability of flooding (AEP improved from .30 to .023) and in flooding consequences (removal of 2-yr, 10-yr, and 25-yr floodplains) in the Minor impact area.

6.7.2.10 Levee Reach Improvement– Fix NAT I

The ninth levee reach improvement was to fix NAT I (along with NAT D, NAT A, NAT E, NAT B, NAT C, NAT H, NAT G, and NAT F). For this improvement, the CIP for the Major impact area remained NAT I. The CIP for the Minor impact area remained NAT F.

For this levee reach improvement, the floodplains selected are shown in Table 6-7 (50-yr = E, and 100-yr to 500-yr = D) for the Major impact area; they are exactly the same as the previous improvement. For the Minor impact area, the floodplain assignments also remained the same from the previous improvement.

Table 6-20
Ninth Levee Reach Improvement: Fix NAT I
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%
Fix D+A+E+B	129	97	226	.04	.30	1,137	83%
Fix D+A+E+B+C	101	95	196	.04	.30	1,167	86%
Fix D+A+E+B+C+H	28	94	122	.015	.30	1,241	91%
Fix D+A+E+B+C+H+G	28	81	109	.015	.30	1,254	92%
Fix D+A+E+B+C+H+G+F	28	37	65	.015	.023	1,298	95%
Fix D+A+E+B+C+H+G+F+I	28	37	65	.015	.023	1,298	95%

Notes: ANN BEN = Annual Benefits% Dam Reduced = Percent Damages Reduced

The results in Table 6-20 show that fixing NAT I does not reduce damages in either the Major or Minor impact areas. This is because that although NAT I is fixed, there are other reaches (NAT D, NAT B, NAT E) where the probability of flooding (with-project AEP; refer to Table__) is still around .015 (which is the without-project AEP of NAT); in other words, the benefits of fixing NAT I are not realized until *additional* improvements (i.e, levee raises) are made to other reaches since there is still an equivalent chance of flooding from these other reaches as there was from NAT I prior to NAT I being fixed.

6.7.2.11 Levee Reach Improvements– Fix All and Raise NAT D, B, E, and F

The tenth levee reach improvement was to fix all reaches and to raise those reaches where AEP still remains relatively high compared to the other reaches. These improvements included raising reaches NAT D, NAT B, and NAT E. For these improvement, the CIP for the Major impact area remained NAT I. NAT I was selected for two reasons: there is more complete data (exceedance probability-discharge and stage-discharge curves) and more reliable data (equivalent record

length of 87 years versus 71 years or 25 years for other reaches) for input into the HEC-FDA model. The CIP for the Minor impact area remained NAT F.

For these levee reach improvements, the floodplains selected are shown in Tables 6-7 and 6-8 (200-yr = D, 500-yr = D) for both areas. Here, the 50-yr and 100-yr floodplains are removed from both impact areas. In effect, raising certain reaches in conjunction with fixing NAT I removes floodplains from the "mix" (improves the flooding consequences) as well as reduces the probability of flooding (AEP is reduced from .016 to .008 in the Major impact area and from .023 to .006 in the Minor impact area).

Table 6-21
Tenth Levee Reach Improvements: Fix All and Raise NAT D, NAT B, NAT E, and NAT F
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%
Fix D+A+E+B	129	97	226	.04	.30	1,137	83%
Fix D+A+E+B+C	101	95	196	.04	.30	1,167	86%
Fix D+A+E+B+C+H	28	94	122	.015	.30	1,241	91%
Fix D+A+E+B+C+H+G	28	81	109	.015	.30	1,254	92%
Fix D+A+E+B+C+H+G+F	28	37	65	.015	.023	1,298	95%
Fix D+A+E+B+C+H+G+F+I	28	37	65	.015	.023	1,298	95%
Fix all and raise D, B, E, and F	21	9	30	.008	.006	1,333	98%

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

The results in Table 6-21 show that fixing all of the reaches and raising NAT D, NAT B, NAT E, and NAT F reduces damages in the Major impact area ($7 million) and the Minor impact area ($28 million) for a combined reduction of $35 million.

6.7.2.12 Levee Reach Improvements– Fix All and Raise NAT D, B, E, F, A, C, I, G

The eleventh levee reach improvements were to fix all reaches and to raise all reaches (except for NAT H). For these improvements, the CIP for the Major impact area remained NAT I. The CIP for the Minor impact area remained NAT F.

For these improvements, the floodplains selected are shown in Tables 6-7 and 6-8 (500-yr = D) for both areas; the 200-yr floodplain is removed from both impact areas. Fixing and raising levees improves the flooding consequences (removes 200-yr floodplain in both areas) as well as

reduces the probability of flooding (AEP is reduced from .008 to .006 in the Major impact area; AEP is reduced from .006 to .004 in the Minor impact area).

Table 6-22
Eleventh Levee Reach Improvements: Fix All and Raise NAT D, NAT B, NAT E, NAT F, NAT A, NAT C, NAT I, NAT G
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%
Fix D+A+E+B	129	97	226	.04	.30	1,137	83%
Fix D+A+E+B+C	101	95	196	.04	.30	1,167	86%
Fix D+A+E+B+C+H	28	94	122	.015	.30	1,241	91%
Fix D+A+E+B+C+H+G	28	81	109	.015	.30	1,254	92%
Fix D+A+E+B+C+H+G+F	28	37	65	.015	.023	1,298	95%
Fix D+A+E+B+C+H+G+F+I	28	37	65	.015	.023	1,298	95%
Fix all and raise D, B, E, F	21	9	30	.008	.006	1,333	98%
Fix all and raise D, B, E, F, A, C, I, G	4	7	11	.006	.004	1,352	99%

Notes: ANN BEN = Annual Benefits; % Dam Reduced = Percent Damages Reduced

The results in Table 6-22 show that fixing all of the reaches and raising all reaches except NAT H reduces damages in the Major impact area ($17 million) and the Minor impact area ($2 million) for a combined reduction of $19 million.

6.7.2.13 Levee Reach Improvements– Fix All and Raise All

The final levee reach improvements were to fix all reaches and to raise all reaches. For these improvements, the CIP for the Major impact area remained NAT I. The CIP for the Minor impact area remained NAT F.

For these improvements, the floodplain assignment remained the same as in the previous levee reach improvements. Fixing and raising levees improves the flooding consequences (removes 200-yr floodplain in both areas) as well as reduces the probability of flooding (AEP is reduced from .006 to .001 in the Major impact area; AEP is reduced from .004 to .002 in the Minor impact area).

Table 6-23
Twelfth Levee Reach Improvements: Fix All and Raise NAT D, NAT B, NAT E, NAT F, NAT A, NAT C, NAT I
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	886	477	1,363	.21	.30	--	--
Fix D	582	449	1,031	.21	.30	332	24%
Fix D+A	576	449	1,025	.18	.30	338	25%
Fix D+A+E	261	449	710	.12	.30	653	48%
Fix D+A+E+B	129	97	226	.04	.30	1,137	83%
Fix D+A+E+B+C	101	95	196	.04	.30	1,167	86%
Fix D+A+E+B+C+H	28	94	122	.015	.30	1,241	91%
Fix D+A+E+B+C+H+G	28	81	109	.015	.30	1,254	92%
Fix D+A+E+B+C+H+G+F	28	37	65	.015	.023	1,298	95%
Fix D+A+E+B+C+H+G+F+I	28	37	65	.015	.023	1,298	95%
Fix all and raise D, B, E, and F	21	9	30	.008	.006	1,333	98%
Fix all and raise D, B, E, F, A, C, I, G	4	7	11	.006	.004	1,352	99%
Fix all and raise all	4	2	6	.001	.002	1,357	99%

Notes: ANN BEN = Annual Benefits;% Dam Reduced = Percent Damages Reduced

The results in Table 6-23 show that fixing all of the reaches and raising all reaches except NAT H reduces damages in the Major impact area ($17 million) and the Minor impact area ($2 million) for a combined reduction of $19 million.

6.8 SUMMARY & EVALUATION OF RESULTS OF WITH-PROJECT ANALYSIS

The following subsections summarize the results of the with-project benefit analysis through tables and graphs. The graphs visually show how benefits increase with each levee reach improvement, either through the reduction in the probability of flooding (measured by AEP), the reduction in the consequences of flooding (i.e., removing floodplains from the "mix" as improvements to the Basin are made), or both.

6.8.1 EAD and Damages Reduced by Levee Reach Improvement

Table 6-24 summarizes the with-project analysis and shows EAD, damages reduced, and damages reduced as a percent of the total for each levee reach improvement and for each type of alternative ("fix-in-place" or "adjacent levee"); Figure 6-3 graphs the total annual benefits by levee reach improvement. As explained in previous sections, a specific method of fix (e.g., cutoff wall) can be considered a "fix-in-place" or an "adjacent levee" alternative depending on the physical location of the fix. From a geotechnical performance standpoint, a specific method of

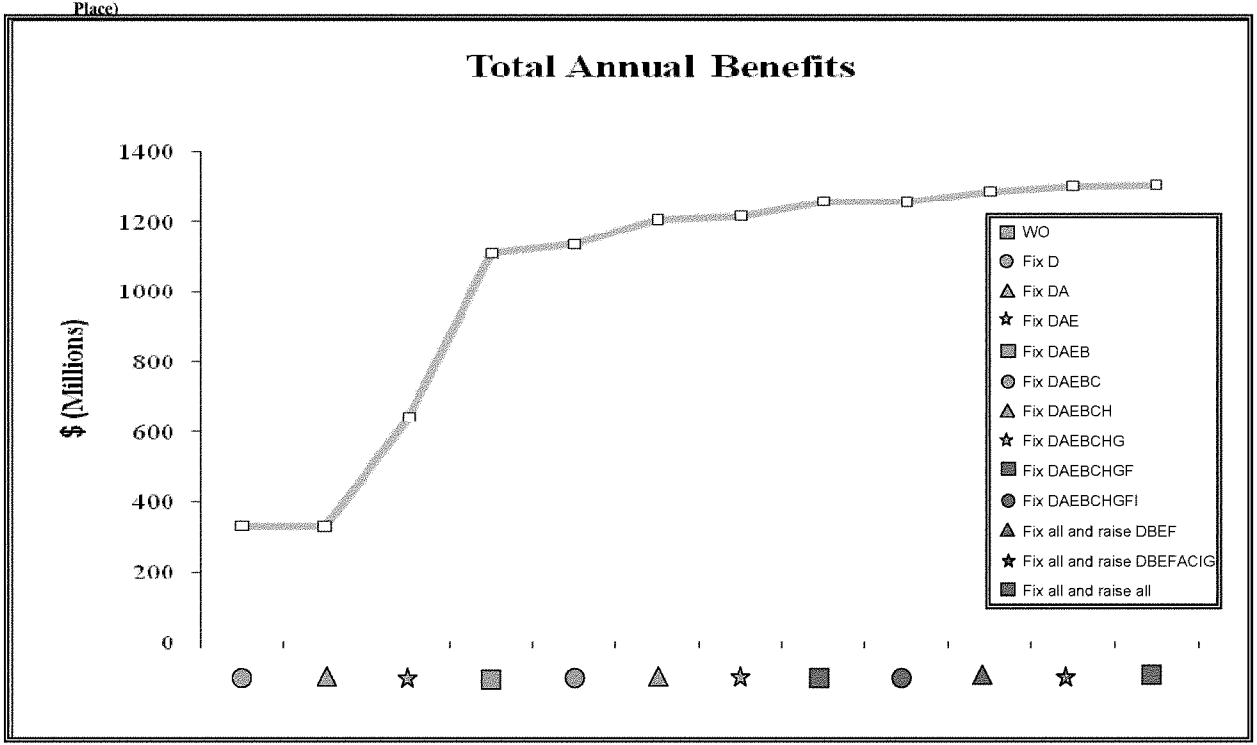
fix provides the same level of performance whether it's considered a "fix-in-place" or an "adjacent levee" alternative; from an economic benefits point of view, a specific method of fix provides the same amount of benefits whether it is considered a "fix-in-place" or an "adjacent levee" alternative.

Table 6-24
Summary of EAD and Damages Reduced by Reach Improvement and Alternative Type
In $Millions and October 2010 Price Level

MEASURES	ALTERNATIVE	EXPECTED ANNUAL DAMAGES	DAMAGES REDUCED (BENEFITS)	% DAMAGES REDUCED
Without	Adjacent Levee Fix-in-Place	1,363	--	--
Fix D	Adjacent Levee Fix-in-Place	1,031	332	24%
Fix D+A	Adjacent Levee Fix-in-Place	1,025	338	25%
Fix D+A+E	Adjacent Levee Fix-in-Place	710	653	48%
Fix D+A+E+B	Adjacent Levee Fix-in-Place	226	1,137	83%
Fix D+A+E+B+C	Adjacent Levee Fix-in-Place	196	1,167	86%
Fix D+A+E+B+C+H	Adjacent Levee Fix-in-Place	122	1,241	91%
Fix D+A+E+B+C+H+G	Adjacent Levee Fix-in-Place	109	1,254	92%
Fix D+A+E+B+C+H+G+F	Adjacent Levee Fix-in-Place	65	1,298	95%
Fix D+A+E+B+C+H+G+F+I	Adjacent Levee Fix-in-Place	65	1,298	95%
Fix all and raise D, B, E, and F	Adjacent Levee Fix-in-Place	30	1,333	98%
Fix all and raise D, B, E, F, A, C, I, G	Adjacent Levee Fix-in-Place	11	1,352	99%
Fix all and raise all	Adjacent Levee Fix-in-Place	6	1,357	100%

One main point that can be made from the data in Table 6-24 is that fixing all reaches except NAT I reduces 95% of the total damages.

Figure 6-3 Total Annual Benefits by Levee Reach Improvement (in $Millions and Oct 2010 Price Level). (Yellow = Adjacent Levee; Blue = Fix-in-Place)



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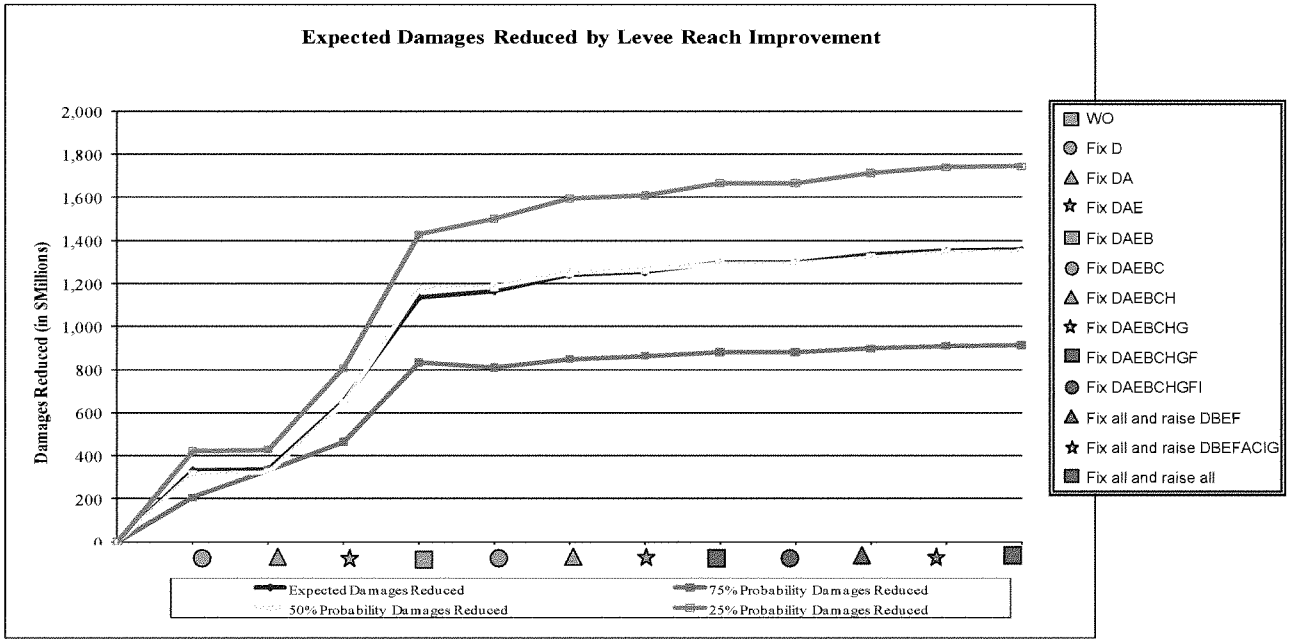
Table 6-25 and Figure 6-4 show the EAD and damages reduced (benefits) for each levee reach improvement, as well as the 25%, 50%, and 75% probabilities that benefits would exceed a specific value. The table and graph describe the magnitude of uncertainty surrounding the benefits.

Table 6-25
Damages Reduced and Probability Damages Reduced Exceeds Indicated Value
In $Millions and October 2010 Price Level

MEASURES	ALTERNATIVE	EXPECTED ANNUAL DAMAGES (EAD)			PROBABILITY DAMAGE REDUCED EXCEEDS INDICATED VALUE		
		Without	With Fix	Damages Reduced	75%	50%	25%
Without	AL or FIP	1,363	--	--	--	--	--
Fix D	AL or FIP	1,363	1,031	332	207	316	422
Fix D + A	AL or FIP	1,363	1,025	338	332	324	429
Fix D + A +E	AL or FIP	1,363	710	653	465	645	808
Fix D + A + E + B	AL or FIP	1,363	226	1,137	835	1,175	1,428
Fix D + A+ E + B + C	AL or FIP	1,363	196	1,167	809	1,185	1,500
Fix D + A + E + B + C + H	AL or FIP	1,363	122	1,241	850	1,249	1,594
Fix D + A + E + B + C + H + G	AL or FIP	1,363	109	1,254	864	1,263	1,610
Fix D + A + E + B + C + H + G + F	AL or FIP	1,363	65	1,298	881	1,293	1,665
Fix D + A + E + B + C + H + G + F + I	AL or FIP	1,363	65	1,298	881	1,293	1,665
Fix All and Raise D, B, E, F	AL or FIP	1,363	30	1,333	898	1,323	1,713
Fix All and Raise D, B, E, F, A, C, I, G	AL or FIP	1,363	11	1,352	911	1,344	1,740
Fix All and Raise All	AL or FIP	1,363	6	1,357	913	1,347	1,745

Notes: AL= Adjacent Levee; FIP = Fix-in-Place

Figure 6-4



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6.8.2 Performance Statistics by Levee Reach Improvement

Tables 6-25 and 6-26 below show the AEP, long-term risk, and conditional non-exceedance probability by event results by levee reach improvement for both the Major and Minor impact areas.

Table 6-26
Performance Statistics by Levee Reach Improvement
Major Impact Area

MEASURE	AEP	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
		10	30	50	10%	4%	2%	1%	.4%	.2%
Without	0.21	.90	.99	1.00	.43	.27	.21	.15	.08	.06
Fix D	0.20	.90	.99	1.00	.36	.23	.19	.14	.06	.03
Fix D+A	0.18	.87	.99	1.00	.37	.23	.19	.15	.08	.06
Fix D+A+E	0.12	.72	.96	.99	.70	.59	.56	.49	.35	.29
Fix D+A+E+B	.04	.33	.63	.86	.85	.74	.71	.64	.43	.30
Fix D+A+E+B+C	.04	.35	.66	.88	.85	.73	.67	.58	.40	.13
Fix D+A+E+B+C+H*	.015	.14	.32	.54	.96	.92	.88	.81	.60	.50
Fix D+A+E+B+C+H+G*	.015	.14	.32	.54	.96	.92	.88	.81	.60	.50
Fix D+A+E+B+C+H+G+F*	.015	.14	.32	.54	.96	.92	.88	.81	.60	.50
Fix D+A+E+B+C+H+G+F+I*	.015	.14	.32	.54	.96	.92	.88	.81	.60	.50
Fix all and raise D, B, E, and F	.008	.08	.18	.33	.98	.97	.96	.96	.91	.14
Fix all and raise D, B, E, F, A, C, I, G	.006	.06	.14	.27	.98	.97	.96	.96	.94	.56
Fix all and raise all	.001	.01	.02	.05	.99	.98	.98	.97	.94	.56

*For these improvements, the performance statistics are associated with NAT D (with-project), since after fixing these reaches (H, G, F, I) NAT D (post-fix) becomes the "weakest link" associated with the Major impact area.

Table 6-27
Performance Statistics by Levee Reach Improvement
Minor Impact Area

MEASURE	AEP	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
		10	30	50	10%	4%	2%	1%	.4%	.2%
Without	0.30	.97	.99	1.00	.42	.25	.17	.12	.06	.02
Fix D	0.30	.97	.99	1.00	.42	.25	.17	.12	.06	.02
Fix D+A	0.30	.97	.99	1.00	.42	.25	.17	.12	.06	.02
Fix D+A+E	0.30	.97	.99	1.00	.42	.25	.17	.12	.06	.02
Fix D+A+E+B	0.30	.97	.99	1.00	.42	.25	.17	.12	.06	.02
Fix D+A+E+B+C	0.30	.97	.99	1.00	.42	.25	.17	.12	.06	.02
Fix D+A+E+B+C+H	0.30	.97	.99	1.00	.42	.25	.17	.12	.06	.02
Fix D+A+E+B+C+H+G	0.30	.97	.99	1.00	.42	.25	.17	.12	.06	.02
Fix D+A+E+B+C+H+G+F	.023	.21	.44	.69	.96	.96	.96	.95	.94	.52
Fix D+A+E+B+C+H+G+F+I	.023	.21	.44	.69	.96	.96	.96	.95	.94	.52
Fix all and raise D, B, E, and F	.006	.01	.01	.03	1.00	1.00	1.00	1.00	.99	.68
Fix all and raise D, B, E, F, A, C, I, G	.006	.01	.01	.03	1.00	1.00	1.00	1.00	.99	.68
Fix all and raise all	.006	.01	.01	.03	1.00	1.00	1.00	1.00	.99	.68

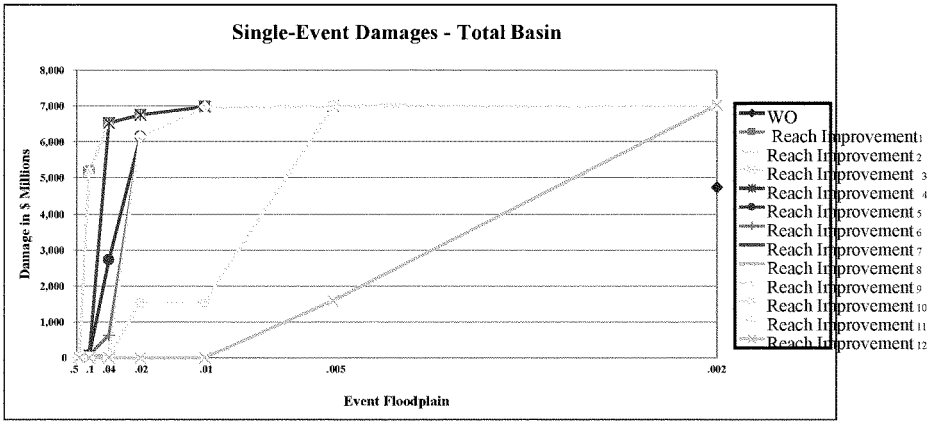
6.8.3 Single-Event Damages by Levee Reach Improvement

Table 6-28 shows the single-event damages (without uncertainty) for both the combined Major and Minor impact areas and for each levee reach improvement. Figure 6-4 shows the graphical representation of Table 6-28.

Table 6-28
Total Single-Event Damages by Levee Reach Improvement (without uncertainty)

MEASURE	(VALUES IN $ MILLIONS, OCTOBER 2010 PRICE LEVEL)						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Without	4,724	6,731	6,825	6,942	6,986	7,015	7,034
Fix D	2,466	5,176	6,540	6,760	6,986	7,015	7,034
Fix D+A	2,466	5,176	6,540	6,760	6,986	7,015	7,034
Fix D+A+E	2,466	5,176	6,540	6,760	6,986	7,015	7,034
Fix D+A+E+B	0	81	6,540	6,760	6,986	7,015	7,034
Fix D+A+E+B+C	0	81	2,727	6,162	6,986	7,015	7,034
Fix D+A+E+B+C+H	0	81	635	6,162	6,986	7,015	7,034
Fix D+A+E+B+C+H+G	0	43	77	6,162	6,986	7,015	7,034
Fix D+A+E+B+C+H+G+F	0	43	77	6,162	6,986	7,015	7,034
Fix D+A+E+B+C+H+G+F+I	0	0	0	6,162	6,986	7,015	7,034
Fix all and raise D, B, E, and F	0	0	0	1,567	1,581	7,015	7,034
Fix all and raise D, B, E, F, A, C, I, G	0	0	0	0	0	1,584	7,034
Fix all and raise all	0	0	0	0	0	1,584	7,034

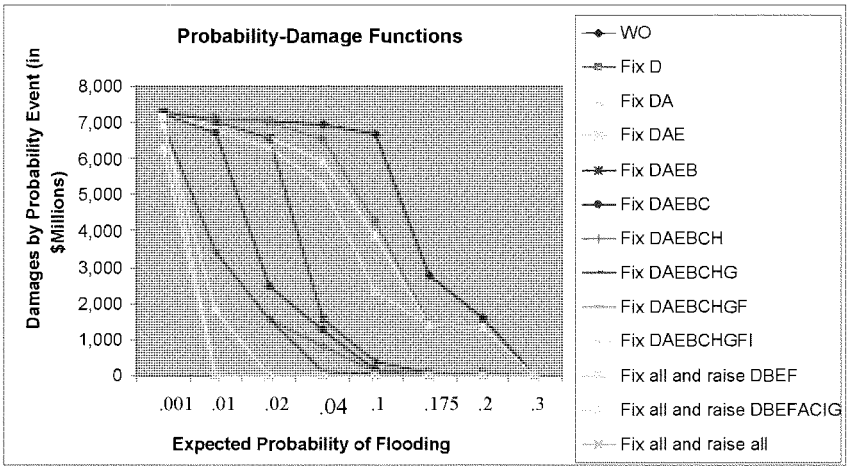
Fignre 6-5 Total Single-Event Damages by Levee Reach Improvement (without uncertainty)



6.8.4 Exceedance-Probability Damage Functions

Figure 6-5 displays the exceedance-probability damage functions for each of the twelve levee reach improvements. The expected probabilities of flooding were plotted against damages by probability event using the HEC-FDA results. Since expected annual damages are computed by integrating under an individual exceedance-probability damage function, it can be seen from the graph that with each successive levee reach improvement the area under the respective curve becomes smaller, indicating a reduction in damages from one improvement to the next.

Figure 6-6 Exceedance-Probability Damage Functions (with uncertainty)



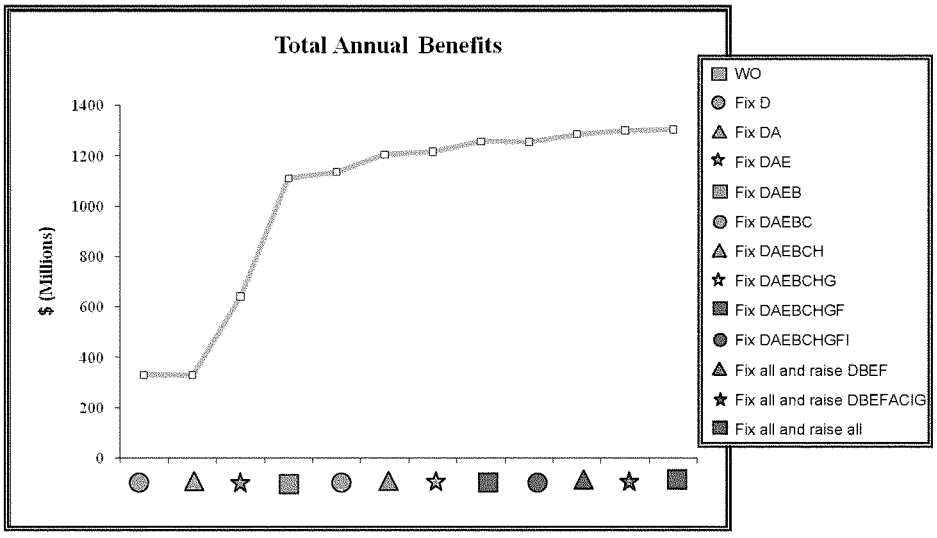
6.9 LEVEE REACH IMPROVEMENTS

Table 6-28 below shows the residual damages and benefits of each levee reach improvement. Figure 6-6 shows the graphical representation of Table 6-28. Total benefits increase with each improvement.

Table 6-259
With-Project Residual Damages and Benefits by Levee Reach Improvement
Damages/Benefits in $Millions and October 2010 Price Level

MEASURES	ALTERNATIVE TYPE	EXPECTED ANNUAL DAMAGES	RESIDUAL DAMAGES	DAMAGES REDUCED (BENEFITS)
Without-Project	Adjacent Levee	462	--	--
	Fix-in-Place			
Fix D	Adjacent Levee	--	341	121
	Fix-in-Place			
Fix D+A	Adjacent Levee	--	330	132
	Fix-in-Place			
Fix D+A+E	Adjacent Levee	--	299	163
	Fix-in-Place			
Fix D+A+E+B	Adjacent Levee	--	101	361
	Fix-in-Place			
Fix D+A+E+B+C	Adjacent Levee	--	60	402
	Fix-in-Place			
Fix D+A+E+B+C+H	Adjacent Levee	--	32	430
	Fix-in-Place			
Fix D+A+E+B+C+H+G	Adjacent Levee	--	24	438
	Fix-in-Place			
Fix D+A+E+B+C+H+G+F	Adjacent Levee	--	19	443
	Fix-in-Place			
Fix D+A+E+B+C+H+G+F+I	Adjacent Levee	--	19	443
	Fix-in-Place			
Fix All + Raise D,B,E,& F	Adjacent Levee	--	10	452
	Fix-in-Place			
Fix All + Raise D,B,E,F, A,C,I,& G	Adjacent Levee	--	8	454
	Fix-in-Place			
Fix All + Raise All	Adjacent Levee	--	2	460
	Fix-in-Place			

Figure 6-7 Total Annual Benefits by Levee Reach Improvement (in $Millions)



These levee reach improvements will be discussed further in Chapter 7, *Net Benefit and Benefit-to-Cost Analyses*. Preliminary costs for each method of fix and alternative type used in economic analysis will be presented. For each improvement and alternative type, average annual benefits will be compared to average annual costs.

CHAPTER 7A
NET BENEFIT AND BENEFIT-TO-COST ANALYSES

This chapter presents the net benefit and benefit-to-cost analyses using the HEC-FDA results presented in Chapters 5 and 6 and screening-level cost estimates provided by the USACE SPK Cost Engineering Section. Again, it is important to note that the results presented here are NOT the results used as the basis for plan formulation. As was previously noted, an adjustment to without-project EAD and benefits was made and this adjustment process/analysis is presented in Chapter 7B. Accordingly, the net benefit and benefit-to-cost analyses have been revised to reflect the adjusted EAD and benefit values; cost estimates have not changed and so the estimates presented in this chapter are the same as those presented in Chapter 7B.

7.1 GENERAL DESCRIPTION OF NET BENEFIT AND BENEFIT-TO-COST ANALYSES

The benefits of each group (1 through 5) and alternative type ("fix-in-place" or "adjacent levee") were compared to the costs of each group and alternative type. A conceptual diagram which shows the benefit and costs curves and graphically describes in general terms the with-project analysis approach is provided below in Figure 7-1.

Optimization
Total Annual Benefits
NA
Plan-1
Plan-2
Plan-3
Total Annual Cost
Plan
TC
TB
Net Benefits
Total Annual Benefits & Costs
Plan
Marginal Benefit & Cost
Plan
The difference in the total benefit and total cost curves are the net benefits of a plan.
When with-project benefits are greater than with-project costs, additional measures are still cost-effective.
BENEFITS
Each reach's AEP was computed in HEC-FDA
Fixes around basin
Reach
W/ Proj. Failure
Plan1
Plan2
Plan3
Acre-Feet
A
B
C
D
E
F
G
H
I
Total Benefits
WO
Inc-1
Inc-2
Inc-3
Total Annual Benefits
NA
Plan-1
Plan-2
Plan-3
Total Annual Benefits are based on fixes for each representative reach around the basin. The with-project benefit analysis, based on AEP, entails fixing the weakest reach first.
COST
Reach A
Total Cost
WSE (Stage)
As a function of WSE cost curves for each fix in each reach were developed.
Natomas Basin
Total Cost
Costs for each additional improvement based on ordered fixes used for benefit analysis
Improvements
Natomas Basin
Natomas Basin
Total Annual Cost
Plan
Total annual costs for each additional improvement by ordered fixes used for benefit analysis.
TA-2
American River Watershed Project, California
Post Authorization Change Report
Natomas Basin
Appendix H Economics – October 2010
Chapter 5A
Cost Analyses

7.2 PROJECT COSTS

Tables 7-1 to 7-5 display the costs by reach, method of fix, and alternative type for each of the five groups. For each reach, the method of fix used in the with-project analysis is identified and its associated first costs, interest during construction (IDC), total investment costs, annualized costs, annual operation and maintenance costs (OMRR&R), and total average annual costs are displayed. Total average annual costs (shaded in green) of each alternative type/group were compared to the total average annual benefits of each alternative type/group. This comparison can be seen in both table and graphical formats in section 7.3.

Table 7A-1
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	Total		**36.68**	**1.56**	**38.24**	**1.90**	**0.06**	**1.96**
Adjacent Levee	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	Total		**36.68**	**1.56**	**38.24**	**1.90**	**0.06**	**1.96**

Table 7A-2
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A,

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	107.30	20.05	127.35	6.31	0.32	6.63
	Total		**143.98**	**21.61**	**165.59**	**8.21**	**0.38**	**8.59**
Adjacent Levee	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	102.87	19.22	122.09	6.05	0.30	6.35
	Total		**139.55**	**20.78**	**160.33**	**7.95**	**0.36**	**8.31**

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Table 7A-3
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	107.30	20.05	127.35	6.31	0.32	6.63
	E	Cutoff Wall	50.79	14.88	65.67	3.26	0.10	3.36
	Total		**194.77**	**36.49**	**231.26**	**11.47**	**0.48**	**11.95**
Adjacent Levee	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	102.87	19.22	122.09	6.05	0.30	6.35
	E	Cutoff Wall	44.87	15.68	60.55	3.00	0.15	3.15
	Total		**184.42**	**36.46**	**220.88**	**10.95**	**0.51**	**11.46**

Table 7A-4
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E, NAT B

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	107.30	20.05	127.35	6.31	0.32	6.63
	E	Cutoff Wall	50.79	14.88	65.67	3.26	0.10	3.36
	B	Cutoff Wall	307.34	23.66	331.00	16.41	0.83	17.24
	Total		**502.11**	**60.15**	**562.26**	**27.88**	**1.31**	**29.19**
Adjacent Levee	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	102.87	19.22	122.09	6.05	0.30	6.35
	E	Cutoff Wall	44.87	15.68	60.55	3.00	0.15	3.15
	B	Cutoff Wall	272.58	20.89	293.47	14.55	0.73	15.28
	Total		**457.00**	**57.35**	**514.35**	**25.50**	**1.24**	**26.74**

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Table 7A-5
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E, NAT B, NAT C

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	107.30	20.05	127.35	6.31	0.32	6.63
	E	Cutoff Wall	50.79	14.88	65.67	3.26	0.10	3.36
	B	Cutoff Wall	307.34	23.66	331.00	16.41	0.83	17.24
	C	Cutoff Wall	127.19	3.06	130.25	6.46	0.33	6.79
	Total		**629.30**	**63.21**	**692.51**	**34.33**	**1.64**	**35.97**
Adjacent Levee	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	102.87	19.22	122.09	6.05	0.30	6.35
	E	Cutoff Wall	44.87	15.68	60.55	3.00	0.15	3.15
	B	Cutoff Wall	272.58	20.89	293.47	14.55	0.73	15.28
	C	Cutoff Wall	91.86	2.59	94.45	4.68	0.24	4.92
	Total		**548.86**	**59.94**	**608.80**	**30.18**	**1.48**	**31.66**

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Table 7A-6
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E, NAT B, NAT C, NAT H

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	107.30	20.05	127.35	6.31	0.32	6.63
	E	Cutoff Wall	50.79	14.88	65.67	3.26	0.10	3.36
	B	Cutoff Wall	307.34	23.66	331.00	16.41	0.83	17.24
	C	Cutoff Wall	127.19	3.06	130.25	6.46	0.33	6.79
	H	Cutoff Wall	64.94	12.13	77.07	3.82	0.11	3.93
	Total		**694.24**	**75.34**	**769.58**	**38.15**	**1.75**	**39.90**
Adjacent Levee	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	102.87	19.22	122.09	6.05	0.30	6.35
	E	Cutoff Wall	44.87	15.68	60.55	3.00	0.15	3.15
	B	Cutoff Wall	272.58	20.89	293.47	14.55	0.73	15.28
	C	Cutoff Wall	91.86	2.59	94.45	4.68	0.24	4.92
	H	Cutoff Wall	64.94	12.13	77.07	3.82	0.11	3.93
	Total		**613.80**	**72.07**	**685.87**	**34.00**	**1.59**	**35.59**

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Table 7A-7
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E, NAT B, NAT C, NAT H, NAT G

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	107.30	20.05	127.35	6.31	0.32	6.63
	E	Cutoff Wall	50.79	14.88	65.67	3.26	0.10	3.36
	B	Cutoff Wall	307.34	23.66	331.00	16.41	0.83	17.24
	C	Cutoff Wall	127.19	3.06	130.25	6.46	0.33	6.79
	H	Cutoff Wall	64.94	12.13	77.07	3.82	0.11	3.93
	G	Cutoff Wall	39.72	9.48	49.20	2.44	0.07	2.51
	Total		**733.96**	**84.82**	**818.78**	**40.59**	**1.82**	**42.41**
Adjacent Levee	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	102.87	19.22	122.09	6.05	0.30	6.35
	E	Cutoff Wall	44.87	15.68	60.55	3.00	0.15	3.15
	B	Cutoff Wall	272.58	20.89	293.47	14.55	0.73	15.28
	C	Cutoff Wall	91.86	2.59	94.45	4.68	0.24	4.92
	H	Cutoff Wall	64.94	12.13	77.07	3.82	0.11	3.93
	G	Cutoff Wall	32.93	9.65	42.58	2.11	0.11	2.22
	Total		**646.73**	**81.72**	**728.45**	**36.11**	**1.70**	**37.81**

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Table 7A-8
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E, NAT B, NAT C, NAT H, NAT G, NAT F

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	107.30	20.05	127.35	6.31	0.32	6.63
	E	Cutoff Wall	50.79	14.88	65.67	3.26	0.10	3.36
	B	Cutoff Wall	307.34	23.66	331.00	16.41	0.83	17.24
	C	Cutoff Wall	127.19	3.06	130.25	6.46	0.33	6.79
	H	Cutoff Wall	64.94	12.13	77.07	3.82	0.11	3.93
	G	Cutoff Wall	39.72	9.48	49.20	2.44	0.07	2.51
	F	Drained Seepage Berm	56.19	16.46	72.65	3.60	0.11	3.71
	Total		**790.15**	**101.28**	**891.43**	**44.19**	**1.93**	**46.12**
Adjacent Levee	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	102.87	19.22	122.09	6.05	0.30	6.35
	E	Cutoff Wall	44.87	15.68	60.55	3.00	0.15	3.15
	B	Cutoff Wall	272.58	20.89	293.47	14.55	0.73	15.28
	C	Cutoff Wall	91.86	2.59	94.45	4.68	0.24	4.92
	H	Cutoff Wall	64.94	12.13	77.07	3.82	0.11	3.93
	G	Cutoff Wall	32.93	9.65	42.58	2.11	0.11	2.22
	F	Drained Seepage Berm	48.91	17.09	66.00	3.27	0.16	3.43
	Total		**695.64**	**98.81**	**794.45**	**39.39**	**1.86**	**41.25**

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Table 7A-9
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E, NAT B, NAT C, NAT H, NAT G, NAT F, NAT I

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	107.30	20.05	127.35	6.31	0.32	6.63
	E	Cutoff Wall	50.79	14.88	65.67	3.26	0.10	3.36
	B	Cutoff Wall	307.34	23.66	331.00	16.41	0.83	17.24
	C	Cutoff Wall	127.19	3.06	130.25	6.46	0.33	6.79
	H	Cutoff Wall	64.94	12.13	77.07	3.82	0.11	3.93
	G	Cutoff Wall	39.72	9.48	49.20	2.44	0.07	2.51
	F	Drained Seepage Berm	56.19	16.46	72.65	3.60	0.11	3.71
	I	Cutoff Wall	25.02	3.43	28.45	1.41	0.07	1.48
	Total		**815.17**	**104.71**	**919.88**	**45.61**	**2.00**	**47.61**
Adjacent Levee	D	Cutoff Wall	36.68	1.56	38.24	1.90	0.06	1.96
	A	Cutoff Wall/Slope Flat.	102.87	19.22	122.09	6.05	0.30	6.35
	E	Cutoff Wall	44.87	15.68	60.55	3.00	0.15	3.15
	B	Cutoff Wall	272.58	20.89	293.47	14.55	0.73	15.28
	C	Cutoff Wall	91.86	2.59	94.45	4.68	0.24	4.92
	H	Cutoff Wall	64.94	12.13	77.07	3.82	0.11	3.93
	G	Cutoff Wall	32.93	9.65	42.58	2.11	0.11	2.22
	F	Drained Seepage Berm	48.91	17.09	66.00	3.27	0.16	3.43
	I	Cutoff Wall	24.89	3.41	28.30	1.40	0.07	1.47
	Total		**720.53**	**102.22**	**822.75**	**40.79**	**1.93**	**42.72**

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Table 7A-10
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E, NAT B, NAT C, NAT H, NAT G, NAT F, NAT I; raise NAT D, B, E, F

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall/raise	75.90	3.08	78.98	3.92	0.12	4.04
	A	Cutoff Wall/Slope Flat.	113.00	21.00	134.00	6.64	0.29	6.93
	E	Cutoff Wall/raise	55.81	16.35	72.16	3.58	0.11	3.69
	B	Cutoff Wall/raise	317.42	24.61	342.03	16.96	0.85	17.81
	C	Cutoff Wall	144.97	4.19	149.16	7.39	0.32	7.71
	H	Cutoff Wall	73.00	13.64	86.64	4.30	0.19	4.49
	G	Cutoff Wall	39.72	9.48	49.20	2.44	0.11	2.55
	F	Drained Seepage Berm/raise	59.11	17.32	76.43	3.79	0.11	3.90
	I	Cutoff Wall	26.44	3.62	30.06	1.49	0.07	1.56
	Total		**905.37**	**113.29**	**1018.66**	**50.50**	**2.17**	**52.67**
Adjacent Levee	D	Cutoff Wall/raise	75.90	3.08	78.98	3.92	0.12	4.04
	A	Cutoff Wall/Slope Flat.	107.33	20.05	127.38	6.32	0.28	6.60
	E	Cutoff Wall/raise	51.10	17.86	68.96	3.42	0.17	3.59
	B	Cutoff Wall/raise	295.25	22.67	317.92	15.76	0.78	16.54
	C	Cutoff Wall	99.28	3.08	102.36	5.07	0.23	5.30
	H	Cutoff Wall	73.00	13.64	86.64	4.30	0.19	4.49
	G	Cutoff Wall	32.93	7.86	40.79	2.02	0.09	2.11
	F	Drained Seepage Berm/raise	55.13	19.27	74.40	3.69	0.18	3.87
	I	Cutoff Wall	25.84	3.54	29.38	1.46	0.06	1.52
	Total		**815.76**	**111.05**	**926.81**	**45.95**	**2.10**	**48.05**

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Table 7A-11
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E, NAT B, NAT C, NAT H, NAT G, NAT F, NAT I; raise NAT D, B, E, F, G, I, A, C

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall/raise	75.90	3.08	78.98	3.92	0.12	4.04
	A	Cutoff Wall/Slope Flat.	145.97	26.40	172.37	8.55	0.43	8.98
	E	Cutoff Wall/raise	61.99	18.16	80.15	3.97	0.12	4.09
	B	Cutoff Wall/raise	317.42	24.61	342.03	16.96	0.85	17.81
	C	Cutoff Wall	130.87	3.16	134.03	6.64	0.33	6.97
	H	Cutoff Wall	73.00	13.64	86.64	4.30	0.19	4.49
	G	Cutoff Wall	43.18	10.31	53.49	2.65	0.08	2.73
	F	Drained Seepage Berm/raise	59.11	17.32	76.43	3.79	0.11	3.90
	I	Cutoff Wall	27.14	3.72	30.86	1.53	0.08	1.61
	Total		**934.58**	**120.40**	**1054.98**	**52.30**	**2.31**	**54.61**
Adjacent Levee	D	Cutoff Wall/raise	75.90	3.08	78.98	3.92	0.12	4.04
	A	Cutoff Wall/Slope Flat.	135.41	24.43	159.84	7.92	0.40	8.32
	E	Cutoff Wall/raise	56.35	19.69	76.04	3.77	0.19	3.96
	B	Cutoff Wall/raise	295.25	22.67	317.92	15.76	0.78	16.54
	C	Cutoff Wall	97.99	2.78	100.77	5.00	0.25	5.25
	H	Cutoff Wall	73.00	13.64	86.64	4.30	0.19	4.49
	G	Cutoff Wall	38.20	11.19	49.39	2.45	0.12	2.57
	F	Drained Seepage Berm/raise	55.13	19.27	74.40	3.69	0.18	3.87
	I	Cutoff Wall	34.98	4.79	39.77	1.97	0.10	2.07
	Total		**862.21**	**121.54**	**983.75**	**48.77**	**2.33**	**51.10**

Table 7A-12
Project Cost Summary (in $Millions, Oct 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis)
Levee Reach Improvement: Fix NAT D, NAT A, NAT E, NAT B, NAT C, NAT H, NAT G, NAT F, NAT I; raise all

ALTERNATIVE	REACH	METHOD OF FIX	TOTAL FIRST COST	IDC	TOTAL INV COSTS	ANNUALIZED COST	ANNUAL OMRR&R	TOTAL AAC
Fix-in-Place	D	Cutoff Wall/raise	75.90	3.08	78.98	3.92	0.12	4.04
	A	Cutoff Wall/Slope Flat.	113.00	21.00	134.00	6.64	0.29	6.93
	E	Cutoff Wall/raise	55.81	16.35	72.16	3.58	0.11	3.69
	B	Cutoff Wall/raise	317.42	24.61	342.03	16.96	0.85	17.81
	C	Cutoff Wall	144.97	4.19	149.16	7.39	0.32	7.71
	H	Cutoff Wall	165.68	30.95	196.63	9.75	0.15	9.90
	G	Cutoff Wall	39.72	9.48	49.20	2.44	0.11	2.55
	F	Drained Seepage Berm/raise	59.11	17.32	76.43	3.79	0.11	3.90
	I	Cutoff Wall	26.44	3.62	30.06	1.49	0.07	1.56
	Total		**998.05**	**130.60**	**1128.65**	**55.96**	**2.13**	**58.09**
Adjacent Levee	D	Cutoff Wall/raise	75.90	3.08	78.98	3.92	0.12	4.04
	A	Cutoff Wall/Slope Flat.	107.33	20.05	127.38	6.32	0.28	6.60
	E	Cutoff Wall/raise	51.10	17.86	68.96	3.42	0.17	3.59
	B	Cutoff Wall/raise	295.25	22.67	317.92	15.76	0.78	16.54
	C	Cutoff Wall	99.28	3.08	102.36	5.07	0.23	5.30
	H	Cutoff Wall	165.68	30.95	196.63	9.75	0.15	9.90
	G	Cutoff Wall	32.93	7.86	40.79	2.02	0.09	2.11
	F	Drained Seepage Berm/raise	55.13	19.27	74.40	3.69	0.18	3.87
	I	Cutoff Wall	25.84	3.54	29.38	1.46	0.06	1.52
	Total		**908.44**	**128.36**	**1036.80**	**51.40**	**2.06**	**53.46**

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7.3 NET BENEFIT AND BENEFIT-TO-COST ANALYSES -- DETAILS

Net benefits determine the efficiency of a plan and are determined by subtracting annual costs from annual benefits. The group that maximizes net benefits is considered the most efficient from an NED perspective. The first costs for each Group displayed in the tables in section 7.2 are the summation of costs by individual reach improvements presented in Enclosure 6, *Project Costs Used for Preliminary Screening of Alternatives.*

Table 7-6[21] shows the comparison of costs and benefits by group and alternative type. As mentioned in previous sections, the benefits for each alternative type ("fix-in-place" and "adjacent levee") are the same as both types perform equally from a geotechnical point of view and so were represented by the same fragility curve (per method of fix); the costs of each alternative type differ, however. Benefits by group are differentiated primarily through scale, as each successive plan incorporates additional reach improvements, levee raises, or both.

[21] For the complete table of with-project "Net Benefit and Benefit-to-Cost Analysis" see Enclosure 2.

Table 7A-13
Net Benefit and Benefit-to-Cost Analysis
In $Millions, October 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis

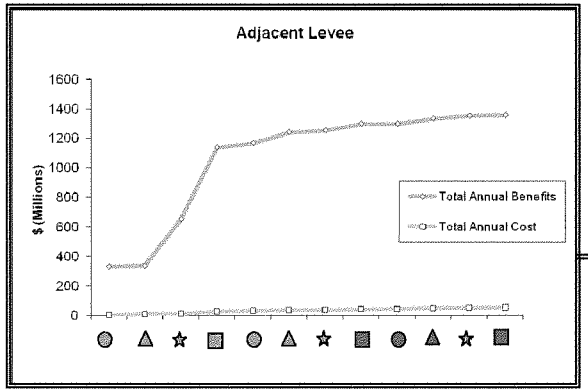
MEASURES	ALTERNATIVE TYPE	EXPECTED ANNUAL DAMAGES	ANNUAL BENEFITS	ANNUAL COST	NET BENEFITS	B/C RATIO
WITHOUT-PROJECT	-	1363	-	-	-	-
FIX D	Adjacent Levee	1031	332	2.0	330.0	169.4
	Fix-in-Place			2.0	330.0	169.4
FIX D, A	Adjacent Levee	1025	338	8.3	329.7	40.7
	Fix-in-Place			8.6	329.4	39.3
FIX D, A, E	Adjacent Levee	710	653	11.5	641.5	57.0
	Fix-in-Place			12.0	641.1	54.6
FIX D, A, E, B	Adjacent Levee	226	1137	26.7	1110.3	42.5
	Fix-in-Place			29.2	1107.8	39.0
FIX D, A, E, B, C	Adjacent Levee	196	1167	31.7	1135.3	36.9
	Fix-in-Place			36.0	1131.0	32.4
FIX D, A, E, B, C, H	Adjacent Levee	122	1241	35.6	1205.4	34.9
	Fix-in-Place			39.9	1201.1	31.1
FIX D, A, E, B, C, H, G	Adjacent Levee	109	1254	37.8	1216.2	33.2
	Fix-in-Place			42.4	1211.6	29.6
FIX D, A, E, B, C, H, G, F	Adjacent Levee	65	1298	41.3	1256.8	31.5
	Fix-in-Place			46.1	1251.9	28.1
FIX D, A, E, B, C, H, G, F, I	Adjacent Levee	65	1298	42.7	1255.3	30.4
	Fix-in-Place			47.6	1250.4	27.3
FIX ALL + RAISE D, B, E, F	Adjacent Levee	30	1333	48.1	1285.0	27.7
	Fix-in-Place			52.7	1280.3	25.3
FIX ALL + RAISE D, B, E-2, F, G, I, A, C	Adjacent Levee	11	1352	51.1	1300.9	26.5
	Fix-in-Place			54.6	1297.4	24.8
FIX ALL + RAISE ALL	Adjacent Levee	6	1357	53.5	1303.5	25.4
	Fix-in-Place			58.1	1298.9	23.4

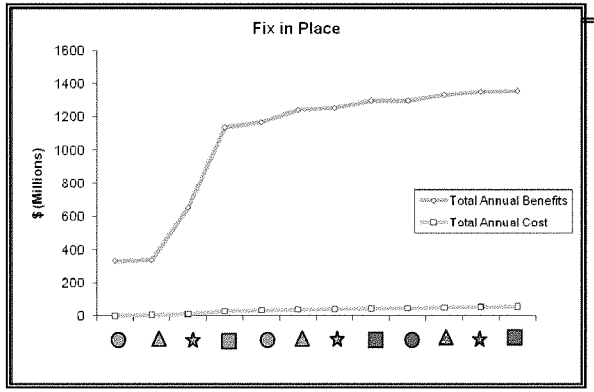
1112

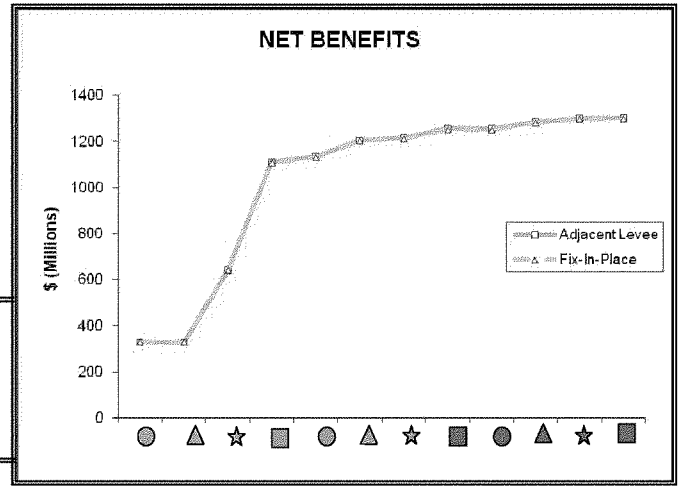
Figure 7-2 shows graphically the annual benefit, annual cost, and net benefit curves by group for the "adjacent levee" alternative type; Figure 7-3 shows graphically the annual benefit, annual cost, and net benefit curves by group for the "fix-in-place" alternative type; Figure 7-4 overlays the net benefit curves of each alternative type. It can be seen from Figure 7-4 that for all groups, the net benefits of the "adjacent levee" alternative are greater than the net benefits of the "fix-on-place" alternative. Figure 7-4 also shows that Groups 1 to 4 are on the 'rising limb' of the net benefit curve, while Group 5 is not.[22]

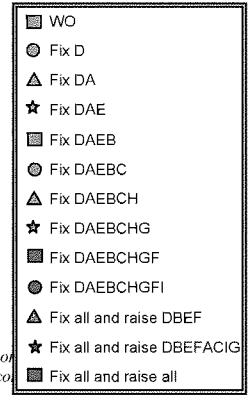
[22] The net benefit curves are comprised of five discrete points, which represent the five plans and their respective net benefits; the points were connected to visually show that net benefits increase with each successive plan up until Plan 5. The net benefit "curve" is not truly a continuous function.

Figure 7A-2, 7A-3, Figure 7A-4









CHAPTER 7B
EAD AND BENEFITS ADJUSTMENTS CONSIDERING REBUILD PERIOD AND DECREASING INVENTORY STOCK

The adjusted EAD, benefits, and net benefit results documented in this chapter were computed using supporting information/data already presented in Chapters 5, 6 and 7A as well as by using an @Risk/MS Excel spreadsheet model. These results are considered the "final" results and override any other EAD/benefit/net benefit results presented previously in Chapters 5, 6, and 7A. The results presented in this chapter are the ones used as the basis for plan formulation, and are also what were presented in the Executive Summary of this Appendix.

7.1 BACKGROUND

This chapter documents the EAD and benefits adjustments that were performed using the without-project AEP and single-event damages results reported in Chapters 5 and 6 of this Economic Appendix. These adjustments are based on the acknowledgement that the without-project damages and with-project benefits as currently reported may be overstated for the Natomas Basin. This acknowledgement, in turn, is based on several factors:

- The current HEC-FDA modeling results, which are based on frequency analysis and not life cycle analysis over the 50-year period of analysis, show a high annual exceedance probability (AEP of .21) and high expected annual damages (EAD of approximately $1.4 billion)
- The Natomas Basin floodplain characteristics, including the population and structure inventory
- The basic economic methodological premise that individuals will behave rationally

Taken together, the salient points above indicate that given the extremely high risk in the Natomas Basin area in terms of frequency of flooding (1 in 5 chance of flooding in any given year)[23] and consequences of flooding ($7.0 billion in damages from a 100-year event from NAT

[23] Although not addressed here, one cause of the high calculations of EAD/AEP in HEC-FDA may be the conservative assumptions in regard to the geotechnical risk and uncertainty (GRU) curves. Following the March 2009 F3 Conference (milestone conference which establishes the without-project condition), Sacramento District's Engineering Division attempted to address Planning Division's concerns about the GRU curves; Engineering Division held an expert elicitation as well as provided input (adjusted GRU curve at NAT C) to account for flood fighting. A sensitivity analysis, which is documented in Enclosure 3, was performed by the Economics Section using the adjusted curves. For NAT C, AEP (and EAD) were reduced significantly using the adjusted GRU curve from the expert elicitation; there was only minimal change to AEP (and EAD) using the revised GRU curves adjusted to account for flood fighting. Since the F3 Conference, additional index points were evaluated in order to better facilitate the with-project analysis; many of these points (e.g., NAT D) are producing high AEP/EAD values.

D) coupled with the fact that the Natomas Basin contains close to 23,000 structures and nearly 80,000 residents, it is highly unlikely that people would continue to occupy the area after multiple floods, assuming they behave rationally. In order to fully consider that individuals act rationally, the damages and benefits adjustments took into account:

- A rebuild period following a flood event
- Rebuild scenarios in terms of how quickly the area would be redeveloped
- A decrease in structure inventory stock following a flood event
- A limit on the number of flood events allowed to occur; once this limit was reached, the assumption was made that floodplain occupants would choose to not live in the Natomas Basin

It is important to note that this analysis was performed using the information documented in Chapters 5 and 6 of this Appendix. Specifically, AEP data and single-event damage data reported in Chapter 5 and the order of fixes used in the with-project analysis as outlined in Chapter 6 were taken and incorporated into this analysis using a newly-developed @Risk spreadsheet model; costs reported in Chapter 7A and used for the net benefit and BCR analyses are the same ones used for the Chapter 7B adjustment analysis.

The @Risk model developed specifically for this study was created to account for rational human behavior, which is the basic economic methodological premise in most economic studies. Rational human behavior, in the case of flooding in the Natomas Basin, was captured within the model in the form of a rebuild period, rebuild scenarios, loss of inventory stock, and a limit to the number of flood events that would occur before the Natomas Basin would be abandoned and people would decide not to live there. One drawback of HEC-FDA is that it is frequency-based, and its computational framework is not set-up to account for these factors related to human behavior; the Natomas @Risk model was set-up to be able to account for human behavior through the use of Monte Carlo simulation and life-cycle analysis.

7.2 PURPOSE OF EAD AND BENEFITS ADJUSTMENTS

The main purpose of this analysis is to adjust the EAD and benefit numbers obtained from the HEC-FDA modeling to account for human behavior by making assumptions about post-flood event rebuild periods, rebuild scenarios, floodplain inventory stock, and a reasonable assumption of the number of floods allowed to occur over the 50-year period of analysis before the Basin would be abandoned. Initially, these adjustments were not intended to replace the results obtained from the HEC-FDA modeling as presented in Chapters 5, 6, and 7a of this Economic Appendix. However, comments received during the Agency Technical Review (ATR) from the technical reviewer (USACE Los Angeles District, SPL) as well as from policy reviewers (USACE Headquarters and USACE SPD) , it was determined that these adjustments should actually be the basis for plan formulation and not just serve as a supplement to the HEC-FDA results. In addition, the PDT believes that the approach to use the @Risk model to make EAD

At this time, it is believed that Engineering Division has followed their process in terms of developing GRU curves and has at least considered Planning Division's concerns about the curves. The issue of high AEP/EAD values, then, has been addressed by the SPK Planning Division through this EAD/benefit adjustment.

and benefits adjustments described in this chapter was a necessary step in light of the fact that there is currently no other Corps-approved economic model that can do this type of analysis and also because there is no approved way to account for this EAD and benefits overestimation.

7.3 ASSUMPTIONS

Several assumptions were made in order to perform the analysis. These assumptions are also indicated in Figure 7B-1, which shows a graphical snapshot of the @Risk model. Figure 7B-1 will be referred to in this section as well as in sections 7.4, 7.5, and 7.6 to explain the EAD and benefits adjustment calculation process and to point out significant details related to the model. For example, the major assumptions used in the model are:

- After a flood event, the floodplain inventory stock would only be replaced by not more than 80% of the damaged property; this assumption captures the idea that not all floodplain occupants would choose to rebuild and live in the Natomas Basin after a flood event – some occupants would choose to leave the area.
- A rebuild period of three (3) years (Figure 7B-1, point 1). Rebuilding would take place over a 3-year period immediately following the flood event. The process of reducing the inventory stock to 80% of damaged property and rebuilding over a 3-year period would start all over with the next flood event
- Four (4) rebuild scenarios were delineated (Figure 7B-1, point 2), and range from a "slow" rebuild to an "aggressive" rebuild. For example, in the "slow" rebuild scenario (see Figure 7B-1), it was assumed that 20% of those properties damaged would be rebuilt in each of the 3 years of rebuilding.
- There is a limit of three (3) flood events that would be allowed to occur in the Basin at which point people would decide not to rebuild and live in the Basin; once this limit was reached, the model assumes that the Natomas community would abandon the region.

7.4 DESRIPTION OF @RISK MODEL: INPUT DATA AND APPLICATION WITHIN MODEL

The @Risk/MS Excel spreadsheet simulation model uses Monte Carlo techniques to derive outputs (e.g., in this case the outputs are EAD and benefits) based on key input variables that have uncertainty parameters attached to them; the uncertainty of key variables are described in the @Risk model through the assignment of probability distributions.

The Natomas @Risk model was developed to address the unique flooding situation in the Natomas Basin – high probability of flooding as well as high consequences (damages) if flooding were to occur – in order to account for rational human behavior. The model is set-up to calculate event damages over a 50-year period of analysis by:

- randomly selecting whether or not a flood event occurs in each year of the 50-year period of analysis; AEP information obtained from the initial HEC-FDA modeling is used as a basis to determine the likelihood of a flood event occurring in any given year
- incorporating a 3-year rebuild period following a flood event and sampling from four different rebuild scenarios to determine how much of the floodplain is rebuilt

- calculating event damages for up to 3 flood events over the 50-year period of analysis for each iteration of the @Risk simulation
- calculating EAD/benefits

The sections below describe the @Risk model developed specifically for the adjustment of Natomas EAD and benefits. The data used in the model and the application of this data within the model are explained in more detail in the subsections below[24]. The discussion below references Figure 7B-1.

7.4.1 HEC-FDA Computed Stage-Damage Curves

The damages from the stage-damage curves computed by HEC-FDA (Chapter 5, initial modeling) were used to populate the frequency-damage table (point A) in Figure 7B-1. For each impact area (Major and Minor) and for each levee reach improvement, the stages associated with each frequency event (2-year to 500-year) were pulled from the engineering frequency-stage curves also taken from the HEC-FDA analysis; the corresponding damages and uncertainty in damages (standard deviation of damages) at each frequency event stage were then pulled from the stage-damage curves computed by HEC-FDA.

For each frequency event, the damage and standard deviation of damage data pulled from the stage-damage curves in HEC-FDA were then used to calculate in @Risk minimum and maximum damage values; a normal probability distribution was used to describe the uncertainty in damages for this @Risk run. The minimum and maximum values obtained from this run were then used as input into the cumulative probability distribution function used to compute event damages (section 7.4.3). Additionally, damage and standard deviation of damage data pulled from the stage-damage curves in HEC-FDA were used to calculate coefficient of variation (COV) information; COVs were also used as input into the cumulative probability distribution functions (section 7.4.3).

7.4.2 Annnal Exceedance Probability (AEP) and Randomly Generated Flood Events

Annual Exceedance Probability (AEP) data reported in Chapters 5 as well as in the with-project analysis documented in Chapter 6 were also used as input into the Natomas @Risk model. The AEP was applied within the @Risk model as the basis for determining whether a flood event resulting in levee failure would occur in any given year over the 50-year period of analysis. For example, in Figure 7B-1 (without-project for the Major area), an AEP of .21 was entered. This AEP corresponds to the AEP obtained at NAT D, which was used as the without-project baseline for the Major impact area in the with-project analysis documented in Chapter 6. The @Risk model is set-up to randomly generate numbers between zero and 1 for each year of the period of analysis; a randomly generated number that was lower than .21 triggered a levee failure and a number greater than or equal to .21 did not trigger a levee failure. In other words, for the without-project and for this impact area, there was 21% chance that a flood event resulting in levee failure would occur in any given year throughout the 50-year period of analysis.

[24] Additional information regarding the Natomas @Risk model can also be found in Enclosure 7 (@Risk Model Approval Documentation) to this Appendix.

7.4.3 @Risk-Computed Event Damages & Cumulative Probability Distribution

In the @Risk model, when a flood event occurs event damages for that specific event are calculated. Event damages are calculated with uncertainty using a cumulative probability distribution function. As is displayed in Figure 7B-1 (point B), event damages for the first flood event in this example and for this iteration of the simulation is $4,217 billion. The formula used to calculate event damages is also shown at point B. In this example, minimum and maximum values were set at $4.211 billion and $5.53 billion, respectively. The cumulative probability distribution function was formed by setting the damage value at each respective frequency event shown in the frequency-damage table (point A) to a corresponding probability based on the actual event frequencies. For example, the first damage point on the cumulative probability distribution function is $4.357 billion, which is taken directly from the frequency-damage table; the corresponding probability for this damage is .5, which says that, should a flood event occur, a damage value of $4.357 billion or lower will occur 50% of the time. The last damage point on the curve is $5.33 billion, which says that, should a flood event occur, a damage value of $5.33 billion or lower will occur 100% of the time[25].

Finally, a COV was entered as part of the formula used to calculate event damages. This COV was based on the HEC-FDA computed stage-damage curves with uncertainty (as described in section 7.4.1). Within the @Risk model, once event damages were calculated for the first flood event (and through using a cumulative probability distribution function as described previously), the uncertainty associated with these event damages were described by setting it to a normal distribution having a standard deviation equal to plus/minus the previously-computed COV. Incorporating the COV into the event damages specifically addresses the requirement of incorporating uncertainty in the first floor elevation of structures, uncertainty in structure and content values, and uncertainty in structure and content depth-damage percentages since the damage values and COVs used here were based on the HEC-FDA computed stage-damage curves with uncertainty, which already have these uncertainties factored in.

7.4.4 @Risk-Computed Expected Annual Damages (EAD)

The @Risk model computes EAD by discounting event damages of each flood event to the present year, summing the discounted values, and then amortizing this value over the 50-year period of analysis. In each @Risk simulation, thousands of iterations are completed, each resulting in a different EAD value; the final EAD value reported in the @Risk output results table is the average of all EAD values across all iterations.

In the example shown in Figure 7B-1, the first flood event occurs in year 3 of the period of analysis and produces damages of $4.217 billion. As can be seen in the table marked by point D, after the first year of rebuild the inventory stock is only restored to the remaining value after the flood event ($6.918 billion minus $4.217 billion = $2.701 billion) plus the amount of rebuilding (15% of damaged property, or $4.217 billion multiplied by .15 = $634 billion) assumed to occur for that year, in this case it's $3.334 billion ($2.701 billion + $633 billion). In the second year, an additional 30% of the damaged property is rebuilt to get a value of $4.599 billion; in the third

[25] In actuality, the probability associated with the last damage point would be .998; however, 1.0 was used in order to be able to satisfy the @Risk software requirement of having a probability of 1.0 (100%) designated as the last point on the cumulative probability distribution function.

year an additional 15% of the damaged property is rebuilt to get a value of $5.231 billion. This value is then carried forward as the baseline total value of damageable property for the next flood event.

Point D also shows that after the third flood event (in this example this flood event occurs in year 25), no other flood event is allowed to occur within the 50-year period of analysis. This effectively prevents any other damages to be incurred and caps the calculation of EAD to three flood events. After this third event, it is assumed that people would abandon the Natomas Basin.

Expected Annual Damages	Net Present Value	Total Value of Damageable Property	Event Damage	Percent Loss	Annual Exceedance Probability	Discount Rate	Reconstruction Scenarios
$277.08	**$5,588.85**	**$6,918**	$4,217	**61%**	0.21	**4.375%**	**2**

D

Year	Event Occurrence	Beginning Price Damage	Damages	Post Event Value	POV Value
0	0	6,918	$ -	6,918	6,918
1	0	6,918	$ -	6,918	6,918
2	0	6,918	$ -	6,918	6,918
3	1	6,918	$ 4,217	2,701	3,334
4	0	3,334	$ -	3,334	4,599
5	0	4,599	$ -	4,599	5,231
6	0	5,231	$ -	5,231	5,231
7	0	5,231	$ -	5,231	5,231
8	0	5,231	$ -	5,231	5,231
9	0	5,231	$ -	5,231	5,231
10	0	5,231	$ -	5,231	5,231
11	0	5,231	$ -	5,231	5,231
12	0	5,231	$ -	5,231	5,231
13	0	5,231	$ -	5,231	5,231
14	0	5,231	$ -	5,231	5,231
15	0	5,231	$ -	5,231	5,231
16	0	5,231	$ -	5,231	5,231
17	0	5,231	$ -	5,231	5,231
18	0	5,231	$ -	5,231	5,231
19	0	5,231	$ -	5,231	5,231
20	0	5,231	$ -	5,231	5,231
21	1	5,231	$ 3,189	2,042	2,521
22	0	2,521	$ -	2,521	3,477
23	0	3,477	$ -	3,477	3,956
24	0	3,956	$ -	3,956	3,956
25	1	3,956	$ 2,411	1,544	1,906
26	0	1,906	$ -	1,906	2,630
27	0	2,630	$ -	2,630	2,991
28	0	2,991	$ -	2,991	2,991
29	0	2,991	$ -	2,991	2,991
30	0	2,991	$ -	2,991	2,991
31	0	2,991	$ -	2,991	2,991
32	0	2,991	$ -	2,991	2,991
33	0	2,991	$ -	2,991	2,991
34	0	2,991	$ -	2,991	2,991
35	0	2,991	$ -	2,991	2,991
36	0	2,991	$ -	2,991	2,991
37	0	2,991	$ -	2,991	2,991

B

=(RiskCumul(4211,5530,{4357,5026,5129,5227,5281,5312,5330},{0.5,0.9,0.96,0.98,0.99,0.995,1}))*RiskNormal(1,N7)

POV
1.40%

1

1st-Year	15%
2nd-Year	30%
3rd-Year	15%

2

Risk Scenario	Year 1	Year 2	Year 3
1	20%	20%	20%
2	15%	30%	15%
3	30%	20%	10%
4	45%	10%	5%

A

Inc.	Stage-Damage Relationship @ Frequency						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
0	4357	5026	5129	5227			
1							
2	2381	3590	4814	5061			
3							
4							
5			1184		5281	5312	5330
6							
7				4086			
8							
9							
10							
11							
12							

C

Inc.	Cumulative Probability Distribution						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
	0.5	0.1	0.04	0.02	0.01	0.005	0.002
0	0.500	0.900	0.960	0.980			
1							
2	0.500	0.900	0.960	0.980			
3							
4							
5			0.960		0.990		
6						0.995	
7				0.980			1.000
8							
9							
10							
11							
12							

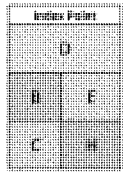


FIGURE 7B-1
Diagram of Natomas EAD Adjustment Model

Damage values are in millions of dollars.

7.5 WITH-PROJECT ANALYSIS & RESULTS USING THE @RISK MODEL

It is important to note that the process described in Section 6.4 above applies to each levee reach improvementof the analysis (from the without-project condition to the final levee reach improvement). A separate worksheet within the @Risk model was created in order to compute without-project EAD (without-project) and with-project residual EAD (Levee Reach Improvements 1 to 12). Additionally, the process also applies to each impact area (Major and Minor) – a separate @Risk model was run for each area.

Table 7B-1 below shows the results of each levee reach improvement analyzed for the Major and Minor impact areas. This is similar to Table 6-23 in Chapter 6 – the levee reach improvements replicate those outlined in Chapter 6, but the adjusted EAD and benefit values derived from the @Risk model are displayed in Table 7B-1. Cost estimates displayed in Tables 7B-2 and 7B-3 are those previously presented in Chapter 7A; a more detailed breakdown of screening-level cost estimates for each of the twelve levee reach improvements can be found in Tables 7A-1 to 7A-12 in Chapter 7A.

The with-project analysis results obtained from the Natomas @Risk model indicate that 26% of the damages are reduced by just fixing reach NAT D (first levee reach improvement); that 93% of the damages are reduced by fixing up to NAT H (sixth levee reach improvement); and that most of the damages are reduced with any type of raises. For each levee reach improvement, the percent of damages reduced results obtained from using the @Risk model follow closely with those obtained from the with-project analysis using the HEC-FDA results (Chapter 6); the major difference is the absolute value of those damages reduced. Table 7B-3 shows a comparison of the HEC-FDA results and the @Risk results. As is displayed in this table, without-project EAD is reduced by 66% (two-thirds), or from $1.363 billion to $462 million.

Table 7B-2 below shows the net benefit analysis for both the fix-in-place and adjacent levee alternatives. It should be noted that the costs used for this analysis are the same ones used in Chapter 7A as the costs, unlike the benefits, have not been adjusted. Table 7B-2 indicates that net benefits continue to rise for all levee reach improvements just like in the HEC-FDA analysis; however, the net benefits do begin to level off starting from the levee reach improvement of NAT H, and the difference in net benefits between the sixth and twelth levee reach improvement are relatively minimal (as compared to the difference in net benefits between the without-project and the sixth levee reach improvement). As in the case with the with-project analysis using HEC-FDA, there are no additiona benefits with fixing NAT I until raises in other reaches occur.

Figures 7B-1, 7B-2, and 7B-3 show in graphical form the total annual benefits, total annual costs, and net benefits for each alternative type displayed in Table 7B-2. The adjacent levee alternative, as previously determined in the HEC-FDA analysis, is still the alternative that is the most efficient (greater net benefits and least costs), albeit the difference between the adjacent levee alternative and fix-in-place alternative is very minimal, as is demonstrated by their almost-identical net benefit curves in Figure 7B-3.

Table 7B-1
Natomas @Risk Model – With-Project Analysis Results
Major and Minor Impact Areas
AEP, EAD, and Annual Benefits, in $Millions and Oct 2010 Price Level

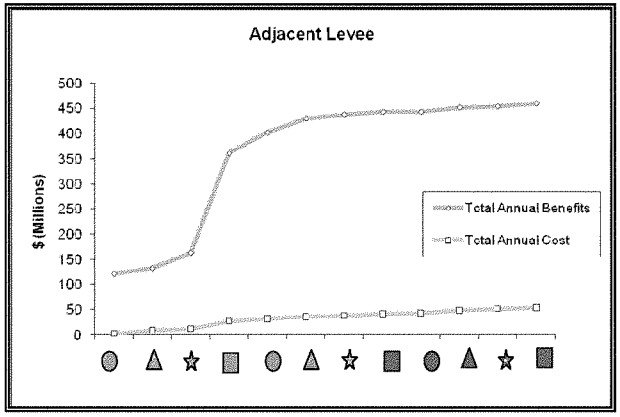
MEASURE	EAD			AEP		ANN BEN	% DAM REDUCED
	Major	Minor	Total	Major	Minor		
Without	346	116	462	.21	.30	--	--
Fix D	239	102	341	.21	.30	121	26%
Fix D+A	228	102	330	.18	.30	132	29%
Fix D+A+E	197	102	299	.12	.30	163	35%
Fix D+A+E+B	84	17	101	.04	.30	361	78%
Fix D+A+E+B+C	45	15	60	.04	.30	402	87%
Fix D+A+E+B+C+H	18	14	32	.015	.30	430	93%
Fix D+A+E+B+C+H+G	18	6	24	.015	.30	438	95%
Fix D+A+E+B+C+H+G+F	18	1	19	.015	.023	443	96%
Fix D+A+E+B+C+H+G+F+I	18	1	19	.015	.023	443	96%
Fix all and raise D, B, E, and F	9	1	10	.008	.006	452	98%
Fix all and raise D, B, E, F, A, C, I, G	7	1	8	.006	.004	454	98%
Fix all and raise all	1	1	2	.001	.002	460	99%

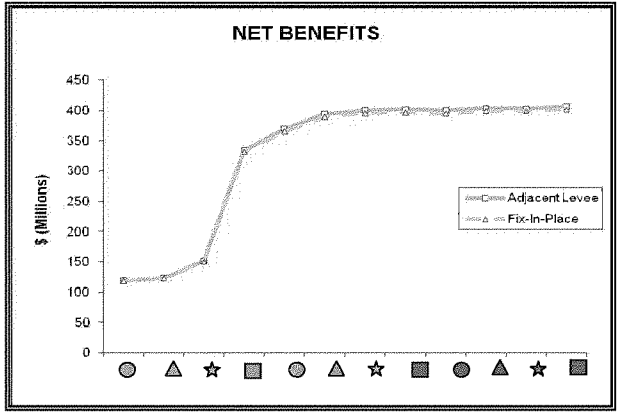
Table 7B-2
Natomas @Risk Model -- Net Benefit and Benefit-to-Cost Analyses
In $Millions, October 2010 Prices, 4.375% Interest Rate, 50-yr Period of Analysis

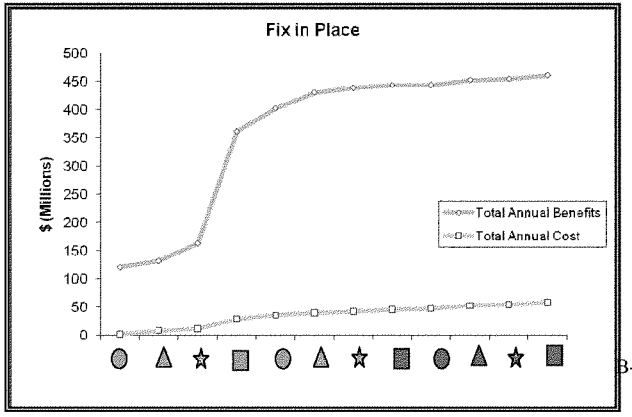
GROUPS	ALTERNATIVE TYPE	EXPECTED ANNUAL DAMAGES	ANNUAL BENEFITS	ANNUAL COST	NET BENEFITS	B/C RATIO
WITHOUT-PROJECT	-	462	-	-	-	-
FIX D	Adjacent Levee	341	121	2.0	119	61.7
	Fix-in-Place			2.0	119	61.7
FIX D, A	Adjacent Levee	330	132	8.3	124	15.9
	Fix-in-Place			8.6	123	15.4
FIX D, A, E	Adjacent Levee	299	163	11.5	152	14.2
	Fix-in-Place			12.0	151	13.6
FIX D, A, E, B	Adjacent Levee	101	361	26.7	334	13.5
	Fix-in-Place			29.2	332	12.4
FIX D, A, E, B, C	Adjacent Levee	60	402	31.7	370	12.7
	Fix-in-Place			36.0	366	11.2
FIX D, A, E, B, C, H	Adjacent Levee	32	430	35.6	394	12.1
	Fix-in-Place			39.9	390	10.8
FIX D, A, E, B, C, H, G	Adjacent Levee	24	438	37.8	400	11.6
	Fix-in-Place			42.4	396	10.3
FIX D, A, E, B, C, H, G, F	Adjacent Levee	19	443	41.3	402	10.7
	Fix-in-Place			46.1	397	9.6
FIX D, A, E, B, C, H, G, F, I	Adjacent Levee	19	443	42.7	400	10.4
	Fix-in-Place			47.6	395	9.3
FIX ALL + RAISE D, B, E, F	Adjacent Levee	10	452	48.1	404	9.4
	Fix-in-Place			52.7	399	8.6
FIX ALL + RAISE D, B, E-2, F, G, I, A, C	Adjacent Levee	8	454	51.1	403	8.9
	Fix-in-Place			54.6	399	8.3
FIX ALL + RAISE ALL	Adjacent Levee	2	460	53.5	407	8.6
	Fix-in-Place			58.1	402	7.9

1124

Figures 7B-2, 7B-3, and 7B-4







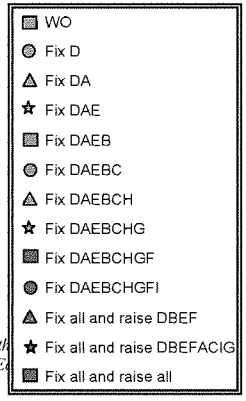


Table 7B-3
Natomas @Risk Model -- Net Benefit and Benefit-to-Cost Analyses (In $Millions and Oct 2010 Price Level)

Measures	Alternative	Expected Annual Damages		Benefits		Annual Cost	Net Benefits	
		HEC-FDA	@RISK RUNS	HEC-FDA	@RISK RUNS		HEC-FDA	@RISK RUNS
Without-Project	Adjacent Levee	1363	462	--	--	--	--	--
	Fix-in-Place					--	--	--
Fix D	Adjacent Levee	1031	341	332	121	2	330	119
	Fix-in-Place					2	330	119
Fix D+A	Adjacent Levee	1025	330	338	132	8	330	124
	Fix-in-Place					9	329	123
Fix D+A+E	Adjacent Levee	710	299	653	163	11	642	152
	Fix-in-Place					12	641	151
Fix D+A+E+B	Adjacent Levee	226	101	1137	361	27	1110	334
	Fix-in-Place					29	1108	332
Fix D+A+E+B+C	Adjacent Levee	196	60	1167	402	32	1135	370
	Fix-in-Place					36	1131	366
Fix D+A+E+B+C+H	Adjacent Levee	122	32	1241	430	36	1205	394
	Fix-in-Place					40	1201	390
Fix D+A+E+B+C+H+G	Adjacent Levee	109	24	1254	438	38	1216	400
	Fix-in-Place					42	1212	396
Fix D+A+E+B+C+H+G+F	Adjacent Levee	65	19	1298	443	41	1257	402
	Fix-in-Place					46	1252	397
Fix D+A+E+B+C+H+G+F+I	Adjacent Levee	65	19	1298	443	43	1255	400
	Fix-in-Place					48	1250	395
Fix All + Raise D,B,E,& F	Adjacent Levee	30	10	1333	452	48	1285	404
	Fix-in-Place					53	1280	399
Fix All + Raise D,B,E,F, A,C,I,& G	Adjacent Levee	11	8	1352	454	51	1301	403
	Fix-in-Place					55	1297	399
Fix All + Raise All	Adjacent Levee	6	2	1357	460	53	1304	407
	Fix-in-Place					58	1299	402

7.6 CONCLUSION

As displayed in Table 7B-3, without-project EAD is reduced from $1.363 billion to approximately $462 million. The table also shows a comparison of the benefits and net benefits for each levee reach improvement and for both the adjacent levee and fix-in-place alternatives. Based on the set of assumptions explained in the previous sections, the results of this analysis using the @Risk model indicate that even with the adjustments to EAD and benefits, the plan formulation, from a net benefits perspective, remains the same. Net benefits continue to increase until the last improvements (fix and raise all).

The Natomas Basin is considered a "closed" ring levee system, whereby flood protection is only as good as its weakest link. Table 7B-4 is a condensed version of Table 7B-3. Table 7B-4 displays the risk remaining after improvements to groups of specific reaches. The purpose of the table is to highlight the notion that the Natomas Basin is a "closed" ring levee system as well as to show the reduction in risk with each levee reach improvement in terms of the chance of flooding and consequences of flooding.

Table 7B-4
Residual Risk and Unit of Measurement
October 2010 Price Level

Unit of Measurement	Improvement	Expected Annual Damages (EAD) In $Millions	Residual Damages In $Millions	Annual Exceedance Probability (AEP)
N/A	No fixes	462	--	.21
3 of 9 reaches	Fix D, A, E	--	299	.12
6 of 9 reaches	Fix D, A, E, B, C, H	--	32	.015
COMPLETE SYSTEM	Fix All Reaches	--	19	.015
COMPLETE SYSTEM	Fix all and raise some	--	10	.008
COMPLETE SYSTEM	Fix all and raise some	--	8	.006
COMPLETE SYSTEM	Fix all and raise all	--	2	.001

CHAPTER 8
RESIDUAL RISK ASSOCIATED WITH FUTURE DEVELOPMENT

Development within the Natomas Basin is projected to increase significantly over the next several decades. Development projections for the Natomas Basin have been estimated by the Sacramento Area Council of Governments (SACOG), which is an association of local governments in the Sacramento region. SACOG is comprised of six counties (El Dorado, Placer, Sacramento, Sutter, Yolo, and Yuba) and 22 cities, and provides transportation planning and funding for the region. Additional information about SACOG and data regarding its future development projections used for this analysis can be found on its website, www.sacog.org.

Once the level of flood protection within the Natomas Basin is increased and the current building moratorium is lifted, an increase in residual risk is expected as the Natomas Basin is developed over the next several decades. This residual risk, described in terms of the additional population at risk, the additional value of property at risk, and the additional structure and content damages incurred from a single flood event, is estimated based on SACOG's projection of the number of additional residential units for the year 2035.

In its analysis, SACOG uses geographical units called traffic analysis zones (TAZ) to aggregate the number of residential units forecasted to be built in the future in a particular TAZ. Using simplifying assumptions, the Sacramento District's Economics & Risk Analysis Section then adjusted SACOG's estimates of additional residential units to derive an estimate of the number of additional residential structures. For example, a single SFR unit was converted to a single SFR structure by dividing by one; an MFR (2-4 units as designated by SACOG) was converted to number of structures by dividing the number of units by four; and an MFR (5+ units as designated by SACOG) was converted to number of structures by dividing by 150.

Table 8-1 lists the TAZs considered for this analysis in order to assess residual risk due to future development in the Natomas Basin. The table displays the TAZ, SACOG's estimate of the number of additional units per residential type (SFR, MFR) for the year 2035, and USACE's estimate of the number of additional structures by residential type for the year 2035. It is estimated that more than 16,000 additional residential structures will be built within the Natomas Basin by the year 2035.

Table 8-1
Natomas Basin
Estimate of Additional Residential Structures Associated with Future Development

TRAFFIC ANALYSIS ZONE (TAZ)	SACOG ESTIMATE OF ADDITIONAL RESIDENTIAL UNITS (2035)			USACE ESTIMATE OF ADDITIONAL RESIDENTIAL STRUCTURES (2035) BASED ON SACOG'S UNIT PROJECTIONS		
	SFR	MFR (2-4 units)	MFR (5+ units)	SFR	MFR (2-4 units)	MFR (5+ units)
247	50	9	267	50	2	2
248	72	18	533	72	5	4
249	43	4	3	43	1	0
251	5	1	58	5	0	0
252	37	7	299	31	2	2
258	389	153	512	389	38	3
259	1,085	453	826	1,085	113	6
264	176	22	73	176	5	0
265	778	28	142	778	7	1
266	354	84	70	354	21	0
267	120	2	1	120	0	0
270	17	0	0	17	0	0
271	1,505	0	0	1,505	0	0
278	1,639	0	0	1,639	0	0
279	1,775	117	444	1,775	29	3
280	460	30	115	460	8	1
283	13	0	0	13	0	0
284	166	96	88	166	24	1
287	1,184	83	318	1,184	21	2
1104	264	110	492	264	28	3
1105	87	117	523	87	29	3
1237	35	25	21	35	6	0
1320	410	263	221	410	66	1
1323	810	247	832	810	62	6
1324	68	44	147	68	11	1
1403	495	263	330	495	66	2
1404	564	37	141	564	9	1
1431	3,209	125	834	3,209	31	6
TOTAL	**15,803**	**2,338**	**7,290**	**15,803**	**584**	**47**

Figure 8-1 shows the traffic analysis zones (TAZ) within the Natomas Basin developed by the Sacramento Area Council of Governments (SACOG).

Figure 8-1 SACOG TAZs used to estimate future development

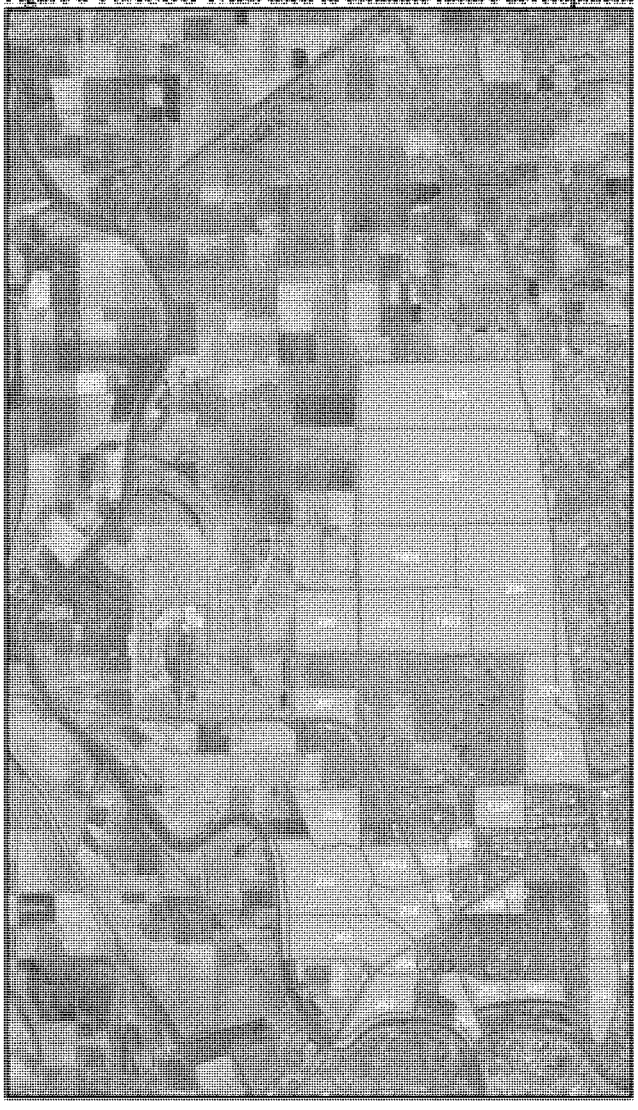


Table 8-2 below describes the residual risk associated with future development in the Natomas Basin for several project alternatives. The increase in the number of people at risk was calculated by multiplying the average number of people per residential unit in the Sacramento area obtained from the U.S. Census Bureau to the number of additional residential units projected for the Natomas Basin in the year 2035.

The increase in the value of damageable property at risk and potential flooding damages from specific frequency events were estimated using the following methodology. Each additional future structure was assigned to an existing structure by geographic location (TAZ). All of the characteristics (structure value, foundation height, etc.) associated with this existing structure were given to the future structure by using the same structure ID (assessor parcel number, APN) in HEC-FDA. Finally, each future structure was assigned to the same grid cell number (and in effect the same depths of flooding for each frequency event) as its associated existing structure, allowing for the computation of flood damages for the future structure within HEC-FDA. In all cases, more than one future structure was tied to an existing structure.

Table 8-2
Increased Residual Risk Associated with Future Development in the Natomas Basin
Population at Risk, Property at Risk, Single-Event Damages

MEASURE	INCREASE IN NUMBER OF PEOPLE AT RISK	INCREASE IN VALUE OF PROPERTY AT RISK (OCT. 2010, $MIL)	INCREASE IN FLOOD DAMAGES (PER FREQUENCY EVENT) OCT. 2010, $MILLIONS		
			100yr	200yr	500yr
Fix All + Raise D,B,E,& F	42,238	5,841	0	3,310	3,312
Fix All + Raise D,B,E,F, A,C,I,& G	42,238	5,841	0	871	3,312
Fix All + Raise All	42,238	5,841	0	871	3,312

Improving the levees in the Natomas Basin and providing flood protection sufficient enough to satisfy FEMA requirements and thereby lifting the current building moratorium would most likely result in further development in the Basin per the General Plans of the local governments. Table 8-2 displays an estimate of the increase risk by group associated with future development within the Basin should specific flood events occur. Future development would likely occur if the 90% conditional non-exceedance probability (CNP) of the 1% chance event is met. Based on the current HEC-FDA performance statistics results, this CNP requirement would be met with levee raises.

CHAPTER 9
FUTURE ECONOMIC ANALYSES

9.1 NATIONAL ECONOMIC DEVELOPMENT (NED) CATEGORIES

This NPACR economic analysis included only the main NED categories for which the majority of damages and benefits usually can be attributed to in a typical USACE FRM economic evaluation[26]. After careful and deliberate consideration of the ambitious schedule outlined for this NPACR, it was determined that the most prudent way forward was to focus the economic analysis on the major damage and benefit categories.

It is recognized, however, that in order to paint a complete picture of the flooding problem in the Natomas Basin, the economic analyses should consider additional NED damage and benefit categories. Many of these analyses, in fact, are already underway. The intent is to include these additional categories in upcoming American River Common Features studies (e.g., GRR). Some of the categories that will be included are described briefly in the following sub-sections.

9.1.1 Emergency Costs

In March of 2009 an expert-opinion elicitation panel comprised of professionals having significant relevant experience in the field of emergency response was convened in Sacramento, California. The main purpose of this expert-opinion elicitation was to develop estimates of economic costs associated with 18 damage categories not usually quantified in USACE FRM studies. These damage categories are listed in Table 9-1 below.

[26] Estimates based on other Division studies that did include other additional categories suggest that the major damage and benefit categories (structures and contents) can comprise between 80 to 95 percent of all damages and benefits.

Table 9-1
Emergency Costs and Relief Categories

GROUP ONE: EVACUATION ACTIVITIES	EVACUATION
	Subsistence
	Reoccupation
GROUP TWO: DEBRIS REMOVAL AND CLEAN-UP	Debris Activities
GROUP THREE: PUBLIC SERVICES PATRONIZED	Education
	Public Agencies
	Library and Indoor Recreation Facilities
	Medical
GROUP FOUR: PUBLIC SERVICE PRODUCED	Police
	Incarceration
	Fire
	Legislative
	Judicial
GROUP FIVE: PUBLIC UTILITIES	Telecommunications
	Electricity
	Gas
	Water Utility
	Wastewater Treatment/Sewer

A final draft report entitled, *Emergency Cost and Relief Methodology and Concept Paper*, was completed in January of 2010. This paper lays out in detail the expert-opinion elicitation process as it occurred in March of 2009, the damage categories considered, the general methodology used to evaluate emergency costs and relief associated with flooding, the specific methodologies

used to determine flood-related emergency costs associated with each loss/damage category, and the results of the analysis.

The next steps will be to use the results obtained from the expert-opinion elicitation to quantify additional NED losses/damages and benefits by category (as appropriate), with the intention to inform decision makers, through plan formulation and a more comprehensive economic analysis, as to what is the plan that maximizes net benefits from a federal perspective (i.e., the NED plan). Currently, work is being completed to format the result data in order to be able to apply it within the confines of the HEC-FDA economic model framework. This work entails developing category-specific depth-percent damage curves that can be imported directly into HEC-FDA.

9.1.2 Traffic Disruption Costs

Traffic-related costs associated with detours and extra time traveled experienced by motorists due to potential flooding in the Natomas Basin will also be evaluated in upcoming economic analysis under the GRR.

9.1.3 Agricultural Damages

Future economic analysis will consider agricultural losses within the Natomas Basin impact area, which does have measurable, but relatively insignificant, agricultural production. Major crop types grown within the Basin include rice and tomatoes. Each of these crop types is grown during the year (April to October) when flooding is least likely to occur. However, there is the potential for other agricultural-related losses, such as those related to land clean-up and restoration, should flooding occur.

9.1.4 Airline-Associated Delay Losses/Rail Freight Delay Losses

Losses associated with airline rerouting and delays and rail freight rerouting and delays within the Natomas Basin impact area will also be estimated and be incorporated into future economic analyses. It is expected that the data obtained from these analyses will be applied within the HEC-FDA model to compute EAD.

9.2 REGIONAL ECONOMIC DEVELOPMENT (RED) ANALYSIS

Regional economic development (RED) analysis will be conducted as part of the GRR and will include the Natomas Basin impact area as well as the other main Basins (American River North and American River South) within the American River Common Features study area. The RED analysis will evaluate income and employment effects within the study area from implementation of either the NED plan or Locally-Preferred Plan (LPP).

The RED analysis will quantify the impacts each alternative has on the local economy by using a regional economic impact model based on the principles of Input-Output (I-O) analysis. The direct, indirect, and induced economic effects of the NED and LPP plans will be evaluated using standard metrics often used in I-O analysis, including industry output, value added, and employment. More details about RED analysis in general and the RED analysis specifically

conducted for the American River Common Features project will be provided in the upcoming GRR.

9.3 OTHER SOCIAL EFFECTS (OSE) ANALYSIS

The Other Social Effects (OSE) account describes the potential effects proposed project alternatives would have on social aspects not explicitly addressed by the NED and RED accounts, such as community impacts (e.g., growth and cohesion), public health and safety impacts, displacement (of populations, businesses, agriculture, recreation, etc.) impacts, and the potential loss of life. The OSE analysis will be completed as part of the upcoming GRR.

CHAPTER 10
REFERENCES

1. Economic Reevaluation Report, American River Watershed Project, CA, Folsom Dam Modification and Folsom Dam Raise Projects. U.S. Army Corps of Engineers, Sacramento District, February 2008.
2. General Reevaluation Report, American River Watershed Common Features Project, Economic Appendix. U.S. Army Corps of Engineers, Sacramento District, January 2009.
3. American River Watershed Common Features Project, Natomas Post-Authorization Change, Draft Hydraulic Appendix. U.S. Army Corps of Engineers, Sacramento District, January 2010.

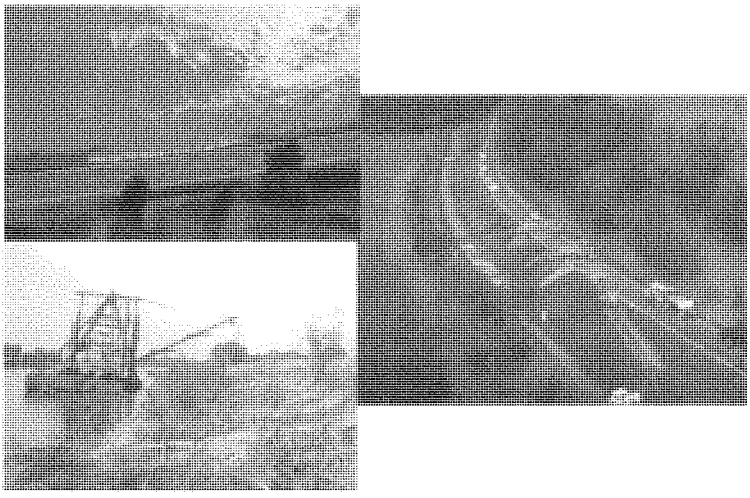
Post-Authorization Change Report

American River Watershed

Common Features Project

Natomas Basin

Sacramento and Sutter Counties, California



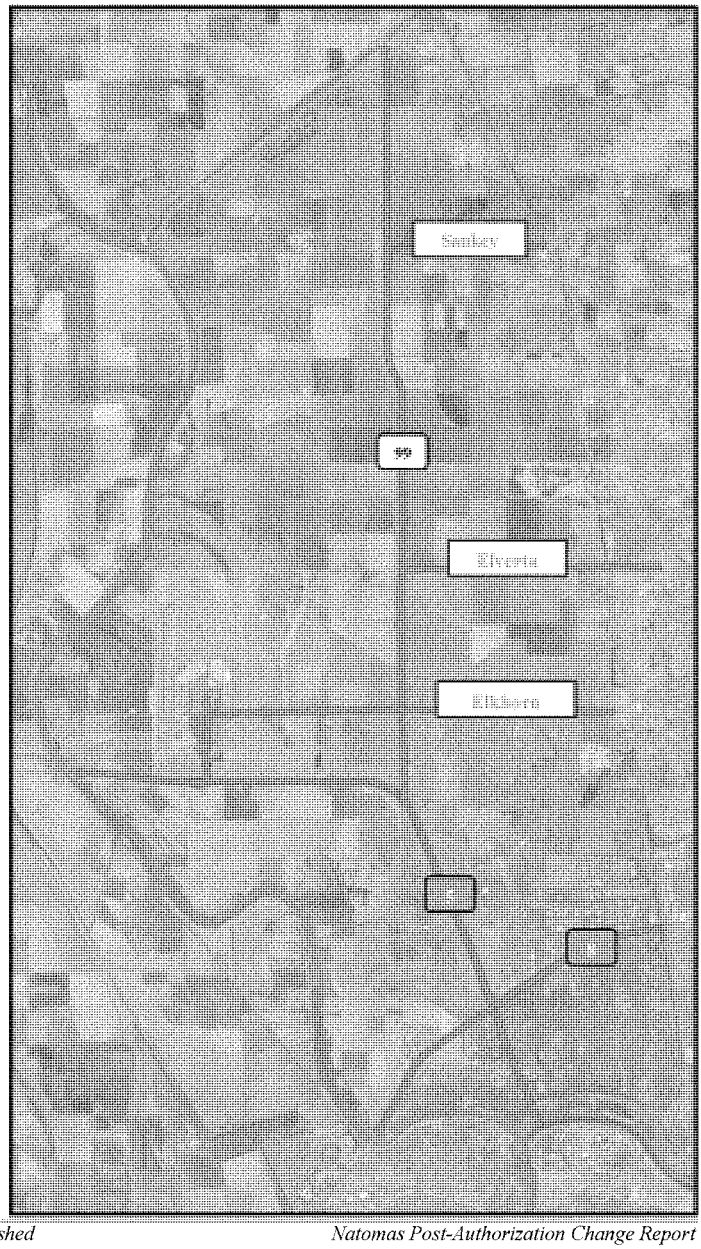
SAFCA
Sacramento
Area Flood
Control
Agency

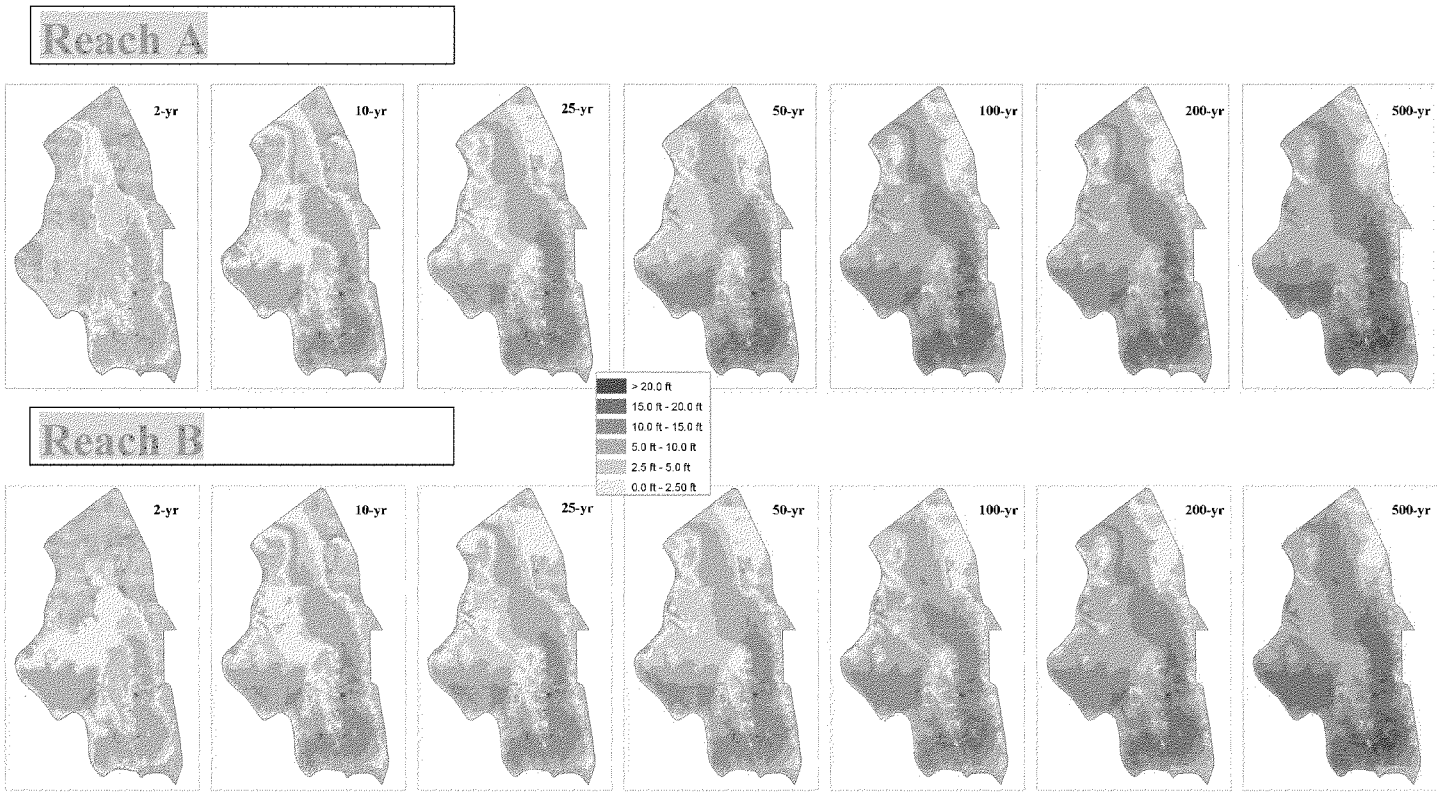
US Army Corps
of Engineers ®
Sacramento District

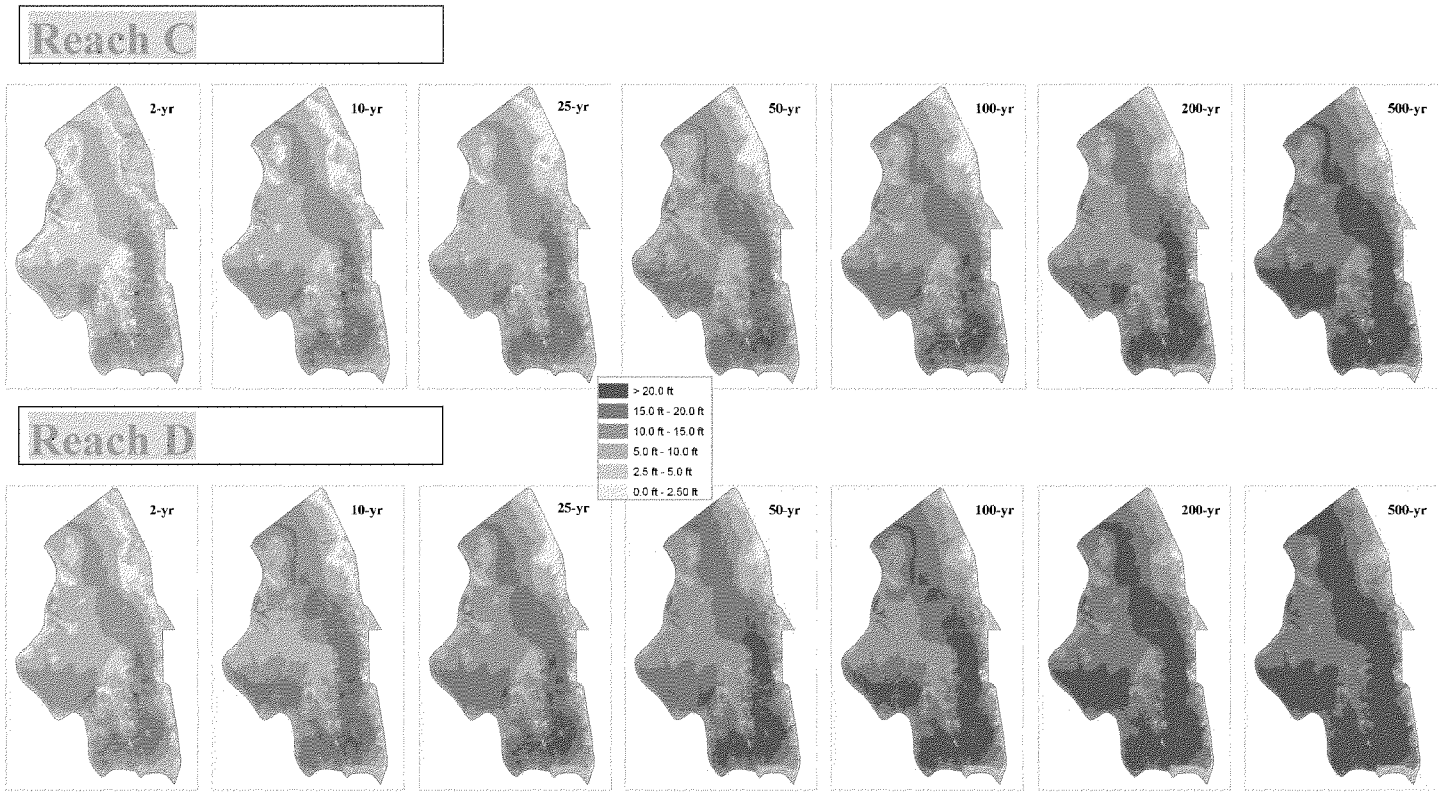
ENCLOSURES TO APPENDIX H

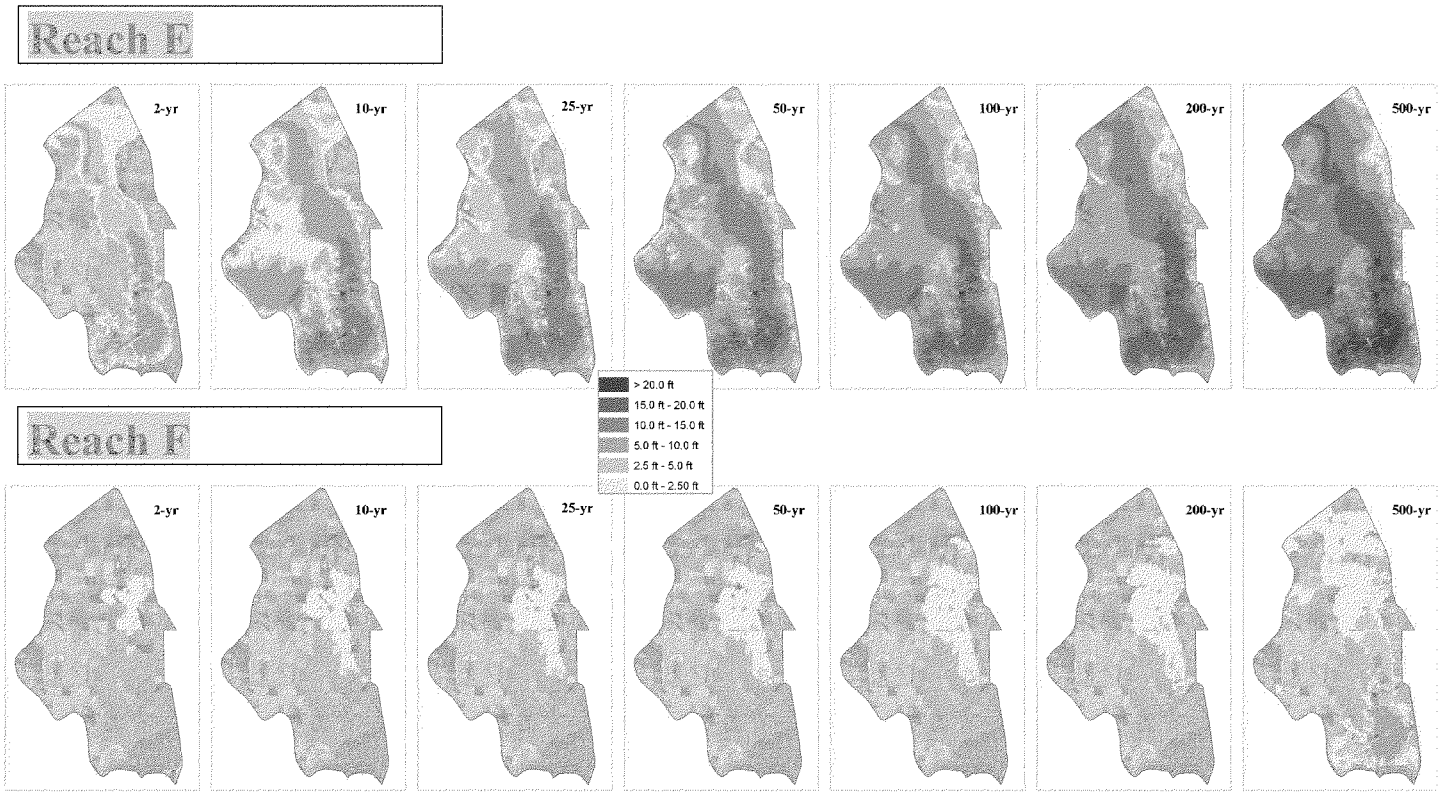
October 2010

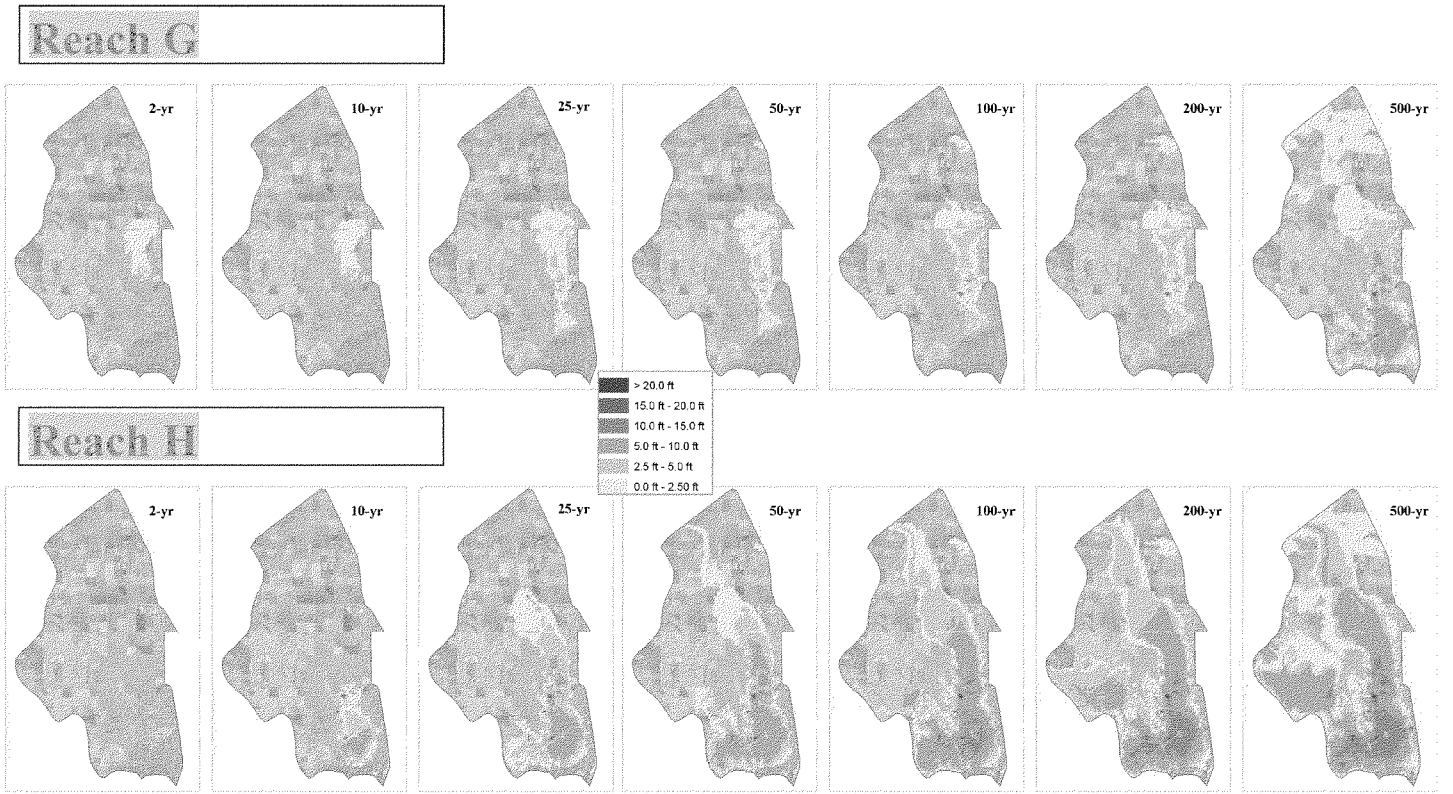
ENCLOSURE 1
FLOODPLAIN PLATES



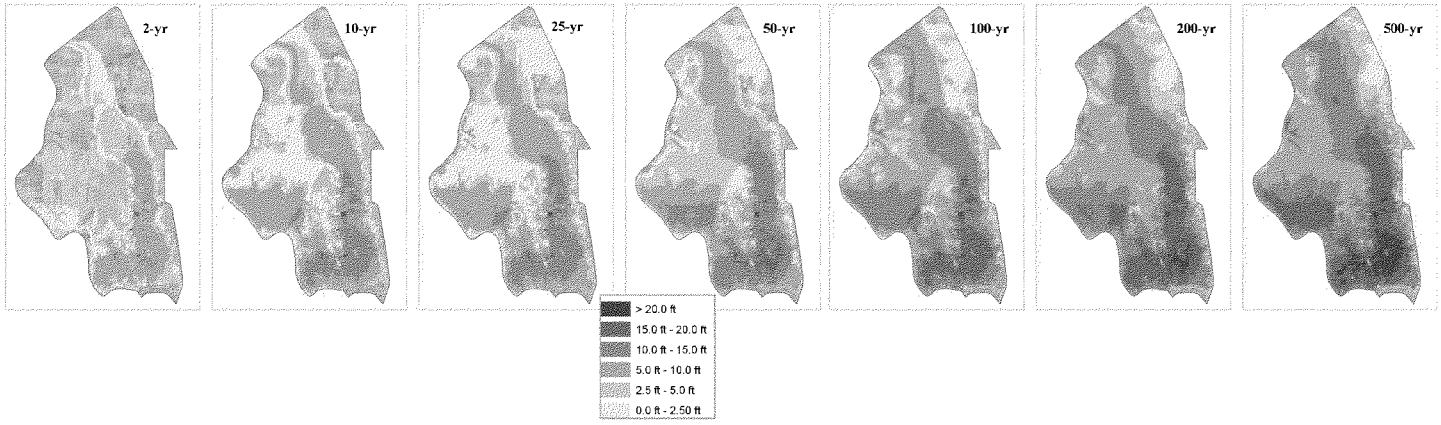

Reach A
2-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr
> 20.0 ft
15.0 ft - 20.0 ft
10.0 ft - 15.0 ft
5.0 ft - 10.0 ft
2.5 ft - 5.0 ft
0.0 ft - 2.50 ft
Reach B
2-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr


Reach C
2-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr
> 20.0 ft
15.0 ft - 20.0 ft
10.0 ft - 15.0 ft
5.0 ft - 10.0 ft
2.5 ft - 5.0 ft
0.0 ft - 2.50 ft
Reach D
2-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr


Reach E
2-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr
> 20.0 ft
15.0 ft - 20.0 ft
10.0 ft - 15.0 ft
5.0 ft - 10.0 ft
2.5 ft - 5.0 ft
0.0 ft - 2.50 ft
Reach F
2-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr

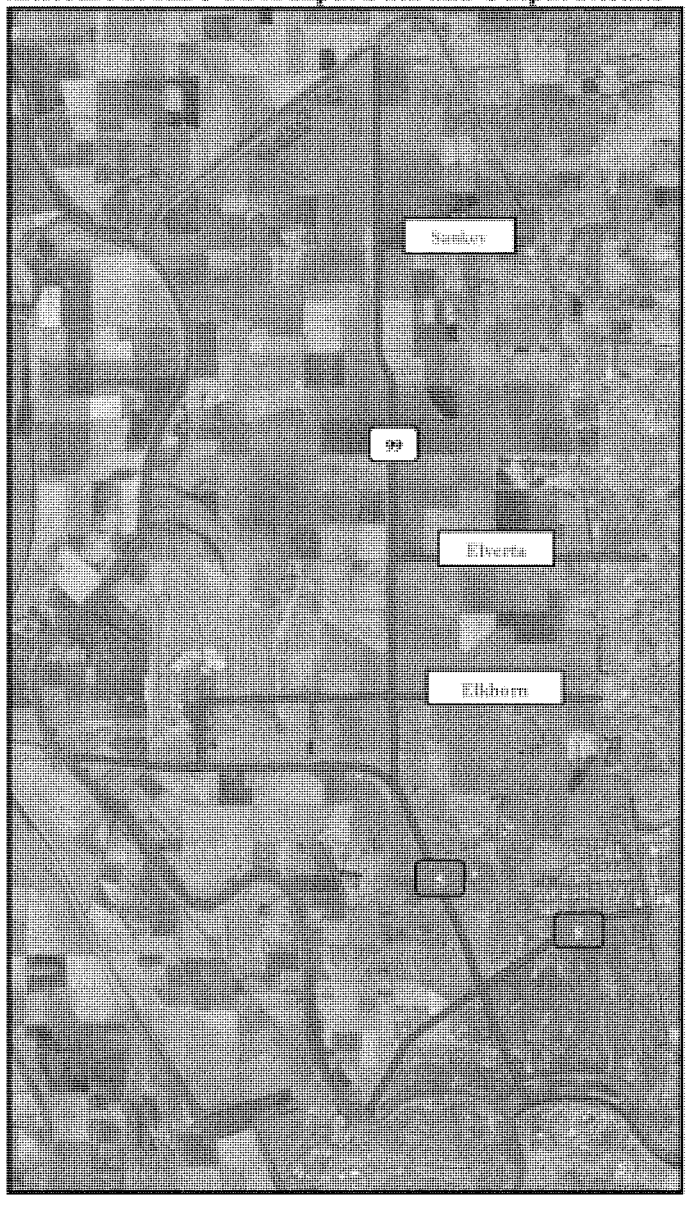

Reach G
2-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr
> 20.0 ft
15.0 ft - 20.0 ft
10.0 ft - 15.0 ft
5.0 ft - 10.0 ft
2.5 ft - 5.0 ft
0.0 ft - 2.50 ft
Reach H
2-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr

Reach 1


2-yr
10-yr
25-yr
50-yr
100-yr
200-yr
500-yr
> 20.0 ft
15.0 ft - 20.0 ft
10.0 ft - 15.0 ft
5.0 ft - 10.0 ft
2.5 ft - 5.0 ft
0.0 ft - 2.50 ft

1144

Enclosure 2: HEC-FDA Input Data and Output Results



HEC-FDA WITHOUT-PROJECT FREQUENCY-DISCHARGE-STAGE CURVES

Sac R, RM 62.7519 (Natomas-Reach A)					
Without Project					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	N/A	N/A	N/A	11.02	0.7
2yr = .5	N/A	N/A	N/A	25.47	0.7
10yr = .1	N/A	N/A	N/A	30.9	0.7
25yr = .04	N/A	N/A	N/A	32.93	0.7
50yr = .02	N/A	N/A	N/A	33.48	0.7
100yr = .01	N/A	N/A	N/A	34.16	0.8
200 yr = .005	N/A	N/A	N/A	36.23	0.8
500yr = .002	N/A	N/A	N/A	39.35	0.8
Equivalent Record Length = 71					

Sac R, RM 69.2511 (Natomas-Reach B)					
Without Project					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	122,600	22,733	0	16.87	0.7
2yr = .5	186,545	55,415	6,200	30.07	0.7
10yr = .1	337,227	86,567	9,310	33.65	0.7
25yr = .04	455,133	93,308	12,800	35.88	0.8
50yr = .02	479,646	97,924	13,200	36.56	0.8
100yr = .01	551,819	104,079	14,200	37.43	0.8
200 yr = .005	690,355	110,145	14,300	38.91	0.8
500yr = .002	917,069	118,164	16,300	40.26	0.8
Equivalent Record Length = 71					

Sac R, RM 76.7497 (Natomas-Reach C)					
Without Project					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	122,600	22,525	0	20.16	0.7
2yr = .5	186,545	55,625	6,200	33.36	0.7
10yr = .1	337,227	86,592	9,310	38.3	0.7
25yr = .04	455,133	93,422	12,800	40.25	0.8
50yr = .02	479,646	98,050	13,200	41.04	0.8
100yr = .01	551,819	104,259	14,200	42.05	0.8
200 yr = .005	690,355	113,524	14,300	43.46	0.8
500yr = .002	917,069	133,795	16,300	44.5	0.8
Equivalent Record Length = 71					

CC, RM 2.63 (Natomas-Reach D)					
Without Project					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	N/A	N/A	N/A	20.27	0.8
2yr = .5	N/A	N/A	N/A	33.47	0.8
10yr = .1	N/A	N/A	N/A	38.47	0.8
25yr = .04	N/A	N/A	N/A	40.41	0.9
50yr = .02	N/A	N/A	N/A	41.21	0.9
100yr = .01	N/A	N/A	N/A	42.22	0.9
200 yr = .005	N/A	N/A	N/A	43.66	0.9
500yr = .002	N/A	N/A	N/A	44.68	0.9
Equivalent Record Length = 25					

NEMDEC , Storage Area Conn. (Reach E)					
Without Project					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	N/A	N/A	N/A	20.27	0.8
2yr = .5	N/A	N/A	N/A	33.47	0.8
10yr = .1	N/A	N/A	N/A	38.46	0.8
25yr = .04	N/A	N/A	N/A	40.4	0.9
50yr = .02	N/A	N/A	N/A	41.23	0.9
100yr = .01	N/A	N/A	N/A	42.23	0.9
200 yr = .005	N/A	N/A	N/A	43.57	0.9
500yr = .002	N/A	N/A	N/A	44.84	0.9
Equivalent Record Length = 25					

NEMDC, RM 12.624 (Natomas-Reach F)					
Without Project					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	N/A	N/A	N/A	26.03	0.9
2yr = .5	N/A	N/A	N/A	33.98	0.9
10yr = .1	N/A	N/A	N/A	35.36	0.7
25yr = .04	N/A	N/A	N/A	36.89	0.7
50yr = .02	N/A	N/A	N/A	37.73	0.7
100yr = .01	N/A	N/A	N/A	38.53	0.7
200 yr = .005	N/A	N/A	N/A	39.26	0.7
500yr = .002	N/A	N/A	N/A	40.98	0.7
Equivalent Record Length = 25					

NEMDC, RM 8.589 (Natomas-Reach G)					
Without Project					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	N/A	N/A	N/A	25.57	0.9
2yr = .5	N/A	N/A	N/A	32.2	0.9
10yr = .1	N/A	N/A	N/A	35.32	0.7
25yr = .04	N/A	N/A	N/A	36.9	0.7
50yr = .02	N/A	N/A	N/A	37.74	0.7
100yr = .01	N/A	N/A	N/A	38.54	0.7
200 yr = .005	N/A	N/A	N/A	39.27	0.7
500yr = .002	N/A	N/A	N/A	40.99	0.7
Equivalent Record Length = 25					

NEMDC, RM 4.319 (Natomas-Reach H)					
Without Project					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	N/A	N/A	N/A	25.25	0.7
2yr = .5	N/A	N/A	N/A	29.53	0.7
10yr = .1	N/A	N/A	N/A	32.46	0.8
25yr = .04	N/A	N/A	N/A	34.6	0.8
50yr = .02	N/A	N/A	N/A	35.86	0.8
100yr = .01	N/A	N/A	N/A	37.46	0.9
200 yr = .005	N/A	N/A	N/A	38.92	0.8
500yr = .002	N/A	N/A	N/A	44.4	0.7
Equivalent Record Length = 25					

NEMDC, RM 1 (Natomas-Reach I)					
Without Project					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	9,600	9,600	20	10.44	0.7
2yr = .5	29,751	27,541	20	24.89	0.7
10yr = .1	77,300	75,446	130	30.77	0.7
25yr = .04	124,073	116,470	320	33.94	0.7
50yr = .02	129,325	116,982	350	34.44	0.7
100yr = .01	131,637	117,000	550	35.05	0.8
200 yr = .005	163,502	147,641	20,000	36.94	0.8
500yr = .002	573,257	249,831	23,700	40.67	0.8
Equivalent Record Length = 87					

HEC-FDA WITH-PROJECT FREQUENCY-DISCHARGE-STAGE CURVES

Sac R, RM 62.7519 (Natomas-Reach A)					
With Project (with selected levee raise SLR)					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	NA	NA	NA	11.02	.0.7
2yr = .5	NA	NA	NA	25.47	0.7
10yr = .1	NA	NA	NA	30.90	0.7
25yr = .04	NA	NA	NA	32.93	0.7
50yr = .02	NA	NA	NA	33.48	0.7
100yr = .01	NA	NA	NA	34.16	0.8
200 yr = .005	NA	NA	NA	36.23	0.8
500yr = .002	NA	NA	NA	39.35	0.8
Equivalent Record Length = 71					

Sac R, RM 69.2511 (Natomas-Reach B)					
With Project (with selected levee raise SLR)					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	122,600	22,733	6,200	19.32	0.7
2yr = .5	186,545	55,415	6,200	32.52	0.7
10yr = .1	337,227	86,606	9,310	37.21	0.7
25yr = .04	455,133	94,165	12,800	39.33	0.8
50yr = .02	479,646	98,470	13,200	40.04	0.8
100yr = .01	551,819	104,254	14,200	40.95	0.8
200 yr = .005	690,355	108,300	14,300	42.38	0.8
500yr = .002	917,069	113,649	16,300	43.16	0.8
Equivalent Record Length = 71					

Sac R, RM 76.7497 (Natomas-Reach C)					
With Project (with selected levee raise SLR)					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	122,600	22,384	6,200	19.3	0.7
2yr = .5	186,545	55,446	6,200	32.5	0.7
10yr = .1	34	86,628	9,310	37.2	0.8
25yr = .04	455,133	94,365	12,800	39.3	0.8
50yr = .02	479,646	98,526	13,200	40.0	0.8
100yr = .01	551,819	104,395	14,200	41.0	0.8
200 yr = .005	690,355	113,126	14,300	42.4	0.8
500yr = .002	917,069	131,173	16,300	43.2	0.8
Equivalent Record Length = 71					
CC, RM 2.63 (Natomas-Reach D)					
With Project (with selected levee raise SLR)					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	NA	NA	NA	20.27	0.8
2yr = .5	NA	NA	NA	33.47	0.8
10yr = .1	NA	NA	NA	38.47	0.8
25yr = .04	NA	NA	NA	40.55	0.9
50yr = .02	NA	NA	NA	41.41	0.9
100yr = .01	NA	NA	NA	42.31	0.9
200 yr = .005	NA	NA	NA	43.3	0.8
500yr = .002	NA	NA	NA	44.9	0.7
Equivalent Record Length = 25					

NEMDEC , Storage Area Conn. (Reach E)					
With Project (with selected levee raise SLR)					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	NA	NA	NA	20.27	0.8
2yr = .5	NA	NA	NA	33.47	0.8
10yr = .1	NA	NA	NA	38.47	0.8
25yr = .04	NA	NA	NA	40.55	0.9
50yr = .02	NA	NA	NA	41.41	0.9
100yr = .01	NA	NA	NA	42.31	0.9
200 yr = .005	NA	NA	NA	43.83	0.8
500yr = .002	NA	NA	NA	44.90	0.7
Equivalent Record Length = 25					

NEMDC, RM 12.624 (Natomas-Reach F)					
With Project (with selected levee raise SLR)					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	NA	NA	NA	26.03	0.9
2yr = .5	NA	NA	NA	33.94	0.9
10yr = .1	NA	NA	NA	35.24	0.7
25yr = .04	NA	NA	NA	36.8	0.7
50yr = .02	NA	NA	NA	37.66	0.7
100yr = .01	NA	NA	NA	38.53	0.7
200 yr = .005	NA	NA	NA	39.32	0.7
500yr = .002	NA	NA	NA	42.59	0.7
Equivalent Record Length = 25					

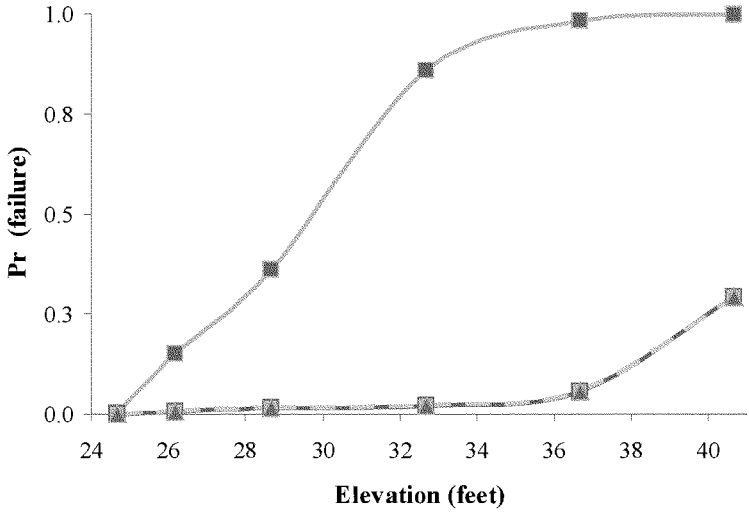
NEMDC, RM 8.589 (Natomas-Reach G)					
With Project (with selected levee raise SLR)					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	NA	NA	NA	25.57	0.9
2yr = .5	NA	NA	NA	31.93	0.9
10yr = .1	NA	NA	NA	35.18	0.7
25yr = .04	NA	NA	NA	36.8	0.7
50yr = .02	NA	NA	NA	37.66	0.7
100yr = .01	NA	NA	NA	38.54	0.7
200 yr = .005	NA	NA	NA	39.33	0.7
500yr = .002	NA	NA	NA	42.60	0.7
Equivalent Record Length = 25					

NEMDC, RM 4.319 (Natomas-Reach H)					
With Project (with selected levee raise SLR)					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	NA	NA	NA	25.25	0.7
2yr = .5	NA	NA	NA	29.51	0.7
10yr = .1	NA	NA	NA	32.46	0.8
25yr = .04	NA	NA	NA	34.59	0.8
50yr = .02	NA	NA	NA	35.79	0.8
100yr = .01	NA	NA	NA	37.46	0.9
200 yr = .005	NA	NA	NA	38.97	0.8
500yr = .002	NA	NA	NA	43.97	0.7
Equivalent Record Length = 25					

NEMDC, RM 1 (Natomas-Reach I)					
With Project (with selected levee raise SLR)					
Frequency	**Inflow**	**Outflow**	**Standard Deviation (I-O)**	**Stage (ft) NAVD '88**	**Standard Deviation (Stage)**
1yr = .999	9600	9600	20	10.44	0.7
2yr = .5	29751	27525	20	24.89	0.7
10yr = .1	77300	75444	130	30.77	0.7
25yr = .04	124073	116562	320	34.03	0.7
50yr = .02	129325	119327	350	34.52	0.7
100yr = .01	131637	119400	550	35.08	0.8
200 yr = .005	163502	166125	20000	37.64	0.8
500yr = .002	573257	313999	23700	43.30	0.8
Equivalent Record Length = 87					

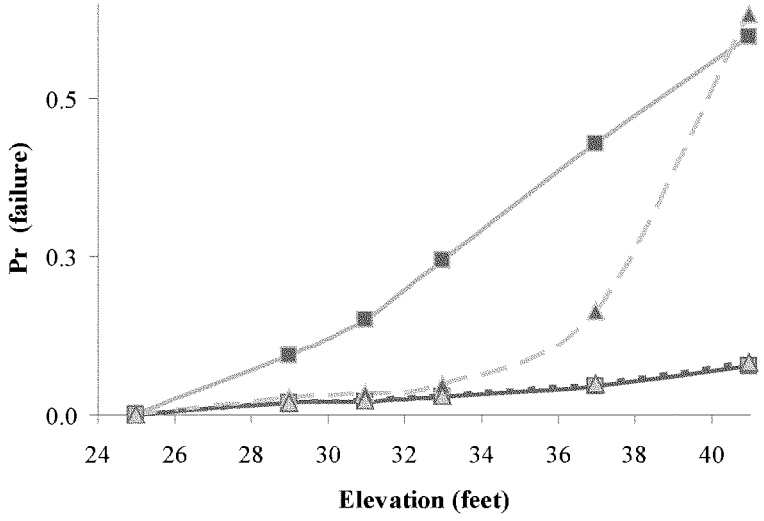
WITHOUT-PROJECT & WITH-PROJECT GRU CURVES

Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve



Elevation	Probability of Failure		
	WO	W-SC B C W	W-C B C W
24.67	0.00178	0.00000	0.00000
26.17	0.15000	0.00584	0.00584
28.67	0.35859	0.01407	0.01407
32.67	0.85814	0.02010	0.02010
36.67	0.98247	0.05635	0.05635
40.67	0.99836	0.29149	0.29149

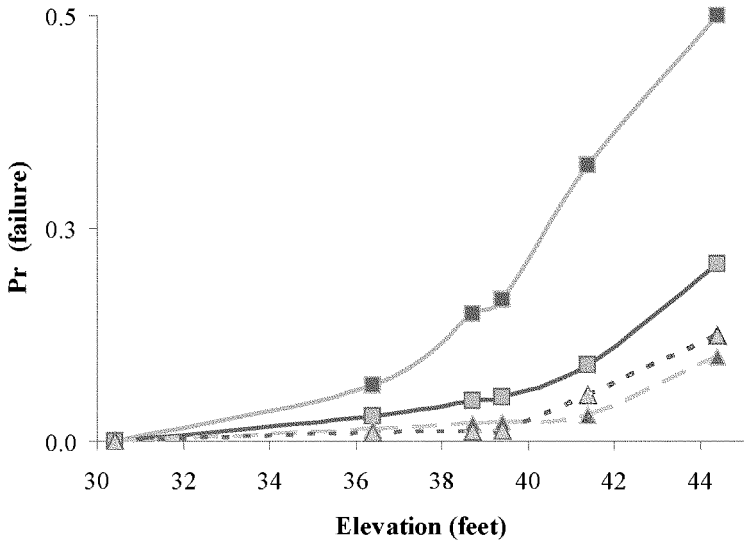
Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve



Elevation	Probability of Failure			
	WO	AE-SB CW	DSB	W-SC B CW
24.98	0.00226	0.00000	0.00000	0.00000
28.98	0.09370	0.01785	0.02721	0.01908
30.98	0.15000	0.02136	0.03429	0.02305
32.98	0.24427	0.02725	0.04614	0.02969
36.98	0.42765	0.04507	0.16257	0.04867
40.98	0.59710	0.07794	0.63360	0.08258

Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve

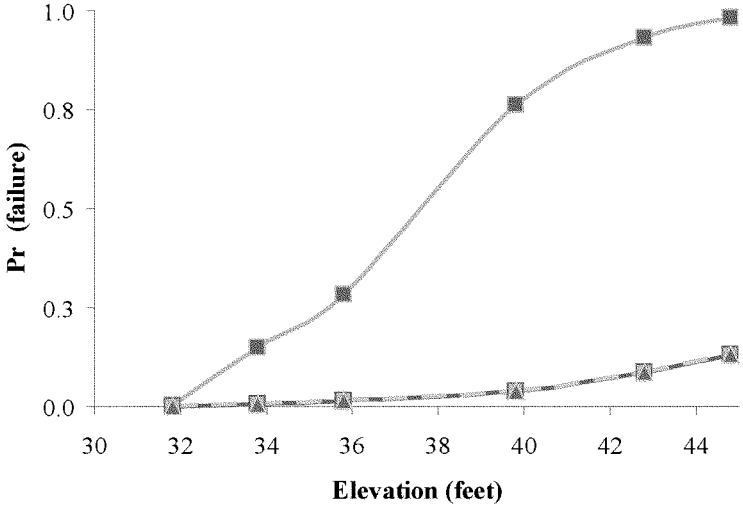
NATOMAS BASIN REACH E



Elevation	Probability of Failure			
	WO	0.5B C/WP	5B C/WP	.5E-5B C/W
30.4	0.00000	0.00000	0.00000	0.00000
36.4	0.06600	0.02967	0.01401	0.01000
38.7	0.15000	0.04745	0.02067	0.01167
39.4	0.16679	0.05100	0.02200	0.01200
41.4	0.32352	0.08901	0.03696	0.05432
44.4	0.49969	0.20741	0.09857	0.12434

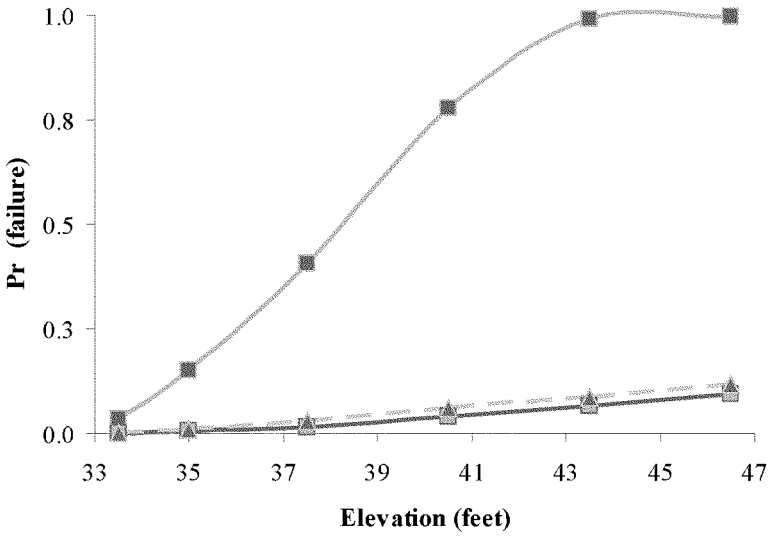
E2-12

Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve



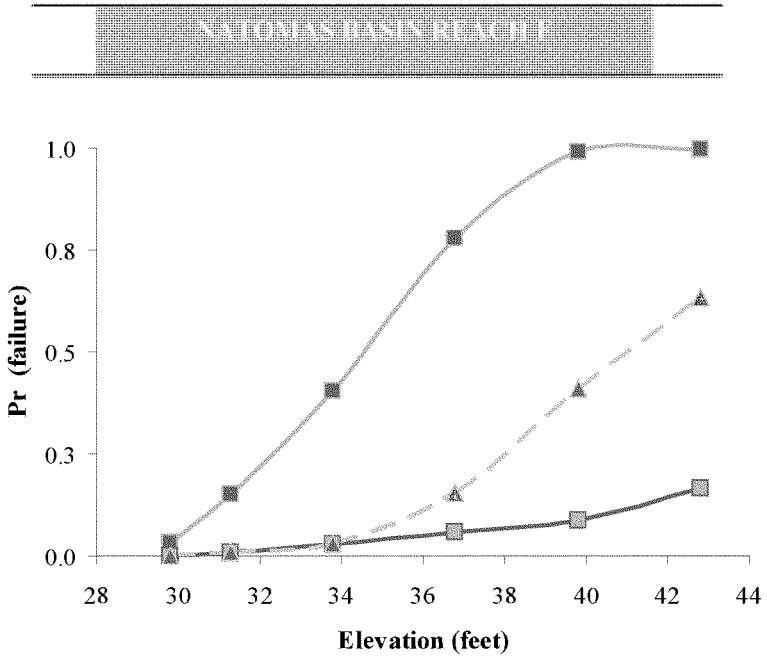
Elevation	Probability of Failure		
	WO	SB/SC B CWP (E)	SB/SC B CWP
31.8	0.00269	0.00040	0.00040
33.8	0.15000	0.00736	0.00736
35.8	0.28324	0.01401	0.01401
39.8	0.76297	0.03982	0.03982
42.8	0.93273	0.08504	0.08504
44.8	0.98191	0.13115	0.13115

Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve



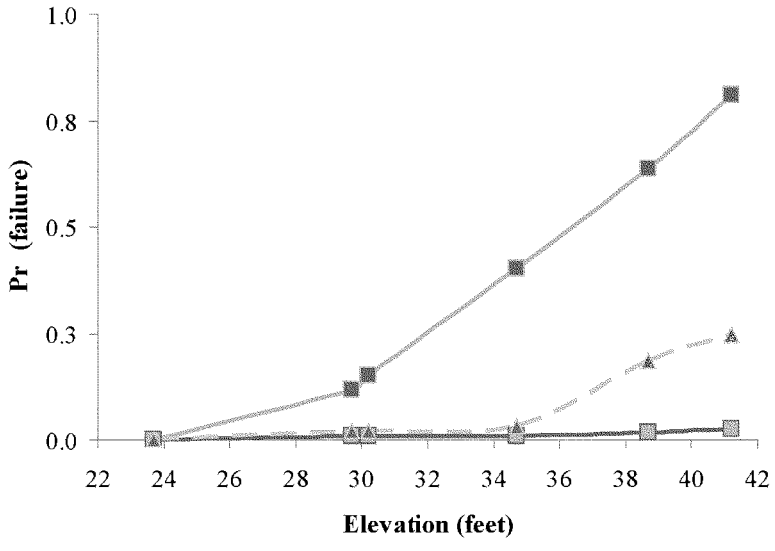
Elevation	Probability of Failure		
	WO	SB(WP)	DSB
33.5	0.03323	0.00000	0.00000
35	0.15000	0.00443	0.00908
37.5	0.40517	0.01412	0.02891
40.5	0.77815	0.03948	0.05869
43.5	0.99163	0.06531	0.08634
46.5	0.99775	0.09306	0.11574

Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve



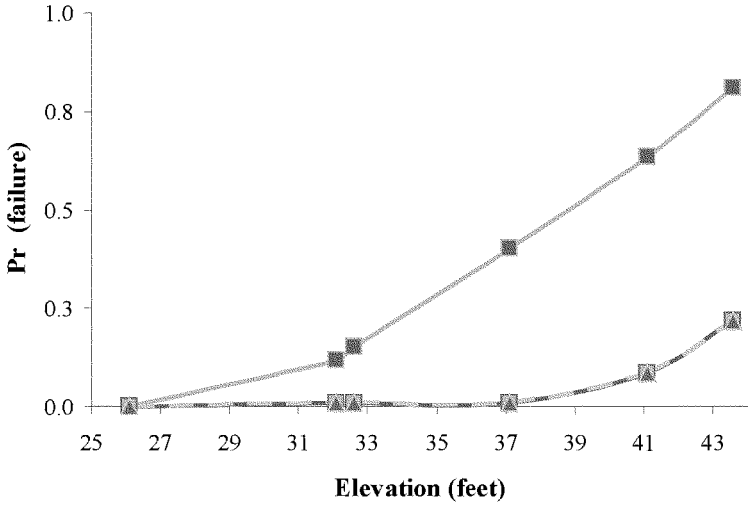
Elevation	Probability of Failure		
	WO	DSIB	FL LS
29.8	0.03325	0.00000	0.00000
31.3	0.15000	0.00908	0.00908
33.8	0.40517	0.02891	0.02891
36.8	0.77815	0.05869	0.15341
39.8	0.99163	0.08634	0.40915
42.8	0.99750	0.16538	0.63471

Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve



Elevation	Probability of Failure		
	WO	SHCWP	DSB
23.7	0.00000	0.00000	0.00000
29.7	0.11764	0.00866	0.01910
30.2	0.15000	0.00876	0.02031
34.7	0.40137	0.00952	0.02958
38.7	0.63587	0.01612	0.18345
41.2	0.80940	0.02480	0.24658

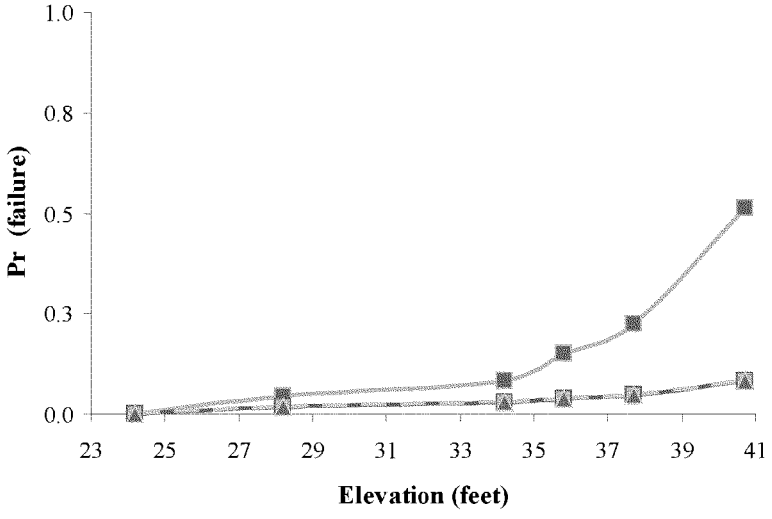
Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve



Elevation	Probability of Failure		
	WO	SB C WP	SC B C WP
26.1	0.00000	0.00000	0.00000
32.1	0.11704	0.00865	0.00865
32.6	0.15000	0.00875	0.00875
37.1	0.40137	0.00952	0.00952
41.1	0.63587	0.08333	0.08333
43.6	0.80940	0.21741	0.21741

Without-Project & With-Project
Geotechnical Risk & Uncertainty Curve

NATOMAS BASIN REACH H



Elevation	Probability of Failure		
	WO	SCB CWP	SCB CWP
24.2	0.00000	0.00000	0.00000
28.2	0.04421	0.01908	0.01908
34.2	0.08180	0.02969	0.02969
35.8	0.15000	0.03878	0.03878
37.7	0.22428	0.04867	0.04867
40.7	0.51416	0.08258	0.08258

STRUCTURE AND CONTENT VALUE UNCERTAINTY

USE CATEGORY	UNCERTAINTY IN VALUE (INPUT TO HEC-FDA)	
	Structure SD/Mean	**Content SD/Mean**
Residential (SFR & MFR)	17%	12%
Mobile Homes	14%	12%
Office 2-Story	17%	14%
Office 1-Story	17%	16%
Retail	17%	18%
Retail-Furniture	17%	20%
Auto Dealerships	12%	12%
Hotel	12%	16%
Food Stores	21%	27%
Restaurants	19%	3%
Restaurants-Fast Food	19%	13%
Medical	13%	46%
Hospitals	21%	46%
Shopping Centers	20%	23%
Large Grocery Stores	20%	4%
Service (Auto)	17%	4%
Warehouse	17%	31%
Light Ind.	21%	19%
Heavy Ind.	21%	31%
Government	31%	16%
Schools	15%	33%
Religious	19%	40%
Recreation	19%	13%
Farms	20%	8%
Automobiles	15%	N/A

The following tables display the depth-percent damage curves for the 53 occupancy types found within the structure inventory and used in the HEC-FDA modeling. The far left column indicates water depth in feet. The remaining two columns show the corresponding structure and content damage expressed as a percentage of structure value (residential categories) or as a percentage of structure value and content value, respectively (non-residential categories).

Table 1

C-RET1		
Commercial Retail 1-story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	42.71
1	21.73	79.83
1.5	26	94.79
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 2

C-RET2		
Commercial Retail 2-story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	20.49
1	15.26	38.31
1.5	17.1	49.61
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 3

C-DEAL1		
Full Service Auto Dealership 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	5.75
-0.5	3.5	5.81
0	7	5.81
0.5	14.4	41.07
1	21.73	80.26
1.5	26	97.18
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 4

C-DEAL2		
Full Service Auto Dealership 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	2.76
-0.5	2.5	2.79
0	5	2.79
0.5	10.1	19.71
1	15.26	38.52
1.5	17.1	50.86
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 5

C-FURN1		
Furniture Store 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	89.48
1	21.73	98.2
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 6

C-FURN2		
Furniture Store 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	42.94
1	15.26	47.13
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 7

C-HOS1		
Hospital 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	75.49
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 8

C-HOS2		
Hospital 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	36.23
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 9

C-AUTO1		
Commercial Auto Sales 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	48.39
1	21.73	96.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 10

C-AUTO2		
Commercial Auto Sales 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	42.89
1	15.26	46.44
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 11

C-HOTEL1		
Hotel 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	47.36
1	21.73	91.34
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 12

C-HOTEL2		
Hotel 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	22.73
1	15.26	43.83
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 13

C-FOOD1		
Commercial Food-Retail 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0.5
0.5	14.4	56.98
1	21.73	78.33
1.5	26	94.47
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 14

C-FOOD2		
Commercial Food-Retail 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0.24
0.5	10.1	27.35
1	15.26	37.59
1.5	17.1	49.44
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 15

C-RESTFF1		
Commercial Fast Food Rest 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	45.1
1	21.73	87.8
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 16

C-RESTFF2		
Commercial Fast Food Rest 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	21.64
1	15.26	42.14
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 17

C-GROC1		
Commercial Grocery Store 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	61.04
1	21.73	87.33
1.5	26	94.38
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 18

C-GROC2		
Commercial Grocery Store 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	29.29
1	15.26	41.91
1.5	17.1	49.39
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 19

C-MED1		
Commercial Medical 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	75.49
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 20

C-MED2		
Commercial Medical 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	36.23
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 21

C-OFF1		
Commercial Office 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	48.39
1	21.73	96.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 22

C-OFF2		
Commercial Office 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	42.89
1	15.26	46.44
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 23

C-SHOP1		
Commercial Shopping Center 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	76.45
1	21.73	95.92
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 24

C-SHOP2		
Commercial Shopping Center 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	36.69
1	15.26	46.03
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 25

C-REST1		
Commercial Restaurant 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	47.36
1	21.73	91.34
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 26

C-REST2		
Commercial Restaurant 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	22.73
1	15.26	43.83
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 27

C-SERV1		
Commercial Service-Auto 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	9.91
-0.5	3.5	10
0	7	10
0.5	14.4	38.69
1	21.73	73.51
1.5	26	97.44
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 28

C-SERV1		
Commercial Service-Auto 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	4.75
-0.5	2.5	4.8
0	5	4.8
0.5	10.1	18.57
1	15.26	35.28
1.5	17.1	50.99
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 29

I-LT1		
Industrial Light 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0.19
0.5	14.4	45.36
1	21.73	87.64
1.5	26	92.79
2	30.19	96.39
3	31.22	98.97
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 30

I-LT2		
Industrial Light 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0.19
0.5	10.1	21.77
1	15.26	42.06
1.5	17.1	48.56
2	18.88	53.95
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 31

I-HV1		
Industrial Heavy Manufacture 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	12.18
1	21.73	32.69
1.5	26	53.81
2	30.19	69.95
3	31.22	77.48
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 32

I-HV2		
Industrial Heavy Manufacture 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	5.85
1	15.26	15.69
1.5	17.1	28.16
2	18.88	39.15
3	21.48	43.37
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 33

I-WH1		
Industrial Warehouse 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	41.32
1	21.73	84.19
1.5	26	94.42
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 34

I-WH2		
Industrial Warehouse 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	19.83
1	15.26	40.4
1.5	17.1	49.41
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 35

P-CH1		
Public Church 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	47.33
1	21.73	73.35
1.5	26	83.86
2	30.19	98.82
3	31.22	98.82
4	32.44	98.82
5	32.44	98.82
6	39.82	98.82
7	42.76	98.82
8	51.72	98.82
9	53.1	98.82
10	54.09	98.82
11	61.78	98.82
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 36

P-CH2		
Public Church 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	22.71
1	15.26	35.2
1.5	17.1	43.88
2	18.88	55.31
3	21.48	55.31
4	22.8	55.31
5	22.8	55.31
6	24.05	55.31
7	26.1	55.31
8	40.4	66.08
9	43.25	66.08
10	46.2	66.08
11	46.2	68.47
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 37

P-GOV1		
Public Government Building 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	48.39
1	21.73	96.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 38

P-GOV2		
Public Government Building 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	40.87
1	15.26	45.43
1.5	17.1	51.23
2	18.88	55.88
3	21.48	55.88
4	22.8	55.88
5	22.8	55.88
6	24.05	55.88
7	26.1	55.88
8	40.4	68.08
9	43.25	68.08
10	46.2	68.08
11	46.2	69.4
12	49.05	100
13	49.05	100
14	55.16	100
15	80.05	100

Table 39

P-REC1		
Public Recreation/Assembly 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	97.95
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 40

P-REC2		
Public Recreation/Assembly 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	47.01
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 41

P-SCH1		
Public and Private Schools 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	87.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 42

P-SCH2		
Public and Private Schools 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	42.12
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 43

FARM		
Farm Buildings Including Primary RES		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	29.67
1	21.73	56.23
1.5	26	69.84
2	30.19	93.46
3	31.22	99.58
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 44

SFRB1		
Single Family Residential 1-story W/Basement		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	5.2	5.7
-3	9	8
-2	13.8	10.5
-1	19.4	13.2
-0.5	22.5	14.6
0	25.5	16
0.5	28.8	17.5
1	32	18.9
1.5	35.4	20.4
2	38.7	21.8
3	45.5	24.7
4	52.2	27.4
5	58.6	30
6	64.5	32.4
7	69.8	34.5
8	74.2	36.3
9	77.7	37.7
10	80.1	38.6
11	81.1	39.1
12	81.1	39.1
13	81.1	39.1
14	81.1	39.1
15	81.1	39.1

Table 45

SFRB2		
Single Family Residential 2-story W/Basement		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	4.7	5.2
-3	7.2	6.8
-2	10.2	8.4
-1	13.9	10.1
-0.5	15.9	11
0	17.9	11.9
0.5	20.1	12.9
1	22.3	13.8
1.5	24.7	14.8
2	27	15.7
3	31.9	17.7
4	36.9	19.8
5	41.9	22
6	46.9	24.3
7	51.8	26.7
8	56.4	29.1
9	60.8	31.7
10	64.8	34.4
11	68.4	37.2
12	71.4	40
13	73.7	43
14	75.4	46.1
15	76.4	49.3

Table 46

SFRBS		
Single Family Residential Split-Level W/Basement		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	4.7	3.8
-3	7.2	5.4
-2	10.4	7.3
-1	14.2	9.4
-0.5	16.4	10.5
0	18.5	11.6
0.5	20.9	12.7
1	23.2	13.8
1.5	25.7	15
2	28.2	16.1
3	33.4	18.2
4	38.6	20.2
5	43.8	22.1
6	48.8	23.6
7	53.5	24.9
8	57.8	25.8
9	61.6	26.3
10	64.8	26.3
11	67.2	26.3
12	68.8	26.3
13	69.3	26.3
14	69.3	26.3
15	69.3	26.3

Table 47

SFR1		
Single Family Residential 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	2.5	2.4
-0.5	8	5.3
0	13.4	8.1
0.5	18.4	10.7
1	23.3	13.3
1.5	27.7	15.6
2	32.1	17.9
3	40.1	22
4	47.1	25.7
5	53.2	28.8
6	58.6	31.5
7	63.2	33.8
8	67.2	35.7
9	70.5	37.2
10	73.2	38.4
11	75.4	39.2
12	77.2	39.7
13	78.5	40
14	79.5	40
15	80.2	40

Table 48

SFR2		
Single Family Residential 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	3	1
-0.5	6.2	3
0	9.3	5
0.5	12.3	6.9
1	15.2	8.7
1.5	18.1	10.5
2	20.9	12.2
3	26.3	15.5
4	31.4	18.5
5	36.2	21.3
6	40.7	23.9
7	44.9	26.3
8	48.8	28.4
9	52.4	30.3
10	55.7	32
11	58.7	33.4
12	61.4	34.7
13	63.8	35.6
14	65.9	36.4
15	67.7	36.9

Table 49

SFRS		
Single Family Residential Split-Level		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	6.4	2.2
-0.5	6.8	2.6
0	7.2	2.9
0.5	8.3	3.8
1	9.4	4.7
1.5	11.2	6.1
2	12.9	7.5
3	17.4	11.1
4	22.8	15.3
5	28.9	20.1
6	35.5	25.2
7	42.3	30.5
8	49.2	35.7
9	56.1	40.9
10	62.6	45.8
11	68.6	50.2
12	73.9	54.1
13	78.4	57.2
14	81.7	59.4
15	83.8	60.5

Table 50

MFR1		
Multi-Family Residential 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	2.5	2.4
-0.5	8	5.3
0	13.4	8.1
0.5	18.4	10.7
1	23.3	13.3
1.5	27.7	15.6
2	32.1	17.9
3	40.1	22
4	47.1	25.7
5	53.2	28.8
6	58.6	31.5
7	63.2	33.8
8	67.2	35.7
9	70.5	37.2
10	73.2	38.4
11	75.4	39.2
12	77.2	39.7
13	78.5	40
14	79.5	40
15	80.2	40

Table 51

MFR2		
Multi-Family Residential 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	3	1
-0.5	6.2	3
0	9.3	5
0.5	12.3	6.9
1	15.2	8.7
1.5	18.1	10.5
2	20.9	12.2
3	26.3	15.5
4	31.4	18.5
5	36.2	21.3
6	40.7	23.9
7	44.9	26.3
8	48.8	28.4
9	52.4	30.3
10	55.7	32
11	58.7	33.4
12	61.4	34.7
13	63.8	35.6
14	65.9	36.4
15	67.7	36.9

Table 52

MH		
Mobile Home Single/Double		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	6.4	0
-0.5	7.3	0
0	9.9	0
0.5	43.4	85
1	44.7	85
1.5	45	90
2	45.7	95
3	96.5	99
4	96.5	99
5	96.5	99
6	96.5	99
7	96.5	99
8	96.5	99
9	96.5	99
10	96.5	99
11	96.5	99
12	96.5	99
13	96.5	99
14	96.5	99
15	96.5	99

Table 53

AUTO		
Automobiles		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	0	0
0	0	0
0.5	2.8	0
1	21.8	0
1.5	31.15	0
2	40.5	0
3	56.9	0
4	71.1	0
5	83.2	0
6	91.9	0
7	96.1	0
8	99.2	0
9	100	0
10	100	0
11	100	0
12	100	0
13	100	0
14	100	0
15	100	0

NAT A Project Performance Results

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	Natomas A	RM 62.7519	levee	0.2117	.2029	.8965	.9966	1.000	.3610	.2258	.1850	.1429	.0588
Fix 1	Sac River	Natomas A	RM 62.7519	levee	0.0071	.0071	.0693	.1643	.3015	.9799	.9661	.9580	.9457	.8115
Fix 2	Sac River	Natomas A	RM 62.7519	levee	0.0071	.0071	.0693	.1643	.3015	.9799	.9661	.9580	.9457	.8115
Levee Raise 1	Sac River	Natomas A	RM 62.7519	levee	0.0056	.0032	.0312	.0762	.1466	.9935	.9731	.9647	.9521	.8406

NAT B Project Performance Results

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	Natomas B	RM 69.2511	levee	.1183	.7162	.9571	.9982	.7048	.5913	.5629	.4881	.3522	.2894
Fix 1	Sac River	Natomas B	RM 69.2511	levee	.0166	.1539	.3414	.5663	.9557	.8499	.8178	.7255	.5715	.5009
Fix 2	Sac River	Natomas B	RM 69.2511	levee	.0355	.3036	.5953	.8362	.9102	.7901	.7557	.6645	.5178	.4526
Fix 3	Sac River	Natomas B	RM 69.2511	levee	.0166	.1539	.3414	.5663	.9557	.8499	.8178	.7255	.5715	.5009
Levee Raise 1	Sac River	Natomas B	RM 69.2511	levee	.0059	.0578	.1384	.2576	.9658	.8508	.8171	.7230	.5673	.4980

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NAT C Project Performance Results

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	Natomas C	RM 79	levee	.0406	.3397	.6457	.8744	.8522	.7344	.7080	.6352	.4825	.4044
Fix 1	Sac River	Natomas C	RM 79	levee	.0171	.1581	.3496	.5769	.9494	.8833	.8639	.8056	.6527	.5651
Fix 2	Sac River	Natomas C	RM 79	levee	.0099	.0951	.2210	.3932	.9769	.9291	.9121	.8580	.7061	.6148
Fix 3	Sac River	Natomas C	RM 79	levee	.0073	.0709	.1680	.3077	.9866	.9549	.9437	.8974	.6869	.5322
Levee Raise 1	Sac River	Natomas C	RM 79	levee	.0046	.0452	.1091	.2063	.9996	.9559	.9378	.8883	.7908	.7298
Levee Raise 2	Sac River	Natomas C	RM 79	levee	****	****	****	****	****	****	****	****	****	****
Levee Raise 3	Sac River	Natomas C	RM 79	levee	****	****	****	****	****	****	****	****	****	****

NAT D Project Performance Results

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	Natomas D	NCC	levee	.2061	.9005	.9969	1.000	.4251	.2690	.2121	.1532	.0808	.5920
Fix 1	Sac River	Natomas D	NCC	levee	.0155	.1444	.3228	.5414	.9644	.9203	.8806	.8051	.5993	.5038
Fix 2	Sac River	Natomas D	NCC	levee	.1550	.1444	.3228	.5414	.9644	.9203	.8806	.8051	.5993	.5038
Levee Raise 1	Sac River	Natomas D	NCC	levee	.0053	.0517	.1244	.2333	.9834	.9365	.9011	.8382	.6714	.5935
Levee Raise 2	Sac River	Natomas D	NCC	levee	****	****	****	****	****	****	****	****	****	****
Levee Raise 3	Sac River	Natomas D	NCC	levee	****	****	****	****	****	****	****	****	****	****
Levee Raise 4	Sac River	Natomas D	NCC	levee	****	****	****	****	****	****	****	****	****	****

NAT E Project Performance Results

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	Natomas E	@ PGCC	levee	.1751	.8542	.9919	.9999	.4581	.2814	.2159	.1501	.0733	.0460
Fix 1	Sac River	Natomas E	@ PGCC	levee	.0194	.1782	.3877	.6251	.9585	.9338	.9073	.8582	.7080	.6243
Levee Raise 1	Sac River	Natomas E	@ PGCC	levee	.0071	.0691	.1639	.3010	.9693	.9358	.9065	.8569	.7040	.6220
Levee Raise 2	Sac River	Natomas E	@ PGCC	levee	.0014	.0140	.0346	.0681	.9980	.9733	.9406	.8847	.7155	.6296

NAT F Project Performance Results

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	Natomas F	PGCC	levee	.3034	.9731	.9999	1.000	.4113	.2473	.1617	.1135	.0608	.0019
Fix 1	Sac River	Natomas F	PGCC	levee	.0226	.2046	.4357	.6815	.9586	.9562	.9562	.9560	.9382	.4994
Fix 2	Sac River	Natomas F	PGCC	levee	.0450	.3693	.6840	.9002	.9138	.9089	.9088	.9086	.8892	.4647
Levee Raise 1	Sac River	Natomas F	PGCC	levee	.0015	.0146	.0362	.0711	1.000	1.000	1.000	.9999	.9921	.6827
Levee Raise 2	****	****	****	****	****	****	****	****	****	****	****	****	****	****
Levee Raise 3	****	****	****	****	****	****	****	****	****	****	****	****	****	****

NAT G Project Performance Results

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	Natomas G	NEMDC	levee	.2024	.8958	.9965	1.000	.5367	.4688	.4267	.3719	.2773	.1748
Fix 1	Sac River	Natomas G	NEMDC	levee	.0061	.5900	.1410	.2621	.9901	.9847	.9749	.9320	.7070	.2469
Levee Raise 1	Sac River	Natomas G	NEMDC	levee	.0044	.0434	.1051	.1991	.9920	.9885	.9863	.9746	.8451	.4015
Levee Raise 2	Sac River	Natomas G	NEMDC	levee	****	****	****	****	****	****	****	****	****	****
Levee Raise 3	Sac River	Natomas G	NEMDC	levee	****	****	****	****	****	****	****	****	****	****
Levee Raise 4	Sac River	Natomas G	NEMDC	levee	****	****	****	****	****	****	****	****	****	****

NAT H Project Performance Results

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	Natomas H	NEMDC	levee	.0420	.3491	.6581	.8831	.8525	.7299	.6746	.5773	.4046	.1336
Fix 1	Sac River	Natomas H	NEMDC	levee	.0042	.0411	.0997	.1895	.9943	.9897	.9832	.9666	.8686	.3992
Fix 2	Sac River	Natomas H	NEMDC	levee	.0042	.0411	.0997	.1895	.9943	.9897	.9832	.9666	.8686	.3992
Levee Raise 1	Sac River	Natomas H	NEMDC	levee	.0022	.0223	.0548	.1067	1.000	1.000	1.000	.9994	.9302	.4472

NAT I Project Performance Results

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	Natomas I	AR	levee	.0152	.1420	.3180	.5349	.9416	.9020	.8926	.8883	.7503	.3705
Fix 1	Sac River	Natomas I	AR	levee	.0081	.0782	.1841	.3343	.9756	.9665	.9647	.9639	.9064	.1344
Fix 2	Sac River	Natomas I	AR	levee	.0081	.0782	.1841	.3343	.9756	.9665	.9647	.9639	.9064	.1344
Levee Raise 1	Sac River	Natomas I	AR	levee	.0015	.0149	.0370	.0725	.9999	.9792	.9753	.9738	.9407	.5640

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Incremental Project Performance
Major Area

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	+Nat D	NCC	levee	.21	.9005	.9969	1.0000	.4251	.2691	.2123	.1534	.0811	.0595
Fix D cip A(.21)	Sac River	+Nat D	NCC	levee	.21	.9073	.9974	1.0000	.3609	.2258	.1850	.1429	.0588	.0267
Fix A cip E (.18)	Sac River	+Nat D	NCC	levee	.18	.8673	.9936	1.0000	.3691	.2335	.1937	.1541	.0784	.0586
Fix E cip B (.12)	Sac River	+Nat D	NCC	levee	.11	.6827	.9433	.9968	.7036	.5862	.5588	.4874	.3470	.2820
Fix B cip C (.04)	Sac River	+Nat D	NCC	levee	.04	.3421	.6489	.8767	.8509	.7333	.7068	.6344	.4815	.4035
Fix C cip H (.04)	Sac River	+Nat D	NCC	levee	.04	.3503	.6598	.8843	.8526	.7298	.6738	.5780	.4053	.1362
Fix H cip D(.015)	Sac River	+Nat D	NCC	levee	.015	.1405	.3151	.5309	.9656	.9193	.8795	.8034	.5983	.5027
Raise B cip E (.019)	Sac River	+Nat D	NCC	levee	.0189	.1733	.3786	.6139	.9581	.9330	.9059	.8583	.7050	.6232
Raise E cip E (.007)	Sac River	+Nat D	NCC	levee	.0071	.0685	.1626	.2987	.9697	.9365	.9078	.8592	.7052	.6233
Raise D icp B (.019)	Sac River	+Nat D	NCC	levee	.0211	.1919	.4130	.6554	.9620	.9102	.8949	.8552	.7896	.7621
Raise B icp I (.016)	Sac River	+Nat D	NCC	levee	.0164	.1521	.3380	.5618	.9426	.8999	.8906	.8862	.7521	.3979
Fix I icp E (.02)	Sac River	+Nat D	NCC	levee	.0189	.1733	.3786	.6139	.9581	.9330	.9059	.8583	.7050	.6232

Incremental Project Performance
Minor Area

PLAN NAME	STREAM NAME	DAMAGE REACH NAME	DAMAGE REACH DESCRIPTION	TARGET STAGE	TARGET STAGE ANNUAL EXCEEDANCE PROBABILITY	LONG-TERM RISK (YEARS)			CONDITIONAL NON-EXCEEDANCE PROBABILITY BY EVENTS					
					Expected	10	30	50	10%	4%	2%	1%	0.4%	0.2%
Without	Sac River	NAT F PGCC	PGCC	levee	.30	.9715	.9999	1.000	.4156	.2508	.1655	.1166	.0619	.0201
Fix D	Sac River	NAT F PGCC	PGCC	levee	.30	.9715	.9999	1.000	.4156	.2508	.1655	.1166	.0619	.0201
Fix A	Sac River	NAT F PGCC	PGCC	levee	.30	.9715	.9999	1.000	.4156	.2508	.1655	.1166	.0619	.0201
Fix E	Sac River	NAT F PGCC	PGCC	levee	.30	.9715	.9999	1.000	.4156	.2508	.1655	.1166	.0619	.0201
Fix B	Sac River	NAT F PGCC	PGCC	levee	.30	.9735	.9999	1.000	.4192	.2513	.1658	.1158	.0615	.0194
Fix C	Sac River	NAT F PGCC	PGCC	levee	.30	.9732	.9999	1.000	.4183	.2507	.1655	.1153	.0614	.0194
Fix H	Sac River	NAT F PGCC	PGCC	levee	.30	.9732	.9999	1.000	.4183	.2507	.1655	.1153	.0614	.0194
Fix G	Sac River	NAT F PGCC	PGCC	levee	.30	.9739	.9999	1.000	.4139	.2491	.1642	.1146	.0605	.0190
Fix F	Sac River	NAT F PGCC	PGCC	levee	.023	.2096	.4446	.6916	.9578	.9551	.9550	.9548	.9364	.5178
Raise F-1	Sac River	NAT F PGCC	PGCC	levee	.001	.0056	.0139	.0276	1.000	1.000	1.000	1.000	.9919	.6821
Raise F-2	Sac River	NAT F PGCC	PGCC	levee	.001	.0056	.0139	.0276	1.000	1.000	1.000	1.000	.9919	.6821

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ENCLOSURE 3
MEMORANDUM FOR FILE DOCUMENTING POST-F3 CONFERENCE SENSITIVITY ANALYSIS

CESPK-PD-WE **SEPTEMBER 2009**

MEMORANDUM FOR FILE

SUBJECT: American River – Common Features (Natomas Basin)
- Revised Expected Annual Damages (EAD) Results
- Revised Annual Exceedance Probability (AEP) Results
- Geotechnical Fragility Curve Sensitivity Analysis
- Probability-Stage Curve Sensitivity Analysis

1. PURPOSE

The purposes of this memorandum are to 1) describe the effect on expected annual damages (EAD) and annual exceedance probability (AEP) in the Natomas Basin impact area due to revisions to the HEC-FDA engineering input data and to report the updated without-project (F3) EAD and AEP numbers 2) document the sensitivity analysis performed to determine the impact on EAD/AEP from changes to the fragility curve 3) document the sensitivity analysis performed to determine whether or not upstream levee failures (as measured by reductions in stages at the Natomas index point) have a significant impact on EAD and AEP results. Key points are:

- A revision was made to the geotechnical fragility curve used as input into the economic analysis and EAD/AEP computations; this curve represents the probability of poor performance at various water surface elevations and has been revised based on information obtained from a geotechnical expert elicitation panel conference held at the Corps' Sacramento District office in June 2009. More information about this conference can be obtained from the Geotechnical Section (USACE Sacramento District).

- Based on updated geotechnical fragility and probability-stage curves, updated without-project floodplains, and the addition of an economic damage category (automobiles), revised without-project EAD for the Natomas Basin impact area is estimated to be approximately $262 million (compared to $2.4 billion reported in the F3 Economic Appendix); AEP is estimated to be .0398 (compared to .3856 as previously reported). These results and input data served as the baseline for performing the sensitivity analysis.

- A sensitivity analysis was performed using a modified fragility curve, in which the probabilities of poor performance at water surface elevations at the landside levee toe, 6 feet above the landside levee toe elevation, and 9 feet above the landside levee toe elevation have a risk reduction of 50%, 30%, and 10%, respectively. Expected annual damages and AEP results did change with these modifications to the probability of failure values, but only minimally.

- A sensitivity analysis (i.e., modifications to the probability-stage curve used as input into the economic analysis and EAD/AEP computations) was performed to gage the effects these changes would have on EAD and AEP. A modified probability-stage curve, which incorporated changes to stages at the Natomas index point (river mile 79 near Verona) due to levee failures at locations upstream of the Natomas index point, was based on levee failures that actually occurred during past flooding events. A second modified probability-stage curve, which does not have any historical basis, was used as an additional test to see the effects even greater stage changes (than what has actually been seen during past flooding events) have on EAD/AEP. Both sensitivity tests demonstrated that nominal changes to stages in the probability-stage curve to account for possible upstream levee failures only have negligible impacts on EAD and AEP results.

2. CHANGES TO EAD/AEP

Revisions to the HEC-FDA input data, including the probability-stage curve and the geotechnical fragility curve, have resulted in changes to EAD and AEP originally reported in the F3 Economic Appendix. The following sections describe how revisions to the HEC-FDA input data have resulted in changes to the EAD and AEP results.

a. Original F3 Analysis

The F3 analysis resulted in an EAD of approximately $2.4 billion and an AEP of .3856, or about a 39% chance of flooding in any given year. The analysis used the following probability-stage and geotechnical fragility curves:

Table PS-1
Original F3 Analysis
Probability-Stage Curve

EXCEEDANCE PROBABILITY	EXTERIOR STAGE (NGVD 29, FT)
.999	32.3
.500	33.8
.100	36.01
.040	37.93
.020	38.74
.010	39.81
.005	40.61
.002	41.07

Table GF-1
Original F3 Analysis
Geotechnical Fragility Curve (Sacramento River Mile 79)

EXTERIOR STAGE (NGVD 29, FT)	PROBABILITY OF FAILURE
33	.23
36	.51
39	.82
42	.98

It is important to note that the elevations used in both the probability-stage and geotechnical fragility curves for the original F3 analysis were in NGVD 29. The HEC-RAS data (probability-stage curve) was developed using NGVD 29 datum; the geotechnical fragility curve was developed using NAVD 88 datum and then converted to NGVD 29 to be consistent with the elevation data in the probability-stage curve.

b. Revision to .999 Probability Stage on the Probability-Stage Curve

Subsequent to the F3 analysis and conference, it was determined that the .999 probability stage (32.3) used in the analysis was incorrect. This value was estimated by the Economics and Risk Analysis Section through extrapolation using the FDA graphical plot of the probability-stage curve. In most analyses the .999 probability stage does not have a significant impact on EAD and AEP since flooding in most urban areas does not occur from such high frequency events (e.g., 1-year to 5-year events). However, the Natomas area differs in that, at the time of the F3 analysis, there was a relatively high probability of levee failure from high frequency (low stage) events, as reflected in the geotechnical fragility curve. In order to isolate the effects the .999 probability stage

change has on EAD and AEP, the .999 probability stage value in the probability-stage curve was changed from 32.3 to 22.8 and the original geotechnical fragility curve was not changed:

Table PS-2
Original F3 Analysis
Probability-Stage Curve

EXCEEDANCE PROBABILITY	EXTERIOR STAGE (NGVD 29, FT)
.999	**22.8**
.500	33.8
.100	36.01
.040	37.93
.020	38.74
.010	39.81
.005	40.61
.002	41.07

Table GF-2
Original F3 Analysis
Geotechnical Fragility Curve (Sacramento River Mile 79)

EXTERIOR STAGE (NGVD 29, FT)	PROBABILITY OF FAILURE
33	.23
36	.51
39	.82
42	.98

With this change in the .999 probability stage, EAD is reduced to approximately $1.61 billion (from $2.4 billion) and AEP is reduced to .2541 (from .3856), or about a 25% chance of flooding in any given year.

c. Updated Probability-Stage Curve (NAVD 88), Geotechnical Fragility Curve (NAVD 88) and Without-Project Floodplains, and the Inclusion of Automobile Damages in the Economics

Following the F3 conference, updated probability-stage (NAVD 88) and geotechnical fragility (NAVD 88) curves were developed and used within the economic model (HEC-FDA) to compute EAD and AEP. These curves are shown below in Tables PS-3 and GF-3, respectively.

Also, without-project floodplains were also updated for this analysis based on new assumptions regarding breach size and timing. A more detailed description of the assumptions used to generate the without-project floodplains can be obtained from the Hydraulic Design Section (USACE Sacramento District).

Finally, automobiles were added to the economic inventory for the Natomas Basin impact area. This damage category had been left out of the F3 analysis. Automobile damages increase total EAD by approximately 5%.

Table PS-3
Revised F3 Analysis
Probability-Stage Curve

EXCEEDANCE PROBABILITY	EXTERIOR STAGE (NAVD 88, FT)
.999	20.16
.500	33.36
.100	38.42
.040	40.36
.020	41.15
.010	42.14
.005	43.50
.002	44.49

Table GF-3
Geotechnical Fragility Curve (Sacramento River Mile 79)

EXTERIOR STAGE (NAVD 88, FT)	PROBABILITY OF FAILURE
36.4	.066
39.4	.167
41.4	.324
44.4	.500

Using these curves in the analysis resulted in an EAD of $262 million and an AEP of .0398, or about a 4% chance of flooding in any given year. The revised curves represent the current state of the analysis and will serve as the baseline for performing the sensitivity analysis (i.e., impact to EAD and AEP) associated with modifications to the geotechnical fragility and probability-stage curves. The sensitivity analysis is described in the following sections.

3. SENSITIVITY ANALYSIS

Sensitivity analyses were performed to see the effect modifications to the geotechnical fragility curve and probability-stage curve has on EAD and AEP results. The most current curves (Tables PS-3 and GF-3) were used as the baseline data.

a. Geotechnical Fragility Curve

A modified geotechnical fragility curve was developed to represent the actual risk of levee failure (versus poor performance) at specific water surface elevations. The modified curve assumed a 50% risk reduction at the landside levee toe elevation, a 30% risk reduction at 6 feet above the landside levee toe, and a 10% risk reduction at 9 feet above the landside levee toe. Table GF-4 displays this curve along side the baseline fragility curve.

Table GF-4
Geotechnical Fragility Curves (Sacramento River Mile 79)

POOR PERFORMANCE		RISK OF FAILURE	
Exterior Stage (NAVD 88)	**P(f)**	**Exterior Stage (NAVD 88)**	**P(f)**
36.4	.066	36.4	.046
39.4	.167	39.4	.151
41.4	.324	41.4	.324
44.4	.500	44.4	.500

The modifications to the fragility curve show a minimal impact on EAD and AEP results. Expected annual damages are estimated to be $240 million and AEP is estimated to be .0363. This compares to the baseline results of $262 million and .0398.

b. Probability-Stage Curve

Modifications to the probability-stage curve were made to account for the effects on index point stages from possible upstream levee failures. Reductions in stages at the Natomas index point were based on empirical data from historical upstream levee failures that occurred during past flood events. For more details regarding the methodology used to generate the historical probability-stage curves please refer to the memo from the Hydraulic Design Section.

Two modified probability-stage curves were run for the sensitivity analysis. In the first run, stages associated with probability events at or above the .01 probability event were reduced by .37 feet. This modification was based on empirical data from historical upstream levee failures that occurred during past flood events. The modified probability

curve is shown in Table PS-4 below. The baseline geotechnical fragility curve, re-displayed in Table GF-5, was used for this analysis.

Table PS-4
Sensitivity Analysis
Probability-Stage Curve
Constant .37 Feet Reduction in Stages at or above .01 Probability Event

EXCEEDANCE PROBABILITY	STAGE (NAVD 88, FT)
.999	20.16
.500	33.36
.100	38.42
.040	40.36
.020	41.15
.010	41.77
.005	43.13
.002	44.12

Table GF-5
Geotechnical Fragility Curve (Sacramento River Mile 79)

EXTERIOR STAGE (NAVD 88, FT)	PROBABILITY OF FAILURE
36.4	.066
39.4	.167
41.4	.324
44.4	.500

These changes resulted in an EAD of $258 million and an AEP of .0392 -- suggesting only negligible impacts on EAD and AEP when compared to the baseline EAD and AEP results ($262 million, .0398).

In the second run, stages associated with probability events at or above the .01 probability event were reduced by an increasing factor of .37 feet. This modified probability-stage curve does not have an historical basis but was used primarily as an additional sensitivity test. The modified probability-stage curve is shown in Table PS-5 below. As in the first run, the baseline geotechnical fragility curve was used in the analysis (Table GF-5).

Table PS-5
Sensitivity Analysis
Probability-Stage Curve
Increasing .37 Feet Factor Reduction for Stages at or above .01 Probability Event

EXCEEDANCE PROBABILITY	STAGE (NAVD 88, FT)
.999	20.16
.500	33.36
.100	38.42
.040	40.36
.020	41.15
.010	41.77
.005	42.76
.002	43.38

These changes resulted in an EAD of $252 million and an AEP of .0384 – again suggesting only neglible impacts on EAD and AEP when compared to the baseline results. The following tables summarize the results of the sensitivity analysis.

Table 6
Summary of Sensitivity Analysis Results
Expected Annual Damages (EAD)

SENSITIVITY ANALYSIS RESULTS COMPARISON OF EAD		GEOTECHNICAL FRAGILITY CURVE	
		Baseline (Poor Performance)	**Modified (Risk of Failure)**
PROBABILITY-STAGE CURVE	**Baseline**	$262 million	$240 million
	Constant .37 ft. decrease	$258 million	NA
	Increasing .37 ft. factor decrease	$252 million	NA

Table 7
Summary of Sensitivity Analysis Results
Annual Exceedance Probability (AEP)

SENSITIVITY ANALYSIS RESULTS COMPARISON OF AEP		GEOTECHNICAL FRAGILITY CURVE	
		Baseline (Poor Performance)	**Modified (Risk of Failure)**
PROBABILITY-STAGE CURVE	**Baseline**	.0398	.0363
	Constant .37 ft. decrease	.0392	NA
	Increasing .37 ft. factor decrease	.0384	NA

4. SUMMARY OF HEC-FDA INPUTS & RESULTS

Revisions to the HEC-FDA input data, including a change to the .999 probability event stage (probability-stage curve), an updated probability-stage curve, and a revised geotechnical fragility curve results in an updated without-project EAD of approximately $262 million and an AEP of .0398. These values have changed considerably from those originally reported (EAD of $2.4 billion and AEP of .3856) at the F3 Conference. Table 8 shows the evolution of the geotechnical fragility curve; Table 9 shows the evolution of the probability-stage curves; Table 10 summarizes the original curves, the new curves, and the associated EAD and AEP results.

Table 8
Evolution of Geotechnical Fragility Curves Used in HEC-FDA

ORIGINAL (F3)		NEW	
Stage (NGVD 29)	**P(f)**	**Stage (NAVD 88)**	**P(f)**
33	.23	36.4	.066
36	.51	39.4	.167
39	.82	41.4	.324
42	.98	44.4	.500

Table 9
Evolution of Probability-Stage Curves Used in HEC-FDA

ORIGINAL (F3)		REVISED .999 STAGE		NEW	
Probability	Stage (NGVD 29)	Probability	Stage (NGVD 29)	Probability	Stage (NAVD 88)
.999	32.3	.999	22.8	.999	20.16
.5	33.8	.5	33.8	.5	33.36
.1	36.01	.1	36.01	.1	38.42
.04	37.93	.04	37.93	.04	40.36
.02	38.74	.02	38.74	.02	41.15
.01	39.81	.01	39.81	.01	42.14
.005	40.61	.005	40.61	.005	43.50
.002	41.07	.002	41.07	.002	44.49

Table 10
Summary of Probability-Stage & Fragility Curves and Results

ORIGINAL CURVES (NGVD 29)				NEW CURVES (NAVD 88)			
Probability-Stage		Fragility (RM 79)		Probability-Stage		Fragility (RM 79)	
Prob.	Stage	Stage	P(f)	Prob.	Stage	Stage	P(f)
.999	32.30	33	.23	.999	20.16	36.5	.066
.500	33.80	36	.51	.500	33.36	39.5	.167
.100	36.01	39	.82	.100	38.42	41.5	.324
.040	37.93	42	.98	.040	40.36	44.5	.500
.020	38.74			.020	41.15		
.010	39.81			.010	42.14		
.005	40.61			.005	43.50		
.002	41.07			.002	44.49		
EAD = $2.4 billion				**EAD = $262 million**			
AEP = .3856				**AEP = .0398**			

Finally, a sensitivity analysis shows that a modified geotechnical fragility curve representing the risk of actual levee failure has a minimal impact on EAD and AEP, and that nominal changes to the probability-stage curve reflecting consideration of possible upstream levee failures have only negligible o EAD and AEP.

ENCLOSURE 4
HECFDA USER GUIDELINES AND FILE DESCRIPTION

HECFDA USER GUIDELINES

Instructions for Using the HECFDA Program

Introduction

The HECFDA program will format the FLO-2D model output data (grid element ground elevation and water surface elevation) into the HEC-FDA file format for evaluating flood damage cost. The program is a stand alone Fortran program and no other software is necessary. The data and output files are in ASCII format. All the data and output files have to be in the same subdirectory. It is necessary to run the FLO-2D model project simulations to generate the maximum water surface elevation files (MAXWSELEV.OUT) for each required discharge profile. The MAXWSELEV.OUT must be renamed with a number ranging from 1 to 8 (e.g. MAXWSELEV1.OUT to MAXWSELEV8.OUT) representing the appropriate return period profile simulation. It is necessary to put one FPLAIN.DAT file in the project subdirectory. The HECFDA.DAT file must be prepared prior to running the program.

Data Requirements

FPLAIN.DAT from one of the FLO-2D profile simulations.

HECFDA.DAT prepared according the HECFDA.DAT file format description document.

MAXWSELEV.OUT files renamed to MAXWSELEV1.OUT to MAXWSELEV8.OUT representing the eight potential FLO-2D water surface profile simulations.

User Instructions

It is necessary to complete the FLO-2D water surface profile simulations for the project before using the HECFDA program. The program is limited to 8 flood simulations profiles representing eight different return period floods. After the simulations are complete, follow these steps to generate the HEC-FDA file format:

Step 1. Create a new project subdirectory (e.g. HECFDA River 1).

Step 2. Copy the HECFDA.EXE file into the new project subdirectory.

Step 3. Copy the FPLAIN.DAT file from one of the FLO-2D profile simulations into the new project subdirectory.

Step 4. Copy MAXWSELEV.OUT file from the project subdirectory for each of the completed FLO-2D water surface profiles simulation to the new project subdirectory and rename the file to MAXWSELEV1.OUT to MAXWSELEV8.OUT according to the

representative water surface profile. There will be up to eight MAXWSELEV_.OUT files in the new project folder when you are done.

Step 5. Prepare the HECFDA.DAT file according the data input file description document.

Step 6. In Windows Explorer, double click on the HECFDA.EXE program. When the program is complete (a typical run will only take a few seconds), the following dialog box will be displayed:



This dialog box will disappear after 2 seconds and the HECFDA.OUT file will have been created. HECFDA.OUT is an ASCII data file and can be reviewed with any ASCII text editor program such as WordPad or NotePad.

Important Hints

1. It is only necessary to run the FLO-2D model profile simulations and generate the MAXWSELEV.DAT files that are necessary. If a given profile(s) is not required, then the corresponding MAXWSELEV_.OUT file can be missing from the project subdirectory.

2. It is not necessary to list the actual profile discharges in the HECFDA.DAT file. These discharge values are not used and are only in the file for the user's edification. In other words, these discharge numbers can be made up. Eight numbers are required for the data file.

3. The number of stations (grid element numbers) is unlimited but must be less than the last grid element number in the grid system. The program is limited to eight water surface profile simulations.

FILE: HECFDA.DAT

VARIABLE DESCRIPTION
(Free Format - Space Delimited)

Line 1 contains the project title.

1 **TITLE (60 characters)**

Line 2 is the reach name.

2 **REACHNAME (15 characters)**

Line 3 is the profile names.

3 **PROFILENAME(J), J = 1, 8 profiles (each name is limited to 4 characters)**

Line 4 is the profile discharge.

4 **DISCHARGE(J), J = 1, 8 profiles (discharges values are not used in the program)**

Line 5 to end is the FLO-2D grid element

5 **STATION(I), I=1, NNOD (number of specified stations, limited to the number of grid elements NNOD in the FLO-2D model)**

Note: Only 1 grid element station per line

An example of the HECFDA.DAT file:

```
HEC-FDA PROJECT TITLE
RIVER REACH
Q2        Q10        Q25     Q50       Q100     Q150       Q200     Q250
Q500
2500.     4250.    6582.    8452.    10528.    12562.     15855.   20856.
31652.
14568
14568
15484
16752
16896
17041
17365
18965
19546
20022
21454
```

ENCLOSURE 5
NON-STANDARD HEC-FDA TECHNIQUE TO INCORPORATE STAGE UNCERTAINTY

Subject: Natomas HEC-FDA Modeling Options for Various Upstream Levee Assumptions- Using Stage-Frequency Relationships.

During the FSM (SPD-F3 milestone), the American River Common Features (ARCF) PDT struggled with how to define the uncertainty of the possibility that upstream levee failures may impact the future without project conditions (FWOP) for Natomas. For the FSM documentation, the exceedance probability- stage functions were developed assuming no upstream failures (only allowing water to leave the system through overtopping). The PDT discussed possibility of developing multiple upstream scenarios, allowing for a range of stages for given events. From these, a minimum, maximum and most-likely could represent the uncertainty based on a triangular distribution. This 'best case', likely and 'worst case' scenario would be consistent with the guidance found in EM 1110-2-1619 and would support comments provided during review that: "the uncertain upstream conditions" should be explicitly described in the modeling.

HEC-FDA allows for a triangular distribution of discharges to be defined in the transform flow function (regulated vs. unregulated). The transform flow function has been used before on other studies to estimate upstream uncertainty. If our Natomas model was developed with exceedance probability-discharge functions, this approach could be applied without modification of the current software (HEC-FDA 1.2.4). Unfortunately our Natomas HEC-FDA model is defined only using exceedance probability-stage. The transform curve is not used in these 'stage-only' runs and the triangular distribution of possible upstream conditions cannot be entered into the model.

The proposed modeling option, is to use all three available discharge and stage relationships in HEC-FDA BUT to define all three relationships ONLY in terms of stage. The exceedance probability function would be entered using the graphical option set for discharge but stages would be entered in place of flow. The transform flow would use the stage distribution by event instead of inflow-outflow and the stage-discharge would be a dummy curve where stage=stage.

Before doing the following tests, the PDT had three primary questions:

1) Would the software operate and provide output using stages instead of flow in all the discharge functions?
2) What would be the difference in the stage errors in exceedance probability function using the discharge option instead of the stage option?
3) Could the FSM results be reasonably replicated using this proposed method (where stage=stage in the transform flow function)?

Good news on question #1: the model operates fine under the proposed modeling option. The levee curves and stage-damage functions were the same as the FSM model and only the three relationships were modified using only the stage-frequency function provided based on no upstream failures.

The concern regarding the second question was based on the fact that we are using HEC-FDA to define the error band based on the shape of the imputed graphical curve and the period of record. The assumption was that because HEC-FDA estimates these using different methods for discharge vs. stage, that the differences may be significant. Figure 1 below shows a table for the range of stage by exceedance probability (+- 1 and 2 standard deviations) using the FSM model. Figure 2 show the range of stage using the proposed 'stage as discharge' option.

Figure 1: FSM Model (Stage Option Graphical Curve)

Natomas 1.2.4 - Exceedance Probability Functions with Uncertainty

File Edit View Help

Plan: Without | Stream: Sacramento River

Analysis Year: 2007 | Damage Reach: Natomas

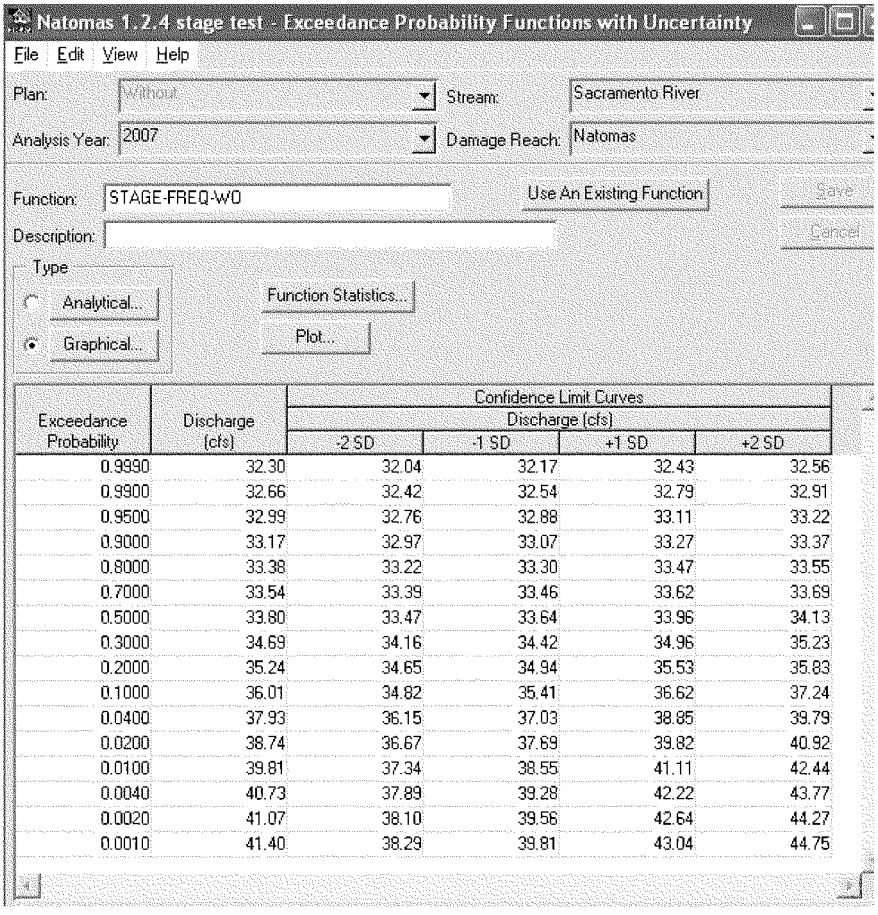
Function: STAGE-FREQ-WO | Use An Existing Function | Save

Description: | Cancel

Type: Analytical... / Graphical... | Function Statistics... | Plot...

Exceedance Probability	Stage (ft.)	Confidence Limit Curves Stage (ft.) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	32.30	32.30	32.19	32.41	32.53
0.9900	32.67	32.44	32.56	32.79	32.90
0.9500	33.00	32.77	32.89	33.12	33.23
0.9000	33.18	32.98	33.08	33.28	33.38
0.8000	33.39	33.23	33.31	33.47	33.56
0.7000	33.55	33.39	33.47	33.62	33.70
0.5000	33.80	33.47	33.63	33.97	34.13
0.3000	34.70	34.17	34.44	34.97	35.24
0.2000	35.25	34.66	34.96	35.55	35.84
0.1000	36.01	34.79	35.40	36.62	37.23
0.0400	37.93	36.16	37.05	38.81	39.70
0.0200	38.74	36.75	37.74	39.74	40.73
0.0100	39.81	37.51	38.66	40.96	42.11
0.0040	40.73	38.17	39.45	42.00	43.28
0.0020	41.07	38.42	39.74	42.40	43.72
0.0010	41.39	38.65	40.02	42.76	44.14

Figure 2: Proposed Model (Stage as Discharge Option Graphical Curve)

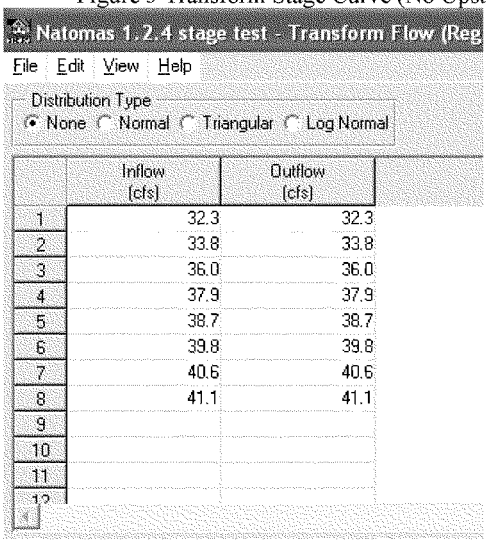


Exceedance Probability	Discharge (cfs)	Confidence Limit Curves Discharge (cfs) -2 SD	-1 SD	+1 SD	+2 SD
0.9990	32.30	32.04	32.17	32.43	32.56
0.9900	32.66	32.42	32.54	32.79	32.91
0.9500	32.99	32.76	32.88	33.11	33.22
0.9000	33.17	32.97	33.07	33.27	33.37
0.8000	33.38	33.22	33.30	33.47	33.55
0.7000	33.54	33.39	33.46	33.62	33.69
0.5000	33.80	33.47	33.64	33.96	34.13
0.3000	34.69	34.16	34.42	34.96	35.23
0.2000	35.24	34.65	34.94	35.53	35.83
0.1000	36.01	34.82	35.41	36.62	37.24
0.0400	37.93	36.15	37.03	38.85	39.79
0.0200	38.74	36.67	37.69	39.82	40.92
0.0100	39.81	37.34	38.55	41.11	42.44
0.0040	40.73	37.89	39.28	42.22	43.77
0.0020	41.07	38.10	39.56	42.64	44.27
0.0010	41.40	38.29	39.81	43.04	44.75

Comparing the two figures, the difference in error in stage at the 'bottom' of the curve is minimal (less than 0.03 feet for 2 sd from 0.999 to 0.1 events). From 0.01 to 0.002, the difference is greater (maximum of 0.55 feet for 2 sd , non-symmetrical and may have some impact on the results.

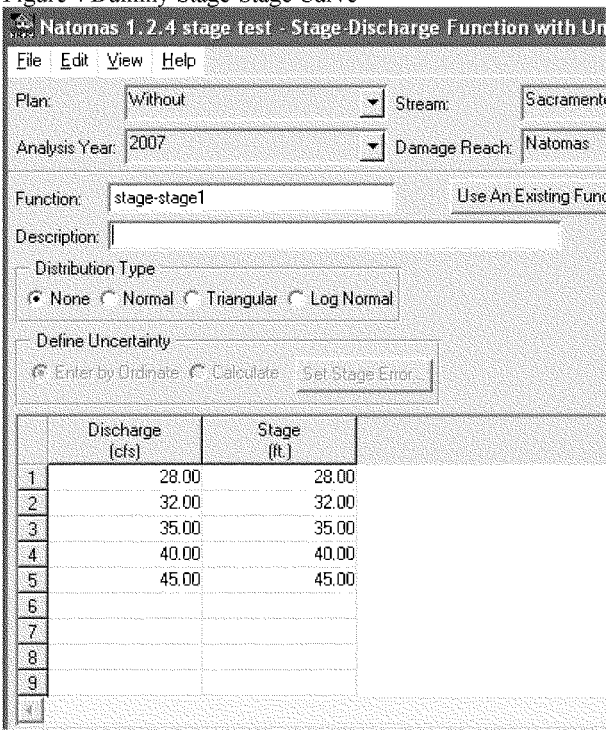
So the third question: could the FSM results be replicated using a transform flow and stage-stage dummy curve? Figures 3 and 4 show the inputs to the HEC-FDA model to complete the test.

Figure 3 Transform Stage Curve (No Upstream Levee Failures- No Uncertainty)



	Inflow (cfs)	Outflow (cfs)
1	32.3	32.3
2	33.8	33.8
3	36.0	36.0
4	37.9	37.9
5	38.7	38.7
6	39.8	39.8
7	40.6	40.6
8	41.1	41.1
9		
10		
11		
12		

Figure 4 Dummy Stage-Stage Curve



HEC-FDA Results were compared for the FSM runs and this test. EAD, AEP and CNP are shown in Table 1.

Table 1 – HEC-FDA RESULTS COMPARISON
EAD is in $ Millions

OUTPUT	FSM	TEST RUNS	DIFFERENCE
EAD-WO	2,451	2,444	-0.3 %
AEP-WO	0.3865	0.3854	-0.3 %
CNP 10%	48.2 %	48.2 %	0 %
CNP 1%	15.1 %	14.8 %	-2.0 %
WITH PROJECT – TEST (RAISE PNP TO 3 feet below TOL)			
EAD-Wp	81	78	-3.7 %
AEP-Wp	0.0124	0.0120	-3.2 %
CNP 10%	100 %	100 %	0 %
CNP 1%	54.7 %	49.1 %	-10.2 %

Based on the results, doesn't appear to be any impact on EAD or AEP under without project. As with project alternatives get closer to reducing flood risk for the 1 % event, looks like there will be a greater difference and may impact which alternatives meet CNP criteria.

Scenarios with uncertainty in the transform 'stage' function were run to describe how the proposed model might be used. The only relationship that would change from our 'test' runs above would be the transform flow. Inflow (stage) would be represented by stage in the exceedance probability function without any upstream failure conditions. The maximum (stage) would be set equal to the inflow (stage). Then the minimum and outflow (stage) would represent the sensitivity runs. Two examples are shown below. Figure 5 lowers only the bottom points on the curve (stage 37.9 ft and below) and Figure 6 lowers the entire curve but at a decreasing rate for higher stages. Both are strictly hypothetical and do not represent any hydraulic runs. These are used only for economic and HEC-FDA model test purposes.

Figure 5 Likely Shift Transform Stage Curve (Bottom only)

Natomas 1.2.4 stage test - Transform Flow (Regulated vs. Unregulated)

File Edit View Help

Distribution Type
None Normal Triangular Log Normal

	Inflow (cfs)	Outflow (cfs)	Minimum Outflow (cfs)	Maximum Outflow (cfs)
1	32.3	30.3	30.300	32.300
2	33.8	32.8	31.800	33.800
3	36.0	35.0	34.000	36.000
4	37.9	36.9	35.900	37.900
5	38.7	38.7	38.700	38.700
6	39.8	39.8	39.800	39.800
7	40.6	40.6	40.600	40.600
8	41.1	41.1	41.100	41.100
9				
10				

Figure 6 Big Shift Transform Stage Curve

Natomas 1.2.4 stage test - Transform Flow (Regulated vs. Unregulated)

File Edit View Help

Distribution Type
None Normal Triangular Log Normal

	Inflow (cfs)	Outflow (cfs)	Minimum Outflow (cfs)	Maximum Outflow (cfs)
1	32.3	30.3	28.300	32.300
2	33.8	31.8	29.800	33.800
3	36.0	34.0	33.000	36.000
4	37.9	35.9	35.000	37.900
5	38.7	37.7	37.200	38.700
6	39.8	39.3	38.800	39.800
7	40.6	40.1	39.600	40.600
8	41.1	40.6	40.100	41.100
9				
10				

The HEC-FDA 1.2.4 model was rerun using these two shifted curves and compared to the results of the test runs. Results are shown in Table 2.

Table 2 HEC-FDA RESULTS COMPARISON
EAD is in $ Millions

OUTPUT	TEST RUNS	Bottom Shift (Fig 5)	Big Shift (Fig 6)
EAD-WO	2,444	1,287	815
AEP-WO	0.3854	0.2026	0.1281
CNP 10%	48.2 %	60.3 %	65.0 %
CNP 1%	14.8 %	15.4 %	21.8 %
WITH PROJECT – TEST (RAISE PNP TO 3 feet below TOL)			
EAD-Wp	78	78	54
AEP-Wp	0.0120	0.0119	0.0083
CNP 10%	100 %	100 %	100 %
CNP 1%	49.1 %	48.7 %	66.0 %

ENLOSURE 6
PROJECT COSTS USED FOR PRELIMINARY SCREENING OF ALTERNATIVES, OCTOBER 2010 PRICE LEVEL

American River Watershed – Common Features
Natomas Post-Authorization Change Report
Screening-Level Cost Estimates
Sacramento River East Levee Reaches (NAT A, NAT B, NAT C)
Fix-in-Place Alternative

REACH	ALTERNATIVE	METHOD OF FIX	WSEL (FT)	RAISE OR TO EXISTING LEVEE HIEGHT	TOTAL FIRST COSTS	INTEREST DURING CONSTRUCTION (IDC)	TOTAL INVESTMENT COST	AMORTIZED COSTS	ANNUAL OMRR&R	TOTAL AVERAGE ANNUAL COSTS
A	Fix-in-Place	Slope Flattening Soil Bentonite Cutoff Wall	39.92	Raise	$135,407,000	$24,430,000	$159,837,000	$7,920,000	$400,000	$8,320,000
			36.73	Existing	$102,869,000	$19,220,000	$122,089,000	$6,050,000	$300,000	$6,350,000
			34.70	Existing	$102,869,000	$19,220,000	$122,089,000	$6,050,000	$300,000	$6,350,000
			34.00	Existing						
			33.45	Existing						
			31.29	Existing						
B	Fix-in-Place	Soil Bentonite Cutoff Wall	39.99	Raise	$317,418,125	$24,610,000	$342,028,125	$16,970,000	$850,000	$17,820,000
			36.92	Existing	$307,337,125	$23,660,000	$330,997,125	$16,420,000	$830,000	$17,250,000
			34.98	Existing	$297,540,125	$22,900,000	$320,440,125	$15,890,000	$800,000	$16,690,000
			34.27	Existing	$275,856,625	$20,140,000	$295,996,625	$14,860,000	$740,000	$15,600,000
			33.72	Existing	$275,856,625	$20,140,000	$296,955,625	$14,730,000	$740,000	$15,470,000
			31.97	Existing	$275,856,625	$20,140,000	$295,996,625	$14,680,000	$730,000	$15,410,000
	Fix-in-Place	Drained Seepage Berm	39.99	Raise	$323,765,125	$27,160,000	$350,925,125	$17,410,000	$890,000	$18,300,000
			36.92	Existing	$298,366,125	$24,980,000	$323,346,125	$16,040,000	$800,000	$16,840,000
			34.98	Existing	$289,827,125	$24,320,000	$314,097,125	$15,570,000	$780,000	$16,350,000
			34.27	Existing	$261,391,625	$20,590,000	$281,981,625	$13,980,000	$700,000	$14,680,000
			33.72	Existing	$261,391,625	$20,590,000	$281,981,625	$13,980,000	$700,000	$14,680,000
			31.97	Existing	$261,391,625	$20,590,000	$281,981,625	$13,980,000	$680,000	$14,680,000
C	Fix-in-Place	Soil Bentonite Cutoff Wall	43.11	Raise	$140,121,900	$3,430,000	$143,551,900	$7,120,000	$350,000	$7,470,000
			42.24	Raise	$137,226,900	$3,360,000	$140,586,900	$6,970,000	$350,000	$7,320,000
			40.86	Raise	$130,866,300	$3,160,000	$134,026,300	$6,640,000	$330,000	$6,970,000
			39.95	Raise	$127,609,700	$3,070,000	$130,679,700	$6,480,000	$330,000	$6,810,000
			39.26	Existing	$127,191,700	$3,060,000	$130,251,700	$6,460,000	$330,000	$6,790,000
			37.08	Existing	$127,191,700	$3,060,000	$130,251,700	$6,460,000	$330,000	$6,790,000
	Fix-in-Place	Soil Bentonite Cutoff Wall & Drained Seepage Berm	43.11	Raise	$141,650,500	$3,540,000	$145,390,500	$7,210,000	$360,000	$7,570,000
			42.24	Raise	$138,426,500	$3,440,000	$141,866,500	$7,030,000	$360,000	$7,390,000
			40.86	Raise	$132,593,500	$3,270,000	$135,863,500	$6,730,000	$330,000	$7,060,000
			39.95	Raise	$129,338,500	$3,180,000	$132,518,500	$6,570,000	$330,000	$6,900,000
			39.26	Existing	$128,920,500	$3,170,000	$132,090,500	$6,550,000	$330,000	$6,880,000
			37.08	Existing	$128,920,500	$3,170,000	$132,090,500	$6,550,000	$330,000	$6,880,000

American River Watershed – Common Features
Natomas Post-Authorization Change Report
Screening-Level Cost Estimates
Natomas Cross Canal (NAT D)
Fix-in-Place Alternative

REACH	ALTERNATIVE	METHOD OF FIX	WSEL (FT)	RAISE OR TO EXISTING LEVEE HIEGHT	TOTAL FIRST COSTS	INTEREST DURING CONSTRUCTION (IDC)	TOTAL INVESTMENT COST	AMORTIZED COSTS	ANNUAL OMRR&R	TOTAL AVERAGE ANNUAL COSTS
D	Fix-in-Place	Soil Bentonite Cutoff Wall	45.13	Raise	$85,030,000	$3,470,000	$88,500,000	$4,390,000	$130,000	$4,520,000
			44.16	Raise	$80,890,000	$3,290,000	$84,180,000	$4,170,000	$130,000	$4,300,000
			42.76	Raise	$75,900,000	$3,080,000	$78,980,000	$3,920,000	$120,000	$4,040,000
			41.80	Raise	$57,640,000	$2,290,000	$59,930,000	$2,970,000	$90,000	$3,060,000
			41.07	Existing	$36,680,000	$1,560,000	$38,240,000	$1,900,000	$60,000	$1,960,000
			38.97	Existing	$36,680,000	$1,560,000	$38,240,000	$1,900,000	$60,000	$1,960,000

American River Watershed – Common Features
Natomas Post-Authorization Change Report
Screening-Level Cost Estimates
Pleasant Grove Creek Canal (NAT E) and Natomas Cross Canal (NAT F, NAT G, NAT H)
Fix-in-Place Alternative

REACH	ALTERNATIVE	METHOD OF FIX	WSEL (FT)	RAISE OR TO EXISTING LEVEE HIEGHT	TOTAL FIRST COSTS	INTEREST DURING CONSTRUCTION (IDC)	TOTAL INVESTMENT COST	AMORTIZED COSTS	ANNUAL OMRR&R	TOTAL AVERAGE ANNUAL COSTS
E	Fix-in-Place	Soil Bentonite Cutoff Wall	45.03	Raise	$61,990,000	$18,160,000	$80,150,000	$3,970,000	$120,000	$4,090,000
			43.89	Raise	$55,810,000	$16,350,000	$72,160,000	$3,580,000	$110,000	$3,690,000
			42.56	Existing	$50,790,000	$14,880,000	$65,670,000	$3,260,000	$100,000	$3,360,000
			41.56	Existing	$50,790,000	$14,880,000	$65,670,000	$3,260,000	$100,000	$3,360,000
			40.75	Existing	$50,790,000	$14,880,000	$65,670,000	$3,260,000	$100,000	$3,360,000
			38.81	Existing	$50,790,000	$14,880,000	$65,670,000	$3,260,000	$100,000	$3,360,000
F	Fix-in-Place	Drained Seepage Berm	43.03	Raise	$74,760,000	$21,900,000	$96,660,000	$4,790,000	$140,000	$4,930,000
			39.76	Raise	$63,530,000	$18,610,000	$82,140,000	$4,070,000	$120,000	$4,190,000
			38.97	Raise	$59,110,000	$17,320,000	$76,430,000	$3,790,000	$110,000	$3,900,000
			38.10	Existing	$56,190,000	$16,460,000	$72,650,000	$3,600,000	$110,000	$3,710,000
			37.24	Existing	$56,190,000	$16,460,000	$72,650,000	$3,600,000	$110,000	$3,710,000
			35.62	Existing	$56,190,000	$16,460,000	$72,650,000	$3,600,000	$110,000	$3,710,000
	Fix-in-Place	Flattened Landside Slope	43.03	Raise	$76,580,000	$22,430,000	$99,010,000	$4,910,000	$150,000	$5,060,000
			39.76	Raise	$56,360,000	$16,510,000	$72,870,000	$3,610,000	$110,000	$3,720,000
			38.97	Raise	$51,300,000	$15,030,000	$66,330,000	$3,290,000	$100,000	$3,390,000
			38.10	Existing	$46,860,000	$13,730,000	$60,590,000	$3,000,000	$90,000	$3,090,000
			37.24	Existing	$46,860,000	$13,730,000	$60,590,000	$3,000,000	$90,000	$3,090,000
			35.62	Existing	$46,860,000	$13,730,000	$60,590,000	$3,000,000	$90,000	$3,090,000
G	Fix-in-Place	Soil Bentonite Cutoff Wall	43.05	Raise	$61,240,000	$14,620,000	$75,860,000	$3,760,000	$110,000	$3,870,000
			39.78	Raise	$45,390,000	$10,840,000	$56,230,000	$2,790,000	$80,000	$2,870,000
			38.99	Raise	$43,180,000	$10,310,000	$53,490,000	$2,650,000	$80,000	$2,730,000
			38.11	Raise	$39,720,000	$9,480,000	$49,200,000	$2,440,000	$70,000	$2,510,000
			37.25	Existing	$39,720,000	$9,480,000	$49,200,000	$2,440,000	$70,000	$2,510,000
			35.63	Existing	$39,720,000	$9,480,000	$49,200,000	$2,440,000	$70,000	$2,510,000
H	Fix-in-Place	Soil Bentonite Cutoff Wall	44.37	Raise	$165,680,000	$30,950,000	$196,630,000	$9,750,000	$150,000	$9,900,000
			39.07	Existing	$73,000,000	$13,640,000	$86,640,000	$4,300,000	$130,000	$4,430,000
			37.53	Existing	$64,940,000	$12,130,000	$77,070,000	$3,820,000	$110,000	$3,930,000
			35.99	Existing	$64,940,000	$12,130,000	$77,070,000	$3,820,000	$110,000	$3,930,000
			34.93	Existing	$64,940,000	$12,130,000	$77,070,000	$3,820,000	$110,000	$3,930,000
			32.55	Existing	$64,940,000	$12,130,000	$77,070,000	$3,820,000	$110,000	$3,930,000

American River Watershed – Common Features
Natomas Post-Authorization Change Report
Screening-Level Cost Estimates
American River North Levee (NAT I)
Fix-in-Place Alternative

REACH	ALTERNATIVE	METHOD OF FIX	WSEL (FT)	RAISE OR TO EXISTING LEVEE HIEGHT	TOTAL FIRST COSTS	INTEREST DURING CONSTRUCTION (IDC)	TOTAL INVESTMENT COST	AMORTIZED COSTS	ANNUAL OMRR&R	TOTAL AVERAGE ANNUAL COSTS
I	Fix-in-Place	Soil Bentonite Cutoff Wall	43.95	Raise	$27,136,750	$3,720,000	$30,856,750	$1,530,000	$80,000	$1,610,000
			38.19	Existing	$25,018,750	$3,430,000	$28,448,750	$1,410,000	$70,000	$1,480,000
			35.66	Existing	$25,018,750	$3,430,000	$28,448,750	$1,410,000	$70,000	$1,480,000
			35.06	Existing	$25,018,750	$3,430,000	$28,448,750	$1,410,000	$70,000	$1,480,000
			34.60	Existing	$25,018,750	$3,430,000	$28,448,750	$1,410,000	$70,000	$1,480,000
			31.24	Existing	$25,018,750	$3,430,000	$28,448,750	$1,410,000	$70,000	$1,480,000

American River Watershed – Common Features
Natomas Post-Authorization Change Report
Screening-Level Cost Estimates
Sacramento River East Levee Reaches (NAT A, NAT B, NAT C)
Adjacent Levee Alternative

REACH	ALTERNATIVE	METHOD OF FIX	WSEL (FT)	RAISE OR TO EXISTING LEVEE HIEGHT	TOTAL FIRST COSTS	INTEREST DURING CONSTRUCTION (IDC)	TOTAL INVESTMENT COST	AMORTIZED COSTS	ANNUAL OMRR&R	TOTAL AVERAGE ANNUAL COSTS
A	Adjacent Levee	Slope Flattening Soil Bentonite Cutoff Wall	39.92	Raise	$135,407,000	$24,430,000	$159,837,000	$7,920,000	$400,000	$8,320,000
			36.73	Existing	$102,869,000	$19,220,000	$122,089,000	$6,050,000	$300,000	$6,350,000
			34.70	Existing	$102,869,000	$19,220,000	$122,089,000	$6,050,000	$300,000	$6,350,000
			34.00	Existing						
			33.45	Existing						
			31.29	Existing						
B	Adjacent Levee	Soil Bentonite Cutoff Wall	39.99	Raise	$295,251,000	$22,670,000	$317,921,000	$15,770,000	$780,000	$16,550,000
			36.92	Existing	$272,575,000	$20,890,000	$293,465,000	$14,540,000	$730,000	$15,270,000
			34.98	Existing	$269,914,000	$20,770,000	$290,684,000	$14,400,000	$720,000	$15,120,000
			34.27	Existing	$253,060,000	$18,670,000	$271,730,000	$13,470,000	$680,000	$14,150,000
			33.72	Existing	$253,060,000	$18,670,000	$271,730,000	$13,470,000	$680,000	$14,150,000
			31.97	Existing	$253,060,000	$18,670,000	$271,730,000	$13,470,000	$680,000	$14,150,000
C	Adjacent Levee	Soil Bentonite Cutoff Wall	43.11	Raise	$107,140,000	$3,040,000	$110,180,000	$5,460,000	$270,000	$5,730,000
			42.24	Raise	$103,989,000	$2,950,000	$106,939,000	$5,300,000	$260,000	$5,560,000
			40.86	Raise	$97,988,000	$2,780,000	$100,768,000	$4,990,000	$250,000	$5,240,000
			39.95	Raise	$94,531,000	$2,650,000	$97,181,000	$4,820,000	$250,000	$5,070,000
			39.26	Existing	$91,855,000	$2,590,000	$94,445,000	$4,680,000	$240,000	$4,920,000
			37.08	Existing	$91,855,000	$2,590,000	$94,445,000	$4,680,000	$240,000	$4,920,000

American River Watershed – Common Features
Natomas Post-Authorization Change Report
Screening-Level Cost Estimates
Pleasant Grove Creek Canal (NAT E) and Natomas Cross Canal (NAT F, NAT G)
Adjacent Levee Alternative

REACH	ALTERNATIVE	METHOD OF FIX	WSEL (FT)	RAISE OR TO EXISTING LEVEE HIEGHT	TOTAL FIRST COSTS	INTEREST DURING CONSTRUCTION (IDC)	TOTAL INVESTMENT COST	AMORTIZED COSTS	ANNUAL OMRR&R	TOTAL AVERAGE ANNUAL COSTS
E	Adjacent Levee	Soil Bentonite Cutoff Wall	45.03	Raise	$56,350,000	$19,690,000	$76,040,000	$3,770,000	$190,000	$3,960,000
			43.89	Raise	$51,100,000	$17,860,000	$68,960,000	$3,420,000	$170,000	$3,590,000
			42.56	Existing	$44,870,000	$15,680,000	$60,550,000	$3,000,000	$150,000	$3,150,000
			41.56	Existing	$44,870,000	$15,680,000	$60,550,000	$3,000,000	$150,000	$3,150,000
			40.75	Existing	$44,870,000	$15,680,000	$60,550,000	$3,000,000	$150,000	$3,150,000
			38.81	Existing	$44,870,000	$15,680,000	$60,550,000	$3,000,000	$150,000	$3,150,000
F	Adjacent Levee	Drained Seepage Berm	43.03	Raise	$69,250,000	$24,200,000	$93,450,000	$4,630,000	$140,000	$4,770,000
			39.76	Raise	$59,270,000	$20,720,000	$79,990,000	$3,970,000	$200,000	$4,170,000
			38.97	Raise	$55,130,000	$19,270,000	$74,400,000	$3,690,000	$180,000	$3,870,000
			38.10	Existing	$48,910,000	$17,090,000	$66,000,000	$3,270,000	$160,000	$3,430,000
			37.24	Existing	$48,910,000	$17,090,000	$66,000,000	$3,270,000	$160,000	$3,430,000
			35.62	Existing	$48,910,000	$17,090,000	$66,000,000	$3,270,000	$160,000	$3,430,000
	Adjacent Levee	Flattened Landside Slope	43.03	Raise	$70,470,000	$24,630,000	$95,100,000	$4,720,000	$240,000	$4,960,000
			39.76	Raise	$52,050,000	$18,190,000	$70,240,000	$3,480,000	$170,000	$3,650,000
			38.97	Raise	$47,370,000	$16,560,000	$63,930,000	$3,170,000	$160,000	$3,330,000
			38.10	Existing	$33,640,000	$11,760,000	$45,400,000	$2,250,000	$110,000	$2,360,000
			37.24	Existing	$33,640,000	$11,760,000	$45,400,000	$2,250,000	$110,000	$2,360,000
			35.62	Existing	$33,640,000	$11,760,000	$45,400,000	$2,250,000	$110,000	$2,360,000
G	Adjacent Levee	Soil Bentonite Cutoff Wall	43.05	Raise	$55,010,000	$16,110,000	$71,120,000	$3,530,000	$180,000	$3,710,000
			39.78	Raise	$40,160,000	$11,760,000	$51,920,000	$2,570,000	$130,000	$2,700,000
			38.99	Raise	$38,200,000	$11,190,000	$49,390,000	$2,450,000	$120,000	$2,570,000
			38.11	Raise	$36,080,000	$10,570,000	$46,650,000	$2,310,000	$120,000	$2,430,000
			37.25	Existing	$32,930,000	$9,650,000	$42,580,000	$2,110,000	$110,000	$2,220,000
			35.63	Existing	$32,930,000	$9,650,000	$42,580,000	$2,110,000	$110,000	$2,220,000

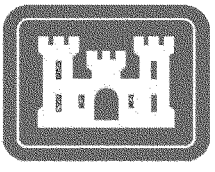
American River Watershed – Common Features
Natomas Post-Authorization Change Report
Screening-Level Cost Estimates
American River North Levee (NAT I)
Adjacent Levee Alternative

REACH	ALTERNATIVE	METHOD OF FIX	WSEL (FT)	RAISE OR TO EXISTING LEVEE HIEGHT	TOTAL FIRST COSTS	INTEREST DURING CONSTRUCTION (IDC)	TOTAL INVESTMENT COST	AMORTIZED COSTS	ANNUAL OMRR&R	TOTAL AVERAGE ANNUAL COSTS
I	Adjacent Levee	Soil Bentonite Cutoff Wall	43.95	Raise	$34,979,000	$4,790,000	$39,769,000	$1,970,000	$100,000	$2,070,000
			38.19	Existing	$24,886,000	$3,410,000	$28,296,000	$1,400,000	$70,000	$1,470,000
			35.66	Existing	$24,886,000	$3,410,000	$28,296,000	$1,400,000	$70,000	$1,470,000
			35.06	Existing	$24,886,000	$3,410,000	$28,296,000	$1,400,000	$70,000	$1,470,000
			34.60	Existing	$24,886,000	$3,410,000	$28,296,000	$1,400,000	$70,000	$1,470,000
			31.24	Existing	$24,886,000	$3,410,000	$28,296,000	$1,400,000	$70,000	$1,470,000

APPROVAL-FOR-USE REPORT

N@RM

(Natomas @Risk Model)



U.S. Army Corps
of Engineers
Sacramento District

Model Name:	Natomas @Risk Model (N@RM)
Functional Area:	Flood Risk Management, Economics Risk Analysis
Model Proponent:	Sacramento District, USACE
Model Developer/Contact:	Timi Shimabukuro and Erik Gomez
Year Developed:	May 2010

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SECTION 1

INTRODUCTION

1.1 Model Purpose

N@RM (subsequently referred to as "the model") is a planning model for flood risk management studies and was developed through collaboration between the Agency Technical Review Lead and the Sacramento District's economists. The model has been designed to be an analytical tool used for the evaluation of flood risk management plans using risk analysis methods.

In accordance with Assuring Quality Planning Models (USACE Engineering Circular No. 1105-2-412, December 2009), approval is required for all planning models developed and/or used by the US Army Corps of Engineers (USACE). The objective of model approval is to ensure that models used by USACE are technically and theoretically sound, computationally accurate, and in compliance with USACE planning policy.

1.2 Model Certification

The model has been reviewed in accordance with requirements for the approval of planning models as identified in EC 1105-2-412 and "Protocols for Certification/Approval of Planning Models," under the Assuring Quality Planning Models.

Following the definitions in the EC 1105-2-412, N@RMis categorized as a **Regional/Local Model** as it was developed by the Sacramento District for specific applications that cannot be adequately addressed using available corporate models. The model addresses a unique regional/local situation and is necessary for depicting the specific characteristics of the study area. In terms of level of review required by the certification team to ensure the model is a high quality model, N@RM is falls into a **Limited Level of Review**. Accordingly, approval review will concentrate on compliance with technical quality criteria, be limited to internal reviewers and limited testing.

Additionally, N@RM will be considered for approval-for-use because it was developed by the Corps and is viewed by the vertical team (including the District, MSC, PCX, and HQ) as single-use or study-specific. Model approval is a corporate determination that the model is a technically and theoretically sound and functional tool that can be applied during the planning process by knowledgeable and trained staff for purposes consistent with the model's purposes and limitations.

The FDR-PCX is proposing to conduct a Limited Level of review based on the frequency of use of the model and a low risk of making an incorrect investment decision that could result in major negative impact. The approval of this model is specifically for the express use in computing

expected annual damages related to the Natomas economic impact area currently being evaluated within the Sacramento District. This report presents the methodology and results of the review and approval process and will make recommendations affecting the level of approval appropriate for the model. N@RM is intended for approval-for-use as a USACE Regional/Local Model.

1.3 Contribution to Planning Effort

USACE requires the use of risk analysis procedures for formulating and evaluation flood risk management measures. Such projects are generally only authorized and implemented when they are economically justified, that is, when the predicted benefits can be demonstrated to exceed the estimated costs. The required analysis involves the estimation of benefits and costs under different alternatives over a project analysis period, while taking into account the probabilistic nature of storm damage, and the uncertainty regarding the measurement of many input variables. Benefits are derived by comparing the expected damages when a flood damage protection project is in place with the expected damages in the absence of any project. Although Corps Certified Model HEC-FDA provides such results, due to the unique nature (high frequency flood events) of the Natomas Basin a model that captures the economic life-cycle of the region is necessary in the estimation of benefits.

1.4 Report Organization

The report is organized as follows: An overview of the model and description of the model, its inputs, key functions, components and elements are provided in Section 2; Section 3 presents the model evaluation, including certification criteria, model testing approach and model assessment; Section 4 presents conclusions and recommendations.

SECTION 2

MODEL DESCRIPTION

2.1 Model Approach

The current corporate certified model (HEC-FDA) does not account for a post-flood rebuild period and assumes immediate rebuild/restoration following a flood event; HEC-FDA does not adjust for a declining inventory stock after flood events. The risk of flooding in the Basin is extremely high in terms of both the probability and consequences of flooding. In this high risk circumstance, HEC-FDA overstates expected annual damages by not accounting for such things as a rebuild period and declining inventory stock, which are reasonable assumptions of rational human behavior. The Natomas expected annual damages, then, should be computed to reflect the basic economic methodological premise of rational human actors.

N@RM is a model built on an EXCEL platform that uses Palisade's @Risk Excel Add-in to account for life-cycle damages; with the basis that high consequence events at a high probability of occurrence, the rebuild time period and the assumption of full replacement needs to be considered. HEC-FDA cannot make this adjustment so with the assistance of Mike Hallisy(ATR), the team collectively developed a base spreadsheet to account for present value damages followed by repair period with the series of potential additional flood events over the 50-year period of analysis. In the future, HEC-FRM will resolve this issue, however, meanwhile approval is necessary to move forward.

2.3 Model Development Process

Comments received during the Agency Technical Review (ATR) from the technical reviewer (USACE Los Angeles District, SPL) as well as from policy reviewers (USACE Headquarters and USACE SPD) , it was determined that the expected annual damages (EAD) obtained from HEC-FDA were overestimated and a post-processing method was necessary. The model developed was to be the basis for plan formulation and not just serve as a supplement to the HEC-FDA results. This model was developed in response to agency technical review comments and adjusts the EAD and benefit values by accounting for human behavior in the floodplain in the form of a rebuild period after a flood event, a loss of inventory stock as people move out of the floodplain after a flood event, and a cap to the number of flood event allowed to occur before the Natomas Basin is completely abandoned. The supplied model has been reviewed for technical quality by the development team in Sacramento District and satisfies expected economic behavior. In addition, the PDT believes that the approach to use the @RISK model to make EAD and benefits adjustments described is a necessary step in light of the fact that there is currently no other Corps-approved economic model that can do this type of analysis and also because there is no approved way to account for this EAD and benefits overestimation.

2.4 Model Capabilities and Limitations

The model incorporates two USACE approaches to flood risk management analysis—consistency with scientific understanding and a reasonable risk analysis procedure. It is able to account for human behavior in the form of a rebuilding period, a rebuilding schedule (percent rebuilt per year during the rebuild period), loss of inventory stock following a flood event, and the number of flood events allowed before floodplain occupants decide to completely abandon the Natomas Basin.

However, the model is limited in the following:

- Rebuild scenarios could be more comprehensive
- Three flood event cap

The rebuilding scenarios and three flood event cap assumptions are believed to be minuscule model shortcomings. It is thought that investment of time and resources in increasing the accuracy of such assumptions would marginally change the results and the overall value added would be minimal. A meeting with section chief, agency technical reviewer, corps economist and headquarter economist, conluded in indicating that both assumptions captures the model behavior of a rational participant.

These limitations have been noted but considering the single-use local use, it is believed that the shortcomings would only fine-tune the model. None of these issues should prevent the model from being certified as they are possible enhancements not corrections to the current capability of the model.

SECTION 3

MODEL EVALUATION

3.1 Certification Criteria

In accordance with the "Protocols for Certification/Approval of Planning Models" and EC 1105-2-412, N@RM is subject to Level 3approval/review. Being a level 3 review, it is important to emphasize that the Natomas @Risk Model (N@RM) was developed specifically for the Natomas Post-Authorization Change Interim Reevaluation Study. This model is intended to be a single-use, project-specific model, and was developed in order to more accurately quantify without-project damages and with-project benefits for the Natomas Basin study area. The primary objective for developing the model was to be able to incorporate economic assumptions which stem directly from the unique flooding characteristics of the Natomas Basin area, where there exists both a potentially high chance of flooding in any given year and extremely high expected damages, if a flood event were to occur. Currently, these assumptions cannot be captured in any existing USACE-approved planning model, including HEC-FDA.

Additionally, while the results of the N@RM were used as the basis for plan formulation, it is important to note that the analysis performed in HEC-FDA and the corresponding HEC-FDA results were not completely replaced with the analysis performed in and the results obtained from the N@RM. In fact, key data obtained from the HEC-FDA analysis or used in the initial with-project analysis served as inputs into the N@RM, including the HEC-FDA-computed stage-damage curves, the annual exceedance probability (AEP) information, and the order of levee reach improvements. In other words, the N@RM analysis is necessarily linked to the data and information derived from the HEC-FDA analysis, but expands upon the HEC-FDA analysis by incorporating additional economic assumptions pertinent specifically to the Natomas Basin study area. A comparison of the results from the HEC-FDA analysis to those from the N@RM shows that, on a relative basis, without-project and with-project benefits follow closely with one another. The main differences lie in the magnitude (that is, in absolute terms) of the without-project damages and with-project benefits. (The without-project damages using only HEC-FDA is close to $1.4 billion; the without-project damages using both HEC-FDA and the N@RM is $462 million.)

A summary of basic approval criteria is outlined below.

Technical Quality-- Analytical tools and models used to support flood risk management analysis are expected to be based on established contemporary scientific theory. The study area and how it responds to the influences that act upon it must be realistically represented by the model's components, in the form of calculations based on the application of scientific theory. The analytical requirements of the model must be identified, and the model must address these requirements. Formulas and calculation routines that form the mechanics of the model must be accurate and correctly applied, with sound relationships between variables. The model should also be able to reflect the influence or restrictions of man-made laws, policies, and practices.

The model should be logically unassailable and all assumptions whether they pertain to natural or human-induced processes, must be valid and documented. Technically correct models with rational assumptions should produce robust, reproducible results that stand up to the rigorous scrutiny in later stages of the plan formulation process.

System Quality-- System quality refers to the entire system used for model development, use and support, including software and hardware requirements, and data interoperability or compatibility with other systems. Efficiency and operation stability of the model have also been considered under system quality criteria. Factors such as appropriateness of the software or programming language, correctness of programming, and availability and quality of supporting software and hardware can be considered in the assessment of system quality. The ability to import model data and/or output into other software analysis tools is another factor associated with system quality.

Usability-- Usability refers to the overall ease and efficiency with which users are able to operate the model to obtain the relevant information required to support decisions made in the planning of flood risk management studies. The issues that can be considered during this component of the approval include:

- User friendliness of the model, including logical configuration and intuitiveness
- Availability of training and technical support for model users
- Availability of training and technical support for model users
- Ease of access in obtaining input data required to run the model
- Availability of the model programs or files to potential users
- Ability to extract understandable, relevant information from model outputs

Note that usability assessment will not be rigorous due the nature and level of review.

3.2 Technical Quality Assessment

Background

The model makes adjustments to the EAD based on the acknowledgement that the without-project damages and with-project benefits as reported by HEC-FDA may be overstated for the Natomas Basin. This acknowledgement, in turn, is based on several factors:

- The current HEC-FDA modeling results, which are based on frequency analysis and not life cycle analysis over the 50-year period of analysis, show a high annual exceedance probability (AEP of .21) and high expected annual damages (EAD of approximately $1.4 billion)
- The Natomas Basin floodplain characteristics, including the population and structure inventory
- The basic economic methodological premise that individuals will behave rationally

Taken together, the salient points above indicate that given the extremely high risk in the Natomas Basin area in terms of frequency of flooding (1 in 5 chance of flooding in any given year)[1] and consequences of flooding ($7.6 billion in damages from a 100-year event from break on the Natomas Cross Canal) coupled with the fact that the Natomas Basin contains close to 23,000 structures and nearly 80,000 residents, it is highly unlikely that people would continue to occupy the area after multiple floods, assuming they behave rationally. In order to fully consider that individuals act rationally, the damages and benefits adjustments took into account:

- A rebuild period following a flood event
- Rebuild scenarios in terms of how quickly the area would be redeveloped
- A decrease in structure inventory stock following a flood event
- A limit on the number of flood events allowed to occur; once this limit was reached, the assumption was made that floodplain occupants would choose to not live in the Natomas Basin

It is important to note that this analysis was performed using the information computed by HEC-FDA. Specifically, AEP data and single-event damage were taken and incorporated into this analysis using a newly-developed @Risk spreadsheet model.

The @Risk model developed specifically for this study was created to account for rational human behavior, which is the basic economic methodological premise in most economic studies. Rational human behavior, in the case of flooding in the Natomas Basin, was captured within the model in the form of a rebuild period, rebuild scenarios, loss of inventory stock, and a limit to the number of flood events that would occur before the Natomas Basin would be abandoned and people would decide not to live there. One drawback of HEC-FDA is that it is frequency-based, and its computational framework is not set-up to account for these factors related to human behavior; the Natomas @Risk model was set-up to be able to account for human behavior through the use of Monte Carlo simulation and life-cycle analysis.

Theory and Analytical Assumptions

[1] Although not addressed here, one cause of the high calculations of EAD/AEP in HEC-FDA may be the conservative assumptions in regard to the geotechnical risk and uncertainty (GRU) curves. Following the March 2009 F3 Conference (milestone conference which establishes the without-project condition), Sacramento District's Engineering Division attempted to address Planning Division's concerns about the GRU curves; Engineering Division held an expert elicitation as well as provided input (adjusted GRU curve at NAT C) to account for flood fighting. A sensitivity analysis, which is documented in Enclosure 3, was performed by the Economics Section using the adjusted curves. For NAT C, AEP (and EAD) were reduced significantly using the adjusted GRU curve from the expert elicitation; there was only minimal change to AEP (and EAD) using the revised GRU curves adjusted to account for flood fighting. Since the F3 Conference, additional index points were evaluated in order to better facilitate the with-project analysis; many of these points (e.g., NAT D) are producing high AEP/EAD values.

At this time, it is believed that Engineering Division has followed their process in terms of developing GRU curves and has at least considered Planning Division's concerns about the curves. The issue of high AEP/EAD values, then, has been addressed by the SPK Planning Division through this EAD/benefit adjustment.

The main purpose of the model is to adjust the EAD and benefit numbers obtained from the HEC-FDA modeling to account for human behavior by making assumptions about post-flood event rebuild periods, rebuild scenarios, floodplain inventory stock, and a reasonable assumption of the number of floods allowed to occur over the 50-year period of analysis before the Basin would be abandoned.

Several assumptions were made in order to perform the analysis. These assumptions are also indicated in Figure 7B-1, which shows a graphical snapshot of the @Risk model. Figure 7B-1 will be referred to in this section as well as in sections 7.4, 7.5, and 7.6 to explain the EAD and benefits adjustment calculation process and to point out significant details related to the model.

The major assumptions used in the model are:

- After a flood event, the floodplain inventory stock would be replaced by not more than 80% of the damaged property; this assumption captures the idea that not all floodplain occupants would choose to rebuild and live in the Natomas Basin after a flood event – some occupants would choose to leave the area. This assumption argues that a diminishing return on housing stock would occur as a result of continued flood events. If flooding were to occur in the Natomas Basin, the damages to structures would require significant rehabilitation and investment. Although insurance claims would provide some means of restoration, the notion that 100% of the inventory would return is inaccurate. The capital required to re-establish thebasin would not be available from insurance claims or investors when considering the potential risk of flooding (AEP of .21).

- A rebuild period of three (3) years (see Label 1). Rebuilding would take place over a 3-year period immediately following the flood event. The process of reducing the inventory stock to 80% of damaged property and rebuilding over a 3-year period would start all over with the next flood event.

- Four (4) rebuild scenarios were delineated (see Label 2), and range from a "slow" rebuild to an "aggressive" rebuild. For example, in the "slow" rebuild scenario (see Figure 7B-1), it was assumed that 20% of those properties damaged would be rebuilt in each of the 3 years of rebuilding. In the Natomas @Risk Model, rebuilding scenarios were held constant with successive levee reach improvement, effectively applying rebuilding assumptions only *after* a flood event occurs. In other words, it was assumed that the range of rebuilding scenarios captured under the sixth levee reach improvement would be similar to those under without-project run; under either of these scenarios, or under any other improvement for that matter, it is likely that flooding in the Natomas Basin would be catastrophic, and it was believed that decisions regarding rebuilding were less likely to be based on the perceived state of flood protection prior to a flood event. Admittedly, predicting any type of post-flood building scenario associated with flood events that may cause major destruction is complex due to the multitude of factors (e.g., resources available to rebuild, the extent of damages incurred, flood policies in place, cultural/historical significance of the area, government bureaucracy, etc.) that may

influence the amount of post-flood rebuilding that may actually be realized. To compensate for this uncertainty in the amount of rebuilding that would take place, the team assumed several scenarios, ranging from a "slow" rebuild to a an "aggressive" rebuild, and incorporated these assumptions into the @Risk model.

- There is a limit of three (3) flood events that would be allowed to occur in the Basin at which point people would decide not to rebuild and live in the Basin; once this limit was reached, the model assumes that the Natomas community would abandon the region. This assumption stems from discussion with project agency technical reviewer, corps economist, and headquarter economist. Although possible discussion to incorporate a rebuild period after a certain amount of time (25-30 years) was discussed, the intricate nature of the assumptions necessary to conduct such an analysis is mostly subjective (deciding when to being rebuild, how much, and what kind of land use would develop). Also, rebuilding that far out in the future would require construction in phases and based on the repetitive nature of flooding in the area (AEP of .21) it would be difficult to quantify the level of inventory at that point in time. Natomas developed because it was the most cost effective location for housing. There were/are other areas that could potentially be developed at higher land rents. The model assumes that after three flood events (6-12 years) sufficient housing stock would occur to supply the demand of residents wanting to escape the repetitive flooding.

Input Data and Application

The model uses Monte Carlo techniques to derive outputs (e.g., in this case the outputs are EAD and benefits) based on key input variables that have uncertainty parameters attached to them; the uncertainty of key variables are described in the @RISK model through the assignment of probability distributions.

The model was developed to address the unique flooding situation in the Natomas Basin – high probability of flooding as well as high consequences (damages) if flooding were to occur – in order to account for rational human behavior. The model is set-up to calculate event damages over a 50-year period of analysis by:

- randomly selecting whether or not a flood event occurs in each year of the 50-year period of analysis; AEP information obtained from the initial HEC-FDA modeling is used as a basis to determine the likelihood of a flood event occurring in any given year
- incorporating a 3-year rebuild period following a flood event and sampling from four different rebuild scenarios to determine how much of the floodplain is rebuilt
- calculating event damages for up to 3 flood events over the 50-year period of analysis for each iteration of the @Risk simulation
- calculating EAD/benefits

The sections below describes the model developed specifically for the adjustment of Natomas EAD and benefits. The data used in the model and the application of this data within the model is explained in more detail in the subsections below. The discussion below references Figure 1.

HEC-FDA Computed Stage-Damage Curves

The damages from the stage-damage curves computed by HEC-FDA and were used to populate the frequency-damage table (point A) in Figure 1. For each impact area and for each levee reach improvement, the stages associated with each frequency event (2-year to 500-year) were pulled from the engineering frequency-stage curves also from the HEC-FDA analysis; the corresponding damages and uncertainty in damages (standard deviation of damages) at each frequency event stage were then pulled from the stage-damage curves computed by HEC-FDA. For each frequency event, the damage and standard deviation of damage data pulled from the stage-damage curves in HEC-FDA were then used to calculate in @RISK minimum and maximum damage values; a normal probability distribution was used to describe the uncertainty in damages for this @RISK run. The minimum and maximum values obtained from this run were then used as input into the cumulative probability distribution function used to compute event damages. Additionally, damage and standard deviation of damage data pulled from the stage-damage curves in HEC-FDA were used to calculate coefficient of variation (COV) information; COVs were also used as input into the cumulative probability distribution functions in @RISK.

Annual Exceedance Probability (AEP) and Randomly Generated Flood Events

Annual Exceedance Probability (AEP) data were also used as input into the model. The AEP was applied within the model as the basis for determining whether a flood event resulting in levee failure would occur in any given year over the 50-year period of analysis. For example, in the scenario shown in Figure 1 (without-project for the Major area), an AEP of .21 was entered. This AEP corresponds to the AEP obtained at the Natomas Cross Canal, which was used as the without-project baseline for the Major impact area. The model is set-up to randomly generate numbers between zero and 1 for each year of the period of analysis; a randomly generated number that was lower than .21 triggered a levee failure and a number greater than or equal to .21 did not trigger a levee failure. In other words, for the without-project and for this impact area, there was a 21% chance that a flood event resulting in levee failure would occur in any given year throughout the 50-year period of analysis.

@Risk-Computed Event Damages & Cumulative Probability Distribution

In the model, when a flood event occurs event damages for that specific event are calculated. Event damages are calculated with uncertainty using a cumulative probability distribution function. As is displayed in Figure 1 (point B), event damages for the first flood event in this example and for this iteration of the simulation is $4,217 billion. The formula used to calculate event damages is also shown at point B. In this example, minimum and maximum values were set at $4.211 billion and $5.53 billion, respectively. The cumulative probability distribution function was formed by setting the damage value at each respective frequency event shown in

the frequency-damage table (point A) to a corresponding probability based on the actual event frequencies. For example, the first damage point on the cumulative probability distribution function is $4.357 billion, which is taken directly from the frequency-damage table; the corresponding probability for this damage is .5, which says that, should a flood event occur, a damage value of $4.357 billion or lower will occur 50% of the time. The last damage point on the curve is $5.33 billion, which says that, should a flood event occur, a damage value of $5.33 billion or lower will occur 100% of the time[2].

Finally, a COV was entered as part of the formula used to calculate event damages. This COV was based on the HEC-FDA computed stage-damage curves with uncertainty. Within the model, once event damages were calculated for the first flood event (and through using a cumulative probability distribution function as described previously), the uncertainty associated with these event damages were described by setting it to a normal distribution having a standard deviation equal to plus/minus the previously-computed COV. Incorporating the COV into the event damages specifically addresses the requirement of incorporating uncertainty in the first floor elevation of structures, uncertainty in structure and content values, and uncertainty in structure and content depth-damage percentages since the damage values and COVs used here were based on the HEC-FDA computed stage-damage curves with uncertainty, which already have these uncertainties factored in.

@Risk-Computed Expected Annual Damages (EAD)

The model computes EAD by discounting event damages of each flood event to the present year, summing the discounted values, and then amortizing this value over the 50-year period of analysis. In each @Risk simulation, thousands of iterations are completed, each resulting in a different EAD value; the final EAD value reported in the @Risk output results table is the average of all EAD values across all iterations.

[2] In actuality, the probability associated with the last damage point would be .998; however, 1.0 was used in order to be able to satisfy the @Risk software requirement of having a probability of 1.0 (100%) designated as the last point on the cumulative probability distribution function.

In the example shown in Figure 1, the first flood event occurs in year 3 of the period of analysis and produces damages of $4.217 billion. As can be seen in the table marked by point D, after the first year of rebuild the inventory stock is only restored to the remaining value after the flood event ($6.918 billion minus $4.217 billion = $2.701 billion) plus the amount of rebuilding (15% of damaged property, or $4.217 billion multiplied by .15 = $634 billion) assumed to occur for that year, in this case it's $3.334 billion ($2.701 billion + $633 billion). In the second year, an additional 30% of the damaged property is rebuilt to get a value of $4.599 billion; in the third year an additional 15% of the damaged property is rebuilt to get a value of $5.231 billion. This value is then carried forward as the baseline total value of damageable property for the next flood event.

Point D also shows that after the third flood event (in this example this flood event occurs in year 25), no other flood event is allowed to occur within the 50-year period of analysis. This effectively prevents any other damages to be incurred and caps the calculation of EAD to three flood events. After this third event, it is assumed that people would abandon the Natomas Basin.

Expected Annual Damages	Net Present Value	Total Value of Damageable Property	Event Damage	Percent Loss	Annual Exceedance Probability	Discount Rate	Reconstruction Scenarios
$277.08	**$5,588.85**	**$6,918**	**B** $4,217	**61%**	0.21	**4.375%**	**2**

D

Year	Event Occurrence	Beginning Prop. Damage	Damages	Post-Event Value	EOY Value
0	0	6,918	$ -	6,918	6,918
1	0	6,918	$ -	6,918	6,918
2	0	6,918	$ -	6,918	6,918
3	1	6,918	$ 4,217	2,701	3,334
4	0	3,334	$ -	3,334	4,599
5	0	4,599	$ -	4,599	5,231
6	0	5,231	$ -	5,231	5,231
7	0	5,231	$ -	5,231	5,231
8	0	5,231	$ -	5,231	5,231
9	0	5,231	$ -	5,231	5,231
10	0	5,231	$ -	5,231	5,231
11	0	5,231	$ -	5,231	5,231
12	0	5,231	$ -	5,231	5,231
13	0	5,231	$ -	5,231	5,231
14	0	5,231	$ -	5,231	5,231
15	0	5,231	$ -	5,231	5,231
16	0	5,231	$ -	5,231	5,231
17	0	5,231	$ -	5,231	5,231
18	0	5,231	$ -	5,231	5,231
19	0	5,231	$ -	5,231	5,231
20	0	5,231	$ -	5,231	5,231
21	1	5,231	$ 3,189	2,042	2,521
22	0	2,521	$ -	2,521	3,477
23	0	3,477	$ -	3,477	3,956
24	0	3,956	$ -	3,956	3,956
25	1	3,956	$ 2,411	1,544	1,906
26	0	1,906	$ -	1,906	2,630
27	0	2,630	$ -	2,630	2,991
28	0	2,991	$ -	2,991	2,991
29	0	2,991	$ -	2,991	2,991
30	0	2,991	$ -	2,991	2,991
31	0	2,991	$ -	2,991	2,991
32	0	2,991	$ -	2,991	2,991
33	0	2,991	$ -	2,991	2,991
34	0	2,991	$ -	2,991	2,991
35	0	2,991	$ -	2,991	2,991
36	0	2,991	$ -	2,991	2,991
37	0	2,991	$ -	2,991	2,991

=(RiskCumul(4211,5530,{4357,5026,5129,5227,5281,5312,5330},{0.5,0.9,0.96,0.98,0.99,0.995,1}))*RiskNormal(1,N7)

COV: 1.40%

I

1st Year	15%
2nd Year	30%
3rd Year	15%

2

Reconstruction	Year I	Year II	Year III
1	20%	20%	20%
2	15%	30%	15%
3	30%	20%	10%
4	45%	10%	5%

A

Inc.	Stage-Damage Relationship @ Frequency						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
0	4357	5026	5129	5227			
1							
2	2381	3590	4814	5061			
3							
4							
5			1184		5281	5312	5330
6							
7				4086			
8							
9							
10							
11							
12							

C

Inc.	Cumulative Probability Distribution						
	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
	0.5	0.1	0.04	0.02	0.01	0.005	0.002
0	0.500	0.900	0.960	0.980			
1							
2	0.500	0.900	0.960	0.980			
3							
4							
5			0.960		0.990	0.995	1.000
6							
7				0.980			
8							
9							
10							
11							
12							

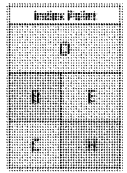


FIGURE 7B-1
Diagram of Natomas EAD Adjustment Model

Damage values are in millions of dollars.

3.3 System Quality and Usability Assessment

The system quality of the model has generally been assessed via the routine installation of the supporting software (@RISK) and the operation of the model, rather than according to a set of discrete test or components identified in advance, although some exercises were specifically undertaken to investigate certain aspects of the model associated with system quality.

@ Risk Software

The model is built on a Windows-based, menu driven MS Excel platform that uses Palisade's @RISK Software. @RISK performs risk analysis using Monte Carlo simulations. It is an add-in to Microsoft Excel, integrating completely with MS Excel spreadsheets. All @RISK functions are true Excel functions, and behave exactly as native Excel functions do.
The usability of the model depends to a great extent on the clarity and efficiency with which the supporting documentation informs the user of the data required and the process that must be followed in order to obtain the desired outputs. The main supporting document is available in the developer's user manual.
Also, Palisades provides training on the use of the software, and the concept of risk analysis. Training includes but is not limited to: regional training courses, live web training, free live webcasts, on-site training, conferences, forums, and symposiums. This training increases the user's knowledge, proficiency, ability, and skill in the use of the model. Since the software was released, maintenance and updates have been provided by Palisades.

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 General Review Summary

The following table presents a general summary of criteria used to review the model. The format mirrors the outline for model documentation provided by the Assuring Quality of Planning Models Protocols. This table is intended to provide a general overview of the more detailed discussion of the model in section 3.2.

4.2 Certification Recommendations

N@RM is a simple model that draws together theory and data from HEC-FDA to compute an EAD number consistent with economic theory. The primary aim of this review and documentation is to generate a single-use/study-specific recommendation for the approval-of-use of the model. Model approval would determine that the model is technically and theoretically sound and a functional tool that can be applied during the planning process by knowledgeable and trained staff for purposes consistent with the model's purpose and limitation.

ENCLOSURE 8: CLARK-WOLCOTT AVERAGE UNIT REPLACEMENT VALUES (PER SQUARE FOOT)

AVERAGE UNIT REPLACEMENT VALUE: RESIDENTIAL			
Description	**Range in Values (2007 Prices)**		
Single-Family Residential (SFR)	**Minimum**	**Typical**	**Maximum**
0 to 1,499 square ft (SF)	$62	$86	$122
1,500 to 1,999 SF	$60	$79	$114
2,000 to 2,999 SF	$58	$77	$111
3,000 to 3,999 SF	$56	$74	$107
>3,999 SF	$55	$72	$105
Residential Garages	**Minimum**	**Typical**	**Maximum**
0 to 299 SF	$20	$27	$36
300 to 499 SF	$14	$18	$25
>499 SF	$13	$17	$24
Multi-Family Residential (MFR)	**Minimum**	**Typical**	**Maximum**
<20,000 SF	$52	$69	$95
20,000 to 100,000 SF	$50	$67	$92
>100,000 SF	$50	$66	$90
Multiple Garages	**Minimum**	**Typical**	**Maximum**
4-car/800 +/- SF	$13	$17	$22
8-car/1,600 +/- SF	$12	$16	$21
12-car/2,400 +/- SF	$12	$15	$20
Manufactured/Mobile Home (MH)	**Minimum**	**Typical**	**Maximum**
<1,000 SF	$53	$59	$74
1,000 to 1,399 SF	$48	$54	$67
>1,399 SF	$44	$49	$61

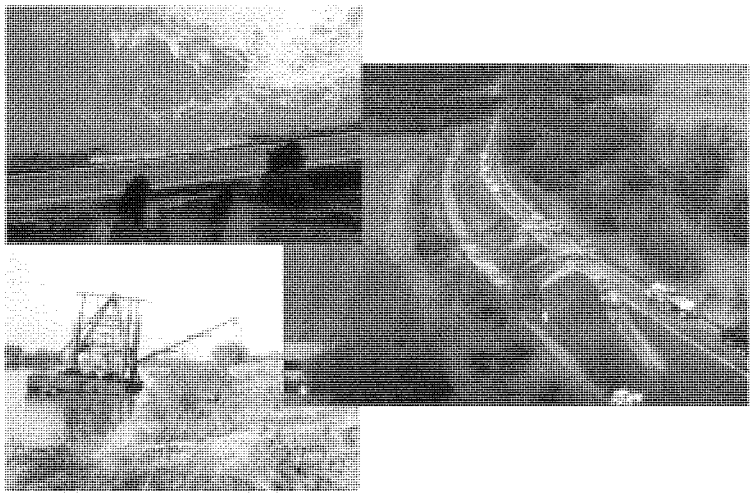
Enclosure 8
Clark-Wolcott Average Unit Replacement Values (Per Square Foot)

AVERAGE UNIT REPLACEMENT VALUE: NON-RESIDENTIAL			
Description	**Range**		
	Minimum	**Typical**	**Maximum**
COMM-OFF (Office Buildings)			
One-Story	$71	$96	$129
Two-Stories (or more)	$99	$139	$161
COMM-RET (Typical retail stores)			
Non-furniture	$45	$66	$97
Furniture	$45	$66	$97
COMM-FOOD (Stores that sell perishable food items)			
Large Supermarkets	$59	$81	$94
Convenience Stores	$66	$86	$99
Gas Station Mini-Marts	$108	$131	$153
COMM-REST (Traditional restaurants/fast-food establishments)			
Non-Fast Food	$85	$144	$186
Fast Food	$83	$148	$202
COMM-MED (Medical and Dental)			
Medical/Dental Offices	$93	$118	$153
Hospitals	N/A	N/A	N/A
COMM-SHOP (Large shopping centers, box stores, malls)			
Lg. Discount/Box Stores	$44	$65	$88
Lg. Shopping Cntrs.	$71	$89	$120
Lg. Shop. Cntr. Grocery	$65	$84	$108
COMM-SERV (Repair shops, auto, full service stations)			
Garages to Auto Svc.	$40	$58	$85
IND-WH (Warehouses, storage, transportation centers)			
Distribution WH	$32	$57	$69
IND-LT (Small tool shops, light manufacturing)			
Office/WH, flex, lt. man.	$31	$52	$82
PUB-GOV (Governing buildings, county, city, state, and federally owned offices)			
Storage, WHs, Office	$32	$57	$139
PUB-SCH (Schools)			
Elem/Middle/High	$105	$133	$165
Day Care Cntr/Nursury	$84	$115	$148
PUB-RF (Religious facilities)			
Churches, sanctuaries	$83	$121	$194
PUB-REC (Recreation, assembly-clubs, theaters)			
Driv. range, halls, clubs	$62	$87	$141
FARM (Non-residential outbuildings and sheds)			
Sheds and barns	$12	$25	$33

Post-Authorization Change Report
And Interim General Reevaluation Report

American River Watershed

Common Features Project
Natomas Basin
Sacramento and Sutter Counties, California



SAFCA
Sacramento
Area Flood
Control
Agency

US Army Corps
of Engineers ®
Sacramento District

Appendix I - Vegetation Variance

August 2010

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

JUN 17 2010

CEMP-SPD

MEMORANDUM FOR Commander, South Pacific Division (CESPD-PDC)

SUBJECT: Central Valley Flood Protection Board, Vegetation Variance Request for the American River Watershed, California, Common Features (Natomas Basin) Project, Post-Authorization Change Report

1. Reference: Memorandum, CECW-CE, subject as above, dated 16 June 2010, attached.

2. As indicated in the referenced memorandum, the vegetation variance requested by the Central Valley Flood Protection Board and Sacramento Area Flood Control Agency, and recommended by the Sacramento District (SPK) and South Pacific Division, has been approved for all reaches except for the reach on Plate 22. The enclosed memorandum provides a detailed explanation for this decision.

3. It is understood that SPK has already initiated consultation with NMFS to develop conservation measures for the Plate 22 reach to ensure no net loss of habitat or species, while meeting levee safety standards. Appropriate changes reflecting this variance approval decision and conditions will be included in the draft Natomas Post-Authorization Change Report (NPACR) and draft Environmental Impact Statement (EIS) and further evaluation will be performed such that a selected option with a Biological Opinion can be included in the final NPACR and EIS.

4. The collaborative solutions associated with this vegetation variance request demonstrate consistent and successful implementation of the partnerships and agreements of the California's Central Valley Flood System Improvement Framework. We recognize the complexities of the situation and look forward to further collaboration at all levels as we work through the Framework and beyond.

5. Please direct questions about this memorandum to Ms. Ada Benavides, Deputy Chief for Civil Works, South Pacific Division Regional Integration Team, 202-761-0415.

Encl

SCOTT L. WHITEFORD
Chief, SPD-Regional Integration Team
Directorate of Military Programs

Printed on Recycled Paper

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
441 G Street N.W.
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:
CECW-CE

JUN 16 2010

MEMORANDUM FOR Commander, US Army Corps of Engineers, ATTN: CEMP-SPD (Mr. Scott L. Whiteford, Chief, SPD-Regional Integration Team), 411 G Street, NW, Washington, DC 20314-1000

SUBJECT: Central Valley Flood Protection Board (CVFPB), Vegetation Variance Request for the American River Watershed, Common Features Project, Natomas Basin, Post-Authorization Change Report (NPACR)

1. References:

   a. California's Central Valley Flood System Improvement Framework, March 2009.

   b. Memorandum, SPK-DE, Subject: CENTRAL VALLEY FLOOD PROTECTION BOARD (CVFPB), Vegetation Variance Request for the American River Common Features Project, Natomas Post Authorization Change Report, 28 May 2010.

   c. Memorandum, CESPD-DE, Subject: Vegetation Variance Request for American River Watershed, Common Features Project, Natomas Basin, Post-Authorization Change Report, 7 June 2010.

   d. Memorandum, CEMVR-EC-DG, Subject: Vegetation Variance Request for American River Watershed, Common Features Project, Natomas Basin, Post-Authorization Change Report, 8 June 2010.

2. Upon review and consideration of the vegetation variance request package submitted by the Central Valley Flood Protection Board (CVFPB) and Sacramento Area Flood Control Agency (SAFCA) and recommendations provided by the Sacramento District (SPK), South Pacific Division (SPD), and Agency Technical Review (ATR) team, a vegetation variance is approved for all reaches, except for the reach on Plate 22 shown in the enclosure.

3. For all approved reaches, sufficient information has been provided by SAFCA that demonstrates that the vegetation permitted to remain on the proposed levee cross-sections, does not diminish system reliability, levee integrity, and public safety. The acceptable conditions include,

   a. For 21.23 miles (example shown in Plate 5, enclosure), a riverside planting berm is provided, preventing impact to the critical levee template.

CECW-CE
SUBJECT: Central Valley Flood Protection Board (CVFPB), Vegetation Variance Request for the American River Watershed, Common Features Project, Natomas Basin, Post-Authorization Change Report (NPACR)

b. For 3.5 miles (Plate 25, enclosure), a variance is requested only from the riverside toe to the river. The nearest vegetation would be 80 feet from the levee crown with minimal potential for impact to the critical levee template.
c. For 0.88 miles (Plate 28, enclosure), a variance is requested riverward of the lower ½ of the riverside slope. The nearest vegetation would be 50 feet from the levee crown with minimal potential for impact to critical levee template.

4. Vegetation on approved reaches will be permitted to remain in-place permanently, provided final constructed levee cross-sections correspond with the proposed levee cross-sections in this vegetation variance request package and as long as the vegetation is maintained in accordance to the associated vegetation management plan, project operation and maintenance manual, and final project partnership agreement. If, at any time, the US Army Corps of Engineers (USACE) determines that conditions within a variance area threaten system reliability and public safety, USACE will collaborate with the sponsor and resource agencies to revise to the approved vegetation variance as needed.

5. Plate 22 includes a portion of the Natomas East Main Drainage Canal (NEMDC) and it is requested that trees be permitted to remain on the lower 1/3 of slope and riverward for this segment. This area has been designated as critical habitat by the National Marine Fisheries Service (NMFS). For the trees remaining on the lower 1/3 slope, it has been proposed and endorsed by SPD and SPK that a "launchable riprap" blanket be installed around the base of each tree to reduce risks against tree overturning. SPD's endorsement recommends approval based on minimal environmental impacts while addressing public safety; minimal levee reconstruction; and no schedule slippage. SPD recognizes that in the event of overturning, there is a chance that the riprap will not fill in the divot created by the root ball as intended. SPD also notes that consultation with the resource agencies on removing these trees will be initiated on a parallel track.

6. For Plate 22, vegetation riverward from the toe is acceptable; however, allowing trees to remain on the lower 1/3 slope is not approved for the following reasons:

a. Due to substantial uncertainties with the Natomas levee system, including underseepage issues, erosive nature of the soil composition, performance history, and the minimum levee cross-section for the Plate 22 reach, allowing the trees to remain on the levee slope in this reach introduces an unacceptable uncertainty to the reliability of the system.
b. The potential impacts of tree roots on cutoff walls are not well documented.
c. The nearest vegetation (large trees) would be only 35 feet from the levee crown with significant potential for impact to the critical levee template.
d. Roots will occupy the riverside levee slope to a general depth of 2 to 4 feet, with potentially significant root intrusion to greater depths, and well into the critical section, as defined by the 1 vertical on 1.7 horizontal slope line.

CECW-CE
SUBJECT: Central Valley Flood Protection Board (CVFPB), Vegetation Variance Request for the American River Watershed, Common Features Project, Natomas Basin, Post-Authorization Change Report (NPACR)

7. There are two alternatives available for the Plate 22 reach that can address both environmental considerations and public safety. The first one is to work with the resource agencies on a conservation plan involving removal of the trees from the levee slope and mitigating in areas that would be more advantageous to the environment. The second alternative includes widening the levee section to provide a planting berm similar to other portions of the levee system.

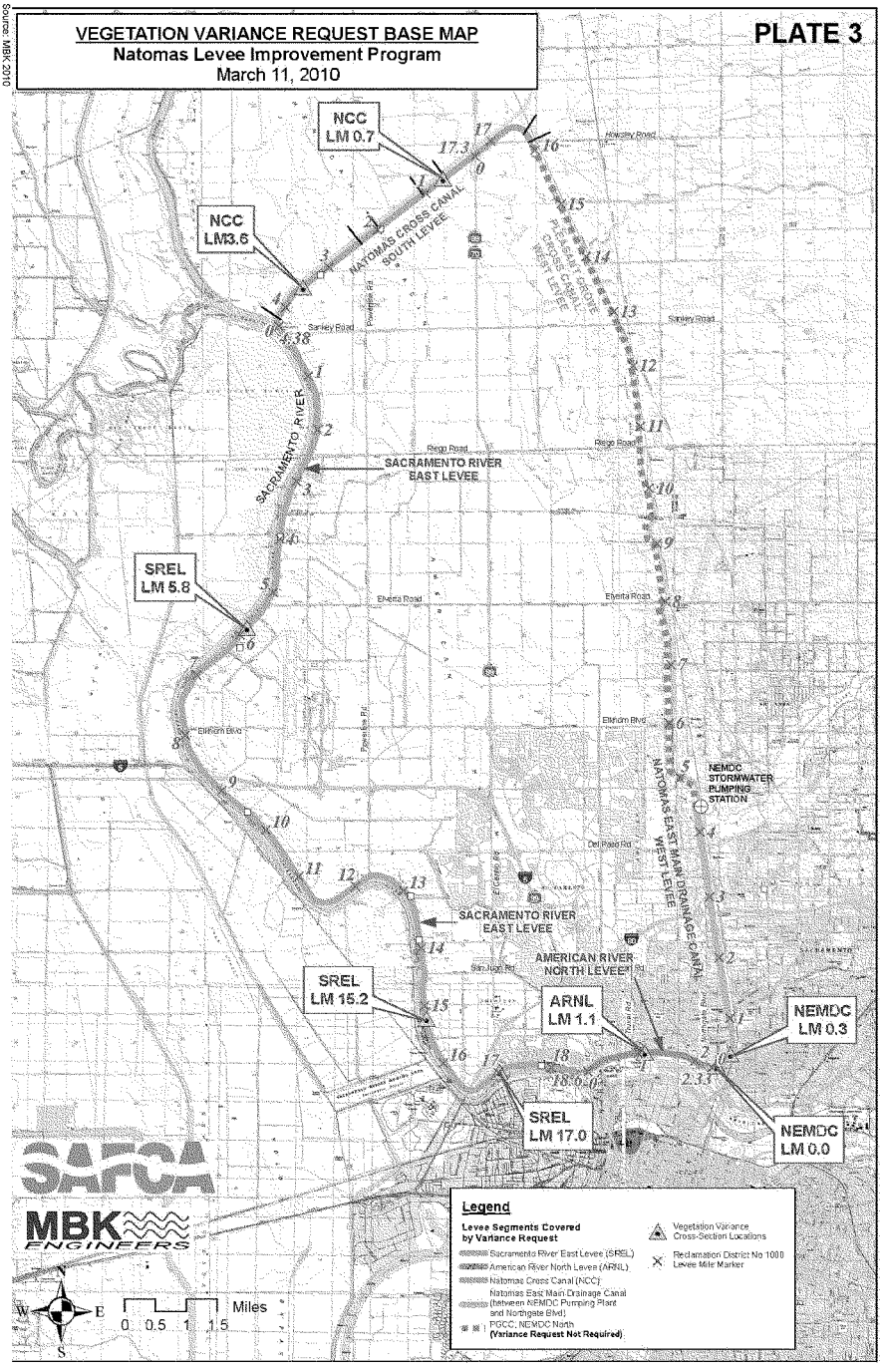
8. It is understood that SPK will work with NMFS to develop conservation measures for this reach to ensure no net loss of habitat or species, while meeting levee safety standards. Alternatives and options for this reach will be included in the draft Environmental Impact Statement (EIS) and further evaluated leading to publication of a selected option with a Biological Opinion and the final EIS for the NPACR. The NPACR will continue as scheduled.

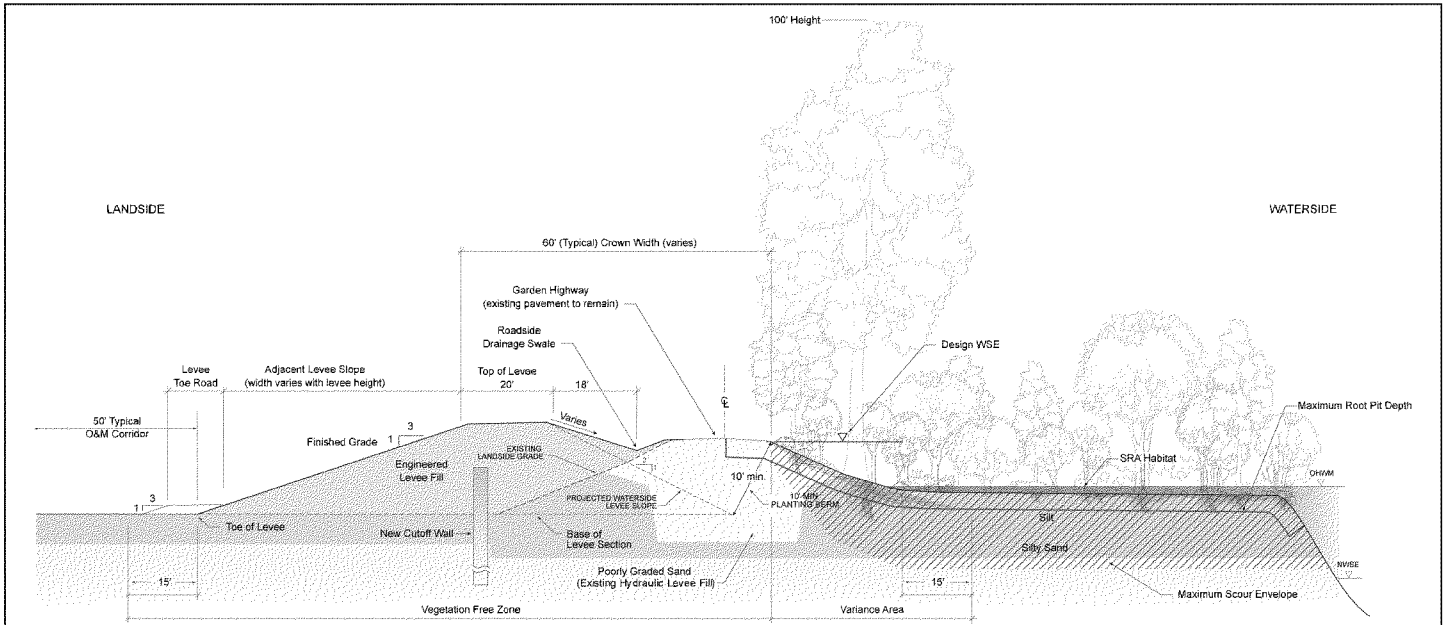
9. The collaborative solutions associated with this vegetation variance request demonstrate consistent and successful implementation of the partnerships and agreements of the California's Central Valley Flood System Improvement Framework. We recognize the complexities of the situation and look forward to further collaboration at all levels as we work through the Framework and beyond.

10. Please direct questions about this memorandum to Ms. Tammy Conforti, HQUSACE Levee Safety Program Manager, at (202) 761-4649.

Encl

JAMES C. DALTON, P.E.
Levee Safety Officer
Chief, Engineering and Construction
Directorate of Civil Works


VEGETATION VARIANCE REQUEST BASE MAP
Natomas Levee Improvement Program
March 11, 2010
PLATE 3
NCC LM 0.7
NCC LM3.6
SREL LM 5.8
SREL LM 15.2
SREL LM 17.0
ARNL LM 1.1
NEMDC LM 0.3
NEMDC LM 0.0
NATOMAS CROSS CANAL SOUTH LEVEE
PLEASANT GROVE CREEK CANAL WEST LEVEE
SACRAMENTO RIVER EAST LEVEE
NATOMAS EAST MAIN DRAINAGE CANAL WEST LEVEE
AMERICAN RIVER NORTH LEVEE
NEMDC STORMWATER PUMPING STATION
Howsley Road
Sankey Road
Riego Road
Elverta Road
Elkhorn Blvd
Del Paso Rd
San Juan Rd
Powerline Rd
Legend
Levee Segments Covered by Variance Request
Sacramento River East Levee (SREL)
American River North Levee (ARNL)
Natomas Cross Canal (NCC)
Natomas East Main Drainage Canal (between NEMDC Pumping Plant and Northgate Blvd)
PGCC, NEMDC North
(Variance Request Not Required)
Vegetation Variance Cross-Section Locations
Reclamation District No 1000 Levee Mile Marker
SAFCA
MBK ENGINEERS
N
W
E
S
0 0.5 1 1.5
Miles



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

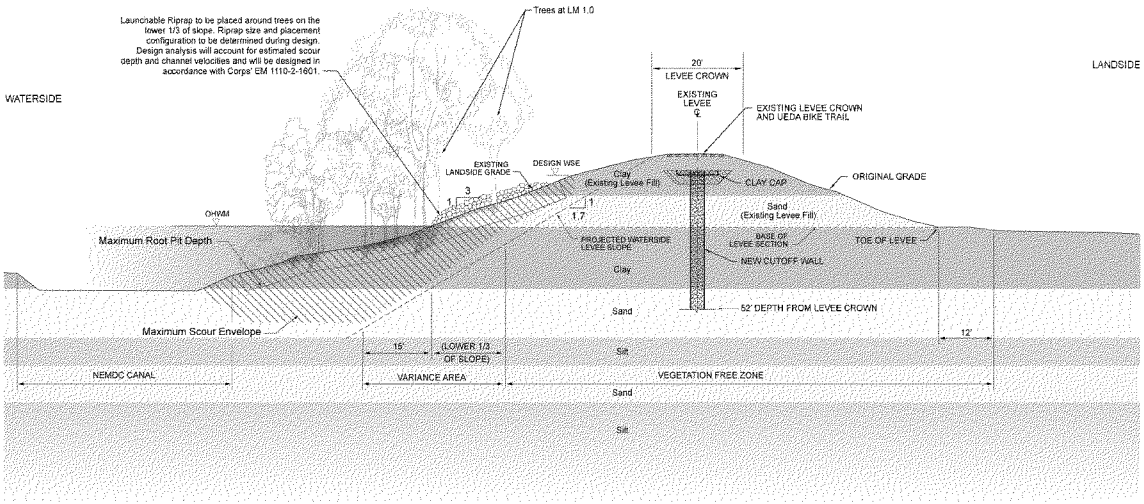
d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.0001 during the 200-year water level. This approximates a velocity of 2.0 ft/s at the levee toe concurrent with the 200-year water level.

e. 100 foot tall trees depicted represent potential maximum Valley Oak tree height and are not representative of actual field conditions.

f. 8' tap root depicted is representative of the worst case scenario and is unlikely to occur in these site conditions.

Source: Data provided by HDR, NHC, and Kleinfelder; adapted by AECOM in 2010

SREL LM 5.8 Levee Section with Cutoff Wall (LM 0 to LM 13.2) **Plate 5 (May 17, 2010)**



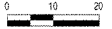
NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

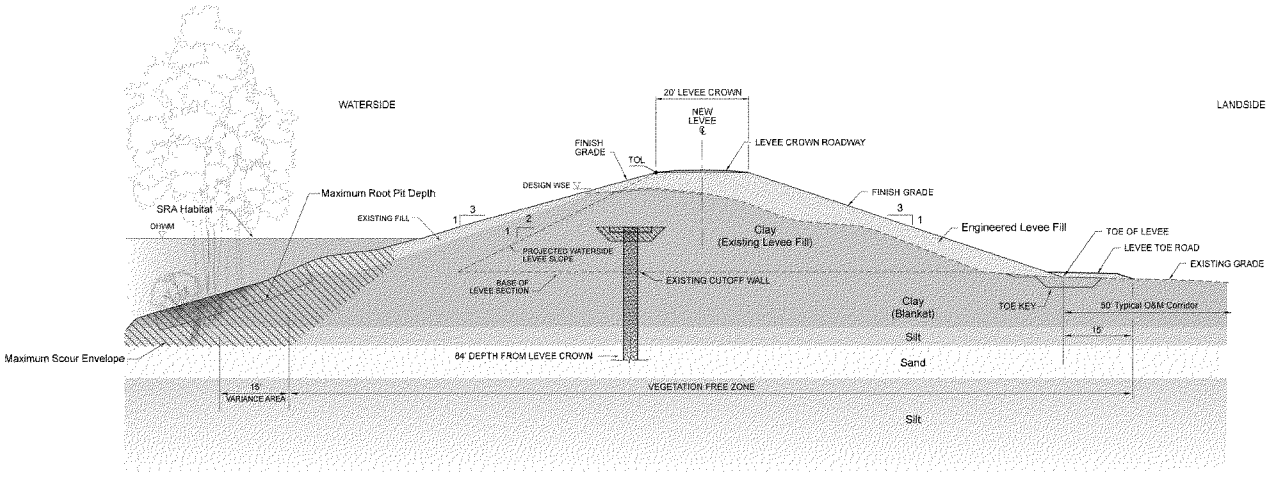
d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.040 and the friction slope was assumed to be 0.00007 during the 200-year water level. This approximates a velocity of 1.9 ft/s at the levee toe concurrent with the 200-year water level.



Source: Wood Rodgers, NHC, and Kleinfelder 2010; Adapted by AECOM 2010

NEMDC LM 0.3 Typical Levee Cross Section (LM 0.3 to LM 1.1)

Plate 22 (May 27, 2010)



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.00005 during the 200-year water level. This approximates a velocity of 2.4 ft/s at the levee toe concurrent with the 200-year water level.

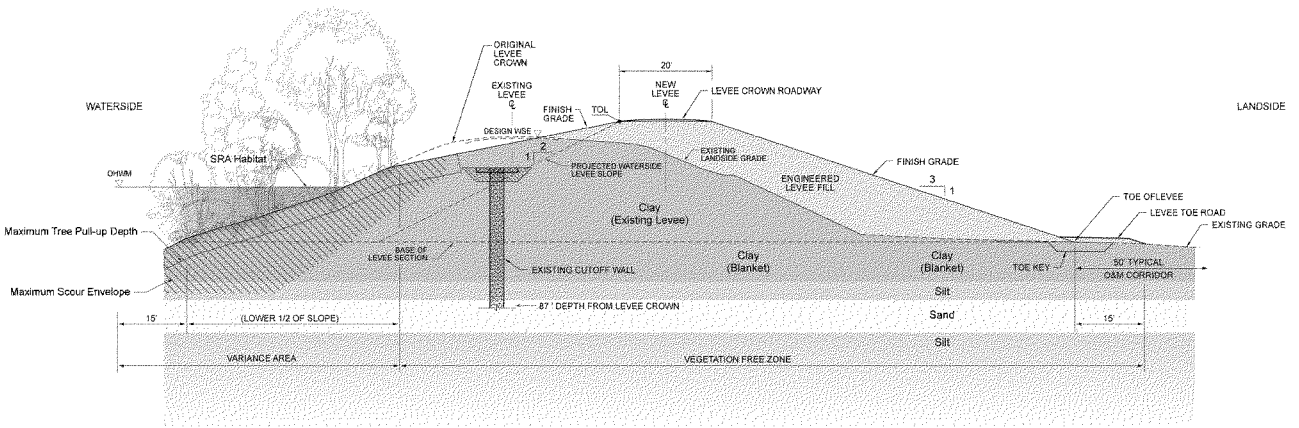
0 10 20
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G:\66110058\01 263

Source: Wood Rodgers, NHC, and Kleinfelder 2010; Adapted by AECOM 2010

NCC LM 0.7 Typical Levee Cross Section (LM 0 to LM 3.5)

Plate 25 (May 18, 2010)



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependance of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.0005 during the 200-year water level. This approximates a velocity of 2.4 ft/s at the levee toe concurrent with the 200-year water level.

Source: Wood Rodgers, NHC, and Kleinfelder 2010; Adapted by AECOM 2010

NCC LM 3.6 Typical Levee Cross Section (LM 3.5 to LM 4.38)

Plate 28 (May 18, 2010)

VEGETATION VARIANCE REQUEST
Natomas Levee Improvement Program

Prepared by:

Sacramento Area Flood Control Agency
1007 7th Street, 7th Floor
Sacramento, CA 95814

SAFCA
Sacramento
Area Flood
Control
Agency

and

Central Valley Flood Protection Board
3310 El Camino Ave., Rm. L140
Sacramento, CA 95821

April 2, 2010

(With additional information provided May 27, 2010)

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ACRONYMS AND ABBREVIATIONS

Airport	Sacramento International Airport
ARNL	American River north levee
Basin	Natomas Basin
CNDDB	California Natural Diversity Database
Common Features Project	American River Watershed Common Features Project
Common Features/Natomas Project	American River Watershed Common Features Project in Natomas
PACR	American River Watershed Common Features Project/Natomas Post-authorization Change Report
CVFPB	Central Valley Flood Protection Board
CVP	Central Valley Project
CVP/SWP Biological Opinion	June 2009 biological opinion issued by the National Marine Fisheries Service on Federal Central Valley Project and State Water Project water management operations, including flood control
dbh	diameter at breast height
Draft Guidance	Draft Policy Guidance on Variances from Vegetation Standards for Levees and Floodwalls published in the Federal Register on February 9, 2010
DST	Decision Support Tool
DWR	California Department of Water Resources
ETL	Engineering Technical Letter 1110-2-571
FPOM	fine particulate organic matter
Ford	David Ford & Associates
Framework	California Central Valley Flood System Improvement Framework adopted by the California Levees Roundtable on March 26, 2009
JSA Study	*Use of Floodplain Habitat of the Sacramento and American Rivers by Juvenile Chinook Salmon and Other Fish Species*
LCM	life cycle management
LM	levee mile
LMA	Local Maintaining Agency
LPP	locally preferred plan
MLD	most likely descendent
MOU	Memorandum of Understanding
Natomas Company	Natomas Company of California
NCC	Natomas Cross Canal
NEMDC	Natomas East Main Drainage Canal

NEPA	National Environmental Policy Act
NHC	Northwest Hydraulic Consultants
NMFS	National Marine Fisheries Service
NLIP	Natomas Levee Improvement Program
NWSE	normal (2-year) water surface elevation
Parkway	American River Parkway
PGCC	Pleasant Grove Creek Canal
Phase 4a FEIS	*Final Environmental Impact Statement for the Natomas Levee Improvement Program Phase 4a Landside Improvements Project*
Phase 4b DEIS/DEIR	*Draft Environmental Impact Statement/Draft Environmental Impact Report on the American River Watershed Common Features Project/Natomas Post-authorization Change Report/Natomas Levee Improvement Program, Phase 4b Landside Improvements Project*
PIR	problem identification report
Plan Formulation Report	Area Plan Formulation Report
RD	Reclamation District
Roundtable Communique	Media Communique issued by the California Levees Roundtable on March 26, 2009
SAFCA	Sacramento Area Flood Control Agency
SIR	Supplemental Information Report
SRA	Shaded Riverine Aquatic
SREL	Sacramento River east levee
SRFCP	Saeramento River Flood Control Project
SWP	State Water Project
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
variance area	proposed vegetation-management zone

EXECUTIVE SUMMARY

This request for a variance from the standard vegetation guidelines set forth in the U.S. Army Corps of Engineers' ("USACE's") Engineering Technical Letter 1110-2-571 ("ETL") is being submitted by the Sacramento Area Flood Control Agency ("SAFCA") and the Central Valley Flood Protection Board ("CVFPB") for consideration by USACE. SAFCA and CVFPB are the non-Federal sponsors of the American River Watershed Common Features Project ("Common Features Project"). This variance request identifies the locally preferred plan for managing vegetation on the 42-mile perimeter levee system protecting the Natomas Basin (or "Basin") in Sacramento and Sutter Counties. It is anticipated that a decision on this variance request will facilitate timely completion of the American River Watershed Common Features Project/Natomas Supplemental Information Report ("SIR"). The information presented herein is organized in accordance with the Draft Policy Guidance on Variances from Vegetation Standards for Levees and Floodwalls published in the Federal Register on February 9, 2010 ("Draft Guidance"). This information will be appropriately referenced and evaluated in the *Draft Environmental Impact Statement/Draft Environmental Impact Report on the American River Watershed Common Features Project/Natomas Post-authorization Change Report/Natomas Levee Improvement Program, Phase 4b Landside Improvements Project* ("Phase 4b DEIS/DEIR") currently being prepared by USACE and SAFCA.

This vegetation variance request is intended to comply with applicable provisions of the California Central Valley Flood System Improvement Framework that was adopted by the California Levees Roundtable on March 26, 2009 ("Framework"). The Framework specifically states that where, as in the case of the American River Watershed Common Features Project in Natomas ("Common Features/Natomas Project"), major modifications of existing levee sections are required, such modifications:

> "will comply with the [USACE] levee vegetation standards, but may allow vegetation to remain if these projects can demonstrate that the public safety risks posed to levee integrity have been adequately addressed and engineered into project designs. The [USACE] levee standards may evolve over time, when appropriate, to incorporate the latest developments in science and engineering."

SAFCA and CVFPB propose that existing vegetation be allowed to remain on all or portions of the waterside slopes of most of the levees protecting the Natomas Basin (or "Basin"). This request is supported by an engineering analysis demonstrating that the public safety risks posed to the integrity of these levees have been adequately addressed by the design of the Common Features/Natomas Project. The analysis reflects the best available information on the root characteristics of the affected waterside vegetation, the vulnerability of this vegetation to uprooting due to wind throw, and the potential for such uprooting to undermine the safety and integrity of the levee structure by triggering scour of the waterside levee slope.

The information on tree root characteristics and wind toppling is derived from studies of vegetation on Central Valley levees in 1989 and 1991, an ongoing study of the root characteristics of trees excavated from a sandy levee along the Loire River in France, reviews of these studies by scientists participating in the science collaborative initiated in connection with the California Levees Roundtable, and recent tree toppling data gathered from Central Valley levees as part of the science collaborative. This information suggests that (1) the root mass of the waterside vegetation is largely contained within the outer 3 to 4 feet of the waterside levee slope and (2) if tree toppling does occur, the resulting root pit is unlikely to have a depth greater than 2 to 3 feet.

The Common Features/Natomas Project has been designed to accommodate waterside vegetation and address the risk of levee instability due to tree fall and root pit scour by enlarging the footprint of the levees protecting the Natomas Basin. To demonstrate the adequacy of the project design, SAFCA retained Kleinfelder to perform a seepage and stability analysis and Northwest Hydraulic Consultants ("NHC") to evaluate scour potential on each the affected levee sections.

For each levee section, Kleinfelder began by comparing a typical cross seetion of the levee as designed to a hypothetically reduced (or "remnant") levee section. The remnant section was created by removing the outer 15 feet of the base of the levee at the waterside toe and extending a new waterside slope back to the levee crown at a grade of between 1.7-to-1 horizontal-to-vertical (1.7H:1V) and 3-to-1 horizontal-to-vertical (3H:1V). Each remnant levee section was evaluated to determine whether minimum USACE criteria for underseepage and rapid drawdown were met. Kleinfelder concluded that all of the remnant levee sections met these criteria. This analysis provided an initial baseline for considering the impact of scour because it showed that levee safety could be maintained even if the portion of the design levee section that contains the vast majority of the root mass of the waterside vegetation was lost.

To test the limits of Kleinfelder's analysis, NHC conducted a scour analysis to determine whether tree toppling could induce enough scour to penetrate Kleinfelder's remnant levee sections and prevent these sections from meeting the minimum underseepage and rapid drawdown criteria. NHC selected one or more sites in each of the levee sections covered by this vegetation variance request where scour potential would likely be greatest. At each site, NHC defined the geometry of the levee section, the size and location of the trees that could be subject to toppling, and the nature and grain size of local soils. Based on a literature review and discussions with experts, the likely dimensions and positions of fallen trees were identified. Local hydraulic conditions were defined based on existing data from MBK Engineers or USACE. NHC developed suitable equations for calculating the maximum depth of scour based on the identified hydraulic conditions, and modeled the maximum scour hole depth and geometry in the vicinity of a fallen tree in each levee section. These scour holes were then compared to the remnant levee sections devised by Kleinfelder to determine if the holes altered these sections and thus threatened levee stability. NHC concluded that tree fall induced scour would alter the critical dimensions of two of the remnant levee sections. Kleinfelder then modeled these two sites with the scour holes in place and determined that the remnant levees nevertheless met the minimum seepage and stability criteria.

To display the results of these analyses, SAFCA developed typical levee cross sectional drawings for each of the eight levee reaches covered by this variance request. These cross sectional drawings displayed the current configuration of the of the levee, the improvements proposed as part of the Common Features/Natomas Project and a "theoretical levee prism" that roughly corresponds to the minimum levee section needed to meet USACE criteria for resistance to underseepage and rapid drawdown. For seven of the reaches this theoretical levee prism has a 20-foot crown width and a 2H:1V waterside slope. The eighth reach comprising the lower portion of the Natomas East Main Drainage Canal (or "NEMDC") west levee has a 20-foot crown and a 1.7H:1V theoretical waterside slope. Each cross sectional drawing also displayed a "maximum scour envelope" reflecting NHC's calculation of the portions of the levee that would be lost due to treefall and scour assuming a maximum initial root pit depth of 3 feet.

Based on this approach, it was determined that none of the maximum scour envelopes developed by NHC penetrated the theoretical levee prisms determined to be stable by Kleinfelder. This suggested that the existing vegetation in the variance areas identified in the cross sectional drawings could be allowed to remain without posing an unacceptable public safety risk to the integrity of the levees covered by the variance request.

Nevertheless, following a round of review and comments by USACE, it was felt that an even more severe scour analysis should be performed based on a maximum initial root pit depth of 4 feet. The new analysis showed that the resulting maximum scour envelope would still avoid the theoretical levee prism in all levee reaches and the cross sectional drawings were revised to reflect this result. However, because of the depth of the maximum scour envelope in relationship to the levee cross section along the NEMDC west levee between levee mile ("LM") 0.3 and LM 4.4, it was determined that scour protection should be provided around all of the trees allowed to remain in this area to reduce the risk that tree fall could trigger scour that would affect levee stability.

The Kleinfelder and NHC analyses demonstrate that the risks to the safety and structural integrity of the Natomas Basin levees due to tree fall and scour have been adequately addressed by the design of the Common Features/Natomas Project. This is the essential finding required by the Framework. In addition, this vegetation variance request presents information showing that the waterside vegetation would not reduce the functionality of the Natomas levee system by reducing the flood conveyance capacity of the river and stream channels surrounding the Basin, nor would this vegetation unacceptably restrict accessibility to the affected levees for routine operation and maintenance and flood response activities.

SAFCA and CVFPB anticipate that this vegetation variance request will be subject to additional review by USACE prior to the Alternative Formulation Briefing on the Common Features/Natomas Project scheduled for May 2010. The goal of this review process is to reach concurrence that this vegetation variance request meets the requirements of the Framework and is thus a justified element of the locally preferred plan ("LPP") to be displayed in the SIR and evaluated in the Phase 4b DEIS/DEIR.

CHAPTER 1 – INTRODUCTION

1.1 Scope of Report

The non-Federal sponsors are requesting a variance that would allow existing vegetation to remain on all or a portion of the waterside slope and berm of several of the levee segments comprising the perimeter levee system protecting the Natomas Basin. Specifically, it is requested that existing vegetation be allowed to remain on the following levee sections, as shown in **Plate 1**:

- The entire waterside slope of the Sacramento River east levee (or "SREL") between the Natomas Cross Canal (or "NCC") and the American River;
- The entire waterside slope of the American River north levee (or "ARNL") between the Sacramento River and the NEMDC at Northgate Boulevard;
- The entire waterside slope of the portion of the NEMDC west levee occupied by the Arden-Garden Connector between Northgate Boulevard (LM 0.0) and the Arden Garden Connector bridge (LM 0.3);
- The lower 1/3 of the waterside slope and berm of the NEMDC west levee between the Arden-Garden Connector bridge (LM 0.3) and the NEMDC Pumping Facility (LM 4.4);
- The lower 1/2 of the waterside slope of the portion of the NCC south levee between LM 3.5 and LM 4.38; and
- The waterside berm of the NCC south levee below the projection of the landside toe of the levee on the waterside slope between LM 0.0 and LM 3.5.

These levee sections represent approximately 30 miles of the 42-mile perimeter levee system protecting the Natomas Basin. The levee sections comprising the remaining 12 miles of the system, including the Pleasant Grove Creek Canal (or "PGCC") west levee and the NEMDC west levee north of the NEMDC Pumping Facility are vegetation free and are therefore not subject to this vegetation variance request.

1.2 Authorization for Vegetation Management Policy

Section 202(g) of the Water Resources Development Act of 1996 directs USACE to provide a coherent and coordinated policy for vegetation management for levees that allows for regional variations in levee management and resource needs:

> (g) VEGETATION MANAGEMENT GUIDELINES.—
>
> (1) REVIEW.—The Secretary shall undertake a comprehensive review of the current policy guidelines on vegetation management for levees. The review shall examine current policies in view of the varied interests in providing flood control, preserving, protecting, and enhancing natural resources, protecting the rights of Native Americans pursuant to treaty and statute, and such other factors as the Secretary considers appropriate.
>
> (2) COOPERATION AND CONSULTATION.—The review under this section shall be undertaken in cooperation with interested Federal agencies and in consultation with interested representatives of State and local governments and the public.

(3) REVISION OF GUIDELINES.—Based upon the results of the review, the Secretary shall revise...the policy guidelines so as to provide a coherent and coordinated policy for vegetation management for levees. Such revised guidelines shall address regional variations in levee management and resource needs...

1.3 Proposed Variance Policy

The Levee Vegetation ETL was issued in accordance with the above authority on April 10, 2009. It supersedes prior USACE guidance on this matter and requires all woody vegetation on or near Federal project levees to be removed with certain exceptions for planting berms and planters as specified in the ETL. In anticipation of the ETL's potential effect on levees in California's Central Valley, a number of Federal, state, and local agencies including USACE, CVFPB, and SAFCA created the California Levees Roundtable and issued a Media Communique dated March 26, 2009 ("Roundtable Communique") signaling their agreement on a framework for accommodating the ETL in efforts to improve the flood control system in the Central Valley. The Framework recognizes that USACE's national standard for levees as embodied in the ETL is an appropriately conservative national public safety standard, and is likely achievable for most of the Federally authorized levees across the country. However, as described in the Roundtable Communique, "legacy levees" built immediately adjacent to California's major riverine systems present unique challenges that will likely require regional variances or other engineered alternatives.

The Framework specifically states that where, as in the case of the Common Features/Natomas Project, major modifications of existing levee sections are required, such modifications:

> "will comply with [USACE's] levee vegetation standards, but may allow vegetation to remain if these projects can demonstrate that the public safety risks posed to levee integrity have been adequately addressed and engineered into project designs. [USACE's] levee standards may evolve over time, when appropriate, to incorporate the latest developments in science and engineering."

The relationship between the Framework and the Draft Policy Guidance is clarified in a letter dated April 2, 2010 from Steve Stockton, USACE Director of Civil Works, to Ben Carter, CVFPB President. The letter states:

> "Addressing the levee issues and challenges facing California is one of our priorities. Therefore, we will continue to seek opportunities to collaborate to find solutions. One opportunity is to continue to support implementation of the Central Valley Framework Agreement which recognizes that factors, other than vegetation on levees, may constitute higher flood risk to California's citizens...The Framework Agreement will continue to be the guiding document as DWR continues to develop its long-term plan to resolve vegetation issues; a plan we understand will be finalized and provided to USACE in July 2012. The draft vegetation variance process published in the Federal Register will not supersede the Framework." (emphasis added).

Consistent with this approach, this variance request focuses on the engineering standard set forth in the Framework for allowing vegetation to remain on Project area levees while relying on the Draft Guidance to provide an organizational structure for presenting the information necessary to demonstrate compliance with this standard. The Draft Guidance asks for a general description of the affected levee system including "potential human and environmental consequences" (description of population at risk, potential economic losses, and identification of critical public facilities and special environmental considerations). And identifies the kind of information that is needed to demonstrate that the levee sections where vegetation is allowed to remain will meet acceptable standards for safety, structural integrity, functionality, and accessibility. The following chapters provide this information.

1.4 Discrepancies

In the event of a discrepancy in the interpretation and enforcement of the requested vegetation variance, the following shall be the order of precedence: (1) the cross-section drawings; (2) the Vegetation Variance Request document, Chapter 8, "Vegetation Maintenance Plan"; (3) the Vegetation Variance Request document, content other than Chapter 8; and (4) the Appendices. Concerning the plates, it is understood that the conditions of the requested vegetation variance are described in the cross-sections, and that approval of this request does not constitute approval of any of the non-compliant conditions or encroachments depicted in the photographs provided on associated plates.

CHAPTER 2 – GENERAL DESCRIPTION

2.1 Project Authority

The Natomas Basin is protected from high flows in the American and Sacramento Rivers and their tributaries by an interconnected levee system that extends for 42 miles around the perimeter of the Basin ("Natomas Levee System"). This levee system is part of the Sacramento River Flood Control Project ("SRFCP"), a comprehensive plan for controlling the flood waters of the Sacramento River and its tributaries that was authorized by the California Legislature in the Flood Control Act of 1911. The SRFCP including the Natomas Levee System was approved by Congress in the Flood Control Act of 1917 (PL 64-367).

2.2 Project Area

Located north of the confluence of the American and Sacramento Rivers, the Natomas Basin ("Project Area") includes portions of the City of Sacramento, the County of Sacramento, and the County of Sutter as shown in **Plate 2**. This area is protected by the Natomas Levee System which includes the SREL, ARNL, NEMDC west levee, PGCC west levee, and NCC south levee. The SREL protects the western flank of the Basin. This levee extends for approximately 18.6 miles along the east bank of the river from the NCC to the mouth of the American River. The ARNL protects the southern flank of the Basin. This levee occupies the north bank of Bannon Slough, an engineered drainage channel that extends for approximately 2.2 miles eastward from the Sacramento River to Northgate Boulevard. At that point, the channel turns northward and becomes the NEMDC. This canal extends for approximately 13 miles from Northgate Boulevard to Sankey Road. It intercepts flows from the tributary streams east of Natomas and diverts them around the southern end of the Basin through Bannon Slough to the Sacramento River in low flow and to the American River in flood stage. The NEMDC west levee occupies the west bank of the canal and protects the eastern flank of the Natomas Basin. The NCC south levee protects the northern flank of the Basin. This levee occupies the south bank of the NCC, an engineered drainage channel that extends for approximately 5.3 miles from the Sacramento River to the PGCC. The NCC receives flows from the tributary streams northeast of Natomas and diverts them around the northern end of the Basin to the Sacramento River.

2.3 Population at Risk

The Natomas Levee System protects approximately 53,000 acres of improved agricultural, environmental, and urban lands. About 30% of the Basin is occupied by developed urban uses mostly located south of Elkhorn Boulevard. The urban area contains approximately 22,200 residential, 380 commercial, and 180 industrial structures, and a population of approximately 80,000 people.

2.4 Critical Public Infrastructure and Facilities

Lands owned by Sacramento County and operated as part of Sacramento International Airport ("Airport") account for about 10% of the land in the Natomas Basin. Half of the Airport lands lie outside of the developed footprint of the Airport Operations Area and consist of "bufferlands" devoted to agricultural or open space use. In addition to the Airport, the Basin also contains three major public transportation facilities—Interstate 5, Interstate 80, and State Route 99/70—as well as numerous public facilities such as police stations, fire stations, libraries, schools, and community centers that serve the Basin's urban population.

Outside the urban area, approximately 30,000 acres of land in the Basin remain in some form of developed agriculture or open space use, including 4,000 acres of aquatic and upland habitat preserves that have been created as part of the Natomas Basin Habitat Conservation Plan and are under the management of The Natomas Basin Conservancy ("TNBC").

2.5 Potential Economic Losses

An uncontrolled flood in the Natomas Basin would cause substantial direct damage to structures and contents and, depending on the timing and circumstances of the flood, pose a serious threat of loss of life and injury. Direct flood damages were estimated based on an inventory of structures created in connection with the formation of SAFCA's Consolidated Capital Assessment District (April 2007). Structure replacement values were estimated by David Ford & Associates ("Ford") in a study prepared for SAFCA in 2008. The estimate was based on Marshall & Swift unit construction cost factors. Content values were derived using structure-to-content ratios established by USACE and the State. Based on these data, it is estimated that the structures and contents exposed to flooding have a depreciated replacement value of approximately $8.2 billion.

Ford also performed an economic and risk analysis to determine the damages that might result from an uncontrolled flood in the Natomas Basin. Exterior (river and drainage channel) and interior (floodplain) water surface elevations and flood inundation-damage relationships were developed for a range of flood events based on USACE models and analysis from the Sacramento-San Joaquin River Basins Comprehensive Study. Based on these relationships, Ford estimated that direct flood damages in a single uncontrolled flood under existing conditions could total $7.0 billion with residential structures and contents accounting for about 70% of this value, commercial about 20%, and industrial about 10%.

2.5.1 Special Environmental Considerations

As discussed in Chapter 4, the woody vegetation on the waterside of the Natomas Levee System provides important habitat to a large number of special-status fish and wildlife species. This habitat is thus protected under the provisions of the Federal and California Endangered Species Acts, California Department of Fish and Game Code 1602, and the Migratory Bird Treaty Act. Along the waterside of the ARNL and the lower reach of the NEMDC west levee, the woody vegetation is within the boundaries of the American River Parkway and is thus also protected under the provisions of the Federal and California Wild and Scenic Rivers Acts. Removal of this vegetation would therefore require a careful balancing of the resulting public safety benefits and environmental harms.

CHAPTER 3 – CROSS SECTIONAL DRAWINGS

This chapter provides cross sectional drawings, photos, and plates displaying vegetation and other relevant conditions that characterize the eight levee reaches covered by this variance request as shown in **Plate 3**. These levee reaches are referenced by location (SREL, ARNL, NEMDC, and NCC) and length by LM. The cross sectional drawings reflect typical conditions at a selected index point in each levee reach. These conditions include the normal water surface elevation ("NWSE") for the Sacramento River and the American River, representing the mean daily river flow during the summer dry season (June/July/August) when river flow and stage are controlled by upstream reservoir releases for downstream urban and agricultural uses; and the ordinary high water mark ("OHWM") for all water bodies, representing the 2-year flood elevation. The drawings also display project right-of-way, the improved levee section (including a theoretical levee prism), appurtenant structures, the proposed vegetation-management zone ("variance area"), and the areas that will be vegetation-free. The theoretical levee prism depicted in each cross sectional drawing was derived by extending a "levee baseline" from the landside toe of the improved levee section and connecting this baseline to the 20-foot levee crown along a 2-to-1 horizontal-to-vertical (2H:1V) slope (or 1.7H:1V in the case of the lower NEMDC) representing the waterside slope of the prism. This slope was selected based on a determination by Kleinfelder that it would be geotechnically stable for sudden drawdown (factor of safety exceeds USACE minimum criteria of 1.1).

Each levee cross sectional drawing also displays the levee soil conditions, maximum scour potential, and foundation stratigraphy representative of the index point depicted in the drawing. For purposes of these displays, scour potential represents the "maximum extent of scour during the 200-year flood" assuming that during the flood, high winds topple a large tree generating a root pit that is 4 feet deep and 20 feet wide. This condition was modeled by NHC at several points along the waterside of each levee cross section. These calculations were generalized to show the maximum extent of scour that could occur at any point along the waterside levee slope and berm. The actual scour hole resulting from fall of a particular tree would be much smaller than the envelope shown in the cross section.

The conditions shown in the cross sectional drawings and the methodologies used to derive these conditions are further described in Chapter 5 by levee reach. **Tables 3-1** through **3-8** provide additional information on the waterside vegetation that is proposed for retention, including a description of the trees found on the waterside of the levee within 50 feet of each index point between the waterside hinge point (crown) and the river channel.

3.1 SREL LM 5.8

Index point SREL LM 5.8 is considered representative of the 12.8-mile reach of the SREL downstream of the NCC between LM 0 and LM 12.8 where the non-Federal sponsors propose to construct a raised adjacent levee section. **Plate 4** depicts the waterside vegetation at this index point. **Plates 5** and **6** display typical cross sections, levee soil conditions, maximum scour potential, and foundation stratigraphy for the raised adjacent levee design, including a cross section containing a seepage cutoff wall (**Plate 5**) and a cross section containing a seepage berm (**Plate 6**). **Plate 7** provides more detail on levee soil conditions and foundation stratigraphy. As indicated in these plates, the raised adjacent levee design will enlarge the existing levee section by approximately 40 feet. As indicated in **Plates 5** and **6**, vegetation would be allowed to remain on the waterside slope and berm of the existing levee and on the levee crown (Garden Highway) 10 feet beyond the centerline of the existing levee.

As shown in **Table 3-1**, trees at this index point are composed of native species. As shown on **Plate 5**, trees tend to grow robustly along the upper sections of the waterside of the levee (variance area) as well as the lower sections (along the waterside "bench" west of the variance area). As shown on **Plate 4** in the upstream and downstream views of the ground level water side photos, the density of trees in this area tends to be higher on the waterside bench than in the variance area.

Table 3-1 Tree Survey Data for SREL LM 5.8			
Species	**Number of Trees**	**Average Diameter at Breast Height (inches)**	**Average Crown Width (feet)**
Valley Oak	11	19	26
Fremont Cottonwood	1	19	25
Box Elder	17	10	12
Willow spp.	3	19	25
Source: Data compiled by AECOM in 2010			

3.2 SREL LM 15.2

Index point SREL LM 15.2 is considered representative of the 3.7-mile reach of the SREL between LM 12.8 and LM 16.5 where the non-Federal sponsors propose to construct an adjacent levee section in an undeveloped portion of the Basin. **Plate 8** depicts the waterside vegetation at this index point. **Plates 9** and **10** display typical cross sections, levee soil conditions, maximum scour potential, and foundation stratigraphy for the adjacent levee design, including a cross section containing a seepage cutoff wall (**Plate 9**) and a cross section containing a seepage berm (**Plate 10**). **Plate 11** provides more detail on levee soil conditions and foundation stratigraphy. As indicated in these plates, the adjacent levee design will widen the existing levee section by approximately 24 feet. As indicated in **Plates 9** and **10**, vegetation would be allowed to remain on the waterside slope and berm of the existing levee and on the levee crown (Garden Highway) 10 feet beyond the centerline of the existing levee.

As shown in **Table 3-2**, trees at this index point are composed of native species. As shown on **Plates 9** and **10**, trees tend to grow more robustly close to the waterside crown of the levee. As shown on **Plate 8**, the density of trees tends to be higher outside of the variance area than in the variance area, especially on the waterside "bench," although the diameter at breast height ("dbh") tends to be lower.

Table 3-2 Tree Survey Data for SREL LM 15.2			
Species	**Number of Trees**	**Average Diameter at Breast Height (inches)**	**Average Crown Width (feet)**
Valley Oak	8	18	25
Fremont Cottonwood	5	43	33
Box Elder	5	13	13
Oregon Ash	8	7	16
Alder	2	11	25
Black Willow	6	24	23
Red Willow	2	13	9
Bishop Pine	2	16	30
Source: Data compiled by AECOM in 2010			

3.3 SREL LM 17.0

Index point SREL LM 17.0 is considered representative of the 2-mile reach of the SREL between LM 16.5 and LM 18.6 where the non-Federal sponsors propose to construct an adjacent levee section in a developed portion of the Basin. **Plate 12** depicts the waterside vegetation at this index point. **Plate 13** displays a typical cross section, levee soil conditions, maximum scour potential, and foundation stratigraphy for the adjacent levee design containing a seepage cutoff wall. **Plate 14** provides more detail on levee soil conditions and foundation stratigraphy. As indicated in these plates, the adjacent levee design will widen the existing levee section by approximately 24 feet depending on the finished grade of the landside levee slope. As indicated in **Plate 13**,

vegetation would be allowed to remain on the waterside slope and berm of the existing levee and on the levee crown (Garden Highway) 10 feet beyond the centerline of the existing levee.

As shown in **Table 3-3**, trees near this index point consist of both native and ornamental species. As shown on the aerial photo on **Plate 12**, vegetation is denser in the variance area than outside of the waterside variance area. This appears to be due mainly to the planting of ornamental tree species by property owners, rather than natural volunteering of locally occurring species. Growth tends to be more robust on the waterside "bench" than on the levee slope as shown on **Plate 13**.

Table 3-3
Tree Survey Data for SREL LM 17.0

Species	Number of Trees	Average Diameter at Breast Height (inches)	Average Crown Width (feet)
Valley Oak	16	23	26
Bishop Pine	9	25	30
California Fan Palm	1	15	10
Ornamental Orange	1	16	33
Unknown Ornamental	2	5	8
Source: Data compiled by AECOM in 2010			

3.4 ARNL LM 1.1

Index point ARNL LM 1.1 is considered representative of the 2.3-mile reach of the ARNL between the Sacramento River (LM 0) and Northgate Boulevard (LM 2.3). **Plate 15** depicts the waterside vegetation and **Plate 16** displays a typical cross section, levee soil conditions, maximum scour potential, and foundation stratigraphy for the oversized levee in this reach of the Natomas levee system which was widened to the waterside in the 1950's to accommodate the Garden Highway. Trees have been added to **Plate 16** from other locations in this reach (approximately 200 feet upstream) to reflect the full range of conditions in the reach. **Plate 17** provides more detail on levee soil conditions and foundation stratigraphy. As indicated in **Plate 16**, vegetation would be allowed to remain on the waterside slope and berm of this oversized levee.

As shown in **Table 3-4**, trees at this index point are composed of native species. As shown on **Plate 15**, robustness of tree growth tends to be similar within the variance area compared to outside the variance area. Species of trees tend to be composed of both native and non-native species.

Table 3-4
Tree Survey Data for ARNL LM 1.1

Species	Number of Trees	Average Diameter at Breast Height (inches)	Average Crown Width (feet)
Valley Oak	24	9	13
Fremont Cottonwood	9	25	26
Box Elder	6	8	13
Oregon Ash	2	24	25
Red Willow	2	28	23
Source: Data compiled by AECOM in 2010			

3.5 NEMDC LM 0.0

Index point NEMDC LM 0.0 is considered representative of the 0.3-mile reach of the NEMDC west levee between Northgate Boulevard (LM 0) and the Arden Garden Connector Bridge (LM 0.3). **Plate 18** displays the waterside vegetation, and **Plate 19** displays a typical cross section, levee soil conditions and foundation stratigraphy for the oversized levee at this index point which was recently widened to accommodate the Arden-Garden Connector. **Plate 20** provides more detail on levee soil conditions and foundation stratigraphy. As indicated in **Plate 19**, vegetation would be allowed to remain on the waterside slope of the levee and the adjacent waterside berm.

As shown in **Table 3-5**, trees at this index point consist of native species. As shown on the cross section on **Plate 18**, trees tend to grow more robustly near this index point towards the crown of the levee. Tree density tends to be greater closer to the water surface. Almost all trees occur within the variance area.

Table 3-5
Tree Survey Data for NEMDC LM 0.0

Species	Number of Trees	Average Diameter at Breast Height (inches)	Average Crown Width (feet)
Valley Oak	7	16	17
Willow spp.	16	15	18
Alder spp.	1	8	18

Source: Data compiled by AECOM in 2010

3.6 NEMDC LM 0.3

Index point NEMDC LM 0.3 is considered representative of the 4.1-mile reach of NEMDC west levee between the NEMDC Pumping Facility (LM 4.4) and the Arden Garden Connector (LM 0.3). **Plate 21** displays the waterside vegetation, and **Plate 22** displays a typical cross section, levee soil conditions, maximum scour potential, and foundation stratigraphy for the standard levee section at this index point. Trees have been added to **Plate 22** from other locations near this reach (NEMDC LM 1.0) to reflect the full range of conditions near the reach. **Plate 23** provides more detail on levee soil conditions and foundation stratigraphy. To avoid the maximum scour envelope at this index point, the waterside slope of the theoretical levee prism has been steepened to 1.7H:1V. This slope has been determined to be geotechnically stable by Kleinfelder for sudden drawdown (factor of safety exceeds the minimum USACE criteria of 1.1). As indicated in **Plate 22**, existing vegetation would be removed from the upper 2/3 of the waterside slope and allowed to remain on the lower 1/3 of the waterside slope and the berm adjacent to the waterside toe of this levee section. As discussed in Section 5.4.2, engineered rock would be placed around all of the trees on the levee slope in this modified variance area to reduce the risk that wind toppling of these trees could trigger scour that would affect levee stability.

As shown in **Table 3-6**, trees at this index point are composed of native and local species. As shown on **Plate 21**, robustness of tree growth is greater near the crown of the levee than near the water surface. Most of the vegetation occurs within the variance area, which encompasses the lower 1/3 of the waterside slope of this levee section and the adjacent waterside berm.

Table 3-6 Tree Survey Data for NEMDC LM 0.3			
Species	**Number of Trees**	**Average Diameter at Breast Height (inches)**	**Average Crown Width (feet)**
Valley Oak	7	18	15
Button Willow	3	11	14
Oregon Ash	3	13	15
Red Willow	2	4	5
Willow spp.	11	19	12
Source: Data compiled by AECOM in 2010			

3.7 NCC LM 0.7

Index point NCC LM 0.7 is considered representative of the 4.3-mile section of the NCC south levee extending west from the PGCC to LM 3.5. **Plate 24** shows the waterside vegetation, and **Plate 25** displays a typical cross section, levee soil conditions, maximum scour potential, and foundation stratigraphy of the standard levee section at this index point. **Plate 26** provides more detail on levee soil conditions and foundation stratigraphy. As shown in **Plate 25**, vegetation would be allowed to remain on the extended waterside slope (or berm) below the waterside levee toe.

As shown in **Table 3-7**, trees consist of native riparian species. As shown on the cross section on **Plate 24**, tree density is evenly distributed in a fairly narrow band. Trees near this index point occur mainly on the waterside berm near the NCC water surface.

Table 3-7 Tree Survey Data for NCC LM 0.7			
Species	**Number of Trees**	**Average Diameter at Breast Height (inches)**	**Average Crown Width (feet)**
Valley Oak	16	10	7
Willow spp.	5	24	7
Source: Data compiled by AECOM in 2010			

3.8 NCC LM 3.6

Index point NCC LM 3.6 is considered representative of the 1-mile section of the NCC south levee between LM 3.5 and LM 4.38. **Plate 27** shows the waterside vegetation, and **Plate 28** displays a typical cross section, levee soil conditions, maximum scour potential, and foundation stratigraphy of the expanded levee section at this index point. **Plate 29** provides more detail on levee soil conditions and foundation stratigraphy. As shown in **Plate 28**, vegetation would be allowed to remain on the lower 1/2 of the waterside slope of this levee section and on the adjacent waterside berm.

As shown in **Table 3-8**, tree species near this index point consist of both native and non native species. As shown on **Plate 27**, growth of trees is more robust on the waterside levee slope than on the waterside berm; however, tree density is greater on the berm than on the slope.

Table 3-8 Tree Survey Data for NCC LM 3.6			
Species	**Number of Trees**	**Average Diameter at Breast Height (inches)**	**Average Crown Width (feet)**
Fremont Cottonwood	10	30	15
Willow spp.	4	6	10
Source: Data compiled by AECOM in 2010			

CHAPTER 4 – ENVIRONMENTAL CONSIDERATIONS AND ALTERNATIVE SOLUTIONS

4.1 Affected Environmental Resources

As shown in **Plate 30**, the levees around the Natomas Basin are part of the integrated system of levees, overflow bypass channels, and dams that comprises the SRFCP. This flood control system was initially designed to improve navigation and reduce the risk of flooding so as to facilitate agricultural development of the extensive floodplains encompassed by the Sacramento Valley. Over time, the capacity of the SRFCP was greatly expanded by the construction of five major, multiple-purpose reservoirs (Shasta, Black Butte, Oroville, New Bullards Bar, and Folsom Reservoirs) containing 2.7 million acre-feet of dedicated flood space. These dams were justified in part by public safety considerations, specifically the need to provide a high level of flood protection to the historical urban settlements that grew up at the confluence of the Feather and Yuba Rivers (Yuba City and Marysville) and the American and Sacramento Rivers (Sacramento and West Sacramento).

The SRFCP and its associated reservoir storage facilities, and the agricultural and urban developments supported by these facilities, have greatly altered the physical landscape of the Sacramento Valley and contributed to the demise of what was once a vast natural floodplain containing extensive riparian and wetland landforms. **Plate 31** depicts the extent of this floodplain in the Sacramento River Basin near the end of the 19th century. Along the main stem of the Sacramento River, the riparian forest averaged four to five miles in width. This area supported more fish and wildlife species than any other river ecosystem in California. Today, only about 2% of these historic woodlands remain.

4.1.1 Importance of Woodlands in the Project Area

Woodlands remaining on the waterside of the levees in the Project Area are comprised of predominately native tree species. The most common are valley oak (*Quercus lobata*). Other common species are Fremont cottonwood (*Populus fremontii*), black willow (*Salix nigra*), California sycamore (*Platanus racemosa*), box elder (*Acer negundo*), black walnut (*Juglans hindsii*), red willow (*Salix laevigata*), arroyo willow (*Salix lasiolepis*), white alder (*Alnus rhombifolia*) and Oregon ash (*Fraxinus latifolia*). These trees are a remnant of the historic riparian ecosystem in the valley. Because of the wide-scale reduction in riparian woodlands over the past century, this ecosystem is now confined to a series of narrow corridors extending along the waterside margins of the Sacramento River and its tributaries. A large percentage of the river margins within the levee system are devoid of all woody vegetation due to the past half century of bank protection projects (rock riprap) placed on river banks. These corridors provide the primary, and in some regions the only, habitat link between the woodland patches that survive on the valley floor and the undeveloped, riparian woodlands of the foothill rivers and creeks surrounding the Coast Range and Sierra Mountains.

In the Project Area, waterside woodlands continue to provide important year-round and migratory habitat for more than 200 species of mammals, fish, amphibians, reptiles, and birds. The migratory fish species include Chinook salmon, steelhead trout, Delta smelt, and white and green sturgeon. The migratory bird species include Swainson's hawk and several species of neotropical songbirds, including the warbling vireo, the blue grosbeak, and the western yellow-billed cuckoo. The year-round wildlife populations include more than 135 species of native birds, native mammals (such as river otter, deer, beaver, and raccoon), and numerous reptiles and amphibians (such as Western pond turtle and Pacific tree frog).

Western riparian habitats, including those along the Sacramento River, are naturally linear systems with extensive edges. Patch isolation (lack of connectivity) may influence bird communities as much as habitat fragmentation. Small patch size and/or patch isolation may increase predation and brood parasitism rates, and limit population dispersal. For example, although a number of riparian areas in California are of sufficient size and structure to support Yellow-billed Cuckoos, individuals may not colonize these areas because of their distance from existing

populations and the lack of enough potential mates in close proximity. When large, contiguous patches of riparian habitat are fragmented, the amount of edge increases, with detrimental effects on songbirds. For example, evidence from coastal riparian habitats in northern California indicates that Song Sparrows at the edge of habitat patches tend of have lower productivity than those nesting farther from the patch edge (PRBO 2000). Song Sparrows with edge territories are more accessible to many predators and may buffer the interior Song Sparrow pairs from predation pressure. Understory (the weedy, shrubby growth underneath trees) is also a crucial habitat feature for many birds. A healthy and diverse understory with lots of ground cover offers well-concealed nest and foraging sites.

Riparian trees are used for nesting, foraging, and protective cover by many bird species, including black-headed grosbeak, tree swallow, Bewick's wren, and Cooper's hawk; and are also used as roosting habitat for some bat species, such as hoary bat and California myotis. Riparian canopies provide nesting and foraging habitat for common mammals, such as western gray squirrel. Understory shrubs provide cover for mammals such as desert cottontail and ground-nesting birds such as spotted towhee that forage among the vegetation and leaf litter. Mammals such as raccoon and opossum benefit from the variety of berries, invertebrates, small mammals, and bird eggs for food. Piscivorous birds in particular–such as Kingfisher, Blue Herons, Cormorants, and Egrets–hunt, roost, and/or nest in banks, trees, and associated woody debris in the riparian corridor. A large number of songbirds (Passerines) use the riparian area heavily for nesting, foraging, roosting, and migration habitat. The complex structure of riparian habitat provides a large diversity of protected nesting substrates (e.g. cavities, tree branches, dense understory), and supports an abundance for food sources including invertebrates, seeds, and vegetation.

Wooded natural floodplains and banks of Central Valley rivers are an essential component of the Sacramento-San Joaquin River Delta ecosystem and the overall food web supporting Delta aquatic life. In particular, these floodplains serve as a major source of allochthonous biomass which contributes nutrients, fine particulate organic matter ("FPOM"), aquatic prey sources (zooplankton and invertebrates), and habitat structure (woody debris). Declining ecosystem health and fish populations of the Delta are a major concern of the Federal and state agencies that have worked together for over fifteen years under the CALFED Bay-Delta Program and Bay Delta Conservation Plan to reverse these declines by preserving and restoring the key elements that support aquatic life in the Delta, including the remnant floodplains of the Sacramento and San Joaquin Rivers and their tributaries.

4.1.2 Special Status Species in the Project Area

Many of the fish and wildlife species that occupy the Project Area are protected under applicable provisions of the Federal and California Endangered Species Acts. Details on these species and the special-status protections they have been granted are presented in the *Final Environmental Impact Statement for the Natomas Levee Improvement Program Phase 4a Landside Improvements Project* ("Phase 4a FEIS") (USACE 2010) and in the environmental documents identified in Chapter 9 which were issued in connection with earlier phases of the Natomas Levee Improvement Program ("NLIP"). These documents are available on SAFCA's website at www.safca.org/Programs_Natomas.html.

The NLIP documents indicate that the following special-status wildlife species are likely to nest in or occupy woody substrate, shrubs or trees in the riparian habitat areas on the waterside of the SREL, ARNL, and the lower reaches of the NEMDC and NCC in the Project Area:

- Valley elderberry longhorn beetle (Federal threatened),
- Cooper's hawk (California species of special concern),
- White-tailed kite (California fully protected),
- Swainson's hawk (California threatened),
- Bank swallow (California threatened), and
- Tri-colored blackbird (California species of special concern).

All of the bird species listed above are also protected under the Migratory Bird Treaty Act and Executive Order 13186, which directs all Federal agencies taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations to cooperate with the U.S. Fish and Wildlife Service ("USFWS") in developing and using principles, standards, and practices that will lessen the amount of unintentional take. This cooperative effort is to be spelled out in a Memorandum of Understanding ("MOU") with USFWS that promotes the conservation of migratory bird populations.

Because riparian woodlands provide important nesting and roosting habitat for a wide variety of wildlife species (including colony-nesting bird speeies and special-status species such as Swainson's hawk) and serve as movement corridors for these species, they are considered sensitive habitats by Federal and state regulatory agencies. Riparian woodlands in partieular are rich in biologieal fauna and flora, and provide valuable resources and protection for aquatic habitats. They are considered sensitive habitats subject to California Fish and Game Code Section 1602. They are identified as "rare and worthy of consideration" in natural communities recognized by the California Natural Diversity Database ("CNDDB"). These sensitive communities provide essential habitat to special-status species that are often restricted in distribution or are decreasing throughout their range. Some woodland patches within the Project Area could be categorized as Great Valley cottonwood riparian forest, which is a natural community documented in the CNDDB.

The waterside riparian corridor along the Sacramento River in Natomas is among the most contiguous and undisturbed in the Project Area and provides the most nesting habitat for bird species, especially Swainson's hawk. Monitoring conducted as part of the Natomas Basin Habitat Conservation Plan annual reporting and other independent data (TNBC 2005–2009; AECOM 2009) indicates that the majority of Swainson's hawk and other raptor nests occur in the riparian area on the waterside of the levee, likely because it is the most contiguous and undisturbed nesting habitat, which is in contrast to the clustered tree groves on the landside of the Basin near active agricultural activities.

Guidance on identifying the riparian zones that provide important habitat to migratory birds is contained in EMRRP *Technical Notes Collection* (TN EMRRP-SI-09) issued by the U.S. Army Engineer Research and Development Center in Vicksburg, Mississippi (Fischer 2000). The guidance states that research has shown that riparian zones must meet certain minimum width and canopy continuity criteria to provide suitable habitat for most bird species. To encourage a diverse avian community, riparian corridors should be as wide and as long as possible, and be relatively free from improved roads, human settlements, and other potential impacts.

The following special-status fish species seasonally occupy or benefit directly from seasonally inundated riparian habitat on the Sacramento River and the lower reaches of the American River, NEMDC, and NCC:

- Central Valley fall/late fall run Chinook salmon (Federal species of concern, California species of special concern);
- Central Valley spring-run Chinook salmon (Federal and California threatened);
- Sacramento River winter-run Chinook salmon (Federal and California endangered);
- Central Valley steelhead (Federal threatened);
- North American Green Sturgeon (Federal threatened);
- Delta Smelt (Federal and California threatened);
- Sacramento Splittail (California species of special concern); and
- Hardhead (Federal species of concern, California species of special concern).

The condition of these fish species is addressed in the June 2009 biological opinion issued by the National Marine Fisheries Service ("NMFS") on Federal Central Valley Project ("CVP") and State Water Project ("SWP") water management operations, including flood control (referred to herein as the "CVP/SWP Biological Opinion"). The opinion finds that these operations are likely to jeopardize the continued existence of protected fish species in the Central Valley (including Central Valley steelhead, Central Valley spring-run Chinook salmon and Sacramento

River winter-run Chinook salmon) in part because of the significant reduction in critical habitat in the Sacramento River Basin and Delta that has resulted from the operation of both projects.

In the Sacramento River, this critical habitat includes the river water column, river bottom, and adjacent riparian zone (limited to those areas above a streambank and on seasonally inundated floodplains that provide cover and shade to the nearshore aquatic areas) used by fry and juveniles for rearing. The lateral extent of this habitat is defined by the 2-year water surface elevation or by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain).

USFWS refers to this habitat as Shaded Riverine Aquatic (or "SRA") habitat. SRA cover is defined as the near-shore aquatic area occurring at the interface between a river and adjacent woody riparian habitat. The principal attributes of this valuable cover type include sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions and support the growth and mobility of juvenile salmonids; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large woody material, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (e.g., the lower Cosumnes River, remnants of Sacramento River reaches with setback levees [i.e., primarily located upstream of the City of Colusa]) and lower elevations of flood bypasses (i.e., Yolo and Sutter Bypasses). However, the channelized, levee confined, and rocked bank river reaches and sloughs that are common in the Sacramento-San Joaquin River system typically have low habitat complexity and low abundance of food organisms, and offer little protection from either fish or avian predators. Juvenile life stages of salmonids are dependent on the function of this habitat for successful survival and recruitment. Steelhead are more susceptible to the negative effects of degraded rearing habitat, as they rear in freshwater longer than winter-run and spring-run. Because of historic reductions in this habitat and the difficulty of replacing ongoing losses, USFWS has categorized SRA cover as Resource Category 1 indicating that this habitat is of high value for evaluation species and is unique and irreplaceable on a national basis or in the ecoregion section. The mitigation goal for habitat in Resource Category 1 is "no loss of existing habitat value."

Although generally lower in complexity and food abundance than other parts of the Sacramento River watershed, the river and stream channels in the Project Area and their adjacent riparian zones nevertheless provide part of the critical rearing habitat that sustains the salmon and steelhead populations that remain in this watershed. The importance of this habitat was underscored by a study completed in June 1999 by Jones & Stokes Associates entitled *Use of Floodplain Habitat of the Sacramento and American Rivers by Juvenile Chinook Salmon and Other Fish Species* ("JSA Study"). This study, which is attached as **Appendix A**, was initiated in February/March 1999, when seasonally high flows in the Sacramento and American Rivers caused Bannon Slough (the channel excavated to create the ARNL) and the NEMDC to backup and overflow into areas of the American River Parkway, including SAFCA's Borrow Site 18a ("Site 18a") adjacent to Northgate Boulevard and the NEMDC. This inundation allowed fish to freely use the resulting flooded habitat. The water surface level over the floodplain subsequently dropped, stranding fish in Site 18a and providing an opportunity to assess floodplain habitat use by juvenile chinook salmon and other species.

During the study, a total of 24 fish species were captured in Site 18a, 6 of which were native. The overwhelming majority of these fish were juvenile (fall-run) chinook salmon. Over 3,000 of these juveniles were captured along with a smaller number of winter- and spring-run sized Chinook salmon. Based on this capture data, the JSA Study estimated that as many as 50,000 juveniles may have been present in Site 18a at one time. These results confirmed the importance of shallow floodplain habitat in the rearing of these protected fish species prior to their migration out to the ocean.

4.1.3 Wild and Scenic Rivers Act Protections

The woody vegetation along the waterside slope of the ARNL and the waterside slope and berm of the NEMDC west levee is an integral component of the habitat highlighted in the JSA Study. All of the waterside vegetation on the ARNL and NEMDC west levee downstream of El Camino Avenue is within the boundaries of the American River Parkway (or "Parkway"). This vegetation is thus afforded added protection under the Federal and California Wild and Scenic Rivers Acts. Both acts designate the Lower American River as wild and scenic within the boundaries of the Parkway. This designation prohibits Federal and State assistance to, or construction of, water resource related projects that adversely affect the extraordinary values qualifying the river for wild and scenic status. These values include support for the anadromous fish populations that seasonally occupy the Lower American River, Bannon Slough, and the lower portion of the NEMDC.

4.2 Affected Cultural/Historic Resources

The Project Area is situated within the lands traditionally occupied by the Nisenan, or Southern Maidu. Numerous archaeological investigations have focused on the lands closest to the rivers and levees, particularly the east side of the Sacramento River. Several prehistoric occupation and burial sites, frequently seen as mounds or the disturbed remnants of mounds, have been identified on the landside of the SREL. These sites fall under the jurisdiction of the National Historic Preservation Act and thus implicate the rights of the most likely descendents ("MLD's") of the Nisenan/Southern Maidu people. Because many of the covered sites likely extend underneath the levee, these MLD rights could be affected by the manner in which woody vegetation on or near the levee is managed.

- **CA-Sac-15/H.** This site, near the Sacramento River east levee south of I-5, consists of a prehistoric occupation midden mound with a concentration of debitage, flaked stone tools, shell artifacts, faunal remains, fire-cracked rock, and baked clay objects. The mound has been heavily affected by farming and ranching activities. There is a ranch complex including a bunkhouse, garden, shed, chicken coop, water tower, garage, and driveway on the mound; historic debris on the site includes glass and broken ceramic fragments. A limited auger testing program was carried out west of the mound along the Sacramento River east levee and found no cultural materials along that transect (Bouey and Herbert 1990).

- **CA-Sac-16/H (P-34-000043).** CA-Sac-16/H is in the Airport north bufferlands south of the Airport Operations Area. This site has been variously called the Bennett Mound, Mound Ranch, Willey Mound, and S-16. It includes the remains of a prehistoric occupation mound, possibly the largest in the Sacramento Valley, but has been leveled in stages by agricultural activities. The site location corresponds to the ethnographic village of Nawrean. What remains today consists of dark midden soils in plowed fields with fragments of human remains, shell, fire-cracked rock, baked clay objects, ground stone, faunal bone, flaked stone artifacts, and debitage. A few historic artifacts, such as brick and ceramic fragments, are also on this site.

- **CA-Sac-17 (P-34-000044).** This is the location of a mound site reported by Heizer in 1934 west of Fisherman's Lake; however, none of the mound remains. In 1990, Bouey and Herbert attempted to locate any cultural remains but could not find any evidence of cultural deposits on the surface or in auger holes.

- **CA-Sac-18 (P-34-000045).** This site, landward of the Sacramento River east levee located north of San Juan Road, consists of a sparse scatter of basalt debitage, one cryptocrystalline biface fragment, a polished stone, and possible fire-cracked rock. It was originally described by Heizer as a mound 30 yards in diameter and 5 feet high; however, Heizer may have misinterpreted a natural rise in the landscape as a mound. CA-Sac-18 appears to be lacking the intensive cultural deposits that are the hallmark other nearby known mound sites (Dames & Moore 1994).

- **CA-Sac-160/H (P-34-000187).** This is a multicomponent site near the Sacramento River east levee located north of San Juan Road. It includes a prehistoric occupation mound with a farm complex situated on top. Excavations in the 1940s removed numerous burials and artifacts, including ground stone, flaked stone tools, shell beads and ornaments, fire-cracked rock, baked clay objects, stone beads, faunal remains, bone awls, bird bone tubes and whistles, obsidian drills, quartz crystals, charmstones, and historic glass trade beads, as well as historic debris related to farming and occupation of the top of the mound.

- **CA-Sac-164 (P-34-000191).** CA-Sac-164 is a very large, deeply stratified prehistoric occupation and burial mound near Sand Cove Park on the Sacramento River that has been explored a number of times using archaeological techniques; however, in spite of these efforts, the true boundaries of the site remain unknown. The site includes shell midden with abundant cultural materials including fire-cracked rock, flaked and ground stone tools, charmstones, polished bone implements, debitage, quartz crystals, bone and shell beads, baked clay objects, and plentiful faunal remains. Large fire-cracked rock features and hearths have also been noted. Because of its significant scientific value and integrity, CA-Sac-164 was nominated for listing on the National Register of Historic Places in 2001.

  The site was first recorded in 1951, after a newspaper article reported that human remains and stone tools were eroding out of the cutbank and into the Sacramento River. Observers who walked along the edge of the cutbank in summer and fall when the river was at its lowest noted that site deposits, interspersed with flood-deposited silt, extended at least 4 meters below the current-day surface. Excavations in the 1970s, 1980s, and 1990s confirmed the depth of intact and resource-bearing cultural strata at the site. Work on the landside of the Sacramento River levee indicated that downward-trending cultural strata might be found there as well, beginning well over a meter below the ground surface.

  Annual river height fluctuation, wave action resulting from boat wakes, and looting combined to cause continual erosion and collapse of the cutbank. This resulted in artifacts and remains falling onto the beach area below, where they either washed into the river or were collected by the public. To address this issue, SAFCA and USACE initiated a site stabilization program in 2005 that included placing dirt and plantings over the cutbank and creating a wave break near the river's edge of the site. This program was funded under USACE's environmental restoration authority.

4.3 Alternative Solutions

Most of the improvements proposed by the non-Federal sponsors for the Natomas levee system are being implemented by SAFCA as part of an early implementation project approved and funded in part (70%) by the California Department of Water Resources ("DWR") with bond funds approved by California voters as part of the Infrastructure Improvement, Smart Growth, Economic Reinvestment and Emergency Preparedness Financing Act of 2006. Under the terms of the State's early implementation program, SAFCA must demonstrate that: (1) the risk to life and property posed by the existing condition of the levee system in Natomas justifies moving quickly forward with improvements to this system; and (2) the proposed improvements will not impair or impede future changes to the regional flood protection system that might be adopted as part of the State's updated flood protection plan for the Central Valley.

4.3.1 Plan Formulation

Based on these guidelines, SAFCA developed a plan of improvements that could be quickly implemented without altering the basic design of the regional flood protection system surrounding the Natomas Basin. In addition, SAFCA's plan was designed to accommodate the vegetation management requirements of the ETL in light of the Framework set forth in the Roundtable Communique. As indicated in the Area Plan Formulation Report ("Plan Formulation Report") that SAFCA submitted as part of its early implementation program grant application

(available at www.safca.org/Programs_Natomas.html), SAFCA evaluated three alternative approaches to improving the Natomas levee system:

- The "Fix-in-Place" alternative (improving the levees generally within their existing footprint);
- The "Adjacent Levee" alternative (widening the footprint of the existing levee system); and
- The "Setback Levee" alternative (constructing setback levees where possible).

The differences between these alternatives focus primarily on their treatment of the existing vegetation on the waterside slope of the SREL in light of the requirements of the ETL. The Fix-in-Place alternative separates the levee from the waterside vegetation by removing the vegetation from the levee; the Setback Levee alternative accomplishes this separation by removing the levee from the waterside vegetation; and the Adjacent Levee alternative allows the waterside vegetation to remain by creating an oversized levee that is wide enough to meet the safety, structural integrity, functionality and accessibility standards typically associated with a vegetation-free levee.

These alternatives were evaluated in the Plan Formulation Report based on the following criteria;

- **Completeness**: The extent to which the alternative provides flexibility to accommodate changing engineering standards and accounts for all necessary investments or other actions to achieve project objectives.

- **Efficiency**: The extent to which the alternative is the most cost-effective means of achieving the project objectives.

- **Effectiveness**: The extent to which the performance of the alternative contributes to achieving the project objectives.

- **Acceptability**: The extent to which the alternative minimizes effects on the environment and otherwise complies with applicable laws, regulations, and public policies.

4.3.2 Fix-in-Place Alternative

Removal of the trees on the waterside of the SREL would create serious engineering challenges and would be extremely costly. Assuming the removal process follows the guidelines in Section 5-3 of the ETL, the trunk (or stem), stump, rootball, and all roots greater than 1/2 inch in diameter would need to be removed. This would require extensive excavation of the existing levee structure to remove tens of thousands of existing waterside trees and shrubs occupying the ETL prescribed "vegetation free zone." The outer layer of the waterside slope and berm of the existing levee would be compromised, exposing the typically sandy materials encapsulated in the levee. It is likely that these materials would need to be removed from the area and the levee reconstructed with competent soil material.

Because residential development has been allowed on the waterside of the levee, much of the vegetation to be removed from the levee is located on private property. These residential developments are covered by encroachment permits and flood control easements which give the government the right to operate and maintain the levee and undertake the improvements that may be deemed necessary. However, these rights have not been extensively tested in court. Assertion of the government's rights to remove woody vegetation from the levee would likely be legally contested and it could take the government several years to be in a position to enter the residential developments so as to remove the vegetation and reconstruct the levee.

Given the extent of the woody vegetation to be removed, it is likely that substantial portions of the levee section would have to be reconstructed. This activity could damage human remains and artifacts of Native Americans associated with some of the cultural resources site described above that extend under the levee. In that event, the

limited window of time available for levee excavation and reconstruction might not allow compliance with the recovery and documentation requirements of the National Historic Preservation Act.

Excavation and reconstruction of the waterside slope of the SREL to remove vegetation would also result in significant and unavoidable impacts to habitat protected under the Federal and California Endangered Species Acts and the Migratory Bird Treaty Act. According to the environmental documents prepared in connection with the NLIP (see Chapter 9), approximately 80 acres of waterside riparian vegetation would be removed as part of this alternative. These documents conclude that this loss could not be fully mitigated because there is insufficient waterside space within the lower portion of the Sacramento River system to accommodate the replacement plantings that would be required for this and other projects affected by USACE's vegetation management policy. Most of the potential riparian mitigation areas (i.e., where there is no existing riparian vegetation and SRA habitat) along rivers in the Sacramento region are narrow bands adjacent to levees that, if planted, would also be in violation of the ETL policy. Even if regulatory agencies approved a 1:1 compensation ratio (2:1 or 3:1 replacement is more common), the maximum potential mitigation area available is considerably less than 80 acres. Mitigation policy of NMFS, USFWS, and California resource regulatory agencies do not allow substantial impacts to waterside riparian and SRA habitat to be compensated by habitat creation landside of the river levees. As a result, pursuit of this alternative would likely result in a jeopardy opinion from NMFS and USFWS that could make it very difficult to proceed with levee improvement activity.

For these reasons, the Fix-in-Place alternative does not adequately address any of the plan formulation criteria.

4.3.3 Setback Levee Alternative

The SRFCP is designed to convey the vast majority of the flood waters entering the system upstream of the Natomas Basin over the Fremont Weir and through the Yolo Bypass, thereby limiting the flows entering the Sacramento River channel downstream of the weir. Accordingly, setting back the levee on the east side of the river would create an inherent risk of encouraging larger flows into the channel that could overwhelm the levee system downstream of Natomas. For this reason, the Setback Levee alternative would have to be integrated into a larger regional plan of flood protection and could not be implemented apart from the updated Central Valley Flood Protection Plan. This alternative would therefore not be eligible for early implementation.

More importantly, the path of the Setback Levee alternative along the east bank of the Sacramento River would be blocked by the Airport. The Sacramento County Airport System has made it clear that it would not welcome any change in the configuration of the Sacramento River channel that would increase the aquatic habitat near the arrival and departure corridors of its aircraft. Such landscape changes would likely be considered inconsistent with the Memorandum of Agreement between the Federal Aviation Administration, the U.S. Air Force, the U.S. Army, the U.S. Environmental Protection Agency, USFWS, and the U.S. Department of Agriculture to Address Aircraft-Wildlife Strikes which was executed in 2002 and 2003. For this reason, the existing Garden Highway levee would have to be maintained and the new setback levee would have to be designed around the Airport. Given the condition of the existing levee, its continued maintenance would not reduce the currently unacceptable risk that this levee could fail catastrophically, alter the flow split at the Fremont Weir, and overwhelm the Sacramento River channel downstream of Natomas.

Thus, the Setback Levee alternative would not address the basic objectives of the NLIP; would not qualify for early implementation; would not address the weaknesses in the existing Garden Highway, or protect the community from these weaknesses; and, because it would have a significantly larger footprint than the Fix-in-Place or Adjacent Levee alternatives, requiring substantially more real estate and borrow material to construct, the Setback Levee alternative would be much more costly than these alternatives. This alternative is thus not only incomplete, but would also be inefficient and ineffective.

4.3.4 Adjacent Levee Alternative

The adjacent levee design is feasible in all reaches of the SREL, including the reaches east of Interstate 80 where urban development has occurred near the landside toe of the levee and the reaches north of RD 1000's Pumping Plant No. 3, where the levee must be raised to meet applicable standards adopted by the California Legislature for levees protecting urban areas. Under these State standards, urban levees must have crowns that are at least 3 feet above the mean 200-year water surface elevation in the channel adjacent to the levee. To meet this standard, the non-Federal sponsors are proposing to implement a "raised adjacent levee" design in the upper 13.1 miles of the SREL. To accommodate stormwater drainage along the landside of the Garden Highway, this design includes a drainage swale between the new adjacent levee crown and the existing levee. The raised adjacent levee footprint is thus significantly larger than the footprint of the adjacent levee in the reaches where no raise is required.

The Phase 4b DEIS/DEIR includes an estimate that approximately 90 acres of landside woody vegetation will have to be relocated or removed to accommodate this expanded levee footprint, the landside berms that are proposed to address underscepage, and the maintenance area along the landside toe of the improved structure. This is a slightly greater landside impact than the Fix-in-Place alternative. However, it is apparent from the coordination that has occurred on this plan to date, that this landside loss can be fully mitigated through preservation or creation of approximately 240 acres of woodlands in corridors parallel to and set back from the landside toe of the improved structure in several reaches of the SREL. Thus, the key to the feasibility of the Adjacent Levee alternative is its ability to address levee integrity issues while avoiding the loss of approximately 80 acres of waterside vegetation that would likely generate a jeopardy opinion and potentially halt progress on flood risk reduction in the Natomas Basin. For these reasons, this plan is the most complete, efficient, effective, and acceptable alternative.

4.3.5 Improvements Undertaken to Date

In 2009, SAFCA and the State entered into an agreement to implement improvements to the NCC south levee and the upper 14.8 miles of the SREL as part of the State's early implementation program. Toward this end, the State has received permission from USACE to raise and strengthen 5.3 miles of the NCC south levee and alter approximately 8.8 miles of the SREL through construction of a raised adjacent levee section. This work will be completed in 2010. The State's request for USACE approval to alter an additional 6 miles of the SREL through construction of a raised adjacent levee section (3.7 miles) and an adjacent levee section (2.3 miles) that would commence in 2010 is currently pending.

CHAPTER 5 – ENGINEERING CONSIDERATIONS

This chapter provides background on the historic construction of the levees around the Natomas Basin, describes the structural measures proposed by the non-Federal sponsors for improving the system, and addresses the adequacy of the improvements with respect to meeting USACE criteria for levee safety, structural integrity, functionality and accessibility for maintenance, inspection, monitoring, and flood fighting.

5.1 Background

The Natomas Company of California ("Natomas Company") constructed the levees around the Natomas Basin between 1912 and 1914 using several clamshell dredges and ditchers and a suction dredge to excavate and place a total of 9.5 million cubic yards of material. The suction dredge did the work along the Sacramento River where the levee followed an alignment along high ground several hundred feet from the river channel. The dredge pumped sand from the channel bottom through a system of pipes into a trench excavated through a woodland clearing. The trench served to confine the sand and convey the excess water back to the river. The sand was configured into the design dimensions of the levee (24-foot crown with 3H:1V waterside and 2H:1V landside slopes) and then covered with a layer of the sediment excavated to create the confinement trench. Away from the Sacramento River, the Natomas Company employed long-boom clamshell dredges using buckets with a capacity of up to 6 cubic yards to construct what the Natomas Company called the "cross" levees along the NCC in the north and Bannon Slough (ARNL) in the south and the "east" levee along the lower portion of the NEMDC. The dredges cut new drainage channels and cast new levees with the excavated material following a template similar to the levee along the Sacramento River (20-foot crown with 3H:1V waterside and 2H:1V landside slopes).

5.1.1 SREL

The SREL protects the western flank of the Natomas Basin. As shown in **Plate 1**, this levee extends for approximately 18.6 miles along the east bank of the river from the NCC to the mouth of the American River. As discussed above, this levee was constructed by suctioning sand from the bottom of the river channel and forming a new levee on high ground several hundred feet away from the channel. This sand was pumped into a receiving trench and then covered with a layer of sediment excavated from the trench. Vegetation was allowed to remain on the berm between the levee and the river, and over time new vegetation established itself on the waterside slope of the levee.

Uniquely among all of the levee systems within the SRFCP, the proximity of the Natomas Basin to the City of Sacramento and the design of the SREL, created a demand for residential development on the waterside of the SREL. The alignment of the levee severed large agricultural parcels, creating remainders between the levee and the river channel that were too small to farm but big enough to support residential development with roadway access off the top of the SREL, which became known as Garden Highway. Landowners petitioned Sacramento County to turn these remainders into legal parcels and then sought permits from the California Reclamation Board, which was the predecessor of the CVFPB, to allow residential structures to be constructed on the new parcels. The California Reclamation Board ultimately adopted special regulations to permit residential development along Garden Highway. As a result of this residential development, the vegetation on the waterside of the SREL largely exists on private property in an area covered by encroachment permits and flood control easements, which give the government the right to operate and maintain the levee and undertake the improvements that may be deemed necessary.

5.1.2 ARNL

The ARNL protects the southern flank of the Natomas Basin. This levee extends for approximately 2.3 miles along the north bank of Bannon Slough from the mouth of the American River to Northgate Boulevard as shown in **Plate 1**. As discussed above, this levee was constructed using a long-boom clamshell dredge. The dredge cut a new drainage channel (Bannon Slough) extending eastward from the Sacramento River along an alignment more

than 1,500 feet north of the American River low flow channel. The material excavated from the channel was used to create the ARNL. East of what is now Northgate Boulevard, the new channel turned northward, became the NEMDC, and extended all the way to high ground south of what is today Sankey Road.

The new channel was designed to intercept flows in the tributary streams, draining the foothills east of the Natomas Basin, and divert these flows around the eastern and southern flanks of the Basin to the Sacramento River in low flow conditions and to the American River in flood conditions. Prior to reclamation, the Natomas Basin functioned as an overflow area known as the American Basin that absorbed run-off from these tributary streams and from the American and Sacramento Rivers. The Basin thus relieved pressure on the American River south levee protecting the City of Sacramento. Accordingly, in response to the Natomas Company's reclamation plan, the City insisted on an alignment of the ARNL that would give the confined portion of the American River channel adequate capacity to pass the run-off from the American River Basin and the diverted run-off from foothill basins during flood conditions. This exchange produced the area's first setback levee.

The ARNL was constructed of the soil material excavated from Bannon Slough. This material consisted of a mixture of sand, silt and clay that provided a much more consistent medium for levee construction than the sands used to construct the SREL. As a result, the ARNL had a more standard geometry with a 20-foot crown width, a 3H:1V waterside slope, and a 2H:1V landside slope. Over the years, the crown has been widened to at least 40 feet to accommodate Garden Highway and more recently to over 80 feet to accommodate the Arden-Garden Connector.

5.1.3 NEMDC West Levee

The NEMDC west levee protects the eastern flank of the Natomas Basin. This levee extends for approximately 14 miles along the west side of the NEMDC from Northgate Boulevard to Sankey Road as shown in **Plate 1**. The NEMDC was created to intercept flows in the tributary streams east of the Natomas Basin and divert them around the Basin to the Sacramento River in low flow and to the American River in flood stage. The NEMDC west levee was constructed from the material excavated from the new channel by a long-boom clamshell dredge. Like the material used to construct the ARNL, this material consisted of a mixture of sand, silt and clay that provided a much more consistent medium for levee construction than the sands used to construct the SREL. Thus like the ARNL, the NEMDC west levee had a standard geometry with a 20-foot crown width, a 3H:1V waterside slope, and a 2H:1V landside slope.

5.1.4 NCC South Levee

The NCC south levee protects the northern flank of the Natomas Basin. This levee extends for approximately 5.3 miles along the south side of the NCC from the Sacramento River to the PGCC as shown in **Plate 1**. The NCC was created to intercept flows in the tributary streams draining the watersheds in western Placer County and southern Sutter County, east of the Natomas Basin, and divert them around the Basin to the Sacramento River. The south levee was constructed from the material excavated from the NCC channel by a long-boom clamshell dredge. This material consisted of a mixture of sand, silt, and clay that provided a consistent medium for levee construction and allowed the levee to be constructed with a standard geometry with a 20-foot crown width, 3H:1V waterside slope, and 2H:1V landside slope.

5.2 Structural Measures

5.2.1 SREL

The SREL improvements proposed by the non-Federal sponsors were designed after USACE issued the levee vegetation management policies set forth in the ETL. As displayed in **Plates 4** through **14** and described in Chapter 3, these improvements consist of constructing a raised adjacent levee section between LM 0.0 and LM 12.8 to meet the State's urban levee height requirement (crown elevation must be at least 3 feet above the 200-

year design water surface elevation) and an adjacent levee section between LM 12.8 and LM 18.6 where the existing levee is already high enough to meet this requirement. The raised adjacent levee section will be approximately 40 feet wider than the existing levee section, while the adjacent levee section will be approximately 20 to 24 feet wider. Depending on foundation conditions, undersecpage risk will be addressed in both designs either by installing cutoff walls of various depths or by constructing seepage berms. Waterside vegetation is proposed to remain on the waterside slope and berm, and on the levee crown 10 feet beyond the centerline of the existing levee. This represents the original crown width of the levee and excludes portions of the crown where waterside widening has occurred to accommodate residential development. Based on the minimum height and width of the adjacent levee section, this design will create an outer layer of material around the geometry of a standard levee section that contains the vast majority of the root mass of the trees allowed to remain in the variance area on the waterside slope and berm.

5.2.2 ARNL

As displayed in **Plates 15** through **17** and described in Chapter 3, the ARNL improvements proposed by the non-Federal sponsors include installing seepage cutoff walls of various depths depending on foundation conditions and flattening or strengthening the landside slope of the levee. The levee does not need to be raised because the existing levee already meets the State's urban levee height requirement. Moreover, the existing levee section is oversized due to the widening the levee crown to accommodate the Garden Highway. Like the adjacent levee design for the SREL, the ARNL's over-widened crown and extended height create an outer layer of material around the geometry of a standard levee section that contains the vast majority of the root mass of the trees and other woody vegetation that would be allowed to remain in the variance area on the waterside slope and berm.

5.2.3 NEMDC West Levee

As displayed in **Plates 18** through **23** and described in Chapter 3, the NEMDC west levee improvements proposed by the non-Federal sponsors between LM 0 and LM 4.4 include installing seepage cutoff walls at selected locations where the NEMDC intersects with the abandoned streambeds of Dry/Robla, Magpie, and Arcade Creeks and strengthening the landside slope of the levee. This portion of the levee was raised by SAFCA following the flood of 1986 and it currently meets the State's urban levee height requirement. SAFCA's improvements replicated the design geometry of this portion of the levee (20-foot-crown width, 3H:1V waterside slope, and 2H:1V landside slope) at the new design height.

Following completion of these improvements, the City of Sacramento constructed the Arden Garden Connector Project connecting Arden Way in North Sacramento to the Garden Highway in Natomas by bridging the NEMDC and widening the crown of the west levee by at least 40 feet between the new bridge and Northgate Boulevard, a distance of approximately 1,500 feet. As a result, this portion of the lower NEMDC west levee is oversized in a manner similar to the section of the ARNL to which it connects.

Like the ARNL, this oversized segment contains a very wide outer layer of material around the geometry of a standard levee section that contains the vast majority of the root mass of the woody vegetation on the waterside slope. Accordingly, vegetation would be allowed to remain in the variance area on the waterside slope and berm of this portion of the levee.

Where the levee section is not oversized (between LM 0.3 and LM 4.4), existing vegetation would be allowed to remain in the modified variance area on the lower 1/3 of the waterside slope and berm. As discussed in Section 5.4.2, engineered rock would be placed around all of the trees in this area to reduce the risk that wind toppling of these trees could trigger scour that would affect levee stability.

5.2.4 NCC South Levee

As displayed in **Plates 24** through **29** and described in Chapter 3, the NCC south levee has already been improved as part of SAFCA's early implementation project. Most of this levee section (LM 0.0 to LM 4.38) has been raised to meet the State's urban levee requirement. This portion of the levee has also been strengthened through installation of a seepage cutoff wall, and the improved levee section has been moved slightly landward. Between LM 3.5 and LM 4.38, the levee has been set back far enough to accommodate a 4-to-1 horizontal-to-vertical (4H:1V) waterside slope and a 3H:1V landside slope. Vegetation would be allowed to remain in the variance area encompassing the lower 1/2 of the waterside slope of this portion of the levee and the adjacent berm.

Between LM 0.0 and LM 3.5, the improved levee has a more standard 3H:1V waterside slope that will be extended by 0.7 mile to complete the NCC improvements in 2010. The waterside slope of this portion of the levee is largely vegetation-free; however, vegetation exists along the extended portion of the slope below the projection of the landside toe of the levee on the waterside slope. Vegetation would be allowed to remain in the variance area encompassing this waterside berm.

5.3 Levee Safety

As displayed in the levee cross sections described in Chapter 3, the trees allowed to remain on the waterside of the affected levees typically have a root structure characterized by a mass of lateral roots concentrated in the upper 3 to 4 feet of the slope with a series of vertical roots extending another 3 feet downward from the trunk. Accordingly, in the levee sections covered by this vegetation variance request, this root mass will be largely concentrated in the space between the waterside slope of the existing levee and the hypothetical waterside slope of the new or designated levee prism, or in the portion of the waterside slope that lies below the landside ground elevation. Moreover, because most of the roots have a lateral orientation, the root mass is unlikely to create pathways for seepage through the affected levee structures.

Although root architecture has not been widely studied, the pattern identified above is consistent with the findings in the *Technical Report on the Effects of Vegetation on the Structural Integrity of Sandy Levees* (August 1991), prepared by Donald H. Gray, F. Douglas Shields, and others for USACE's Waterway Experiment Station in Vicksburg, Mississippi. This report, which is attached as **Appendix B**, is referred to herein as the "WES Report." The WES Report focuses on the relationship between vegetation and the structural integrity of river levees. Field work was carried out on a portion of the Sacramento River west levee directly across from the Natomas Basin in RD 1600. This levee is very similar in composition and structure to the SREL. Thus, the observations and conclusions of this study are particularly relevant to the Common Features Project in Natomas.

The identified root pattern is also consistent with field studies reported in the Letter Report from Kleinfelder to Larry Aksland dated February 14, 1989 and the supplemental *Root Pattern Investigation* prepared by Agro Environmental Services, which is attached thereto. This report, which is attached as **Appendix C**, is referred to herein as the "Kleinfelder Report." At SAFCA's request, this report was reviewed by Dr. Alison Berry, a research professor in plant sciences at the University of California, Davis; and Dr. Chris Peterson, a research professor at the University of Georgia, Athens. These scientists are both members of the Levee Vegetation Science Team created by SAFCA and DWR to advise the California Levees Roundtable. Dr. Berry's review is included as an attachment to **Appendix C**. Dr. Peterson's review along with the preliminary results of his analysis of tree toppling data in the Central Valley is contained in **Appendix H**. The Kleinfelder Report focuses on native riparian vegetation on the Mosher Slough levee in the San Joaquin River Delta near the City of Stockton. This levee is formed more of clay than sand, and is more frequently inundated than the SREL. Nevertheless, the conclusions and observations of the study, particularly with respect to the root architecture of riparian vegetation, are in accord with the WES Report and generally reflect the more recent research being conducted by Dr. Berry.

Finally, the identified root pattern is consistent with data being developed for a dissertation on tree root structure by Caroline Zanetti. Ms. Zanetti is a doctoral student currently evaluating root structures found in trees growing on the waterside of a sandy dike on the Loire River in France. As part of this effort, she has participated in excavating and examining several trees of a similar species, size, and relationship to the dike and the river as those found in the Project Area. Her observations along with photos of some of the excavated trees are attached as **Appendix D**. As in the WES and Kleinfelder Reports, she notes that the trees in dikes along the Loire River bank produce a mass of shallow lateral roots that grow in the surface soil of the dike structure (upper 3 to 4 feet) parallel to the levee slope. These trees also produce a smaller number of vertical roots (including tap roots in the case of oak trees) that may extend up to 5 feet down.

As observed in the WES Report, this kind of root structure has the effect of reinforcing the surface layer of sandy levees such as those that were constructed along both sides of the Sacramento River. This root structure also increases the shear strength of the sandy soils comprising these levees, thus making the waterside slope and berm more resistant to erosion from river flows and wind and wave action and more resistant to slope instability due to ground shaking, toe scour, or rapid draw down. Moreover, according to the WES Report, woody vegetation on the waterside slope and berm of sandy levees does not appear to adversely affect the structural integrity of these levees by creating open voids or conduits, which might facilitate through levee seepage. Not only does the root structure not penetrate beyond the surface layer of the levee, rotted or decayed roots tend to infill with soil.

5.4 Structural Integrity

5.4.1 Levee Seepage and Stability Analysis

At SAFCA's request, Kleinfelder performed an analysis of potential seepage and stability impacts associated with the presence of vegetation along the waterside slope and base of the levees covered by this vegetation variance request. As shown in **Table 5-1**, the analysis was performed at levee cross section locations at or near seven of the eight index points identified in Chapter 3 where Kleinfelder had previously gathered data and conducted analyses as part of the Problem Identification Reports and Alternative Analyses prepared in connection with the NLIP. No analysis was performed at index point NEMDC LM 0.0 because this levee section has an 85-foot crown.

Table 5-1
Representative Cross Section Station

Kleinfelder Seepage and Stability Analysis			Variance Request
Levee Section	**Representative Site (Model)**	**Corresponding Levee Mile**	**Levee Cross Section**
SREL	320+00	LM 6.5	SREL LM 5.8
SREL	838+00	LM 16.3	SREL LM 15.2
SREL	904+50	LM 17.4	SREL LM 17.0
ARNL	47+50	LM 0.75	ARNL LM 1.1
NEMDC South	a.n.p.		NEMDC LM 0.0
NEMDC South	58+00	LM 1.1	NEMDC LM 0.3
NCC	183+00	LM 0.8	NCC LM 0.7
NCC	21+00	LM 4.0	NCC LM 3.6

Note: a.n.p. = analysis not performed on this section because no remediation is planned for this section and the section had an 85-foot crown.
Source: SAFCA 2010

Kleinfelder analyzed the potential effects of vegetation presence along the waterside slope and toe of the affected levees by evaluating the performance of the levee as designed and after removal of the portion of the waterside slope believed to contain the vast majority of the root mass of the waterside vegetation. This was accomplished by removing a 15-foot section from the base of the levee (as designed) at the waterside toe and projecting a

hypothetical slope back to the levee crown. The hypothetical slope was projected on a 3H:1V grade as long as the remnant crown was at least 20 feet wide, otherwise the grade was adjusted to intersect a 20-foot crown or the existing crown if it was less than 20-feet wide. This created remnant levee sections with waterside slopes that varied from 1.7H:1V to 3H:1V.

Kleinfelder then analyzed the structural integrity of the remnant levee sections by calculating underseepage gradients at the landside toe of these sections and by comparing the sudden drawdown factors of safety produced by the remnant sections and the levees as designed. The calculated underseepage gradients were below USACE criteria in all cases and although the remnant levee sections generally showed a decrease in drawdown factor of safety by comparison to the levees as designed, all of the remnant sections exceeded minimum USACE criteria for the sudden drawdown condition.

The results of the Kleinfelder analysis are set forth in the letter report entitled *Levee Seepage and Stability Analysis* attached as **Appendix E**. These results suggest that even if the outer layer of the waterside slope of the modeled levee sections, which likely contains the vast majority of the root structure of any waterside vegetation on the levee, was lost due to erosion, scour or other factors, the remaining remnant levee section would be considered stable with respect to underseepage and sudden drawdown.

To ensure that these results are applicable to all levee sections included in this vegetation variance request, Kleinfelder reviewed the soils data that was gathered for all of these sections as part of the NLIP to determine whether there are unique conditions at locations other than the selected index points where replication of the remnant levee analysis might produce different results. Based on this review, Kleinfelder concluded that the selected index points adequately represent soil conditions in their respective levee segments and thus serve as appropriate indicators of seepage and stability risk.

5.4.2 Wind Toppling and Scour Potential

To test the limits of Kleinfelder's analysis, NHC conducted a scour analysis to determine whether tree (fall) toppling could create root pits and subsequently under flood conditions could induce enough scour to penetrate Kleinfelder's remnant levee sections and prevent these sections from meeting the minimum underseepage and rapid drawdown criteria. An enlarged root pit could alter the remnant levee sections devised by Kleinfelder and potentially invalidate their seepage and stability conclusions. This analysis is set forth in **Appendix F**.

The sites selected for this analysis were based on identifying at least one large tree that might potentially erode the levee if the tree fell. At least one such site was located in each of the levee reaches included in the variance request. These sites are summarized in **Table 5-2**. They do not necessarily match the index points used to develop the typical cross sectional drawings described in Chapter 3. Rather, NHC chose "worst case" sites, where scour around a fallen tree might penetrate the levee template. Hence, the sites in **Table 5-2** represent locations where a large tree existed on the waterside levee slope where local hydraulics would likely maximize scour. Further details on these sites are included in **Appendix F**.

Tree Fall and Scour Analysis

The presence of a structure in flowing water, in this case the root plate and trunk of a fallen tree, changes the velocity field in several ways that lead to local scour or erosion of exposed soils. These changes include (1) increased local velocities as the flow accelerates around the upstream end of the root plate; (2) deflection of flow towards the bed; and (3) flow separation downstream of the root plate and trunk, creating a turbulent wake with vortices in the flow. All these changes to the velocity field increase the erosive forces exerted on the exposed soil in the root pit and result in scour around the structure. Breusers and Raudkivi (1991) describe the flow and scour characteristics for various structures in detail; May et al. (2002), Melville and Coleman (2000), and Transport Association of Canada (TAC) (2004) describe scour processes for bridges and piers.

Table 5-2 NHC-Selected Scour Sites			
NHC Study Site	**Soil Type**	**Scour Condition**	**Proposed Improvement**
Sac 1 (LM 0.3)	Silty Sand	Large trees on lower bank	Raised adjacent levee
Sac 2 (LM 5.3)	Silty Sand	Large tree on berm at levee toe	Raised adjacent levee
Sac 3 (LM 12.0)	Silty Sand	Very large tree 20 feet from levee toe	Raised adjacent levee
Sac 4 (LM 13.3)	Silty Sand	Large tree on levee slope	Raised adjacent levee
Sac 5 (LM 14.9)	Silty Sand	Large tree on berm 15 feet from levee toe	Adjacent levee in agricultural area
Sac 6 (LM 17.4)	Silty Sand	Large tree on levee slope	Adjacent levee in urban area
NEMDC 1 (LM 1.3)	Silty Clay	Large trees at levee toe	Cut-off wall in standard levee section
NCC 1 (LM 3.7)	Silty Clay	Large trees on levee slope and berm	Raised levee with flattened waterside slope and cut-off wall
Amer 1 (LM 0.7)	Silty Sand	Large tree on levee slope	Cut-off wall in oversized levee
Amer 2 (LM 1.7)	Silty Sand	Large trees near levee toe	Cut-off wall in oversized levee
Source: SAFCA 2010			

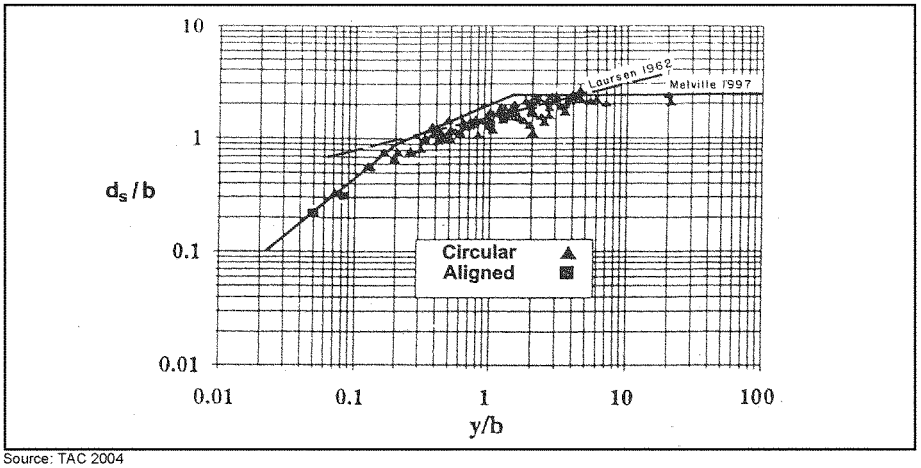
The scour that occurs at structures is divided into "live-bed" and "clear-water" types. In the clear-water type the velocities upstream of the structure are too low to mobilize the local soil or bed material—no bed load transport occurs—and this case is typical for the fallen trees considered in **Appendix F**. Under this condition, scour will occur if the intensified flows around the structure are sufficient to mobilize the local soils. As the scour hole increases in size, the flow acceleration near the structure and the interaction of the flow with the bed become less intense, reducing the ability of the flow to transport the bed material and deposited it downstream. Eventually, the scour hole becomes so large that the flow is incapable of removing more material. This is referred to as the maximum or equilibrium scour depth for the particular flow, structure and material. The time taken to reach this maximum or equilibrium depth depends on upstream flow conditions and local soil characteristics and can be very long.

Calculating Scour Depths around Fallen Trees

There is no known procedure for calculating the maximum or equilibrium scour depth around fallen trees. After internal discussion, NHC adopted scour calculation procedures for bridge piers using parameters that reflected the general character of the root plate. This approach ignored scour associated with the trunk. As discussed in more detail in **Appendix F**, the root plate is closest to the levee and will cause scour towards the levee section and greater scour depths are expected at the root plate because of its greater vertical extent or height.

Pier scour equations are generally empirical equations based on physical modeling of scour around different pier dimensions and shapes in non-cohesive bed materials. A number of different equations have been recommended or developed by different organizations, but most equations rely on predicting the depth of scour from local flow depth and pier width, then adjusting this prediction for other factors. As an example, **Figure 5-1** shows the basic relationship between the ratio of scour depth (d_s) to pier width (b) and that of flow depth (y) to pier width (TAC 2004; their Figure 4-17).

Figure 5-1 (refer to curve labeled Melville 1997) shows that when the flow depth is much greater than the pier width, the maximum scour depth tends to be a constant ratio of the pier width. For very shallow depths, the maximum scour depth goes to a very small portion of the pier width, or to zero. For intermediate depth to pier width ratios, which often occur around the root plates of fallen trees on the levee slope, the maximum scour depth is a function of both pier width and flow depth. The Melville and Coleman (2000) equations are described in detail in **Appendix F**. Velocity becomes important in determining if scour will occur and the time it takes for the scour hole to reach maximum or equilibrium depth.



Source: TAC 2004

Figure 5-1: Basic Local Scour Relationship for Aligned or Circular Piers

Applying Pier Scour Equations

NHC applied both the FWHA HEC-18 (Richardson and Davies 2001) and the New Zealand (Melville and Coleman 2000) pier scour equations to calculate maximum scour depths. The following information was required for the calculations:

- the depth and velocity just upstream or in the vicinity of the fallen tree;
- the width, length, and height of the root plate of the fallen tree;
- the angle of the root plate relative to flow direction (called "skew");
- the median size and characteristics of the soils exposed in the root pits (the soils were assumed to be erodible silty sands except at the NCC and NEMDC sites [**Table 5-2**]. **Appendix F** describes field investigations and assumptions);
- an estimate of the correction factor for pier shape (assumed to be 1.1);
- the correction factor for clear-water scour (assumed to be 1.1); and
- the duration of the design flood when the scour occurs.

Appendix F provides details on how the above variables were estimated and how scour depths were calculated from the two pier equations. Initial analysis indicated that the Melville and Coleman equation predicted greater maximum scour depths than the FWHA equations at all the study sites and their equation was adopted to calculate all the subsequent maximum scour depths.

Addressing Uncertainty and Worst Case Conditions

There is some uncertainty in all the variables used for the pier scour equations at each site. To ensure that worst case conditions or the greatest maximum scour depths were calculated NHC adopted the assumptions described below to incorporate "worst case" hydraulic conditions and root plate dimensions.

Although great effort was put into choosing conservative yet representative flow and root plate characteristics, it is recognized that there is some uncertainty involved in determining all of these variables. A Monte Carlo approach was used to account for uncertainty in these input variables: root plate geometry, orientation to flow, flow velocity and flow depth. In this approach, the input variables are assigned a range of values centered on the expected value for a given variable. A repetitive numerical process randomly selected the input variables from these ranges and computed a scour depth for each random set of input variables. The final outcome of this approach is a distribution of scour depths centered on the expected scour depth with a variance representative of the uncertainty in the various inputs to the scour depth equations. **Appendix F** provides a more detailed discussion of this approach.

Along the Sacramento and American Rivers, both depths and velocities increase with discharge, so the most extreme case for scour is at the most extreme discharge; for this analysis, the 200-year flood was adopted. The NEMDC and the NCC are backwatered during the 200-year flood; depths are greatest then, but velocities are near zero. In these two canals, the worst case for scour occurs at intermediate conditions as is demonstrated in **Appendix F**. In its calculations NHC adopted velocities appropriate for this intermediate condition but assumed depths that are equivalent to those during the 200-year flood. Given that flow depth dominates the calculated scour, this is a very conservative assumption for maximum scour calculations.

Determining Root Plate Dimensions

The majority of the trees on the waterside of the levees in the Project Area are winter deciduous. As such, these trees are less subject to wind force leverage during the flood season. On the other hand, flood conditions could weaken the stability of tree root structures through erosion soil saturation. In any event, as discussed in the 1989 Kleinfelder Report (**Appendix C**) and in Dr. Chris Peterson's review of this report (**Appendix H**), if one of these trees is toppled by high winds, the uprooted plate is likely to be relatively shallow (2 to 3 feet). Dr. Peterson notes:

> "My own experience after observing literally thousands of uprooted trees in eastern U.S. forests, is that a majority of root pits are indeed less than 2 feet deep, and probably 95% or more of root pits are less than 3 feet deep. I don't think I have seen a single root pit more than 4 feet deep…More specific to trees on California levees, initial findings from the California Levee Research Program's 'windthrow' study, of which I am the lead investigator, support the above conclusions. In this study, over 50 trees, most on levee slopes, were winched down to document their wind-firmness and the size of root pits for the ones that uprooted. Of those that uprooted, none created root pits greater than 3 feet deep, and most were less than 2-feet deep."

In light of these findings, NHC initially assumed a typical root plate thickness of 3 feet and a width and length of 15 feet. As described in **Appendix F** the width of the root plate was varied from 2 to 3.5 feet and the height and length were varied from 12 to 15 feet in the Monte Carlo. The simulated scour analysis associated with these root plate dimensions is referred herein as "Trial 1." Following a round of review and comment on the results of this analysis, a second simulated scour analysis was performed assuming a typical root plate thickness of 4 feet and a width and length of 20 feet. As described in **Appendix F** the width, length and depth of the root plate were not varied in the subsequent Monte Carlo simulation but the hydraulic conditions were varied. This second simulation is referred to herein as "Trial 2."

NHC notes that the 4-foot-thick root plate with a length and width of 20 feet may not actually occur. The wind forces required to blow down a tree and topple or lift such a weight may seldom be reached (see **Appendix H**). Consequently, the Trial 2 calculations provide very conservative scour depths.

Results of Scour Calculations

Table 5-3 summarizes the maximum scour depths calculated from the Melville and Coleman (2002) equations for each study site for the three trials described above. The maximum scour depths were adjusted for flow duration as described in **Appendix F**.

Table 5-3
Maximum 200-Year Scour Depths (feet)

NHC Study Site	Trial 1	Trial 2
SREL 1 (LM 0.3)	11.8	17.9
SREL 2 (LM 5.3)	11.6	16.5
SREL 3 (LM 12.0)	11.7	16.5
SREL 4 (LM 13.5)	2.4	2.8
SREL 5 (LM 14.9)	11.7	16.6
SREL 6 (LM 17.4)	0.1	0.1
ARNL 1 (LM 0.7)	3.9	7.4
ARNL 2 (LM 1.7)	11.7	17.4
NEMDC 1 (LM 1.3)	7.3	9.8
NCC 1 (LM 3.6)	9.6	13.3
Source: **Appendix F**		

An eroded section, or a scour hole, was drawn around each fallen tree root plate assuming 2:1 side slopes and other assumptions described in **Appendix F**. The selected trees, the assumed root pits, and the subsequent eroded areas are shown on drawings for each study site in **Appendix F**. The drawings also show 1:3 and 1:2 theoretical waterside slopes for the existing levee and for the proposed improvements for reference.

Sources of Conservatism in the Scour Analyses

The scour depths cited in **Table 5-3** are conservative and likely overestimate the actual scour that is likely to occur. The elements of conservatism that are incorporated into the calculations include the following:

- It was assumed that the root plate was similar to a pier when calculating scour even though the root plate will not extend to maximum scour depth at a constant diameter. It is believed that drag and buoyancy may move the tree from the site before scour reaches the maximum calculated depth.

- Scour was calculated from depth-averaged velocities taken from 2-D model grid cells that are much larger than the individual trees. These velocities do not fully account for the effect of structures or other large trees on local velocities and they are an average over a large area so they do not predict the velocities near the levee face well. The velocities adopted for analysis are expected to exceed actual values that occur at the study sites.

- NHC assumed erodible silty sands to depth along the Sacramento River and did not account for erosion resistance from roots, other vegetation, erosion-resistant layers, etc. All of these would reduce the maximum scour depth reached during the 200-year flood.

- NHC calculated maximum scour depths from two common sets of equations. Both equations predict maximum scour depth from envelope curves based on laboratory studies and are known to overestimate the observed scour under field conditions by up to 100% (May et al. 2002). NHC adopted the greater of the two sets of estimates for calculating the eroded section.

- The eroded section that develops from the maximum scour hole assumed 2:1 side slopes based on the ASCE Manual No. 110 on Sedimentation Engineering (Garcia 2006). Other advice suggested that these side slopes are conservative and that steeper slopes may develop, resulting in less erosion than predicted.

Interpreting Levee Stability

The preliminary interpretation of levee stability under tree fall scour at the study sites was based on comparing the interpreted Trial 1 scour hole to the remnant levee section defined by Kleinfelder in **Appendix E**. The maximum scour depths calculated for Trial 1 penetrated the remnant levee section along the upper SREL reach and the lower NCC reach. Kleinfelder then re-calculated the stability of levee waterside slope under sudden drawdown with the scour holes in place (**Appendix E**). Based on this re-analysis, they concluded that factors of safety at the levee sections exceed the minimum USACE criterion of 1.1 and all the levee sections remained stable under the worst case maximum scour depths for Trial 1. Subsequently, Kleinfelder analyzed the Trial 2 eroded sections following their earlier procedures described above. The results of this analysis also indicated that all the levee sections remained stable under drawdown. **Table 5-4** provides a summary of Kleinfelder's Trial 1 and Trial 2 analyses and a removal of the 15-foot section from the base of the levee as described in Section 5.4.1.

Table 5-4
Summary of Analysis of Tree-Fall Scour and Erosion

Reach	Levee Section	Kleinfelder Representative Model Station	Type of Analysis/Concern in Area of Analysis	Scour Depth	Seepage Gradient at Levee Toe	Sudden Draw-down Factor of Safety
NCC	LM 0.7[1]	183+00	15-foot levee section removal zone		<0.10	1.35
	LM 3.6[1]	21+00	15-foot levee section removal zone		0.46	1.56
	LM 3.7[2]	21+00	15-foot by 3-foot root plate	9.6	a.n.p.	1.19
			20-foot by 4-foot root plate	13.3	a.n.p.	1.11
SREL	LM 5.8[1]	320+00	15-foot levee section removal zone		<0.10	1.86
	LM 15.2[1]	838+00	15-foot levee section removal zone		0.20	1.35
	LM 17.0[1]	904+50	15-foot levee section removal zone		0.10	2.50
	LM 0.3[2]	27+00	15-foot by 3-foot root plate	11.8	a.n.p.	1.34
			20-foot by 4-foot root plate	17.9	a.n.p.	1.11
	LM 5.3[2]	287+00	15-foot by 3-foot root plate	11.6	a.n.p.	1.27
			20-foot by 4-foot root plate	16.8	a.n.p.	1.11
	LM 12.0[2]	640+00	15-foot by 3-foot root plate	11.7	a.n.p.	2.23
			20-foot by 4-foot root plate	16.5	a.n.p.	1.35
	LM 14.9[2]	789+00	15-foot by 3-foot root plate	11.7	a.n.p.	1.58
			20-foot by 4-foot root plate	16.6	a.n.p.	1.33
	LM 17.4[2]	838+00	tree fall within upper 1/3 of slope		a.n.p.	1.31
ARNL	LM 1.1[1]	47+98	15-foot levee section removal zone		<0.10	1.42
	LM 0.7[2]	47+98	tree fall within upper 1/3 of slope		a.n.p.	1.17
	LM 1.7[2]	96+65	15-foot by 3-foot root plate	11.7	a.n.p.	1.15
			20-foot by 4-foot root plate	17.4	a.n.p.	1.50
NEMDC	LM 0.3[1]	58+00	15-foot vegetation zone		0.29	1.42
	LM 1.3[2]	58+00	15-foot by 3-foot root plate	7.3	a.n.p.	1.29
			20-foot by 4-foot root plate	9.8	a.n.p.	1.17
			scour envelope		a.n.p.	1.18
USACE Criteria					0.80	1.1

Notes: a.n.p = analysis not performed
1. Provided by AECOM
2. Provided by NHC (as detailed in **Appendix F**)
3. Seepage gradients provided by Kleinfelder (as detailed in **Appendix E**)
Source: AECOM 2010, Kleinfelder 2010, NHC 2010

Scour Depths at the Representative Cross Sections

To display the results of these analyses, NHC calculated a "maximum scour envelope" for display in the cross sectional drawings for each of the eight levee reaches described in Chapter 3. Maximum scour depths for each cross section were calculated following the procedures described above for the local site conditions and incorporating the Trial 2 assumptions regarding root plate dimensions. Based on these calculated depths, maximum scour envelopes for each cross section were calculated as follows:

- At the elevation of the 200-year water surface, the scour depth was assumed to be zero.
- Root pits below the 200-year water surface elevation were extended to 15 feet of slope distance uphill from the position of large trees located on the levee slope.
- The maximum scour depth at the waterside toe of the levee or the waterside edge of the variance area was plotted on the cross section based on the values shown in **Table 5-5** and a line was extended horizontally from this elevation towards the waterside bank. A line was also projected from this point to join existing ground at or near the 200-year water surface elevation or the landside edge of the variance area while encompassing root pits on the levee slope below this elevation. In cases where the levee shape varied significantly from a basic levee shape, additional scour depth calculations were made to adjust the envelope.
- To account for the presence of trees at or near the 200-year water surface elevation (or the landside edge of the variance area), the maximum scour envelope was adjusted to reflect the 4-foot depth of the root pit for these trees.

Table 5-5
200-Year Maximum Scour Depths (feet) on the Representative Sections

Site	SREL LM 5.8	SREL LM 15.2	SREL LM 17.0	ARNL LM 1.1	NEMDC LM 0.0	NEMDC LM 0.3	NCC LM 0.7	NCC LM 3.6
Near the toe of the levee or edge of the Variance Area	17	16.4	0.3	13	15.0	12.0	11.4	12.7

Source: NHC 2010 (as detailed in **Appendix F**)

Scour Protection

Because of the depth of the maximum scour envelope in relationship to the levee cross section along the NEMDC west levee between LM 0.3 and LM 4.4, scour protection is needed in the variance area to reduce the risk that wind toppling of the trees allowed to remain in this area could trigger scour that would affect levee stability. The scour protection would include engineered rock placed around all trees as needed to prevent scour holes from developing or becoming large enough to impair the integrity of the levee section.

5.5 Functionality

For purposes of this variance request, "functionality" is related to maintaining the conveyance capacity of the flood control channels in which the waterside vegetation is proposed to remain. Conceptually, the proposed variance should not cause any change in channel capacity because no new vegetation plantings are proposed for the upper 2/3 of the waterside slope of the affected levees. In addition, hydraulic modeling conducted for SAFCA by MBK Engineers indicates that channel roughness is not a significant factor in determining water surface elevations in the Sacramento and American River channels because these channels are several hundred feet wide and vegetation roughness on the channel margins represents a very small fraction of the overall wetted perimeter. Channel roughness is not a significant determinant of flood stages in the NCC either. Here, the location of the waterside vegetation near the low flow channel and the backwater condition produced in this channel by high flows in the Sacramento River mitigate the roughness effect. Roughness is more of a concern along the lower

NEMDC; however, the design of the NEMDC west levee improvements (installation of cutoff walls) will not contribute to this concern, and the non-Federal sponsors are committed to properly managing the vegetation that is allowed to remain on the waterside slope of the levee (see Chapter 8).

5.6 Accessibility

All woody vegetation will be removed from the landside toe, levee slope, and levee crown of the ARNL, NEMDC west levee, and NCC south levee; and from the landside toe, levee slope, and widened levee crown of the SREL (extending 10 feet beyond the centerline of the existing levee on the waterside). This will improve accessibility for maintenance, inspection, monitoring, and flood fighting. Along the SREL, the levee crown will contain the existing Garden Highway and a separate levee maintenance road that will facilitate rapid daytime or nighttime deployment of vehicles and personnel. The 50-foot easement area along the landside toe will provide additional capacity. As discussed in Chapter 8, RD 1000, CVFPB, and SAFCA are taking actions that will ensure unimpaired access to and visibility of the waterside slope of the levee for routine maintenance and inspection, flood monitoring, and flood fighting activities.

Along the ARNL, the vegetation-free zone on the over-widened levee crown, landside levee slope, and landside easement areas will provide unimpaired access to and visibility of these areas under all conditions and at all times for these purposes. The levee crown will contain the existing Garden Highway, which is wide enough to accommodate rapid daytime or nighttime deployment of vehicles and personnel. The maintenance road in the easement area along the landside toe will provide additional capacity. The waterside slope and berm of the existing levee will be accessible from the Garden Highway for inspection under routine non-flood conditions and under flood alert conditions.

Along the lower NEMDC west levee, all woody vegetation will be removed from the easement area along the landside toe of the lower NEMDC west levee. This will improve accessibility for maintenance, inspection, monitoring, and flood fighting. The vegetation-free zone along the landside slope, levee crown, and the upper portion of the waterside slope upstream of the Aden-Garden Connector will provide unimpaired access to and visibility of these areas under all conditions and at all times for routine maintenance and flood fighting purposes. The levee crown upstream of El Camino Avenue will contain the Ueda Bike Trail, which is wide enough to accommodate rapid daytime or nighttime deployment of vehicles and personnel. The waterside slope and berm of the oversized portion of the levee between the Arden Garden Connector and Northgate Boulevard will be accessible from this roadway for inspection under routine non-flood conditions and monitoring during flood alert conditions.

Along the upper NCC south levee, there will be no woody vegetation in the 50-foot landside easement area that has been established as part of the non-Federal plan of improvements, or on the landside slope, levee crown, or waterside slope above the landside ground elevation. This vegetation-free zone will provide adequate accessibility for maintenance, inspection, monitoring, and flood fighting in this segment of the levee. Along the lower NCC south levee, there will be no woody vegetation in the 50-foot landside easement area, landside slope, or levee crown. The over-widened easement area and levee crown will readily accommodate two-way traffic and provide room for staging flood-fighting activities during high water events.

CHAPTER 6 – INSPECTION REPORTS

Appendix G contains the most current DWR inspection reports for all segments of the Natomas perimeter levee system. These reports have been issued pursuant to an understanding with USACE on the mutual responsibilities of the parties with respect to levee inspection. The reports include:

- Fall 2009 Levee Maintenance Deficiency Summary Report by Local Maintaining Agency ("LMA") and by unit;
- Levee Inspection Report by Mile for each unit with unit cover sheets and LMA cover sheet;
- 2009 Channel Summary Report;
- 2009 Structure Summary Report; and
- 2009 Pumping Plant Summary Report.

CHAPTER 7 – LEVEE PERFORMANCE HISTORY

This chapter summarizes the performance history of each of the four levee segments affected by this variance request.

7.1 SREL

The flood of 1986 exposed significant deficiencies in the sandy levees along the Sacramento River channel. Many days of high flow in the river saturated the sandy interior of the levee section, causing the encapsulating material on the landside slope to slough in several Garden Highway locations, nearly triggering a catastrophic levee failure. Thereafter, between 1990 and 1993, the levee strengthened through the installation of stability berms along the landside toe of the SREL for approximately 12 miles from the NCC to Powerline Road. From there to the American River confluence, seepage cutoff walls were installed through the levee and its foundation to a depth of up to 30 feet.

These repairs functioned well during the flood of 1997. However, subsequent analysis of foundation conditions, including at locations occupied by RD 1000 pumping facilities and drainage canals, revealed unacceptable vulnerability to underseepage. At RD 1000's Pumping Plant No. 2 near RM 75, this vulnerability was considered particularly unacceptable. Accordingly, in 2006, SAFCA, RD 1000, and CVFPB initiated an emergency repair project at this site. As part of this project, several hundred feet of the levee were excavated to allow removal of an impaired discharge pipe, the levee was reconstructed, and the pumping facility was set back from the levee to allow a portion of the drainage canal to be filled and to accommodate the footprint of the new raised adjacent levee at this location.

7.2 ARNL

The ARNL has experienced many high water events in the 95 years since its completion, including in 1928, 1951, 1956, 1964, 1986, and 1997. Kleinfelder reviewed the performance history of the levee in February 2006 as part of a problem identification report ("PIR") prepared for SAFCA. The PIR referenced historic documents from the State Department of Water Resources (1967) and a map issued by RD 1000 and RD 1400 (1938) showing areas affected by high water conditious in the Sacramento River during spring 1938. This event subjected the ARNL to high water for its entire length; however, it is unclear from DWR's and RDs' maps whether the seepage observed on the north side of the levee at several locations east of what is now Interstate 5 resulted from levee or foundation seepage, or from interior canal overflows.

The PIR notes that during the 1986 flood a slip was observed uear the levee crown at Station 78+00. After the flood, Wahler Associates was retained by USACE to evaluate the performance of the ARNL. Despite anecdotal reports of "notorious" leakage at several locations along the levee, the Wahler Report identified no problem sites. Finally, the PIR indicates that in 1995, seepage and pin boils were observed near Station 88+00. No other indications of distress were identified in the PIR.

7.3 NEMDC

The lower NEMDC west levee has experienced many high water events iu the 95 years since its completion, including in 1928, 1951, 1956, 1964, 1986, and 1997. Kleinfelder reviewed the performance history of the levee in June 2009 as part of a PIR prepared for SAFCA. The report notes that of all of these flood events, the 1986 flood was the most significant. High flows in the American River (up 134,000 cfs) combined with high flows in the tributary streams discharging to the NEMDC produced record high water stages in the lower NEMDC channel. High water marks measured south of Dry/Robla Creek are equivalent to the elevation of the current 100-year flow beiug used for levee design purposes.

After the flood, Wahler Associates was retained by USACE to evaluate the performanee of the lower NEMDC west levee during the flood. The Wahler Report indicates that there was evidence of seepage through the levee, and foundation and internal erosion (or piping) of sandy materials through the levee by the presence of sand boils and deposits at the landside toe of the levee in the general vicinity of the abandoned Arcade Creek streambed. A depression, or possible slump, was observed at about the midpoint of the waterside slope directly opposite the landside toe sand deposit, possibly indicating internal erosion. Despite anecdotal reports of "notorious" leakage at other locations along the lower NEMDC west levee particularly downstream of Arcade Creek, the Wahler Report identified no other problem sites.

7.4 NCC

Kleinfelder reviewed the historic performance of the NCC south levee as part of a PIR prepared for SAFCA in March 2006. Historical documents and maps were reviewed to evaluate the past performance of the NCC south levee, including maps produced by DWR in 1967 and the Natomas Company in 1938. These maps indicate that as many as 6,810 acres on the landside of the NCC south levee were inundated during a high water event in May 1938. It is not clear from the maps, however, whether the conditions observed in these areas were produced by seepage through or under the levee, or by collected surface water at that location.

In addition to the observations recorded on the maps described above, Kleinfelder also noted that:

- During high water in 1997, a small pencil boil was observed near the confluence of the NCC south levee and the SREL.
- According to USACE (2002), a slide that occurred "approximately 3,500 feet southwest of Highway 99" was repaired in 1993.
- According to USACE, a slide also occurred in 1986, approximately 2,000 feet west of Highway 99, and longitudinal cracks indicative of slope instability were observed in the levee crown approximately 400 feet southwest of the highway. No clearly defined slide planes were observed, and the slide did not involve the crown. Investigators concluded that seepage forces resulting from spring flooding may have initiated the slide movement; however, the 1987 Wahler Report stated that these soil conditions were not encountered during their 1987 field investigation, and concluded that Wahler Associates was unable to explain the instability that led to the slide. A repair was performed in 1987 by Borcalli, Ensign & Buckley, encompassing approximately 300 linear feet of levee slope.

No documentation of other problems was found for this reach of the levee system.

CHAPTER 8 – VEGETATION MAINTENANCE PLAN

By agreement with CVFPB, the trees and other woody vegetation allowed to remain in the variance areas of the levee reaches covered by this variance request will be monitored and maintained by SAFCA and RD 1000 as follows.

8.1 Vegetation Management

There are two distinct areas along the Natomas Basin levees.

- **Vegetation variance areas with the equivalent of a waterside planting berm.** A waterside planting berm is a berm at least 10 feet in depth, measured perpendicular to the levee template. The standard Sacramento District requirement for a waterside levee slope is at least 3H:1V. However, considering the design of the levees in the Project Area, including construction of an adjacent levee landside of the existing levee on the Sacramento River, Sacramento District has accepted a steeper levee waterside slope as 2H:1V because for most of the levee sections covered by the variance request, that slope is covered by the equivalent of a planting berm as described above and the scour analysis demonstrates that there is a buffer between the maximum calculated scour depth and the levee slope. These conditions exist all along the SREL (**Plates 4** to **14**); ARNL (**Plates 15** to **17**); the NCC south levee between LM 0.0 and 3.9 (**Plates 24** to **26**); and a portion of the NEMDC west levee between levee mile 0 and 0.3, where the existing levee is overbuilt to accommodate the highway on the levee crest (**Plates 18** to **20**). Vegetation will be allowed to remain in these areas provided that the areas are maintained to ensure adequate access and visibility of the waterside levee slope and berm for routine inspection activities. Vegetation may be removed or trimmed as necessary to conduct levee repair and flood fighting activities. Consistent with ETL 1110-2-571, no vegetation, other than grasses, will be allowed to be planted in any portion of the delineated Vegetation Free Zone. Any new vegetation in these areas shall be removed by mowing, spraying, or other appropriate management. The delineated variance areas shall be maintained to the grade and condition illustrated in the plates.

- **Vegetation variance areas with no waterside planting berm.** There are areas where conditions equivalent to a waterside planting berm do not exist and a vegetation variance is requested. Such areas are on the waterside levee slopes on the NEMDC upstream of LM 0.3 (**Plates 21** to **23**) and on the NCC between LM 3.5 and 4.38 (**Plates 27** to **29**). Portions of these waterside slopes are covered with vegetation. The grade of these slopes is 3H:1V. The potential maximum scour hole determined by the hydraulic analysis penetrates the levee embankment. Geotechnical analysis for the remaining levee slope beyond the maximum scour depth shows the stability of the levee is still stable for rapid drawdown of the water in the canal. There are no changes expected in the seepage gradient at the landside levee slope due to a seepage cut-off wall constructed to the deep impervious layer in the foundation. Vegetation will be allowed to remain in the designated variance areas shown in **Plates 22** and **28**; however, maintenance of these areas will be different than the areas where the equivalent of a planting berm exists. Along the NEMDC upstream of LM 0.3, as shown in **Plate 22**, engineered rock will be placed on the portion of the waterside slope where existing trees and woody vegetation are allowed to remain to retard erosion/scour in the event of a tree toppling during a storm event. In addition, trees uprooted by winds or wave actions will be removed promptly from the levee slope, all roots greater than one and one-half inches in diameter within the drip line of the tree will be removed and the pit backfilled with suitable material similar with the surrounding soil compacted to the same density. The designated variance areas will be maintained to ensure adequate access and visibility of the waterside levee slope and berm for routine inspection activities. Vegetation may be removed or trimmed as necessary to conduct levee repair and flood fighting activities. Consistent with ETL 1110-2-571, no vegetation, other than grasses, will be allowed to be planted in any portion of the delineated Vegetation Free Zone. Any new vegetation in these areas shall be removed by mowing, spraying, or other appropriate management. The delineated variance areas shall be maintained to the grade and condition illustrated in the plates.

The O&M manual will be revised to include maintenance of the vegetation on the areas where the variance is approved.

8.2 Repair of Damage

CVFPB, through SAFCA and RD 1000, will be responsible for immediately repairing any damage to the waterside slope of any of the levees covered by the variance request that is caused by vegetation allowed to remain under the variance, including any damage due to erosion, scour, or other mechanisms. This responsibility will be set forth in the operation and maintenance manual. Pursuant to this agreement, CVFPB will defend and indemnify the Federal Government for all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the levees improved, except for damages due to the fault or negligence of the Federal Government or its contractors. SAFCA and RD 1000 will enter into a matching agreement with CVFPB through which these local agencies will agree to defend and indemnify the State and carry out CVFPB's commitments to the Federal Government. The operation and maintenance manual will also set forth the levee vegetation management respousibilities outlined in Section 8.1, above.

8.3 Access to the Waterside Slope of the SREL

Managing the vegetation on the waterside slope of the SREL and conducting other necessary maintenance monitoring and flood fighting responsibilities presents particular challenges because of the residential development that has been allowed on the waterside of the levee. To carry out these responsibilities, on a long-term basis, RD 1000 and CVFPB personnel must be able to inspect the waterside slope of the levee from Garden Highway. This will require that existing hedges and other vegetation that presently prevent roadside visibility of the slope be appropriately trimmed or otherwise relocated or removed.

RD 1000 and CVFPB personnel must be able to safely park patrol vehicles at periodic locations along the Garden Highway so as to perform foot patrols during both non-flood season and high water events. These inspectors must also be able to safely walk along the Garden Highway to perform inspections of the waterside levee slope and adjacent areas. Finally, RD 1000 and CVFPB personnel must be able to access affected properties during non-flood season inspections, as well as during high water events to monitor the levee for signs of distress.

RD 1000 and CVFPB will evaluate existing opportunities for safely parking vehicles. Where inadequate parking opportunities exist, they will work with the landowners to develop safe locations at a reasonable spacing.

CHAPTER 9 – NEPA DOCUMENTATION

The improvements proposed by the non-Federal sponsors for all the levee segments discussed above, including removal of landside levee vegetation and limited removal of waterside levee vegetation have been described and evaluated in a series of National Environmental Policy Act ("NEPA") documents issued in connection with the Common Features Project. These NEPA documents include:

- *Final Environmental Impact Statement for 408 Permission and 404 Permit to the Sacramento Area Flood Control Agency for the Natomas Levee Improvement Project, Sacramento, CA* (USACE 2008), which presents a programmatic overview of the NLIP and covers project construction along the NCC south levee and the upper 4.3 miles of the SREL in Sutter County;

- *Final Environmental Impact Statement on the Natomas Levee Improvement Program Phase 3 Landside Improvements Project* (USACE 2009), which covers project construction along 4.5 miles of the SREL mostly north of Interstate 5 and the Lower NEMDC west levee in Sacramento County and the PGCC west levee in Sutter County;

- *Final Environmental Impact Statement on the Natomas Levee Improvement Program Phase 4a Landside Improvements Project* (USACE 2010), which covers project construction along 6.0 miles of the SREL south of Interstate 5 in Sacramento County; and

- *Draft Environmental Impact Statement/Draft Environmental Impact Report on the Natomas Levee Improvement Program Phase 4b Landside Improvements Project* (USACE and SAFCA in prep.), which covers project construction along 3.2 miles of the SREL, 2.2 miles of the ARNL, and portions of the NEMDC west levee in Sacramento County.

As indicated by this list, USACE has pursued a tiered approach to evaluate the effects of the NLIP (also referred to herein as the Common Features Project). A programmatic overview of the project was provided in the 2008 document. Each successive document has incorporated by reference the information presented in the prior document(s). In accordance with the Draft Guidance, it is anticipated that the Natomas Basin-wide variance request will be referenced in the description of the Phase 4b Project and the impacts of the vegetation and encroachment removals described herein will be evaluated as part of the Phase 4b DEIS/DEIR, either through incorporation of prior analyses or through evaluation of impacts not previously addressed. To facilitate this interaction, the Phase 4b Administrative DEIS/DEIR will be circulated with this variance request.

CHAPTER 10 – REFERENCES

AECOM. 2009. Unpublished data regarding raptor nest locations. Sacramento, CA.

Bouey, P. D., and R. Herbert. 1990. *Intensive Cultural Resources Survey and National Register Evaluation: Sacramento Urban Area Flood Control Project*. Report on file, North Central Information Center, California State University, Sacramento, CA.

Breusers, H., Raudkivi, A. 1991. Scouring. International Association for Hydraulic Research Hydraulic Structures Design Manual: Hydraulic Design Considerations. A. A. Balkema, Rotterdam.

Dames & Moore. 1994. *Archaeological Inventory Report, Natomas Locality, Cultural Resources Inventory and Evaluation, American River Watershed Investigation, El Dorado, Placer, Sacramento, and Sutter Counties, California*. Report on file, North Central Information Center, California State University, Sacramento, CA.

Fischer. 2000. EMRRP *Technical Notes Collection* (TN EMRRP-SI-09). Issued by the U.S. Army Engineer Research and Development Center. Vicksburg, Mississippi.

Garcia, M. H. (ed). 2008. Sedimentation Engineering: Processes, Measurements, Modeling and Practice. ASCE Manuals and Reports on Engineering Practice 110. Reston VA. 1,132 p.

May, R., Ackers J., Kirby, A. 2002. Manual on scour at bridges and other hydraulic structures. Construction Industry Research and Information Association (CIRIA). London. 225 pp.

Melville, B. W., Coleman, S. 2000. Bridge scour. Water Resources Publications, Colorado.

Point Reyes Bird Observatory. 2000 (August). The Riparian Bird Conservation Plan: A Strategy for Reversing the Decline of Riparian Associated Birds in California. Stinson Beach, CA.

PRBO. *See* Point Reyes Bird Observatory.

SAFCA. *See* Sacramento Area Flood Control Agency.

Sacramento Area Flood Control Agency. 2009 (February 27). *Draft Life Cycle Management of Levee Vegetation.*

TAC. *See* Transport Association of Canada.

The Natomas Basin Conservancy. 2005–2009. GIS data regarding Swainson's hawks nest locations in the Natomas Basin. Sacramento, CA.

TNBC. *See* The Natomas Basin Conservancy.

Transport Association of Canada. 2004. Guide to Bridge Hydraulics: Second Edition. Thomas Telford, London. 181 p.

USACE. *See* U.S. Army Corps of Engineers.

USACE and SAFCA. *See* U.S. Army Corps of Engineers and Sacramento Area Flood Control Agency.

U.S. Army Corps of Engineers. 2008 (November). *Final Environmental Impact Statement for 408 Permission and 404 Permit to Sacramento Area Flood Control Agency for the Natomas Levee Improvement Project, Sacramento, CA*. Prepared by EDAW (now AECOM), Sacramento, CA.

———. 2009 (August). *Final Environmental Impact Statement on the Natomas Levee Improvement Program Phase 3 Landside Improvements Project*. Prepared by AECOM, Sacramento, CA.

———. 2010 (February). *Final Environmental Impact Statement on the Natomas Levee Improvement Program Phase 4a Landside Improvements Project*. Prepared by AECOM, Sacramento, CA.

U.S. Army Corps of Engineers and Sacramento Area Flood Control Agency. In prep. *Draft Environmental Impact Statement/Draft Environmental Impact Report on the Natomas Levee Improvement Program Phase 4b Landside Improvements Project*. Prepared by AECOM, Sacramento, CA.

APPENDIX A

JSA Report: Use of Floodplain Habitat of the Sacramento and American Rivers by Juvenile Chinook Salmon and Other Fish Species

Use of Floodplain Habitat of the Sacramento and American Rivers by Juvenile Chinook Salmon and Other Fish Species

Prepared for:

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June 1999

SUMMARY

During February and early March, high flows in the Sacramento and American Rivers caused the Natomas East Main Drainage Canal (NEMDC) to backup and overflow the site 18a pond and surrounding areas, allowing fish to freely use flooded habitat. The water surface level over the floodplain subsequently dropped, stranding fish in the site 18a pond and providing the opportunity to assess habitat use and conditions required to trigger movement of juvenile chinook salmon and other species out of the pond.

Twenty four fish species were captured during this study, 6 of which were native. Total abundance, however, was dominated by native species, primarily juvenile chinook salmon. Over 3,000 juvenile chinook salmon were captured, including the winter-run chinook salmon that is listed as endangered under the federal and California Endangered Species Acts. A total of 262 winter- and spring-run sized chinook salmon were captured and 124 had adipose clips indicating the presence of coded wire tags. Reading of the coded wire tags confirmed that most of the tagged salmon were winter run.

Return of juvenile chinook salmon to river habitats seems to be determined by size and readiness to migrate downstream that is likely associated with smoltification, the physiological change that occurs prior to movement to sea water. Growth in floodplain habitat is fast (i.e., exceeding 1 mm each day), relative to growth in river habitat, and migration of fish rearing in floodplain habitat likely precedes migration of fish rearing in the main river channel. Mortality in floodplain habitat, however, may be high, and is partially attributable to predation. Stomach contents of crappie indicated significant predation on juvenile chinook salmon. The six crappie examined contained 10 juvenile chinook salmon, from 0 to 3 individual salmon in each crappie.

Floodplain habitat use by juvenile chinook salmon and stranding in isolated ponds indicates potential benefits of restoration actions. Removal of material from the bench in the lower American River will increase the frequency and duration of floodplain inundation, subsequently increasing habitat availability. Floodplain restoration projects should be designed to drain completely, minimizing the occurrence of ponds and associated fish stranding following receding flood flows. Connecting existing ponds to the NEMDC or the American River will provide juveniles access to the rivers and potentially increase overall production of juvenile chinook salmon in floodplain habitat.

INTRODUCTION

In March 1999, juvenile chinook salmon were observed surface feeding in a 17 acre borrow pond at site 18a (i.e., site 18a pond). The pond is adjacent to the Natomas East Main Drainage Canal (NEMDC) and is approximately 2 miles upstream from the mutual confluence of the NEMDC, American River, and Sacramento River. The pond was designed to retain water to support tules and riparian vegetation planted as mitigation at the borrow site.

During February and early March, high flows in the Sacramento and American Rivers caused the NEMDC to backup and overflow the pond and surrounding areas, allowing fish to freely use flooded habitat. On about March 15, 1999, flow in the Sacramento and American Rivers had decreased sufficiently to cause the water surface level in the NEMDC to drop below the elevation of the site 18a pond. Fish that remained in the pond after the overflow period were stranded, including juvenile chinook salmon.

Stranding of fish in the site 18a pond and the presence of a 30-inch gated culvert that drains the pond to the NEMDC provided an opportunity to assess habitat use and conditions required to trigger movement of juvenile chinook salmon and other species out of the pond. This study produced the following data:

- species composition and relative abundance of fish using the restored floodplain habitat;
- observations on the response of juvenile fall-run chinook salmon and other species to pond draining, pond depth, and water temperature conditions; and
- relative abundance of predatory fish and potential predation.

The study led to preliminary development of operations and design criteria to increase benefits of floodplain restoration projects to fish species.

METHODS

Activities included sampling ponds on the floodplain after flood waters had receded and left the ponds without surface connections to the river system. A beach seine was used to sample fish in the site 18a pond and in an adjacent borrow pond. A hoop net was used to sample water discharged from the site 18a pond. Juvenile chinook salmon were marked to enable estimates of abundance. In addition, water surface elevation and water temperature data was collected.

Beach Seine

A 3/16 inch mesh bagged beach seine, measuring 75 feet long and 5 feet deep, was used to sample the site 18a pond and a nearby borrow pond adjacent to the NEMDC .

Borrow Pond

Juvenile chinook salmon were captured from a borrow pond adjacent to the NEMDC and near the northeast corner of the site 18a pond. The fork length of all fish captured in the seine was measured to the nearest millimeter and each fish was categorized to species. Predatory species (i.e., introduced sunfish and catfish) were sacrificed and their stomach contents examined and recorded. Fall-run chinook salmon (i.e., salmon less than 80 mm fork length) were held for

marking. All other chinook salmon and steelhead were immediately released to the NEMDC.

Juvenile fall-run chinook salmon were held in a trash can with approximately 20 gallons of water from the pond. Aeration of water in the trash cans was provided by air stones connected to an air tank and ice was added when needed to maintain the water temperature at or slightly below (i.e., within 5°F) the water temperature in the pond. About 0.75 grams of Bismarck brown was added for each 10 gallons of water (Sommer pers. comm.). The dye was thoroughly mixed in the water using dip net. For each batch of fish, between 500 and 1,000 fish were held for about 30 minutes. Fish were removed from the container using a dip net, transported in 5 gallon buckets, and released in the site 18a pond. The number and fork length of fish released was recorded. A sample of 8 marked fish and 8 unmarked fish were transferred to an enclosure submerged in the pond to allow observation of mark retention and handling mortality.

Site 18a Pond

Fish were captured by seine from several locations in the site 18a pond on April 11, 13, 17, 23, and 27. For maximum efficiency, the seine was fished in areas less than 4 feet deep and devoid of trees. The fork length of all fish captured in the seine was measured to the nearest millimeter and each fish was categorized to species. During sampling activities on April 11, fall-run chinook salmon were marked prior to immediate release. Approximately half the length of the left pelvic fin was clipped and all marked fish were immediately released back into the site 18a pond. During subsequent sampling, juvenile chinook salmon were examined for the pelvic fin clip and were either released back into the site 18a pond or into the NEMDC.

Hoop Net

A 3/16 inch mesh hoop net measuring about 5 feet in diameter at the large end, 1.5 feet in diameter at the small end, and 20 feet long was used to capture all fish exiting the pond through the gated culvert. The hoop net was fixed to the culvert apron in the NEMDC. All of the flow exiting the pond passed through the net and all fish larger than approximately 30 mm were effectively captured. When feasible, the net was fished continuously when the culvert gate was open. The hoop net was fitted with a fyke to increase capture efficiency and impede movement back into the pond.

The fork length of all fish captured in the hoop net was measured to the nearest millimeter and each fish was categorized to species. In most cases, all fish were immediately released to the NEMDC. Approximately 10 fish that were considered predatory species (i.e., introduced sunfish and catfish) were sacrificed and their stomach contents examined and recorded. All adipose and pelvic fin clips were noted for chinook salmon and steelhead. Juvenile chinook salmon with adipose fin clips are likely to have a coded wire tag imbedded in their head. The coded wire tag provides information on fish origin and release location. A sample of 20 adipose clipped chinook salmon was kept and sent to the U.S. Fish and Wildlife Service for removal and reading of the microscopic coded wires. All other juvenile chinook salmon were immediately released to the NEMDC. Adipose clipped steelhead are generally not tagged with coded wires and all were immediately released after measurement.

Water Surface Elevation and Water Temperature

Water surface elevation for the NEMDC was based on Sacramento River stage data recorded at I Street (California Department of Water Resources, Division of Flood Management, Operational Hydrologic Data, California Data Exchange Center: http://cdec.water.ca.gov). Water surface elevation in the pond was measured relative to the NEMDC surface elevation and recorded approximately hourly during all sampling activities.

Water temperature was recorded approximately hourly during all sampling activities. In addition, a recording thermometer (Onset Optic Stowaway Temp) was placed near the bottom of the deepest part of the site 18a pond on April 13 and remained in place through April 27.

Endangered Species Issues

Given the location of the site 18a pond in the floodplain, its proximity to the Sacramento River approximately 2 miles to the west, and flooding during February and March caused by high winter flows, species that occur in the Sacramento River and its tributaries may also occur in the pond. Species found in the Sacramento River and protected under the federal and California Endangered Species Acts (ESA) include winter-run chinook salmon, spring-run chinook salmon, steelhead, and splittail. Appropriate ESA take authorization for scientific research was obtained through contact with Mr. Dan Logan of the National Marine Fisheries Service, Ms Stephanie Brady of the U.S. Fish and Wildlife Service, and Ms Deborah McKee of the California Department of Fish and Game. Fortunately, National Marine Fisheries Service concurred that capture of winter-run could be covered under an existing California Department of Water Resources permit for an ongoing study on the Yolo Bypass. Mr. Logan confirmed that a special research take permit was not required for steelhead.

U.S. Fish and Wildlife Service verbally indicated that, given the short time frame for the study within the isolated ponds, a formal take permit would not be required as long as any splittail captured were immediately released to the NEMDC. Department of Fish and Game similarly indicated by verbal confirmation that the study could proceed as long as all spring-run sized chinook salmon were immediately released to the NEMDC.

RESULTS

On about March 15, 1999, flow in the Sacramento and American Rivers receded sufficiently to cause the water surface levels to drop below the elevation of the site 18a pond and subsequently sever connection with the NEMDC (Figure 1). The water surface level continued to drop and several days later on about March 18 the borrow pond was disconnected from the NEMDC. Field observations on March 25 confirmed the presence of chinook salmon in both the site 18a pond and the borrow pond. On March 29, with the onset of warm weather, surface water temperature in the ponds was approximately 65°F. Because water temperatures greater than 65°F

potentially stress juvenile chinook salmon (Armour 1991), the decision was made to initiate the study. In all, 24 fish species were captured during the study, 6 of which were native. Although the diversity of non-native species exceeded diversity of native species, abundance was dominated by native species, primarily juvenile chinook salmon.

Winter-run sized (i.e., greater than 80 mm to 100 mm in fork length, depending on date) chinook salmon and steelhead captured during seining and trapping were processed prior to all other species and immediately released to the NEMDC. Release to the NEMDC allowed downstream migration to the Sacramento River. Splittail were not captured during this study. Of the 262 winter-run sized chinook salmon captured, 124 had adipose clips. A sample of 20 adipose clips was kept and sent to the U.S. Fish and Wildlife Service in Stockton for processing. As a prior condition for moving ahead with this study, a copy of this report has been provided to the appropriate permitting agencies.

Beach Seine: Borrow Pond

The borrow pond was sampled on April 3, 1999. The species and number of fish captured by seine from the borrow pond are listed in Table 1. For chinook salmon, run is indicated by body size at this time of year. Fall-run chinook salmon averaged 67 mm fork length (SD = 5, n = 77) and winter- or spring-run chinook salmon averaged 93 mm fork length (SD = 4, n = 8). All steelhead were hatchery produced as indicated by clipped adipose fins and averaged 225 mm fork length (SD = 22, n = 8).

A total of 2,043 fall-run chinook salmon were marked with Bismarck brown. Approximately 40 juveniles died or appeared to be near death at the time of release. On April 7, the fish held to determine mark retention were examined. Of the original 16 fish, 12 were alive and none of the fish retained any indication of the dye. Fish released in the site 18a pond were, therefore, assumed to be indistinguishable from unmarked fish.

Stomach contents of crappie and largemouth bass were examined. The six crappie examined contained 10 juvenile chinook salmon, from 0 to 3 individual chinook salmon in each crappie. Of the 4 largemouth bass examined, 1 contained a juvenile chinook salmon and 1 contained a crayfish. The 2 redear sunfish examined did not contain any prey organisms.

Beach Seine: Site 18a Pond

The site 18a pond was sampled on April 11, 13, 17, 23, and 27. The species and number of fish captured by seine from the site 18a pond are listed in Table 2. The length of chinook salmon varied by date, but generally averaged around 87 mm (standard deviation ranging from 6 to 12 mm) for fall-run chinook salmon. Frequency of juveniles in each size class illustrates possible growth of about 15 mm for fall-run sized chinook salmon between April 3 and April 11 and about 5 mm between April 11 and April 17 (Figure 2). Growth is not apparent between April 17 and April 23. Chinook salmon were not captured on April 27.

Of the juvenile chinook salmon captured on April 11, 491 fall-run sized fish were clipped

(i.e., left pelvic fin). The clips were subsequently recaptured on April 13, 17, and 23. The ratio of pelvic fin clips to total fish averaged 6.46% (SD=0.04 for a total of 7 samples). The ratio of clips to total fish ranged from 0 to 11% over all samples. Based on the ratio of pelvic clips to unmarked fish, the estimated total abundance of fall-run sized chinook salmon on April 11 is 10,000 ± 5,000 (α=0.05).

Juvenile chinook salmon captured by beach seine were primarily fall-run sized. Four winter- and spring-run sized chinook salmon were captured on April 11, including 2 adipose clipped. Only fall-run sized chinook were captured on April 13, 17, and 23. Efficiency of the seine on April 17 and 23 was high because the pond was shallow (i.e., < 2 feet deep) and the net reached across entire sections. Given the high net efficiency, it appears unlikely that any winter- and spring-run sized chinook remained in the site 18a pond after the culvert gate was open on April 15, allowing fish to freely move out of the pond and into the NEMDC.

Hoop Net

The culvert gate draining the site 18a pond to the NEMDC was opened on April 7 at about 8:00 a.m. and closed on April 8 at about 10:00 p.m. The flow through the net was approximately 20 cubic feet per second (cfs) for the entire 38 hour period. Although higher flow rates could have been released, the lower flow avoided abrasion and other injury to captured fish.

Table 3 lists the species and number of fish captured in the hoop net for April 7 and 8 and April 12. Between 8:00 a.m. and 8:00 p.m. on April 8, yellow bullhead and crappie were the primary species moving out of the pond. Examination of stomach contents for a white crappie and 4 black bullheads indicated that the crappie had eaten 2 fall-run sized juvenile chinook salmon and the bullheads were eating insect larvae.

During the first 12 hours of pond drainage, chinook salmon were not captured. With the onset of darkness, 5 winter-run sized chinook salmon (i.e., 120 to 135 mm fork length) moved out of the pond and were captured in the hoop net along with 7 adult suckers. Through the night, the catch consisted of winter- and spring-run sized chinook salmon, suckers, and steelhead, all native species. Two mitten crabs were also captured.

At dawn, another group of white crappie (ranging from 150 to 240 mm fork length) and black bullheads moved into the net. Between 8:00 a.m. and 10:00 a.m., no additional fish were captured. At 11:15 a.m., 20 winter- and spring-run sized chinook salmon and one steelhead were captured. Winter- and spring-run sized chinook salmon were greater than 100 mm fork length. The juvenile chinook salmon continued to exit the pond and enter the net throughout the day. During the study, the peak capture rate for juvenile chinook salmon occurred at about 3:00 p.m. on April 8 when over 100 winter- and spring-run sized chinook salmon entered the net during one hour. The rate of capture declined to less than 3 winter-run sized chinook salmon per hour after 5:00 p.m. With the onset of darkness, 27 winter- and spring-run sized chinook salmon moved into the net, similar to a pulse of fish that occurred on the preceding night. Through the evening, chinook salmon, steelhead , and suckers continued to move into the net. A riffle sculpin was also captured during this period, another native species. The culvert gate was closed at

10:00 p.m. and the hoop net was removed.

At 7:00 p.m. on April 12, fall-run sized juvenile chinook salmon (i.e., less than 100 mm fork length) were observed feeding in the site 18a pond and in the NEMDC. The hoop net was installed at 7:50 p.m. and the culvert gate was opened. Flow through the net was approximately 20 cfs. Initial catch consisted of black bullhead, crappie, and goldfish. At the onset of darkness, 10 winter- and spring-run sized chinook salmon and 4 steelhead were captured. Winter- and spring-run sized chinook salmon and steelhead continued to enter the hoop net until the culvert gate was closed at about 10:00 p.m. After removal from the culvert outlet, 2 mitten crabs were found in the hoop net.

Even though beach seine samples indicated that the majority of fish inhabiting the site 18a pond were fall-run sized fish (i.e., <100 mm fork length), only 4 fall-run sized chinook salmon moved into the hoop net (Figure 3). Winter- and spring-run sized chinook salmon, greater than 110 mm fork length, dominated the hoop net catch.

Of the winter- and spring-run sized fish captured, 124 out of 262 were adipose clipped, indicating the presence of coded wire tags in each fish at the time of release. Twenty of the adipose clipped juvenile chinook salmon were kept and subsequently sent to the U.S. Fish and Wildlife Service. The remaining fish were released unharmed to the NEMDC. The U.S. Fish and Wildlife Service found that seventeen out of the twenty adipose clipped chinook salmon had coded wire tags (Sauls pers. comm.). The numbers on the coded wire tags enabled the origin of each fish to be determined (Table 4). Sixteen of the fish were winter-run chinook salmon produced at Livingston Stone National Fish Hatchery and were released near Redding on January 28, 1999 (Niemela pers. comm.). The other coded wire tagged fish was a fall-run chinook salmon from the Feather River Fish Hatchery that was released on the Sacramento River near the Elkhorn Boat Ramp on February 11, 1999 (Sommer pers. comm.).

Water Surface Elevation and Water Temperature

Water Surface Elevation

As flows in the Sacramento and American Rivers declined in mid-March, water surface elevation in the NEMDC dropped and lost connection with the site 18a pond. Maximum pond depth was about 11 feet on March 15 (Figure 1). Evaporation, seepage, and leakage through the gated culvert caused about a 2 foot drop in pond surface elevation between March 15 and April 7.

On April 7, the gated culvert was opened and approximately 60 acre feet of water drained from the site 18a pond in 38 hours. Before the gated culvert was closed on April 8, the surface elevation of the pond dropped over 4 feet and reduced the maximum pond depth to about 5 feet (Figure 1). On April 12, the gated culvert was opened for about 3 hours and surface elevation dropped another 4 inches.

The gated culvert was opened for the last time on April 15, allowing the site 18A pond

elevation to drop about 2.5 feet, reaching equilibrium with the water surface elevation in the NEMDC at about 10 feet above sea level (Figure 1). The surface elevation in the site 18A pond fluctuated with the elevation in the NEMDC over the following 9 days. On April 25, the surface elevation of the NEMDC had dropped to about 8 feet above sea level, equal to the elevation of the bottom of the gated culvert, and the connection between the site 18a pond and the NEMDC was cut off. Up to 1 foot of water remained at several locations in the site 18a pond, totaling approximately one quarter acre in surface area.

Water Temperature

Between March 29 and April 27, surface water temperature in the site 18a pond ranged from about 55°F to near 78°F (Figure 4). Surface temperature responds to daily weather conditions and was often substantially greater than water temperature near the bottom of the pond. On April 13 and 15, surface water temperature exceeded bottom water temperature by about 10°F (Figure 4). As pond depth was reduced, daily temperature fluctuation increased and surface temperature approached bottom temperature. Although the recording thermometer was not in place for the entire study period, bottom water temperature probably remained below 65°F until after April 15. With maximum depth of the site 18a pond reduced to 3 feet or less, bottom water temperature exceeded 75°F several times after April 15.

DISCUSSION

Floodplain habitat, seasonally available during high river flow, has substantial benefits to fish species in the Sacramento River system. High food abundance, a range of water temperature conditions, and improved water clarity may, depending on fish species, enable high growth rates and provide conditions needed for spawning and rearing. Inundation of floodplains also increases input of nutrients to the aquatic ecosystem, potentially increasing overall system productivity with benefits to many species.

Floodplain habitat may also present considerable risk to the survival of individual fish. Temporary and year-round ponds, primarily created by human activities (i.e., gravel mining, levee borrow areas), potentially strand fish as river flow recedes. Fish stranded in temporary ponds die when the ponds dry out. Many species, primarily non-native, thrive in year-round ponds, but other species cannot survive through the summer. Warm water temperature, disease, and predation cause high mortality of juvenile chinook salmon, steelhead, splittail, and other species stranded in perennial ponds as spring progresses toward summer (Shaul pers. comm.). The current study provides preliminary indications of why juvenile chinook remain in floodplain habitat and are sometimes stranded in isolated ponds.

Habitat Use

In the Sacramento River system, native species are adept at using seasonally inundated habitats, especially during the winter and early spring months. Although non-native fish

communities dominate the lower Sacramento and American rivers and the Sacramento-San Joaquin Delta during most of the year (Moyle 1976), juvenile chinook salmon are seasonally abundant. Juvenile chinook salmon hare been the primary species observed in the flooded Yolo and Sutter Bypasses and on the floodplain of the lower Feather River during the winter and early spring (California Department of Water Resources 1999, Jones & Stokes Associates 1993, Shaul pers. comm.).

In February and March 1999, high flows backed water up the NEMDC and inundated portions of the floodplain. Consistent with observations in other areas, juvenile chinook salmon were the numerically dominant species in the floodplain habitat (Table 1 and 2). The presence of tagged winter-run chinook salmon illustrates the importance of floodplain habitat along the American River to fish originating from the entire Sacramento River system, not only chinook salmon in the American River. Juvenile winter-run chinook salmon moved out of the Sacramento River and up the NEMDC, onto floodplain habitat, and eventually remained in the site 18a pond. Upstream movement by juvenile chinook salmon has previously been documented for small intermittent streams (Maslin, Mckinney, and Moore 1995), and in both cases movement may be a response to warmer water temperature and increased food availability.

The duration of habitat use by juvenile chinook salmon is dependent on habitat availability and species needs. Habitat availability is a function of floodplain elevation and location; magnitude, timing, and duration of flood flows; and other physical, chemical, and biological conditions, including water temperature, water clarity, prey availability, and predator interactions. Species needs relate to growth, reproduction, survival, and migration. In 1999, floodplain habitat on the lower American River and adjacent to the NEMDC was inundated on February 9 and remained accessible to juvenile chinook salmon and other species through March 15. Although the date that chinook salmon moved into the floodplain habitat adjacent to the NEMDC is unknown, coded wire tagged juvenile salmon captured from the site 18a pond were released near Redding on January 28 and at Elkhorn boat ramp on the lower Sacramento River on February 11. The juvenile salmon potentially used floodplain habitat during most of the inundation period and, as indicated by their presence in the site 18a pond, would have continued to rear in floodplain habitat if inundation had extended beyond March 15.

Fish Stranding

As flow declined during March, the rivers and the NEMDC were again confined to their channels. Ponds on the lower American River flood plain were disconnected from the main rivers and many fish were stranded in the ponds. The beach seine samples from the borrow pond during early April illustrate the high abundance of juvenile chinook salmon relative to the abundance of other species (Table 1).

Magnitude of Loss

Although many species occur in floodplain ponds, high numbers of juvenile chinook salmon are stranded. Adipose clipped juveniles provide a rough basis for estimating initial abundance of fall-run chinook salmon in the site 18a pond. On April 3, approximately 2,050

juvenile chinook salmon were captured in the small borrow pond adjacent to the site 18a pond. Five of the 2,050 fish were adipose clipped, giving a ratio of 0.0025 for clipped to unclipped fish. For the 17 acre site 18a pond, 117 adipose clipped juvenile chinook salmon were captured in the hoop net. Initial abundance of juvenile fall-run sized chinook salmon in the site 18a pond, therefore, may have exceeded 50,000 fish (i.e., 117 ÷ 0.0025). [Note: This estimate assumes an equal ratio of clipped to unclipped fish in both ponds and should be considered as illustrative because of the very small ratio of marked to unmarked fish (i.e., 0.0025) and the availability of only a single sample.]

Although the loss of 50,000 juvenile chinook salmon may be small relative to total production of juveniles in the system, given other factors, the loss warrants consideration. There are thousands of acres of ponds that are isolated throughout the Sacramento River system following flood events, including several hundred acres of ponds on the lower American River floodplain. If similar numbers of fish are lost per acre, loss in all ponds may have exceeded millions of juvenile salmon. Also, given that over 100 smolt-sized winter-run chinook salmon were captured this year, expanded losses of coded wire tagged winter run potentially totaled several thousand, a large number considering that only about 150,000 tagged juvenile winter-run were initially released at Redding.

Factors Affecting Stranding

For juvenile chinook salmon, the magnitude of stranding is determined by floodplain structure and habitat use. As flood flows recede, juvenile chinook salmon and other fish species will move from drained areas. Stranding may occur when fish move into ponded areas that loose connection from the river system. If the timing, frequency, and duration of floodplain availability encompasses the necessary period of use, juvenile chinook salmon will return to the river prior to loss of connection. Return of juvenile chinook salmon to river habitats seems to be determined by size and readiness to migrate downstream that is likely associated with smoltification, the physiological change that occurs prior to movement to sea water.

Size related movement is supported by data collected throughout the study. On April 7, the opportunity for movement out of the site 18a pond and into the NEMDC was provided through the open gated culvert. Capture of juvenile winter- and spring-run sized chinook salmon in the hoop net, and their physical appearance, indicated their readiness to migrate downstream. The length of juvenile chinook salmon was consistent with California Department of Fish and Game observations that the average size of winter-run chinook salmon at saltwater entry is about 118mm (Niemela pers. comm.). Juvenile chinook salmon that moved through the gated culvert draining the site 18a pond on April 7 averaged 122 mm in fork length and had apparently undergone smoltification, as indicated by the absence of parr marks, deciduous scales, and a silvery appearance.

Juvenile chinook salmon that remained in the site 18a pond during beach seine sampling on April 11 through April 23 averaged about 87 mm fork length and displayed parr marks, characteristic of the freshwater residence life stage. The juvenile chinook salmon were observed actively feeding at the surface of the site 18a pond throughout the study, especially during the

evenings. Fall-run sized juveniles appeared to avoid moving through the gated culvert because they had apparently not grown to a size ready to move to salt water. Warm water temperature also did not cause substantial movement of juvenile chinook salmon from the pond. After the gated culvert was opened to the NEMDC on April 15, bottom water temperature in the pond exceeded 70°F, but substantial numbers of juvenile chinook salmon remained in the pond up through April 23.

On April 27, it appears that juvenile chinook salmon and other fish left the pond prior to complete isolation from the NEMDC. This conclusion, however, is based on the absence of fish in the residual water remaining in the pond and movement out of the pond was not directly observed. Chinook salmon and other species were abundant in the site 18a pond on April 23 (Table 3), but few fish and no chinook salmon were present in the pond on April 27. It is possible that the depth of the water, primarily less than 1 foot, stimulated final movement through the culvert.

Nightfall is another factor affecting movement. During drainage of the site 18a pond through the hoop net, juvenile chinook salmon did not initially move through the gated culvert until night. A pulse of juvenile movement at nightfall was apparent for all hoop net sampling of the pond drainage. During the second day of pond drainage, however, the highest pulse of juvenile salmon movement occurred at about 3:00 p.m. Movement at this time of day may have been associated with reduced pond depth and increasing water temperature, but the actual cause of movement is unknown.

Fish Growth

Growth of juvenile chinook salmon in floodplain habitat of the Yolo Bypass has been shown to be substantially greater than growth of salmon remaining in the Sacramento River (California Department of Water Resources 1999). Growth of juvenile chinook salmon during this study provides additional confirmation of the potential benefits provided by rearing in floodplain habitat. Growth for fall-run sized chinook salmon is illustrated in Figure 2, where the increase in length appeared to exceed 1 mm each day from April 3 to April 11.

Growth for juvenile winter-run chinook salmon is also indicated. The average size of coded wire tagged winter run released in the Sacramento River near Redding was approximately 80 mm in fork length on January 28, 1999 (Niemela pers. comm.). Two months later during the sampling on April 3, the average size of the 8 winter- and spring-run sized fish captured was 93 mm and the maximum size was 103 mm. On April 7 and 8, the average size of juvenile winter-run exiting the pond was about 122 mm. Although the increase in juvenile size may reflect substantial growth, the size of fish captured is potentially biased because only small fish from the original release may have moved into floodplain habitat, fish captured in the small borrow pond may have been stunted because of the high fish density, predation may have eliminated smaller juveniles during pond residence, and only larger juveniles left the site 18a pond and were captured in the hoop net.

Juvenile steelhead also appeared to grow over the April sampling period, illustrating the

potential value of floodplain habitat to juvenile steelhead. The number of fish captured, however, was small and did not permit any definitive conclusions. Also, the presence of only hatchery fish is puzzling, potentially indicating a relationship to release location or hatchery fish behavior.

Predation

Based on an initial rough estimate of 50,000 chinook salmon and an abundance of about 10,000 juvenile chinook salmon estimated in the pond about 2 weeks later (± 5,000, α=0.05), mortality may have approached 80%. Although the mortality estimate is based on minimal statistics, mortality in the pond was potentially high and is partially attributable to predation by fish, birds, and otters. Black and white crappie, as indicated by stomach contents, were the primary predatory fish species. Large mouth bass and other sunfish species may also prey on juvenile chinook salmon, although the stomach contents examined did not reflect substantial predation. Juvenile steelhead may also prey on juvenile chinook salmon, but all steelhead were released immediately to the NEMDC and stomach contents were not examined. Fish-eating bird species observed in the site 18a pond included great egrets, snowy egrets, great blue herons, pied-billed grebes, western grebe, and double-crested cormorants. Herons and egrets were observed to capture juvenile chinook salmon. Otters were sighted in the NEMDC but were not observed feeding in the site 18a pond.

Several factors may affect predation on the floodplain. Perennial pond habitat that supports substantial populations of crappie and other predatory fish species may lead to high predation on juvenile chinook salmon, especially as juveniles are concentrated in ponds as flood flow recedes. In addition, the relatively low amount of vegetative cover in the site 18a pond may have increased vulnerability of juvenile chinook salmon to predation by birds.

Recommendations for Floodplain Restoration

Available information on floodplain habitat use by juvenile chinook salmon and stranding in isolated ponds, including information developed by this study, indicates the potential benefits of the following floodplain restoration actions:

1. Remove material from the perched floodplain along the lower American River to increase frequency and duration of floodplain inundation, subsequently increasing habitat availability for juvenile chinook salmon.

2. Design floodplain restoration projects to drain completely and minimize ponding following receding flows.

3. Connect existing ponds to the NEMDC or the American River.

4. Provide vegetative cover in inundated areas consistent with riparian and marsh restoration objectives.

Increasing floodplain habitat availability could have substantial benefits to juvenile chinook salmon. Existing floodplain habitat in the Sacramento River system is limited relative to historic availability primarily because levees have reduced the active floodplain to less than 5% of its pre-1850 extent (CALFED Bay-Delta Program 1998). Along the Sacramento River and the lower American River, the active floodplain is even more constricted. In addition to levees, hydraulic mining debris introduced into the channels of the American and Sacramento Rivers during the mid- to late-1800s has resulted in the remaining floodplain perched several meters above the existing river channel (U.S. Army Corps of Engineers and State of California Reclamation Board 1998). The combination of levees and perched floodplain has reduced inundation frequency and duration and, therefore, seasonal availability of floodplain habitat to juvenile chinook salmon. Removing material from the bench in the lower American River would increase the frequency and duration of floodplain inundation.

As discussed above, stranding is potentially significant source of mortality following flood events. Floodplain restoration projects must be designed to drain completely and minimize ponding following receding flows. This study showed that the gated culvert on the site 18a pond, in combination with pond structure, allowed egress of stranded fish to the NEMDC. If the gated culvert had not been installed, juvenile chinook salmon, steelhead, and other fish species stranded in the isolated pond would have died during the ensuing warmer months. Although the residual ponds remaining after the site 18a pond drainage did not contain substantial numbers of stranded fish, additional contouring to allow complete drainage would avoid stranding that might occur during cooler weather or when connection with the NEMDC is rapidly severed.

The site 18a pond represents 17 acres out of several hundred acres of ponds on the American River floodplain. The magnitude of stranding for juvenile chinook salmon, including winter-run chinook salmon, indicates potential benefits of improved connections that allow fish to exit existing ponds and complete downstream migration. In ephemeral ponds, stranding losses could be reduced by recontouring the ponds so that they drain completely to the NEMDC or the American River. For perennial ponds, habitat values for wood ducks, pond turtles, otters, and other species need to be considered. Connections to the NEMDC may be appropriate, either through permanent sloughs or through gated culverts that may be operated consistent with multiple species needs. Management of perennial ponds should also consider factors that could reduce predation by non-native fish species, especially crappie, largemouth bass, and other predators on juvenile chinook salmon.

Riparian and marsh vegetation may provide cover that could benefit rearing chinook salmon. Riparian vegetation provides velocity refuge during high flow events. As flows recede, vegetative cover provides shade that may minimize water temperature fluctuation and maintain conditions that improve growth and survival. Vegetative cover may also increase food availability and provide refuge from predators, especially from birds.

Additional Information Needs

Future studies are needed to provide information for improved floodplain management

for fish species, including design and prioritization of restoration actions. Improved connectivity of the floodplain would increase use and reduce stranding losses. Recording the timing, frequency, and duration of floodplain inundation and the location, elevation, and size of existing ephemeral and perennial ponds would improve understanding of the potential use and extent of stranding. Restoration actions could then be prioritized based on cost of improving connectivity, species affected, and frequency of potential stranding.

Although benefits of riparian and marsh restoration are recognized for many species, the benefits of vegetative cover to fish species in floodplain habitats is relatively undocumented. Comparison of juvenile chinook salmon survival and growth in ponded areas with and without vegetative cover, along with measurement of water temperature and other water quality parameters, would provide additional support and direction for riparian and marsh restoration actions.

Substantial numbers of juvenile chinook salmon are known to use floodplain habitat and become stranded in floodplain ponds, but potential effects on population abundance have not been determined. Population effects are difficult to determine because annual abundance varies by orders of magnitude and the importance of floodplain habitat is largely dependent on weather. Relatively simple and inexpensive tagging studies could provide information on the magnitude of habitat use and stranding in any given year. Studies to determine population effects, however, would be costly and require a long-term commitment.

Studies are needed to better understand the types of connections that will allow movement from ponded areas. Unanswered questions include:

- Must ponded areas drain completely or is there a minimum depth that will result in fish movement?
- Are there advantages of open channels over culverts?
- What is the minimum size of a connection required for fish movement?
- Is a static connection sufficient, or is tidal or net flow needed to stimulate movement of fish?
- What effect does water quality, such as water temperature, water clarity, and dissolved oxygen, have on fish movement?

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A relatively simple study quickly became complex because of endangered species issues and unexpected capture of adipose clipped chinook salmon. The help and cooperation of Mr. Dan Logan of the National Marine Fisheries Service, Ms Stephanie Brady of the U.S. Fish and

Wildlife Service, Ms Deborah McKee of the California Department of Fish and Game, and Ted Sommer of California Department of Water Resources enabled quick resolution of endangered species issues and subsequent implementation of the study within a very short window of opportunity. Erin Sauls (U.S. Fish and Wildlife Service), Kevin Niemela (U.S. Fish and Wildlife Service), and Jerry Big Eagle (Big Eagle and Associates) took time out of their busy schedules to furnish information on coded wire tags.

Funding for the study was generously provided by Sacramento Area Flood Control Agency. Mr. Tim Washburn recognized the potential importance of the study relative to ongoing restoration activities in the American River floodplain and expedited funding. Mr. John Basset facilitated repair of the gate valve and provided the tools needed for draining the site 18a pond.

Many individuals donated time to complete this study. Particular thanks is due to Tom Cannon and Mike Bryan for critical comments on study design. Tom Cannon also participated in and video recorded sampling activities.

REFERENCES

Armour, C.L. 1991. Guidance for evaluating and recommending temperature regimes to protect fish. Instream Flow Information Paper 28. (Biological Report 90 [22]). U.S. Fish and Wildlife Service, Washington, D.C.

CALFED Bay-Delta Program. 1998. Strategic plan for the Ecosystem Restoration Program. Strategic Plan Core Team. Sacramento, CA.

California Department of Water Resources. 1999. Results and recommendations from 1997-1998 Yolo Bypass Studies. Draft. Sacramento, CA.

Jones & Stokes Associates. 1993. Sutter Bypass technical memorandum II: potential entrapment of juvenile chinook salmon in the proposed gravel mining pond. (JSA 91-272). Sacramento, CA. Prepared for Teichert Aggregates, Sacramento, CA.

Maslin, P.E., W.R. McKinney, and T.L. Moore. 1995. Intermittent streams as rearing habitat for Sacramento River chinook salmon. Draft.

Moyle, P. 1976. Inland fishes of California. University of California Press, Berkeley, CA.

U.S. Army Corps of Engineers and State of California Reclamation Board. 1998. Streambank protection for the lower American River. Final Environmental Impact Report and Supplemental Environmental Impact Statement V for the Sacramento River Bank Protection Project. Prepared by Jones & Stokes Associates, Sacramento, CA.

Personal Communications

Niemela, Kevin. Fish Biologist. Northern Central Valley Fish and Wildlife Office, U.S. Fish and Wildlife Service, Redding, CA. E-Mail and telephone communication about coded wire tagged winter-run chinook salmon released in the Sacramento River. E-Mail: kevin_niemela@r1.fws.gov. Phone: 530 527 3043.

Sauls, Erin. Fish Biologist. U.S. Fish and Wildlife Service, Stockton, CA. E-Mail and telephone communication about coded wire tagged chinook salmon. E-Mail: esauls@delta.dfg.ca.gov. Phone: 209 946 6400

Shaul, Warren. Fish Biologist. Jones & Stokes Associates, Sacramento, CA. Personal records of fish sampling in the Sacramento and Sutter Bypasses and on the Feather River floodplain. E-Mail: warrens@jsanet.com. Phone: 916 737 3000.

Sommer, Ted. Fish Biologist. California Department of Water Resources, Sacramento, CA. E-Mail communication and phone conversations about use of Bismarck brown and inclusion on scientific research take permit for winter-run chinook salmon: March 25, April 2, and April 7, 1999. E-Mail: tsommer@water.ca.gov. Phone: 916 227 7537.

Table 1. Species and Number of Fish Captured in the Borrow Pond by Beach Seine on April 3, 1999

Species	**Number**	**Comment**
chinook salmon[1] *Oncorhynchus tshawytschya*	2,051	includes juveniles of all runs
steelhead[1] *Oncorhynchus mykiss*	9	all adipose clipped hatchery fish
golden shiner *Notemigonus crysoleucas*	80	adult, spawning condition
Sacramento pikeminnow[1] *Ptychocheilus grandis*	35	juveniles, most less than 100 mm
Sacramento blackfish[1] *Orthodon microlepidotus*	2	juveniles, about 100 mm in length
Sacramento sucker[1] *Catostomus occidentalis*	2	juveniles <60 mm
threadfin shad *Dorosoma petenense*	32	adult
inland silverside *Menidia beryllina*	28	adult
bluegill *Lepomis macrochirus*	30	adults and juveniles
black crappie *Pomoxis nigromaculatus*	10	adults (170 - 200 mm)
white crappie *Pomoxis annularis*	1	adult
largemouth bass *Micropterus salmoides*	7	adult (300 - 420 mm) and juveniles
redear sunfish *Lepomis microlophus*	2	adult

[1]Native species

Table 2. Species and Number of Fish Captured in the Site 18a Pond by Beach Seine

Species	Number by Sampling Date April 1999					Comment
	11	13	17	23	27	
chinook salmon[1] *Oncorhynchus tshawytschya*	495	49	310			includes juveniles of all runs
steelhead[1] *Oncorhynchus mykiss*	1					adipose clipped hatchery fish
golden shiner *Notemigonus crysoleucas*	18	5	4	12		adults
fathead minnow *Pimephales promelas*	1					adult
goldfish *Carassius auratus*		2			1	adult
carp *Cyprinus carpio*			1			juvenile
red shiner *Notropis lutrensis*		1		1	1	
Sacramento pikeminnow[1] *Ptychocheilus grandis*	9	5	7	2		juveniles (<100 mm)
Sacramento sucker[1] *Catostomus occidentalis*	1	1				juveniles (<100 mm)
threadfin shad *Dorosoma petenense*	11	80	76	120	4	adult
inland silverside *Menidia beryllina*	1	1	16		6	adult
bluegill *Lepomis macrochirus*			4			adults and juveniles
pumpkinseed *Lepomis gibbosus*			1			
black crappie *Pomoxis nigromaculatus*			1			adult
white crappie *Pomoxis annularis*		2	1	1		adult
redear sunfish						

Species	Number by Sampling Date April 1999					Comment
	11	13	17	23	27	
Lepomis microlophus			2	25		adults and juveniles
logperch *Percina macrolepida*			5	2		adult
black bullhead *Ictalurus melas*			6	32		adult and juvenile
brown bullhead *Ictalurus nebulosus*			1			adult
white catfish *Ictalurus catus*				1		adult
mosquitofish *Gambusia affinis*					1	adult

[1]Native species

Table 3. Species and Number of Fish Captured in a Hoop Net on a Gated Culvert between the NEMDC and the Site 18a Pond

Species	Number by Sample Date - April 1999		Comment
	7-8	12	
chinook salmon[1] *Oncorhynchus tshawytschya*	237	17	winter-run sized juveniles except for 4 fall-run sized
steelhead[1] *Oncorhynchus mykiss*	11	9	adipose clipped hatchery fish
golden shiner *Notemigonus crysoleucas*	5		adults
fathead minnow *Pimephales promelas*	2		adult
goldfish *Carassius auratus*	1	4	juveniles
carp *Cyprinus carpio*		1	juvenile
Sacramento pikeminnow[1] *Ptychocheilus grandis*	1		juveniles (<100 mm)
Sacramento sucker[1] *Catostomus occidentalis*	19		juveniles (<100 mm)
bluegill *Lepomis macrochirus*	4		adults and juveniles
black crappie *Pomoxis nigromaculatus*	4		adult
white crappie *Pomoxis annularis*	16	11	adult
redear sunfish *Lepomis microlophus*	3		adults and juveniles
black bullhead *Ictalurus melas*	98	9	adult and juvenile
riffle sculpin[1] *Cottus gulosus*	1		

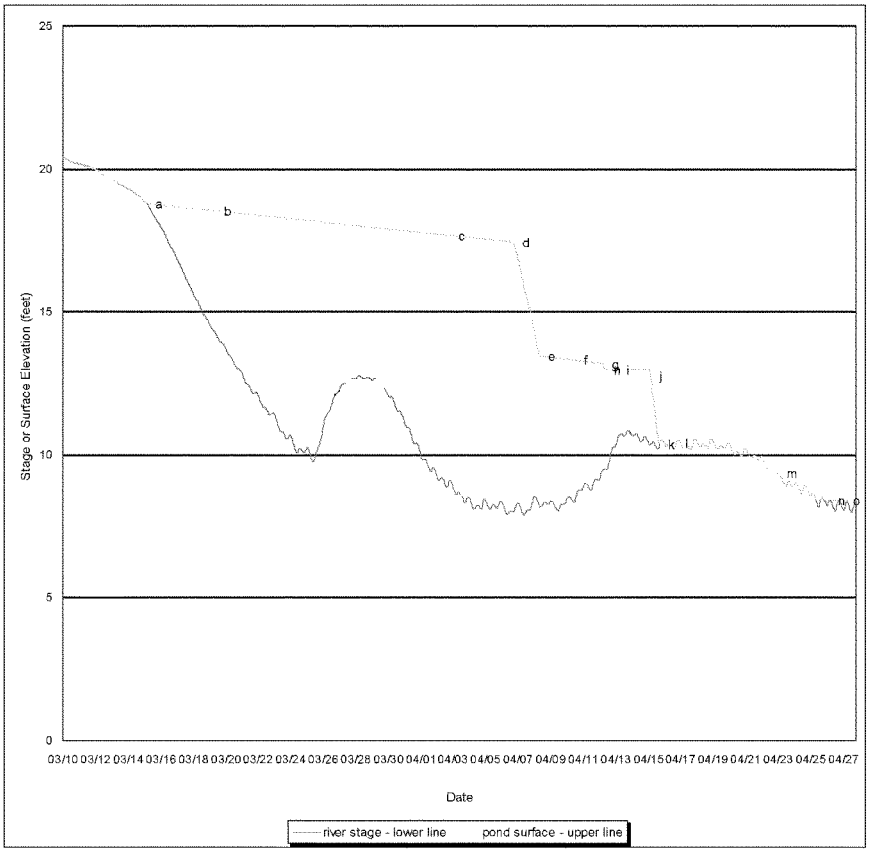
[1]Native species

Table 4. Coded Wire Tagged Chinook Salmon Recovered At Site 18A Pond, April 1999

Number	Date	Fork Length	Tag Code	Run
1	04/07	126 mm	05-01-02-08-11	winter
2	04/07	122 mm	No Tag	
3	04/07	114 mm	05-01-02-09-02	winter
4	04/07	128 mm	05-01-02-08-11	winter
5	04/07	105 mm	No Tag	
6	04/07	130 mm	05-01-02-08-15	winter
7	04/08	118 mm	No Tag	
8	04/08	109 mm	05-01-02-09-08	winter
9	04/08	120 mm	05-01-02-09-08	winter
10	04/08	121 mm	05-01-02-09-03	winter
11	04/08	121 mm	05-01-02-09-06	winter
12	04/08	125 mm	05-01-02-09-09	winter
13	04/08	119 mm	05-01-02-09-02	winter
14	04/08	128 mm	05-01-02-09-07	winter
15	04/08	124 mm	05-01-02-09-08	winter
16	04/08	118 mm	05-01-02-09-12	winter
17	04/08	113 mm	05-01-02-08-12	winter
18	04/08	135 mm	05-01-02-09-06	winter
19	04/08	130 mm	05-01-02-09-08	winter
20	04/08	125 mm	06-01-06-07-08	fall

Note: All of these fish (except 06-01-06-07-08) were from Coleman NFH. They were all released at Caldwell Park on the Sacramento River near Redding on January 28, 1999. Mean fork lengths for each group ranged from 70 mm to 84 mm. Tag 06-01-06-07-08 is from the Feather River Hatchery and was released on the Sacramento River at Elkhorn boat ramp on February 11, 1999. (Sauls, Sommer, and Niemela pers.comm.).

Figure 1. Sacramento River Stage at I Street and Approximate Site 18a Pond Surface Elevation during March and April 1999



Key Dates:
a - site 18a pond disconnects from NEMDC
b - small borrow pond disconnects from NEMDC
c - sample and mark fish from small borrow pond
d - begin first drainage of site 18a pond through hoop net
e - end first drainage of site 18a pond through hoop net
f - seine and fin clip fish in site 18a pond
g - begin second drainage of site 18a pond through hoop net
h - end second drainage of site 18a pond through hoop net
i - seine site 18a pond
j - open gated culvert
k - site 18a pond reaches equilibrium with NEMDC
l - seine site 18a pond
m - seine site 18a pond
n - site 18a pond drainage is complete
o - seine residual ponds within site 18a pond

Figure 2. Fork Length of Juvenile Chinook Salmon Captured by Beach Seine during April 1999

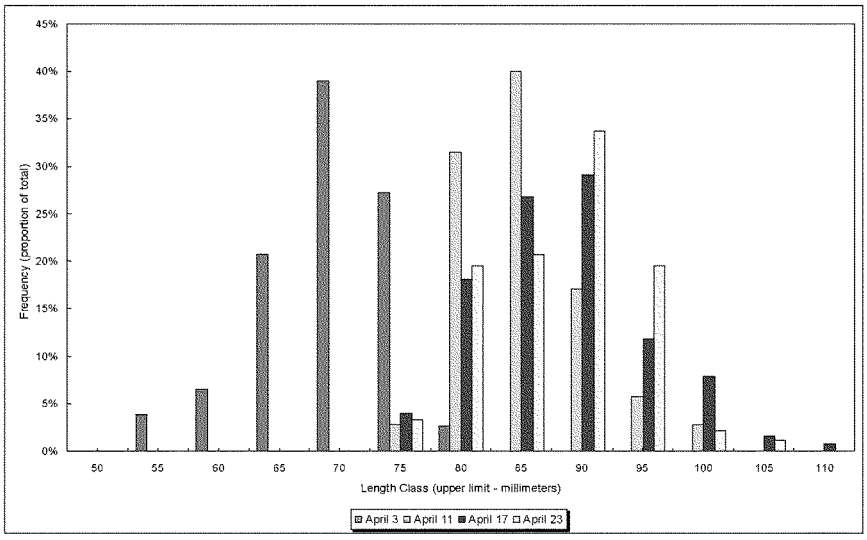


Figure 3. Comparison of Fork Length of Juvenile Chinook Salmon for Beach Seine and Hoop Net Catches from the Site 18a Pond during April 1999

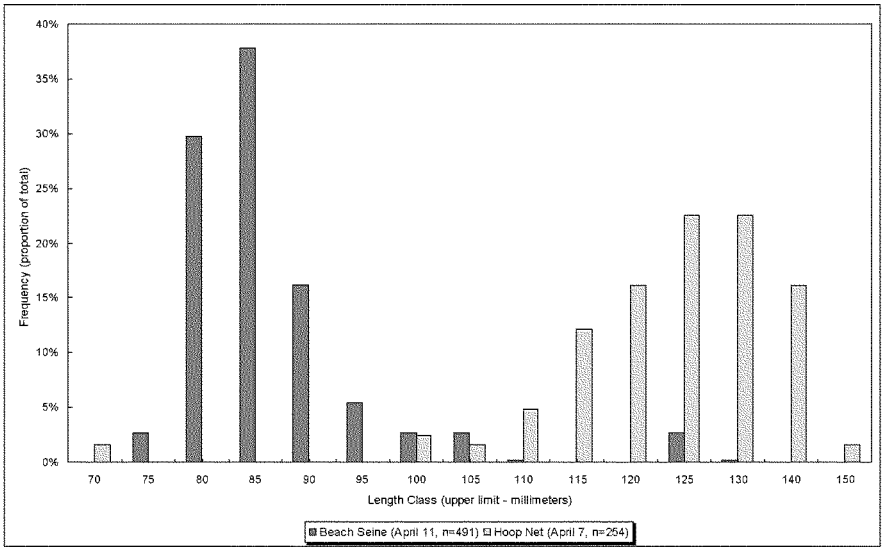
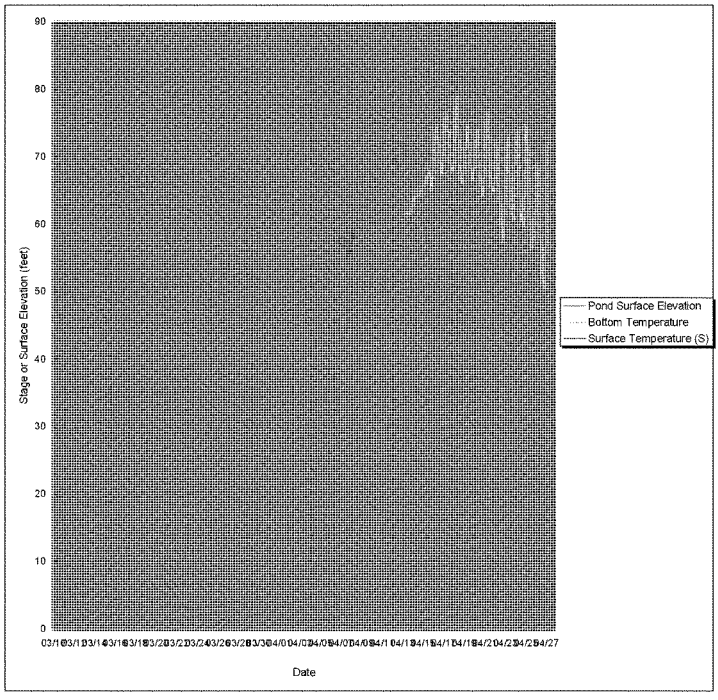


Figure 4. Site 18a Pond Surface Elevation and Water Temperature during March and April 1999



Key Dates:
a - site 18a pond disconnects from NEMDC
b - small borrow pond disconnects from NEMDC
c - sample and mark fish from small borrow pond
d - begin first drainage of site 18a pond through hoop net
e - end first drainage of site 18a pond through hoop net
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l - seine site 18a pond
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n - site 18a pond drainage is complete
o - seine residual ponds within site 18a pond

APPENDIX B

WES Report: The Effects of Vegetation
on the Structural Integrity of Sandy Levees

AD-A240 267

US Army Corps of Engineers





REPAIR, EVALUATION, MAINTENANCE, AND REHABILITATION RESEARCH PROGRAM

TECHNICAL REPORT REMR-EI-5

THE EFFECTS OF VEGETATION ON THE STRUCTURAL INTEGRITY OF SANDY LEVEES

by

Donald H. Gray, Anne MacDonald, Thomas Thomann
Imogene Blatz, F. Douglas Shields, Jr.

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

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Under Work Unit 32374

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	Problem Area		Problem Area
CS	Concrete and Steel Structures	EM	Electrical and Mechanical
GT	Geotechnical	EI	Environmental Impacts
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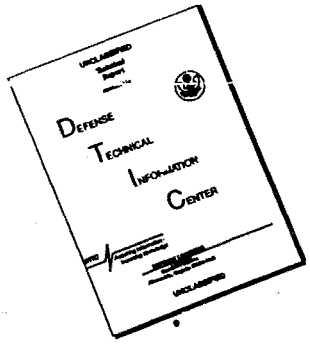
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COVER PHOTOS:

TOP — View of levee at study site showing vegetation growing on riverward side

BOTTOM — View of trench layout for root mapping

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13. ABSTRACT *(Maximum 200 words)*

The purpose of this study was to investigate the relationship between vegetation and the structural integrity of river levees. A specific objective was to determine the distribution of roots within levee embankments, and how these roots alter soil properties of levee embankments and affect their resistance to mass wasting, surficial erosion, piping, etc. With this information, engineering criteria can be developed in the future that may allow additional (particularly woody) vegetation to remain on levee embankments where sufficient effort can be made for levee inspection. Current Corps of Engineers guidelines for levee maintenance and operation limit vegetation on the embankment to sod-forming grasses 2 to 12 in. in height to provide for structural integrity, inspectability, and unhindered flood fight access to levees.

A field study was conducted along a 6-mile reach of a sandy channel levee along the Sacramento River near Elkhorn, CA. Root concentrations and distributions were determined using the profile-wall method in which root cross

(Continued)

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Earth reinforcement	Plant roots	Soil properties	16. PRICE CODE
Levee	Seepage analyses	Vegetation survey	

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sections were exposed in the vertical wall of an excavated trench. Transects were excavated running both parallel and perpendicular to the crest of the levee through areas dominated by different woody plant species typical of riparian vegetation.

Lateral plant roots were restricted to, and modified, mainly the first few feet between the surface of a levee. Root area ratios did not exceed 2 percent and generally decreased approximately exponentially with depth. Most of the root biomass was concentrated in the top 2 ft. Voids and pedotubules (infilled holes or conduits) were also mapped in the vertical faces of the trenches at each site. No voids clearly attributable to plant roots were observed.

Plant roots reinforce the levee soil and increase shear strength in a measurable manner. A shear strength increase or root cohesion can be estimated from the root biomass per unit volume or alternatively from the root area ratio. Both infinite slope and circular arc stability analyses were performed on the landward and riverward slope for steady seepage and sudden drawdown conditions, respectively. These analyses showed that even low root concentrations as measured along selected transects in the sandy levee sufficed to make the slope more secure under "worst case" scenario conditions.



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PREFACE

The work described in this report was authorized by Headquarters, US Army Corps of Engineers (HQUSACE), under Civil Works Research Work Unit No. 32374, "Techniques to Reduce Environmental Impacts for REMR." The study was part of the Environmental Impacts Problem Area of the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program. The Overview Committee at HQUSACE for the REMR Research Program consists of Dr. Tony C. Liu (CECW-EG) and Mr. James E. Crews (CECW-O). Technical Monitor for the study was Mr. Crews.

The report was prepared by Dr. Donald H. Gray of the University of Michigan and by Dr. F. Douglas Shields, Jr., and Ms. Anne MacDonald of the Water Resources Engineering Group (WREG), Environmental Engineering Division (EED), Environmental Laboratory (EL), US Army Engineer Waterways Experiment Station (WES). Dr. Gray was employed in the EL under the Summer Faculty Research and Engineering Program sponsored by the US Army Research Office. Technical review was provided by Dr. C. V. Klimas, EL, and Mr. Earl Edris of the WES Geotechnical Laboratory. Ms. MacDonald was responsible for all data acquisition, reduction, and analysis. Dr. Shields and Ms. MacDonald worked under the direct supervision of Dr. John J. Ingram, Chief, WREG, and Dr. P. R. Schroeder, Acting Chief, WREG, and under the general supervision of Dr. Raymond L. Montgomery, Chief, EED, and Dr. John Harrison, Chief, EL. Problem Area Leader for the Environmental Impacts Problem Area is Mr. John Cullinane, Water Supply and Waste Treatment Group (WSWTG). Program Manager for REMR is Mr. William F. McCleese, Concrete Technology Division, Structures Laboratory, WES. The report was edited by Ms. Janean Shirley of the WES Information Technology Laboratory.

Assistance with field data collection was provided by the following individuals: Ms. Imogene Blatz, San Jose State University, Ms. Leslie Tacon, University of Illinois, Chicago Circle; Mr. Wayne Sharp, WES; Mr. Thomas Thomann, University of Michigan; and Mr. Sterling Sorensen, backhoe operator, California Department of Water Resources (DWR). Their assistance was crucial to the study and is much appreciated.

A large amount of data was collected in the field study that required careful and systematic analysis. Help with this task was provided by the following: Mr. Albert Edney, Mr. James Mock, Mr. James Battle, Mr. Thomas Thomann, and Mr. Abu-El-Sha'r, all from the University of Michigan.

Site selection guidance, logistical assistance, and entry permission were provided by the following: Mr. Scott Morris, US Army Engineer District, Sacramento; Mr. Mel Schartz, California DWR; and Mr. Frank Lang, President, Reclamation District RD 1600. Their help is likewise acknowledged.

COL Larry B. Fulton, EN, was the Commander and Director of WES. Dr. Robert W. Whalin was the Technical Director.

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CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	metres
gallons (US liquid)	3.785412	cubic decimetres
inches	2.54	centimetres
miles (US statute)	1.609347	kilometres
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
pounds (force) per square inch	6.894757	kilopascals

THE EFFECTS OF VEGETATION ON THE STRUCTURAL INTEGRITY OF SANDY LEVEES

PART I: INTRODUCTION

Background

1. The effect of vegetation on the structural integrity of sandy levees was investigated as part of the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program. REMR is a comprehensive program to investigate REMR problems associated with Civil Works Programs of the US Army Corps of Engineers. This study was conducted as part of REMR research regarding reduction of adverse environmental impacts of REMR activities.

2. Current Corps guidelines for levee maintenance and operation limit vegetation on the embankment to sod-forming grasses 2 to 12 in.* in height to provide for the structural integrity, inspectability, and unhindered flood fight access to levees (Code of Federal Regulations [CFR], Section 208.1, Title 33; US Army Corps of Engineers 1968). Sufficient vegetation to reduce surface erosion on levees is allowed.** Finally, management to retain this type of vegetation is to be carried at least 5 ft beyond the toe of the levee or any associated seepage berm. The regulations assume that maintenance will be dominated by mowing, with burning, chemical treatments (including herbicides), and grazing also allowed. Exceptions to the sod-only policy are made to allow willow (or similar) growth on riverward berms/foreshore/batture land and overbuilt levee sections to provide additional erosion control in areas of high wave or river current attack.

3. The Corps requires that non-Federal levees for which emergency repair assistance is requested be maintained in accordance with Corps guidelines for Federal project levees. Maintenance according to Corps guidelines typically is stipulated in assurance agreements between the Corps and the

---

* A table of factors for converting Non-SI units of measurement to SI (metric) units is presented on page 7.

** Herbaceous vegetation which is allowed to remain substantially taller than allowable standards from year to year, and all woody vegetation, will be called "additional vegetation" throughout the body of this report. Where information is more specific, botanical classes (grasses, forbs, shrubs, trees) or species names will be used.

local sponsor to whom the levee is turned over at the end of project construction. The agreements generally cover all aspects of operations and maintenance responsibilities to be done by the local sponsor. This restriction also holds for non-Federal project levees, although the Corps has fewer means of enforcing their maintenance standards. For a more thorough review of pertinent Corps guidelines for vegetation control on levees, see Nolan (1984).

4. These standards are appropriate in the absence of data which clearly establish the relationship between the properties of vegetation on levees (size of individual plants, plant density, and rooting structure) and structural impairment of the levees. However, there are perennial maintenance costs associated with these stringent requirements, ranging from a few to tens of dollars per acre per year depending upon the physical maintenance activity (Hynson, Elmer, and Shields 1985). Clearing of brush allowed to grow on unmaintained levees is more costly, ranging in the Sacramento District from nearly $100 to over $1,000 per acre per year. The other, less tangible price exacted by limiting vegetation on levees is lost riparian habitat, particularly where the levee is located very near the river channel in an area with historically wooded riparian strips. Hynson, Elmer, and Shields (1985) summarize the wildlife issues associated with the placement and management of levees.

5. Levee embankments are designed to retain seasonal high waters within a limited overbank area. As such, they are subject to hydraulic loading for short durations, generally less than a few weeks per year. Therefore, a levee embankment usually is less intensively engineered than an earthen dam. Furthermore, due to the constraints imposed on levee alignment by flood protection considerations, foundation material may be less than ideal. Levees may fail by several means, e.g., overtopping, surface erosion, shear failure of the embankment or foundation, and piping or seepage erosion (US Army Corps of Engineers 1978). The presence of vegetation on levees can potentially influence all of these processes to varying degrees.

6. Underseepage (i.e., seepage at the base of, or through, the levee foundation) is locally a serious threat to levee integrity and must be guarded against. Underseepage and the emergence of water on the landward side is often manifested by localized upwellings or seeps that can result in sand boils. Concentrated seepage streams emerging at these boils often carry with them entrained fines. This loss of fines can result in subsidence and other distress to a levee. The occurrence and severity of boils are controlled

primarily by the relative permeability and stratigraphy of sediments on which a levee is constructed. If the boil occurs close to the toe of the levee it may undercut the toe and cause a slipout or mass stability failure of the landward slope.

7. The possibility of an embankment failure by internal erosion as a result of through-seepage is also a major concern in the case of earth dams and levees. The problem is exacerbated under long-term hydraulic loading when the phreatic surface can eventually reach the landward face of an embankment unless intercepted by internal drains. Through-seepage can also result in the formation of pipes or conduits which lead to a washout or piping failure, particularly if dispersive clays are present. Pre-existing macropores (cracks, fissures, etc.) appear to be a necessary precondition for the initiation and propagation of a washout failure involving clay fines (American Society for Testing and Materials (ASTM) 1977). Cracks or macropores can be formed in earth dams and levees by a variety of causes quite unrelated to faunal (burrowing) and floral (rooting) activity. These causes include differential settlement and internal stress redistribution. The latter produces surfaces on which little or no normal compressive stress acts. These surfaces become the loci for hydraulic fractures which can occur under very low hydraulic gradients (Sherard 1986).

Purpose

8. The purpose of this study was to investigate the relationship between vegetation and the structural integrity of river levees. A specific objective was to determine the distribution of roots within levee embankments, and how these roots alter soil properties and affect resistance to mass wasting, surficial erosion, piping, etc. of levee embankments. With this information, engineering criteria can be developed in the future which may allow additional (particularly woody) vegetation to remain on levee embankments where sufficient effort can be made for levee inspection.

9. A second objective, therefore, was to provide a summary of findings that could serve as a basis for eventual development of vegetation management guidelines that would allow maximum vegetation cover and biomass without compromising the structural integrity of levees. As the study progressed, it became apparent that the development of study methods to address these

questions was itself a fundamental objective as well. Accordingly, this study serves as a guide to future studies of this type.

Scope

10. A field investigation of a levee along the Sacramento River in northern California was conducted. Data acquired in the field include above-ground plant cover and the distribution of associated roots, and selected geotechnical properties of the levee embankment (dry bulk density, gross particle size distribution, and in situ shear strength). Permeability tests of levee sediments reconstituted to the same field density were made in the laboratory.

11. These data were used in two primary analyses. First, slope stability of a design levee embankment along the Sacramento River was analyzed for both steady-state seepage and rapid drawdown conditions using representative values of root density, soil strength properties, and permeability. Next, gross seepage and hydraulic head distributions through a representative cross section were analyzed assuming a permeable base, the phreatic surface intersecting the levee toe for steady seepage, and a skin or surface layer of variable permeability to account for the possible effect of vegetation. Seepage analysis was repeated for an approximate transient state as well. Unfortunately, neither of these two-dimensional type seepage analyses can actually predict piping potential. A transient, three-dimensional (3-D) analysis is necessary to obtain point measurements of hydraulic head and exit seepage velocity required to determine whether seepage forces are high enough to initiate piping or trigger seepage erosion. This will be the focus of future research on this topic.

12. This study has not attempted to resolve the issue of vegetation and levee inspectability. Corps project levees are to be inspected twice annually, before and after seasonal high water. The most common means of inspection is to visually observe the levee embankment for signs of piping, sloughing, surface erosion, and animal burrowing while driving the levee crown road. Such a rapid assessment of the levee surface demands that visibility on the embankment be very good; this, in turn, suggests that the vegetation cover be the minimum necessary to reduce surface erosion, i.e., short grass. However, the cost, level, and means of inspection are human resource issues, rather than technical issues. It is not known at present how much additional

inspection effort might be needed with a specified level of additional vegetation to achieve comparable results. The issue of levee inspectability and techniques to facilitate inspection, e.g., careful selection and placement of vegetation, are addressed elsewhere (California Reclamation Board 1967, 1982). Finally, local sponsors may decide that this expense is reasonable for a more aesthetically or biologically valuable levee.

13. Fundamentally, then, the issues of inspectability and ease of flood fighting are separable from geotechnical considerations in determining the extent to which vegetation in excess of current standards should be allowed to grow on a levee. However, if geotechnical considerations do not warrant allowing additional vegetation in a given situation, these human resource issues become moot.

PART II: INFORMATION REVIEW

Levee Vegetation Guidelines and Regulations

USACE regulations and standards

14. The Code of Federal Regulations (US Army Corps of Engineers 1967) contains basic regulations governing the ope. ion and maintenance of local flood protection works. With regard to vegetation, these regulations require that measures be taken to promote the growth of sod, exterminate burrowing animals, and provide for routine mowing of grass and weeds, and removal of wild growth and drift deposits. The Corps has several ancillary regulations which further address vegetation and the operation and maintenance of levees. Pertinent standards (US Army Corps of Engineers 1968) are excerpted below:

Maintenance Standards

> *The levees will be maintained as necessary to insure serviceability against floods at all times. Standards for accomplishing the foregoing are as follows:*
>
> *A good growth of sod will be maintained where feasible with grass height from 2 inches to 12 inches, substantially free of weeds.*
>
> *All brush, trees, or other undesirable wild growth will be removed from the levee embankment. Vegetation specifically planted for aesthetics or recreation purposes may remain.*

15. Corps guidance for plantings on levees for aesthetic or environmental purposes is contained in a separate manual (US Army Corps of Engineers 1972). The guidance is to keep the basic levee structure free of roots and to provide a buffer zone of at least 3 ft (1 m) between the deepest expected penetration of plant roots and the face of the basic levee structure. If trees and shrubs are desired on a levee, the levee section must be overbuilt to accommodate the plant roots as depicted schematically in Figure 1. Alternatively, the woody vegetation may be placed in concrete tubs or planters whose purpose is to limit and confine root penetration.

California Department of Water Resources Reclamation Board guidelines

16. Concern about the environmental impacts of removing or stripping levee vegetation in the San Joaquin-Sacramento delta region spurred efforts by both the California Department of Water Resources and the Reclamation Board to seek alternative levee maintenance standards. This effort was directed at

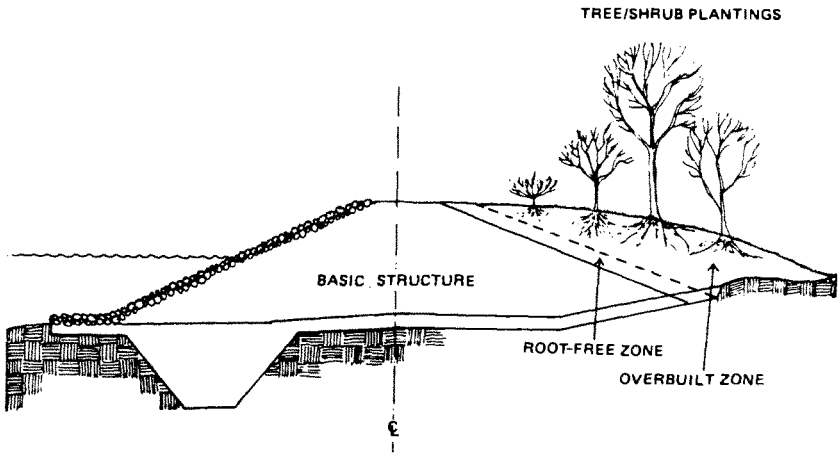


Figure 1. Cross section of an overbuilt levee

evaluating and finding feasible means to plant/retain a controlled vegetative cover for wildlife, recreation, scenic, and aesthetic purposes.

17. Results of a 5-year study to test alternative methods of levee maintenance were published in a Pilot Levee Maintenance Study (Davis, Ito, and Zwanch 1967). The study concluded that native riparian as well as other plant species could be maintained and propagated compatibly with the flood control function. Coincidental with the Pilot Levee Maintenance Study, the California Reclamation Board released a guide for encroaching vegetation on project levees (California Reclamation Board 1967) which was adopted by the Sacramento District. The guide recommended that vegetation be maintained in a controlled manner to ensure that it does not compromise levee integrity or interfere with levee inspection, maintenance, operation, or flood-fight activities. The guide required that the levee be oversized in order to provide for a root zone. The guide also specified minimum spacing intervals for trees and shrubs in order not to hinder inspection during low-flow and flood periods. Furthermore, the guide listed acceptable and unacceptable species of trees and shrubs--from the viewpoint of growth character, impairment of inspection and maintenance, and potential hindrance during flood-fighting activities. In recent years vegetation maintenance standards have been promulgated by the State of California that are more tolerant than current Corps guidelines (California Reclamation Board 1982). These State maintenance objectives and vegetation characteristics for levee maintenance zones are listed in Table 1.

Table 1

Maintenance Objectives and Vegetation Characteristics for Levee Vegetation Management Zones (California Reclamation Board 1982)

Zone	Maintenance Objectives	Vegetation Characteristics
A Ten-foot maintenance access	In areas where lands within 10 ft of the levee toe are used for levee maintenance, access for maintenance equipment must be kept open.	Low-growing grasses or ground covers which can tolerate but not impede periodic vehicle passage are desired.
B Landside slope	The integrity of the landside slope is critical during seasonal high water since it is the last line of defense against flooding of adjacent property. It is also the slope which remains visible during high water and provides opportunities for early detection of leaks, seeps, or boils. The vegetation on the landside of levees should be selectively managed to maximize its soil-binding rootmass, while providing for visibility. This will maximize both the stability of the slope as well as its visibility in case of a flood fight.	Perennial plant species with long-lived, extensive root systems adept at binding soil particles and inhibiting erosion are desired. "Cool season" species which develop extensive root systems with the onset of fall rains but whose top growth remains low until early spring meet the maintenance objectives. Clusters of taller growing shrubs or trees which meet requirements set forth in the Reclamation Board's Guide for Vegetation on Project Levees can also be desirable.
C Crown roadway and shoulders	Crown roadways are usually surfaced with gravel, although asphalt is sometimes used. Vegetation is considered undesirable when it creates automobile catalytic converter fire hazards, breaks up paved surfaces, makes gravel recovery or blading difficult, or physically prevents access or passage on the road surface.	It is desirable to keep crown roadways cleared of most vegetation. Plant populations can be tolerated if they do not impede road maintenance or vehicle movement at any time of the year.

European practice

18. In European practice, vegetation is promoted as a means of stabilizing streambanks and levee slopes. In Bavaria, West Germany, a common design practice is to construct widely spaced, vegetated levees as shown in Figure 2. A mixture of plants, including reeds, grasses, and trees, is used with riprap and other standard engineering control measures to retard erosion (Keller and Brookes 1984).

Survey of Corps District Practice

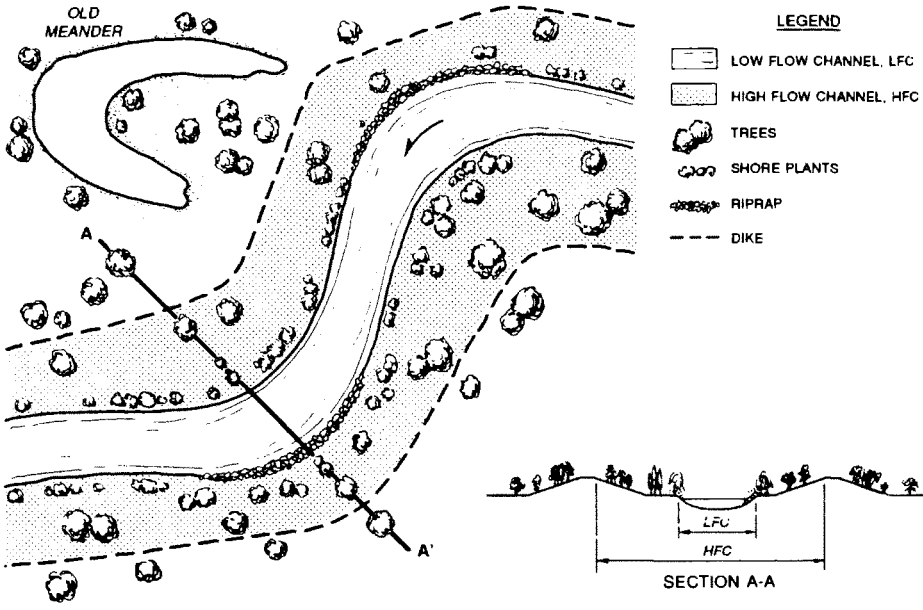
Scope of survey

19. Variances and differences in vegetation management practice exist between Corps Districts in spite of national guidelines. These differences are driven by such factors as levee types, climate, money available for inspection, and local environmental pressures. A limited study of Corps District practice was undertaken to obtain some idea of (a) major vegetation maintenance issues or problems, and (b) reasons for differences in response to these issues. The information was derived largely from site visits and interviews with District personnel.

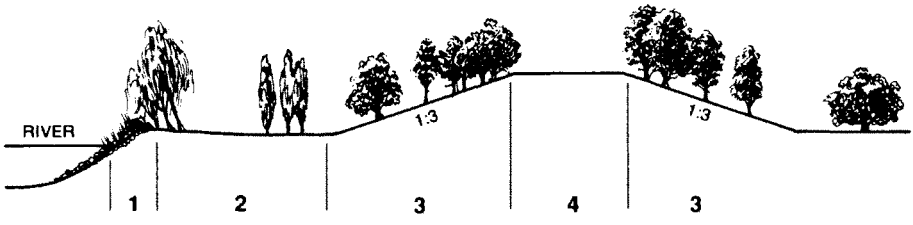
Seattle District

20. The Seattle District has adopted minimum maintenance standards for levees in their jurisdiction that differ from most other Corps Districts. The standards explicitly address concerns about levee structural integrity while including measures which consider the impact of levees on fish and wildlife. The maintenance standards include variable standards for vegetation on levees depending upon position along the river channel as depicted in Figure 3. More extensive vegetation is allowed on riverward levee slopes located on convex bends or in straight reaches on gentle bends. The standards limit tree and shrub size to a main stem diameter of 2 in. or less. No trees or shrubs are allowed on the landward slopes or crowns. Undesirable growth that hinders inspection (e.g., blackberries and wild roses) must be removed annually.

21. The variance was approved by the North Pacific Division on the basis of the unique circumstances of levee project settings along the Puyallup River near Tacoma, WA. The variance was part of a local sponsor agreement between the Corps and the Puyallup Indian Tribe. The Tribe made retention of vegetation on the embankment a condition of construction. Since the levee is maintained by the Corps, it was felt that all maintenance could be done in a



IDEALIZED DIAGRAM SHOWING THE CONCEPT OF "NATURAL RIVER ENGINEERING" BEING PRACTICED IN BAVARIA, WEST GERMANY.



FLOOD-BANK, DIKE

1. SHORE PLANTS; REEDS, LARGE SEDGES, ETC. PLANTED IN RIPRAP.
2. TREES (NEAR WATER TABLE) POPULAR, ALDER, WILLOW, ETC.
3. TREES (HIGHER, LESS WET SITES) OAK, MAPLE, ASH, ETC.
4. GRASS

Figure 2. Use of vegetation on flood dikes in Bavaria, West Germany (after Keller and Brookes 1984)

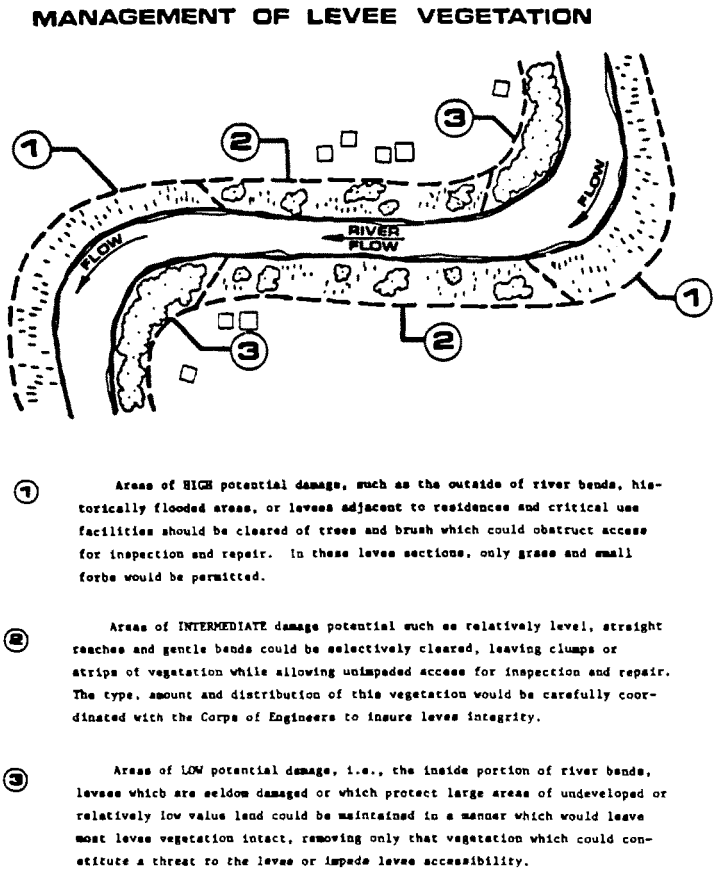


Figure 3. Seattle District guidelines for management of vegetation on Puyallup River levees

timely fashion, and that there was therefore a much reduced risk of levee failure as a result of excessive vegetation growth.

Vicksburg District

22. The Vicksburg District has project levees on the Ouachita, White, Red, Mississippi, Yazoo, and Pearl Rivers. Project levees are composed primarily of fine-grained soils--silts and silty clays. Underseepage appears to be the main problem of concern. None of the project levees are overbuilt, although seepage berms are common. District personnel that were interviewed could recall no levee failures directly attributable to vegetation; however,

boils had been observed around trees growing hundreds of feet landward of levees.

23. Vegetation management on project levees consists typically of mowing, herbicides, and burning, in that order. The Corps encourages growth of Bermuda rather than Johnson grass on these levees. Few problems with vegetation maintenance on berms and embankments were reported except on the Red River, which was taken over from the New Orleans District about 1983. A review of District files suggests that most vegetation problems on the Red River levees are caused by (a) overhanging limbs from trees at the toe; (b) encroachment of vegetation on levee toes; and (c) woody vegetation growing along fencerows.

24. Different conditions and problems prevail in the case of nonproject levees. Unlike the local, engineered project levees, these levees are very sandy. The main deficiencies with non-project levees arise from overgrown vegetation conditions, insufficient freeboard caused by post-construction settling, and bank erosion, including some caving. Inspection of these levees is less frequent and less thorough.

Potential Impacts of Vegetation on Levee Structural Stability

General considerations

25. The benefits and detriments, respectively, of vegetation on embankment slopes and levees have been discussed in a number of reports, articles, and books (Nolan 1984; Greenway 1987; Tschantz and Weaver 1988; Carter and Anderson 1984; Gray and Leiser 1982). The role of vegetation has been considered with regard to a variety of issues, which include:

a. Structural stability.

b. Inspectability.

c. Flood fighting.

d. Recreation and wildlife.

e. Agricultural impact.

f. Channel conveyance.

g. Burrowing animals.

26. Of necessity this report and review are restricted primarily to one of these issues alone; namely, the influence of vegetation on structural stability and integrity. Admittedly, there are linkages between these issues. For example, to the extent that vegetation actually hinders inspection and the

ability to detect cracks, burrow holes, slumps, scour pockets, boils, and other defects in a levee it indirectly affects structural stability as well. Likewise, to the extent that vegetation attracts, or conversely discourages, burrowing animals it also affects structural stability--particularly with regard to the danger of piping and internal erosion. Voids and tunnels clearly attributable to burrowing animals were mapped during the field investigation which is the main subject of this report. The linkage between vegetation, burrowing animals, and structural stability is direct and significant enough, therefore, to merit inclusion both in a literature review and later discussion in the report.

27. The structural stability of a levee can be affected or compromised by several processes in which vegetation plays a potential role, namely:

a. Mass stability (slipouts or slides).

b. Surficial (rainfall) erosion.

c. Current/scour erosion.

d. Piping or internal erosion.

Each of these processes and the role/influence of vegetation will be reviewed briefly.

28. Unfortunately, indictments reported in the technical literature against vegetation, particularly woody plants, are often general and unspecific in nature. It is difficult, therefore, to conclude in what way and how vegetation adversely affected stability. The opinions of professional engineers (Nolan 1984) regarding the undesirability of significant vegetation on levees is characteristic in this regard. Tschantz and Weaver (1988) published a highly negative report with regard to the presence of vegetation on earthen embankment dams. Conclusions in the report were based mainly on an opinion survey of state dam safety officials. The literature on beneficial effects of vegetation on slope stability is dismissed out of hand in this report with a single sentence... "However, some people do not agree that the beneficial effects of trees on hill slopes are transferable to earth dams." Questionable cause and effect relationships have also been cited occasionally as the basis for indicting vegetation. A good example is the discovery of tree roots exposed in a breached or failed section of a dam (Shaw 1978; Tschantz and Weaver 1988).

29. The lack of specificity and carefully documented field evidence demonstrating harmful effects of levee vegetation on structural stability have been alluded to by Carter and Anderson (1984). These authors note that causes

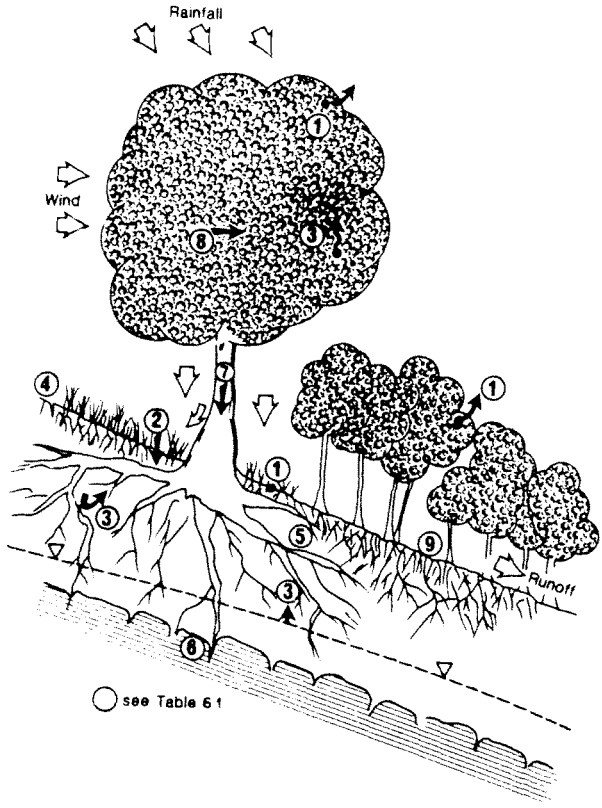
of levee failure are difficult to document and they claim that no levee failure in the Central Valley region has been attributable directly to the existence of riparian vegetation on unrevetted levee slopes. However, they also caution that vegetation which hinders a local maintaining agency in the performance of adequate inspection and maintenance increases the risk of failure. In this regard, the Pilot Levee Maintenance Study (Davis, Ito, and Zwanch 1967) developed some preliminary data and information which suggested that native and other vegetation could be maintained compatibly with flood control functions.

Vegetation and mass stability

30. Slopes fail by movement along a critical surface when the shear stress exceeds the available shear strength along the surface. A mass stability failure commonly consists of shallow, largely planar surface sliding in sandy soils or along a deeper seated, rotational failure surface which tends to occur in cohesive soils. Mass stability is strongly influenced by pore water pressures. Seepage patterns and the location of the phreatic surface affect the landside slope of a levee or earth dam, whereas sudden drawdown conditions, e.g., quickly receding flood levels, affect the stability of the riverward slope.

31. The effects of vegetation on slope stability are best documented in the soil conservation and forest engineering literature. Greenway (1987) has provided a good summary of the hydromechanical influences of vegetation as related to mass stability. These influences are depicted schematically in Figure 4 and tabulated according to whether they exert a beneficial or adverse effect. The most obvious way in which woody vegetation enhances mass stability is via root reinforcement. Extensive laboratory studies (Gray and Ohashi 1983; Gray and Maher 1989) on fiber-reinforced sands indicate that small amounts of fiber can provide substantial increases in shear strength. These findings have been corroborated by field tests on root-permeated soils (Endo and Tsuruta 1969; Ziemer 1981; Riestenberg and Sovonick-Dunford 1983).

32. Soil buttressing and arching action associated with roots and the stems/trunks of woody vegetation are also important components of slope stabilization. In addition, evapotranspiration by vegetation can reduce pore water pressures within the soil mantle on natural slopes, promoting stability (Brenner 1973). The levee environment, which can experience saturation and rapid drawdown, and in which groundwater seeps nearly horizontally across the



Hydrological Mechanisms		*Influence*
1	Foliage intercepts rainfall, causing absorptive and evaporative losses that reduce rainfall available for infiltration.	B
2	Roots and stems increase the roughness of the ground surface and the permeability of the soil, leading to increased infiltration capacity.	A
3	Roots extract moisture from the soil which is lost to the atmosphere via transpiration, leading to lower pore-water pressures.	B
4	Depletion of soil moisture may accentuate desiccation cracking in the soil, resulting in higher infiltration capacity.	A
Mechanical Mechanisms		
5	Roots reinforce the soil, increasing soil shear strength.	B
6	Tree roots may anchor into firm strata, providing support to the upslope soil mantle through buttressing and arching.	B
7	Weight of trees surcharges the slope, increasing normal and downhill force components.	A/B
8	Vegetation exposed to the wind transmits dynamic forces into the slope.	A
9	Roots bind soil particles at the ground surface, reducing their susceptibility to erosion.	B

Legend: A - Adverse to stability
B Beneficial to stability

Figure 1. Hydromechanical influences of vegetation on the mass stability of slopes (From Greenway 1987)

levee, presents a different case. It is not yet known whether the latter observations might apply to a levee embankment. Evapotranspiration effects will be significant, for example, only if flooding coincides with the vegetation growing season.

33. The primary detrimental influence on mass stability associated with woody vegetation appears to be the concern about external loading and the danger of overturning or uprooting in high winds or currents (Nolan 1984; Tschantz and Weaver 1988). If a large soil mass is disturbed during uprooting it could reduce the stability of a cross section depending upon a tree's position on the slope. This problem is likely to be more critical for large trees growing on relatively small dams or levees. With regard to external loading, levee embankment slopes are generally shallow enough that the main component of the overburden weight may act perpendicular to, rather than parallel to, the failure surface, thereby increasing stability. However, the location of trees on the embankment must be considered in any slope stability analysis in order to ascertain the extent to which their weight might affect the balance of forces.

Vegetation and surficial rainfall erosion

34. Surficial erosion entails the detachment and transport of individual soil particles as a result of a fluid (air or water) flowing over a soil bed boundary. Bare soils are particularly vulnerable to both wind and rainfall erosion. Rainfall erosion occurs in various forms ranging from raindrop splash to rilling and gullying.

35. Vegetation plays an extremely important role in controlling rainfall erosion. Soil losses due to rainfall erosion can be decreased a hundredfold on bare, fallow soil (US Department of Agriculture Soil Conservation Service 1978) by maintaining a dense cover of sod, grasses, or herbaceous vegetation. Regulations governing levee maintenance (US Army Corps of Engineers 1968) recognize the value of a sod cover and recommend its use whenever feasible.

Vegetation and current/scour erosion

36. Levee slopes are also susceptible to erosion by water currents during flood events. The erosive power of flowing water increases with velocity. Slope vegetation can help to reduce this type of erosion in the following manner: aboveground shoots bend over and cover the surface and/or reduce flow velocity adjacent to the soil/water interface, while belowground roots

physically hold soil particles in place. The extent to which vegetation provides these benefits depends upon the surface area of vegetation presented to the flow and the flexibility of the stems (Kouwen and Li 1980). Dense grass swards and low shrubs which extend numerous, non-rigid branches and leaves into the flow are the most effective in this regard. Uniformly rooted grasses (as opposed to tussocks) and supple, young willows have proven to be valuable for erosion protection (Parsons 1963; Seibert 1968). In large, wide-leveed rivers, this additional channel roughness will have a negligible effect on the stage of the design flood. In the case of a grassed surface, the hydraulic roughness depends upon the physical characteristics of the grass sward such as its height, stiffness and density, and its interaction with the flow. This interaction can be divided into three basic regimes (Hewlett, Boorman, and Bramley 1987) as shown schematically in Figure 5.

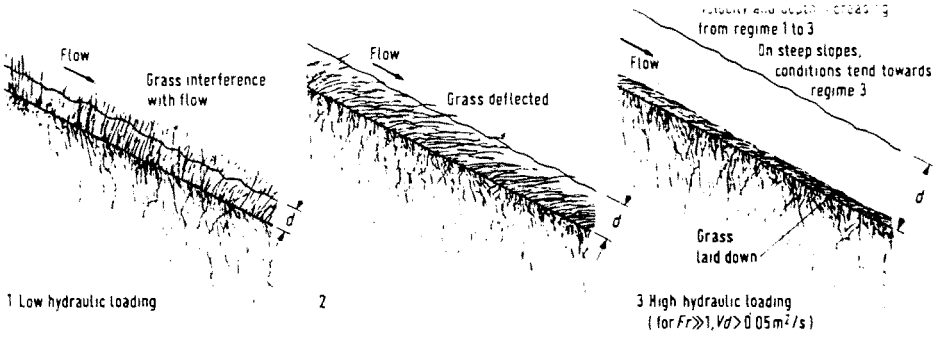


Figure 5. Effect of hydraulic loading on a grassed surface (from Hewlett, Boorman, and Bramley 1987)

In flow regime 1, the flow depth is significantly less than the height of the vegetation, which is not deflected, and the velocity at the soil surface is low due to the interference effect of the vegetation. In flow regime 2, the combined effect of increasing flow velocity and depth causes the vegetation to deflect and oscillate in the flow. In regime 3, the velocity is high enough to flatten the vegetation and a relatively smooth, stationary surface is presented to the flow. The effect of this laydown is to armor the surface and to assist in reducing local surface irregularities which might otherwise be subject to high drag forces during floods.

37. Large, isolated, rigid trees do not provide these benefits. They do not significantly reduce water velocities and instead may behave much like bridge pilings (Raudkivi and Ettema 1985). Scour around the trunk, both upstream and downstream, may be sufficient to undermine the trunk and to accelerate local bank erosion. Differential scour around large roots exposed in the streambank has been cited as a contributing cause of bank erosion (Nolan 1984); but, in undisturbed river systems with low banks and well developed bank vegetation, bank erosion is minimized because of the protection afforded by such root structures (Klingeman and Bradley 1976).

Vegetation and piping/internal erosion

38. Water seeping through an earth dam or levee can lead to a piping failure. Piping is a form of subterranean or internal erosion in which soil fines become entrained in a seepage stream. Piping can lead to washout of soil particles, removal of underlying support, and eventual collapse of an earthen structure that is subjected to hydraulic loading. Piping may pose a greater threat to stability and integrity of low, earthen embankments with gentle side slopes, e.g., levees, than mass stability failures such as slumping or rotational slides (Sherard, Decker, and Ryker 1972).

39. The phenomenon of piping in soils and earthen embankments--its causes, identification, and manifestations--has been the subject of a number of studies and symposia (ASTM 1977; Sherard, Decker, and Ryker 1972; Perry 1975; Jones 1981; and Sherard 1986). The critical role played by the presence of dispersive clays in a soil during piping is now well recognized. These clays, when present, can be easily entrained in a seepage stream, and under the right conditions, be flushed out.

40. Except in the case of internally unstable soil gradations (Kenney and Lau 1985) the consensus today is that some kind of internal fissure, crack, or macropore is required to initiate and propagate piping. Sources of quasiplanar macropores include dessication and syneresis cracks, settlement cracks, and compaction lift planes. Vegetation management itself may influence the occurrence of significant macropores. Mowing and grazing decrease macropore density because of associated compaction, while uneven, rapid surface drying in the absence of significant vegetation cover can lead to dessication cracks in an embankment (Beven and German 1982).

41. Sherard (1986), after an extensive review of available evidence, concluded that cracking in earth dams commonly occurs by hydraulic fracturing. Hydraulic fracturing is a tensile separation along an internal surface in a

soil mass or embankment on which the effective stress approaches zero; in other words, where the neutral (pore water pressure) equals the total confining stress. This hydraulic fracturing is facilitated by differential settlement and internal stress transfer in an earthen structure. Sherard also showed that in some cases a surprisingly small head differential is sufficient to "jack open" a pre-existing crack or propagate a fracture in a zone where internal stress redistribution has reduced the minor principal stress to zero or even to a tensile stress. Low, homogeneous dams without internal drains or filters appear especially vulnerable to this action following the first hydraulic loading. Channel levees fall into this category of earthen structure. One low earthen dam that Sherard inspected had developed a concentrated leak, and erosion tunnels (pipes) 225 m long under a 50:1 hydraulic gradient when the reservoir head of water acting on the upstream face of the dam was not more than 4 m. This relatively low head and gradient initiated the hydraulic fracturing.

42. Biotic activity, i.e., the actions of plant roots and burrowing animals, has provided a popular explanation for pipe development. Given the fact that the presence of some form of macropore is a prerequisite for piping in most soils, it is not surprising that biotic activity has been viewed as a likely and indeed principal cause of piping. It is, after all, a lot easier to envision relict root holes than it is to picture hydraulically induced fracture planes in an earthen embankment. Numerous levees failed along the Columbia River in 1948 when flood waters allegedly filled and spurted through channels and conduits in the levees (Cedergren 1967). Channels left by either rotted roots or burrowing animals were suspected as the cause. Root systems, or more particularly, root holes left behind by decayed roots, are frequently cited (Nolan 1981; Tschantz and Weaver 1988) as the probable cause and origin of conduits and pipes in earthen structures. Unfortunately hard evidence with regard to the penetration of roots across (or through) levees and their subsequent decay to form conduits is lacking in the published literature.

43. Much of the evidence with regard to the biotic origin and/or cause of pipes appears to be inferential or anecdotal in nature. The relative importance of animal burrows versus root holes does not seem to have been weighed nor have other causes of piping failure such as hydraulic fractures (Sherard 1986) been considered carefully.

Relationship Between Vegetation and Burrowing Activity

44. If burrow holes do indeed constitute a major threat to levee stability then it is important to ascertain to what extent vegetation either encourages or discourages such activity. The fact that the basic regulations governing the operation and maintenance of project levees (US Army Corps of Engineers 1967) explicitly call for the extermination of burrowing animals, suggests that animal burrows are a major concern. Corps levee maintenance policy (US Army Corps of Engineers 1968) requires both backfilling of animal burrows in levees and efforts to exterminate the animals by chemical and other means.

45. Hynson, Elmer, and Shields (1985) describe the types of rodents and rodent control programs associated with levees. Habitat modification is a control technique that consists of understanding the requirements of pest species and modifying vegetation types on and around a levee to produce conditions that do not meet basic food and/or cover requirements of pest species and modifying vegetation types on and around a levee to produce conditions that do not meet basic food and/or cover requirements of the species.

46. The California ground squirrel (*Spermophilus* sp.) has been the focus of much study with regard to its burrowing habits and methods to control its population (Salmon, Marsh, and Stroud 1987; Fitzgerald and Marsh 1986; Daar, Klitz, and Olkowski 1984). The California ground squirrel digs a complex burrow system in levees. Burrows average 10 cm in diameter with varying horizontal lengths of 1.5 to more than 9 m. Burrow depth varies but most are less than 1.2 m deep. Several investigators (Owings, Borchert, and Virginia 1977; Darr, Klitz, and Olkowski 1984) have noted that ground squirrels are attracted to sparsely vegetated areas where they can readily observe their surroundings for predators and communicate more easily with one another. Based on their studies in California, Darr, Klitz, and Olkowski (1984) also remarked that the traditional approach of annually burning levee slopes followed by dragging to obliterate burrow openings unwittingly improves the quality of ground squirrel habitat. In contrast, a program of deliberately maintaining certain vegetation on levee slopes may tend to discourage squirrel colonization. Fitzgerald and Marsh (1986) are doubtful about the success of this approach, however, in light of their experiment with special plantings of tall grass and broad-leafed species which actually resulted in larger squirrel populations in some grass plots. It appears from a review of the literature

on this subject that differences of opinion exist on the connection or causal relationship between vegetation and burrowing activity. Further studies are required to resolve this issue.

Root Distribution and Architecture

47. It is considerably more difficult to obtain information about the development and distribution of plant roots below ground than about stems and foliage above ground. Nevertheless, quite a lot of information has been published on this subject (Hermann 1977; Sutton 1980). Furthermore, there are well-documented techniques and methods for studying plant roots (Bohm 1979).

48. Roots can extend considerably beyond the width of the crown in some species although rooting density decreases rapidly with distance from the stem (Hermann 1977). Numerous studies have shown that most roots are found in the upper 50 cm of soil, and most root activity and mycorrhizae in the top 20 cm, depending on soil aeration and fertility (Fogel 1980; Hermann 1977). Roots have been found at depths as great as 6 m in sandy soils where aeration requirements are not as restrictive. Localized concentration of roots may occur in decaying roots, channels formed by decaying roots, and in thick litter (McGinn 1963). These observations simply underscore the fact that roots also tend to find and exploit pathways or channels of least resistance or favorable rooting environment.

49. Field methods for studying root distribution and architecture can be classified as follows:

a. Excavation methods.

b. Monolith methods.

c. Auger method.

d. Profile-wall method.

e. Glass-wall method (rhizotron).

50. Bohm (1979) provides detailed information on each of the methods and their relative advantages and limitations. Selection of the best method depends upon the root parameter information of interest, site constraints, available labor, level of accuracy, and detail required. Root parameters commonly used to express growth and distribution are number, weight, surface, volume, diameter, length, and number of root tips.

51. The excavation method provides the clearest picture of the entire root system as it exists naturally in the ground. The length, size, shape,

orientation, and other characteristics of individual roots making up the root system can be studied directly. In addition, the interrelationship between competing root systems of other plants can be studied. On the negative side, the excavation method requires large amounts of physical labor and is very time-consuming. It also results in considerable site disturbance and does not record much about relict roots or biopores, except as they may be exposed during the excavation process.

52. The profile-wall method is probably the method most suited for studying the distribution of both woody plant roots and biopores in earthen levees. In this method, either tangential or radial trenches are dug at certain distances from a tree or along specified transects and the tips of the cut roots are mapped in one of the walls of the trench. This is done by first carefully scraping, brushing, or spraying the surface to reveal the tips of the cut roots. A gridded, acetate overlay is then placed over the vertical face or wall of the trench. Roots are mapped according to their location and size category. A different symbol can be used for each size category. The overlay technique is appropriate for investigating not only root distribution but also for determining root area ratios as a function of depth and the distribution of biopores and pedotubules.

53. The profile-wall method can be adapted for nearly all kinds of soils. Problems arise in soils of very high clay content or in very loose soils. The method requires no expensive equipment; the trench is dug by hand or with a backhoe. The combined soil and root profiles obtained by this method are good basic material for interpreting root data, especially if results for different sites are to be compared (Bohm 1979). It also permits observations and mapping of soil biopores and pedotubules.

PART III: FIELD DATA ACQUISITION

Site Selection and Description

Selection criteria

54. Site selection was governed by both study objectives and practical constraints. The main study objectives of the field work were to examine the influences of additional vegetation on levee structural stability and to develop techniques for determining the distribution of roots and biopores in a levee cross section. The initial site was selected to meet these objectives and to maximize useful information gained from the study. Inquiries about possible field study sites were directed to all USACE Divisions. Candidate sites for an initial study were narrowed down to the Sacramento District in California and the Seattle District in Washington. Time limitations and funding availability eventually limited the field study to a single area.

55. The search for a suitable site was focused in the Sacramento District because this District has severely overgrown project levees and because this condition has been an issue there since the publication of the Pilot Levee Maintenance Study (Davis, Ito, and Zwanch 1967). Selection criteria used in locating a suitable site included the following:

a. Presence of a mixed, woody species vegetation community.

b. Roadway access and backhoe accessibility.

c. Availability of levee construction and channel hydrologic records.

d. Permission and cooperation of local jurisdictions to trench and excavate.

The availability of good levee management/maintenance records should be considered as a criterion in future studies of this type because this would improve understanding of vegetation development or succession on the levee over time.

Study site location

56. Several potential study sites were investigated along the Sacramento River between Knight's Landing and Sacramento. The site ultimately selected is located on the west bank of the Sacramento River between the confluence of the Sacramento and Feather Rivers and the Interstate-5 bridge at Elkhorn, CA (see Figure 6). The study reach is approximately 6 miles long and is located in Reclamation District No. 1600. This reach was chosen because it

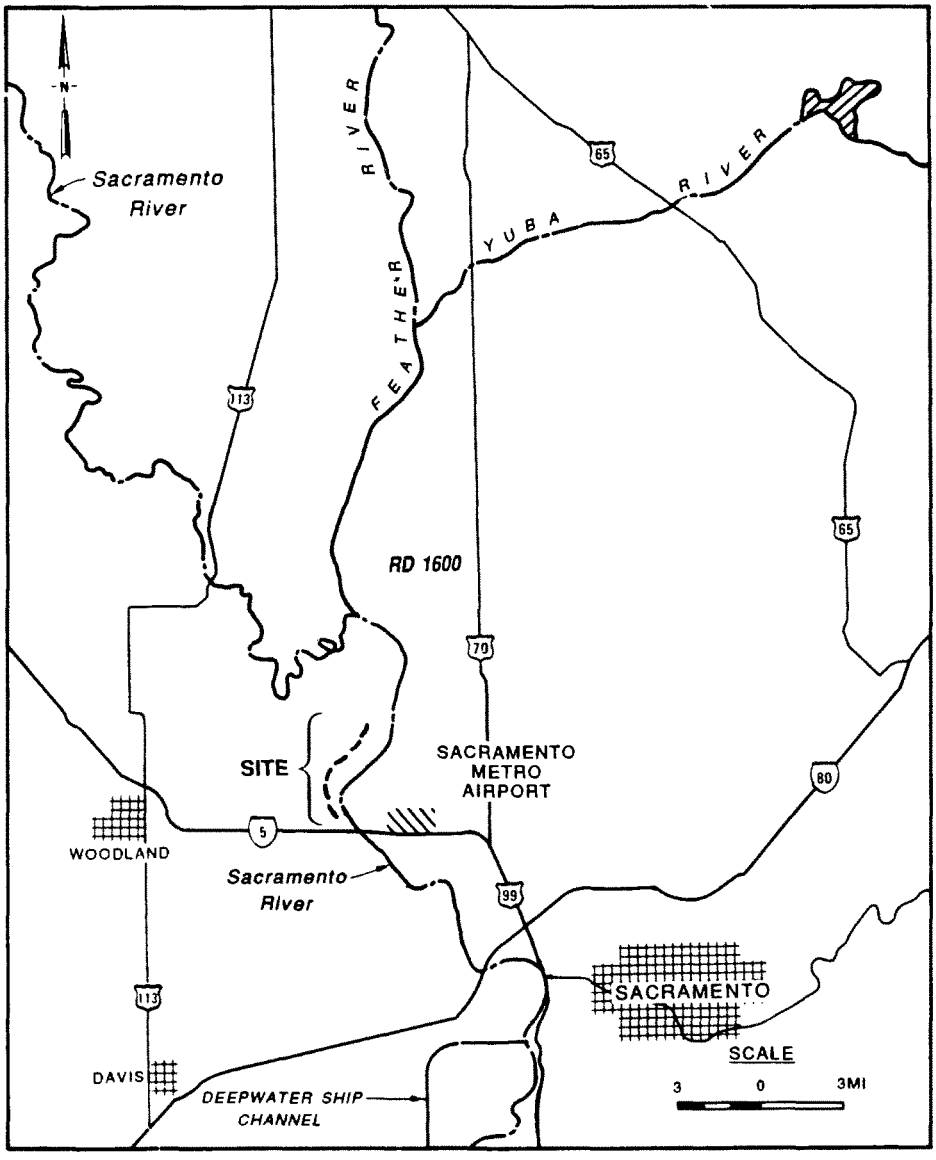


Figure 6. Study site location, Sacramento River, near Elkhorn, CA

met the selection criteria and afforded the best mix of vegetation on an active levee. The levee reach in question contained monospecific clumps of typical native and introduced riparian vegetation, some of which were objectionable from the Sacramento District maintenance point of view, and were not in compliance with levee maintenance engineering manuals (US Army Corps of Engineers 1972, 1978). The director of the local reclamation district, who was a local landowner, gave his permission for the study. Logistical support in the form of a backhoe with an operator and watertank truck was supplied by the local office of the California Department of Water Resources.

Levee characteristics

57. The levee section in question was not engineered, having been built of material dredged from the river and hydraulically deposited on the bank. The levee was constructed between 1912 and 1916 at the height of hydraulic-mining-induced flooding in the Sacramento-Feather River system. The levee consists of a low embankment or dike approximately 12 ft high. An unsurfaced road about 20 ft wide runs along the crest. Seepage is locally a problem; a filter cloth/gravel berm was recently placed along a 100-ft section of the levee on the landward toe of the levee immediately upstream of the study location. There is also a rock revetment bank protection project near the south (downstream) end of the study site.

58. The levee embankment is composed primarily of sandy soils which support mature, 30+-year-old cottonwoods and valley oaks. Black locust, shrubby willows, wild rose, and poison oak make up the balance of the woody plant community growing on the levee. Burning is used to maintain the levee vegetation at its current levels. The fire environment can significantly modify or change levee vegetation. Unfortunately, reliable information on the frequency and timing of burning was not readily available. Only limited information was gathered about the extent to which past burning practices might have altered the vegetative spectrum and other conditions, e.g., root structure and distribution, relative to that which would exist under natural succession. California ground squirrel burrows are ubiquitous in the levee. A general view of the levee illustrating some of the aforementioned features is shown in Figure 7.

59. The steeper, xeric landward slope of the levee generally faces to the west and receives not only the afternoon sun but also the force of occasional strong winds. Additionally, this face of the levee is burned annually to help prevent field fires (see Figure 7). Little grew in this harsh



Figure 7. General view of levee at study site showing vegetation growing on riverward side and burned-over slope on landward side

environment during most of the field sampling period (October through March). During March, after the advent of winter rains and warmer weather, vegetation became lush here. This proved to be the best time to identify species on the landward slope. Valley oaks are the dominant woody species here. Under the oak canopies, grasses and other ground cover, e.g., horsetails (*Equisetum*) are protected from the desiccating sun into the early summer.

60. The level crest of the levee includes a frequently travelled crest road and road shoulders. Most plants here are stunted and only hardy pioneers survive. Most of the growth on this high, dry surface occurs in the early spring when lupine (presumably hydroseeded) covers much of the area. During most of the year, storksbill (*Erodium*) blankets the area.

61. The generally east-facing riverward slope is less steep and more mesic than the landward slope and supports plant growth over a broader temporal range. Valley oaks and Fremont cottonwoods are the dominant species with storksbill totally covering most of the areas that have no tree or shrub canopy.

62. Hydraulic information for the reach of channel adjoining the levee study was calculated from flood hydrograph data measured at the Verona gaging station. Discharges of known duration from the post-Shasta Dam time series of

daily values at the Verona gage were carried upstream using HEC-2 from known stage-discharge relationships at the I-Street bridge discharge gage in downtown Sacramento. HEC-2 cross sections were located at particular study locations along the levee reach in order to estimate the total durations of hydraulic loading at various elevations and to determine the amount of freeboard during peak floods. At its lowest point the levee had less than 2 ft of freeboard during the peak of the winter 1986 floods. The stage-duration estimates were used in conjunction with transient seepage analyses, described later in the report, to determine likely frequency for development of an equilibrium or steady-state phreatic surface in the levee that would intersect the landward toe.

Trench sites

63. The distribution of roots and biopores at various locations in the levee was determined using an adaptation of the profile-wall method (Bohm 1979). This method requires the excavation of a narrow trench in order to expose and map roots, pedotubules, conduits, and other inclusions that intersect the vertical face of the trench. The trench sites were selected so that the root architecture and distribution of the principal woody species of interest growing on the levee could be mapped. Each trench site was located in an area dominated by the following woody species: live and dead valley oaks (*Quercus lobata*) willow (*Salix hindsiana*) elderberry (*Sambucus mexicana*), and black locust (*Robinia pseudoacacia*). In addition a control site consisting of herbaceous cover and low shrubs was also trenched. A total of seven sites were thus identified and selected for trenching; their location is noted on Figure 8. Site No. 1 (cottonwood) was not trenched simply because of time limitations.

Physical Data

Levee cross-section surveys

64. The geometry and dimensions of the levee were determined by field surveys. A cross section was surveyed at each trench site location starting from the landward toe, across the levee crown, to the closest proximity of the edge of the active channel. The latter was usually the top of the riverbank, although poison oak and blackberry bushes precluded this option at the willow and elderberry sites.

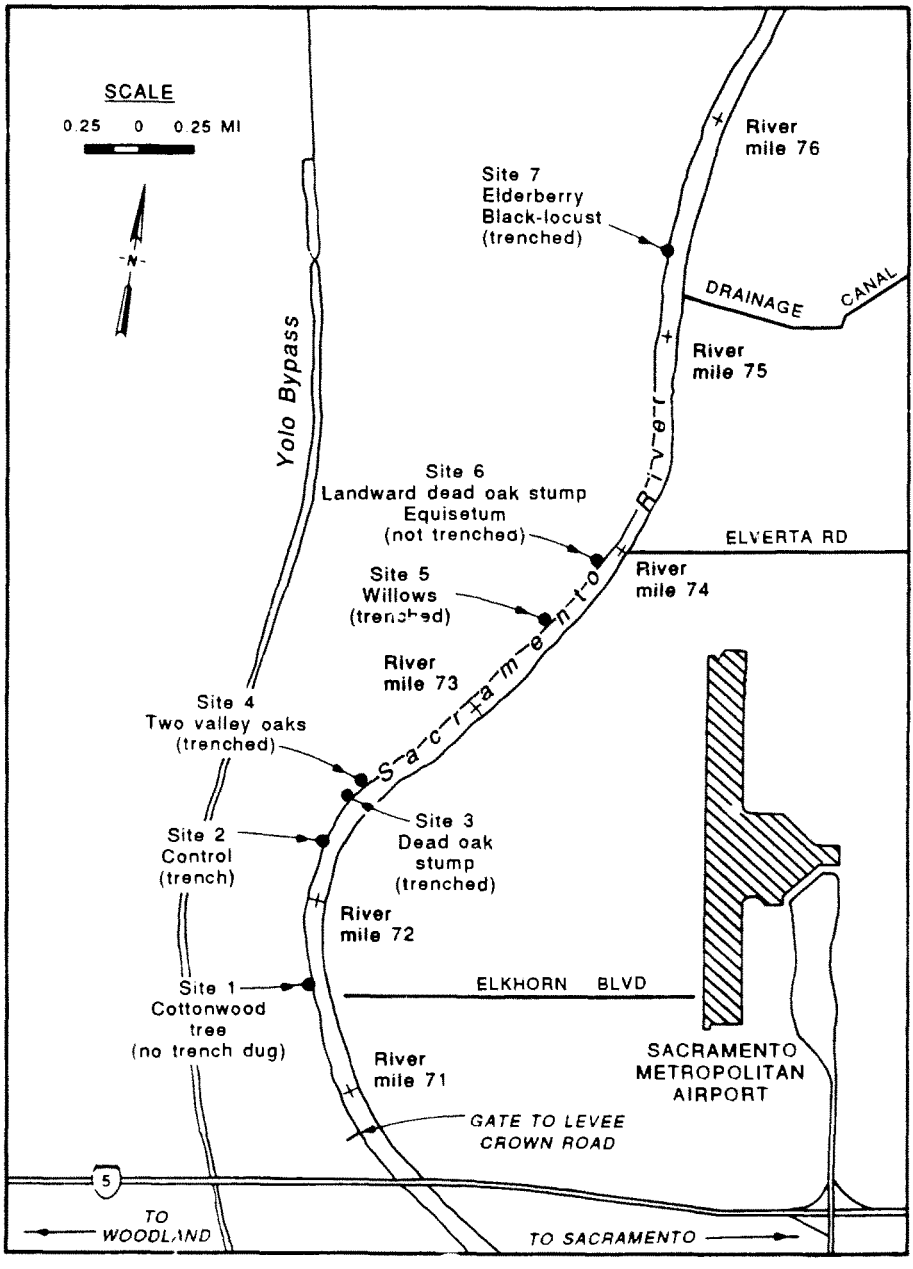


Figure 8. Location of trench sites for determination of root and biopore distribution associated with different types of vegetation

Soil information

65. Grain size analysis. Grain size analyses were conducted in order to classify and characterize the levee soils at each trench site location. Samples for grain size tests were obtained at 6-in. intervals to a depth of 4 ft using a 2-in. bucket type auger. The auger holes or borings were also used in connection with bore hole, direct shear tests. The borings were made along the axis of each trench site prior to trenching. Samples were also collected from suspected pedotubules. A pedotubule is a relict conduit or biopore that has been infilled by soil that is washed in from the surrounding area (Brewer and Sleeman 1963). In this case samples were taken from the area of the suspected pedotubule and surrounding soil as well. Differences in gradation between the two areas were interpreted as supporting evidence for a pedotubule. An example of a pedotubule that was exposed in a trench at the live oak site is shown in Figure 9.

66. Grain size distribution was determined using standard testing procedures as described in ASTM D422-58 (ASTM 1985). Most samples were predominantly coarse-grained, so that a sieve analysis alone sufficed to determine gradation.

67. Field density tests. Field densities were measured at different depths and locations along the trenches in order to determine the influence, if detectable, of plant roots on soil void ratio or porosity. Porosity is inversely proportional to dry density. The field density of soils at the trench sites was determined by means of a small tube sampler known as an Eley volumeter. The volumeter consists of a tube with a piston that is pushed into the soil a distance of approximately 3 in. The volumeter and its contents are then excavated, and a calibrated volume of soil (usually 30 cm^3) is extruded from the sampler into a sample bag. The soil is later oven-dried and weighed to determine the dry density. The dry density is determined by dividing the dry weight of solids by the extruded volume.

68. Volumeter samples were obtained from the exposed, vertical faces of the trenches as close to the bore holes used for grain size sampling and the insitu, direct shear tests. Samples were also removed from areas of suspected pedotubules. Contrasts in density between the suspected pedotubule and surrounding soil were also used as supporting evidence for the existence of a pedotubule at that location in the same manner cited previously.

69. Borehole shear tests. Effective shear strength parameters, i.e., friction ($\emptyset'$) and cohesion (c') were determined in situ using an Iowa



Figure 9. Suspected pedotubule exposed in vertical face of trench at live valley oak site (site 4) at depth of 2 ft (pedotubule appears as light-colored area with eliptical cross section in center of photograph)

borehole, direct shear device (Wineland 1975; Handy 1986). Shear strength can be determined rapidly as a function of depth with this device without the need to obtain samples. The borehole shear test consists of augering a pilot hole and then reaming to a diameter of 3 in. in order to create a borehole with smooth sides. A small pneumatic piston with serrated shearing heads at either end is then lowered down the borehole to the depth of interest. The serrated heads are next expanded out against the sides of the hole with a known normal stress. After an appropriate consolidation interval, the heads are pulled up the hole, thus creating a shearing stress. The tangential or shearing stress is recorded by means of a force platform at the surface which transfers the tensile force in the pulling rods to hydulic cells which record the shearing stress at the serrated heads in the borehole as shown schematically in Figure 10. A photograph of a borehole shear test set up at a levee site is shown in Figure 11.

70. Some difficulty with the borehole shear method is encountered in the case of very dry, cohesionless soils where the borehole tends to cave.

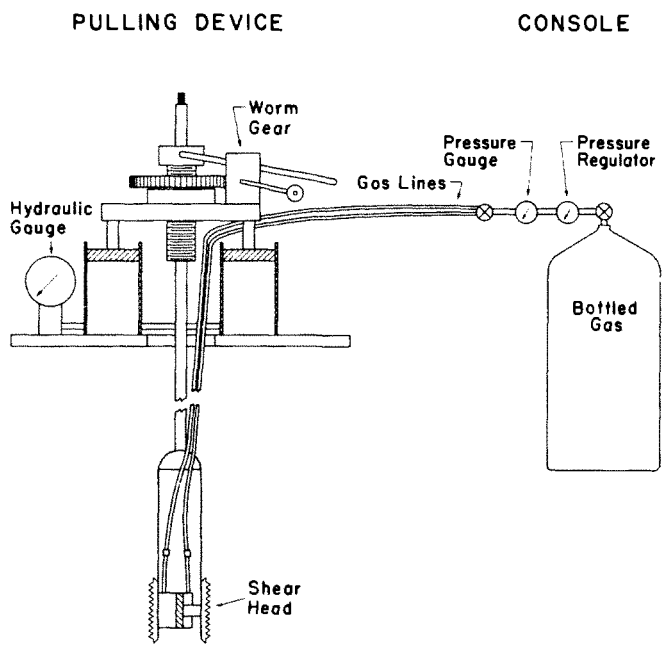


Figure 10. Schematic illustration of Iowa borehole direct shear device (*from* Wineland 1975)

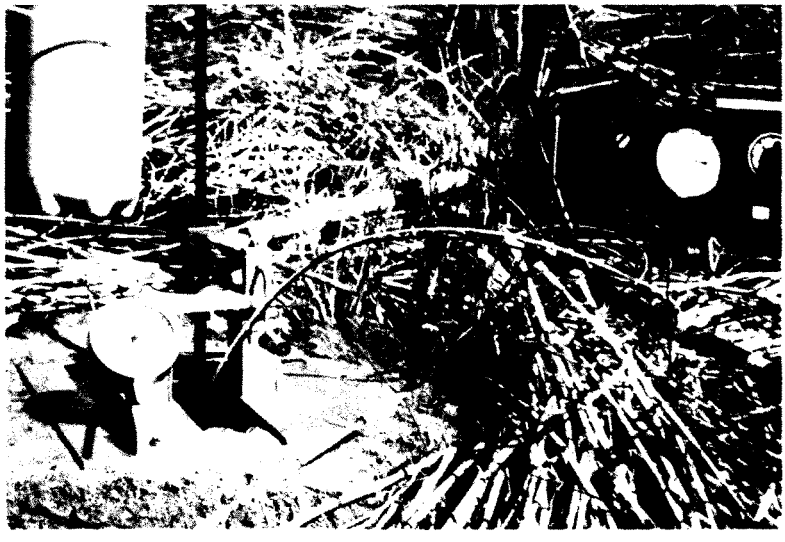


Figure 11. Iowa borehole shear test set up at levee site

This problem was circumvented at the levee site by prewetting the soil to provide sufficient capillary cohesion to prevent the soil from collapsing. This small amount of capillary or apparent cohesion vanishes below the groundwater table or when a sand dries out completely.

Botanical Data

Aboveground (vegetation inventories)

71. Transect surveys. The levee vegetation was surveyed in order to determine typical species composition, distribution, and cover in the study reach cover. In order to obtain a random sample of the vegetation along the 6-mile study section, the levee was divided into miles, starting from the gate on the levee crest road at the south end of the section. Each of the miles was divided into tenths and the tenths subdivided into fifty-three 10-ft-wide segments. The segments were oriented perpendicular to the crest road (or river) and extended from the landward toe of the levee to the riverbank edge. A random numbers table was then used to choose a mile tenth and a 10-ft segment within that tenth for a vegetation survey. A single 1-m-wide transect was then located at the south end of each selected 10-ft segment.

72. The boundaries of the 1-m transects were marked on the ground. Starting at the riverbank, the percent of each transect covered with vegetation was noted in addition to the cover fraction contributed by each genus (if it could be discerned). General categories were utilized if no identifications could be made. The vegetation was divided into three categories: trees, shrubs, and ground cover. Each category was estimated or actually drawn on the plots of the transects and later counted using graph paper. A matrix of plant genera (or general class) versus environment of the transect was plotted following the procedure described by Whitlow and Bahre (1984).

73. Trench site surveys. The trench sites were not randomly selected; instead they were located according to vegetation of interest, e.g., valley oak, willow, elderberry, etc. In general, the trenches were excavated on a line that intersected the canopy edge of the dominant species at the site. All of the live, aboveground vegetation within a 1-m strip 1 m on either side of what eventually would become the inspection face of the trench was inventoried. Measurements were made of the exact location of the plant stem or stems, the canopy cover and the height of each species of grass, forb, or shrub. This information was plotted on a graph of the area. In the case of

the valley oak and black locust canopies, notations were entered on the plot but not recorded as ground cover. The percent of total ground covered and the total cover of each species within the total cover were recorded in a tabular format.

Belowground (excavation and trench profiling)

74. In order to address the question of the amount and distribution of roots in levees, a series of trenches were excavated in the levee section at selected locations. Each trench was located in an area dominated by a different type of woody species of interest. The root density distribution with depth was mapped on two trench faces, one parallel and one perpendicular to the levee crest. The profile-wall method described by Bohm (1979) was adapted for root and bipore mapping at all the trench sites with live vegetation present. The so-called "partial excavation" method, also described by Bohm, was used at the dead valley oak site in order to gain a better idea of the root architecture as well.

75. Trenching procedure. An L-shaped trench approximately 4-ft deep was dug at each site. One arm of the trench was oriented parallel, and the other perpendicular, to the levee crest. The trench arms were usually located at the drip line or crown edge of the plant(s) of interest. In some cases the trench was positioned to pass close to the approximate center of a clump of stems.

76. Because of the loose, sandy nature of the levee soils it was necessary to water the site before excavation could proceed. Watering developed sufficient capillary cohesion in the soil to permit trenching without collapse of the vertical face of the trench. An 8,000-gal watering truck and spray hose (see Figure 12) were employed for this purpose. The live oak site required four truckloads of water before sufficient capillary cohesion developed over the entire trench site.

77. Following watering and prior to excavation, a pruning saw was run along the flagged trench face line to cut surface roots. The saw cut roots up to 8 to 10 in. below the ground line, thereby limiting disturbance to the mapping face from subsequent excavation. The trench was excavated with a backhoe; the bucket was kept approximately 6 in. away from the proposed mapping face. Care was taken not to break roots back into the face. Field crew members were on hand with pruning saws to cut any roots that were not easily



Figure 12. Watering truck and spray hose employed to wet site prior to excavation

broken by the backhoe bucket. This requirement was especially critical in the case of any large-diameter lateral roots encountered in the trench.

78. After the backhoe work, the soil along the trench sides was trimmed back to the mapping face using hand tools. A square-nosed shovel was used for rough trimming followed by smoothing with a mason's trowel. Roots were cut back to the finished face with either a pruning saw or shears. Mist spraying was employed periodically to keep the face moist and to prevent sloughing or ravelling. Hand trimming was done in two stages. The upper half of the trench was finished first, leaving a ledge on which to rest the mapping apparatus. General views of the trench layout and finishing operations prior to mapping are shown in Figures 13 and 14.

79. Mapping procedure. The roots were mapped on an acetate overlay held on a portable PVC mapping frame. The tubular frames were rectangular in shape with a mapping area 1.0 m by 0.5 m. Strings were strung across the frame on a 10-cm grid spacing. The string grid greatly facilitated keeping track of features as they were mapped and also maintaining correct placement of the mapping frame. Removable holders were placed at each end of the frame for both take-up and supply of the acetate rolls. The frames were pressed against the smoothed, vertical face of the trench, and roots plus other



Figure 13. General view of trench layout for root mapping at valley oak site



Figure 14. View of trench showing vertical mapping face and roots protruding from trench sides (burrow is visible in upper center of photo)

features mapped directly on the acetate. Mapping was done along the upper half of the trench by successively moving the frame along the ledge and advancing the acetate roll to a new position. After the upper half was mapped, the ledge at midheight was trimmed away, and the bottom half mapped in a similar fashion. Views of a mapping operation in progress are shown in Figures 15 and 16.

80. The following features were mapped on the acetate overlay:

a. Roots in the size classes < 1 mm, 1-2 mm, 2-5 mm, 5-10 mm, 10-20 mm, 20-30 mm, 30-50 mm, and > 50 mm. The actual diameter was noted or the root cross section outlined on the acetate for roots in the last category.

b. Voids or macropores with the shape and likely cause of void where obvious. Recent ground squirrel burrows were relatively easy to identify.

c. Mineral inclusions of rocks, clay clods, etc.

d. Gross stratigraphy such as different soil layers, burned layers.

81. At the conclusion of mapping, the trenches were backfilled with the excavated soil and compacted. Trench profiling was employed at all the sites of interest with the exception of the dead valley oak site. Only a stump was present here so the soil was removed on all sides in order to expose as much of the root system as possible and reveal the root structure or architecture.



Figure 15. Mapping in progress along upper half of trench face at valley oak site (mapping frame is resting on mid-height ledge)



Figure 16. Closeup view of mapping frame showing acetate sheet, take-up and supply holders, and string grid

PART IV: DATA ANALYSIS AND RESULTS

Physical Data

Levee geometry and stratigraphy

82. Channel levees along the Sacramento River typically consist of a low embankment approximately 12 ft high with a 3:1 slope on the riverward side and 2:1 slope on the landward side. An unsurfaced roadway about 20 ft wide runs along the crest of the levee.

83. Levee cross sections surveyed at each of the trench sites are shown in Figures 17 through 20. The standard levee section is superimposed on these diagrams for comparison. In general the actual cross sections closely matched the standard section. In some locations, e.g., sites 2-4, the riverward slope is less steep than the standard 3:1 slope. A relatively flat terrace of varying width separated the riverward toe of the levee from the top of the riverbank.

84. The levee in the study section was constructed primarily of sandy materials dredged from the river and hydraulically deposited on the bank. The levee soils consist primarily of medium to fine sands with little or no fines (silt or clay). Evidence from boreholes and trenches dug in the levee suggests that the finer materials that occasionally showed up tend to be located at depth, and in some cases may actually occur in the foundation as opposed to the levee itself. Nevertheless, small zones or inclusions of clay or silty clay can also be found in the structure. In some cases fissures or cracks in these clay inclusions are permeated with roots as shown in Figure 21. Roots exploit these zones, most likely because of greater water retention and availability in comparison to the surrounding, droughty sand. There was little evidence of any consistent vertical zonation or stratigraphic pattern. Stratification was evident in some locations on the riverward side where sediments had been deposited on the levee slope during overbank flows. Stratification was clearly delineated in this case by the presence of buried carbonaceous layers from previous levee burning. Examples of this stratification are shown in Figure 22.

Soil properties

85. Gradation and classification. The levee soils generally consist of fairly uniform, medium to fine sands with little or no fines (silts or clays).

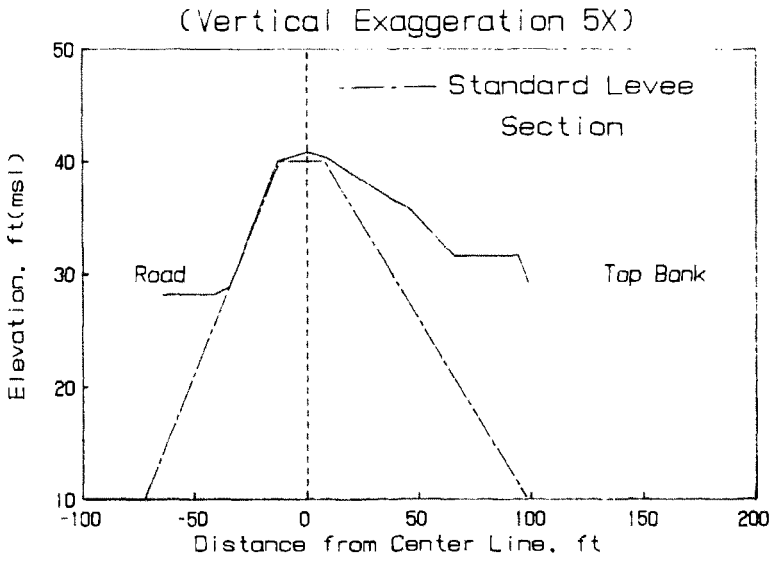


Figure 17. Levee cross-section profile, control site (site 2)

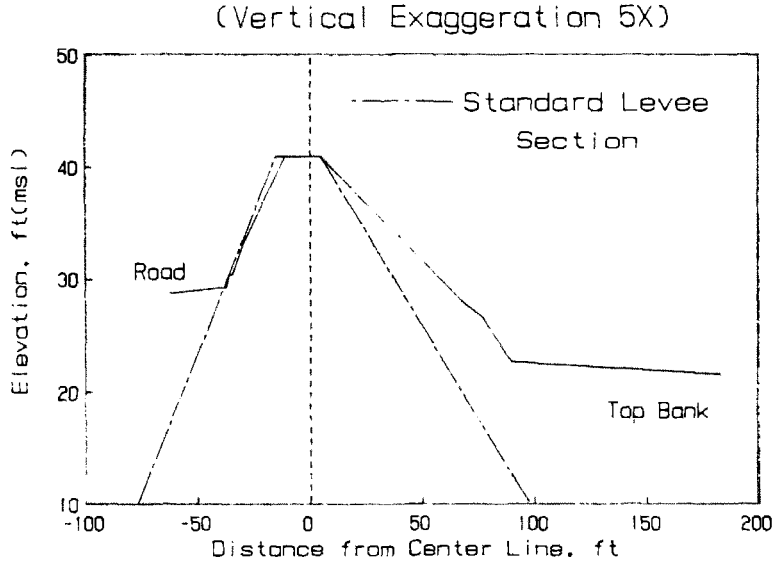


Figure 18. Levee cross-section profile, live oak site (site 4)

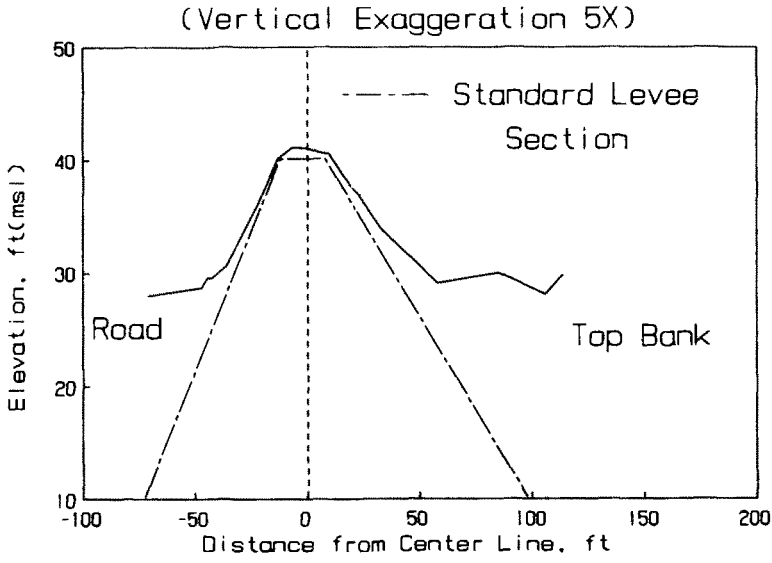


Figure 19. Levee cross-section profile, willow site (site 5)

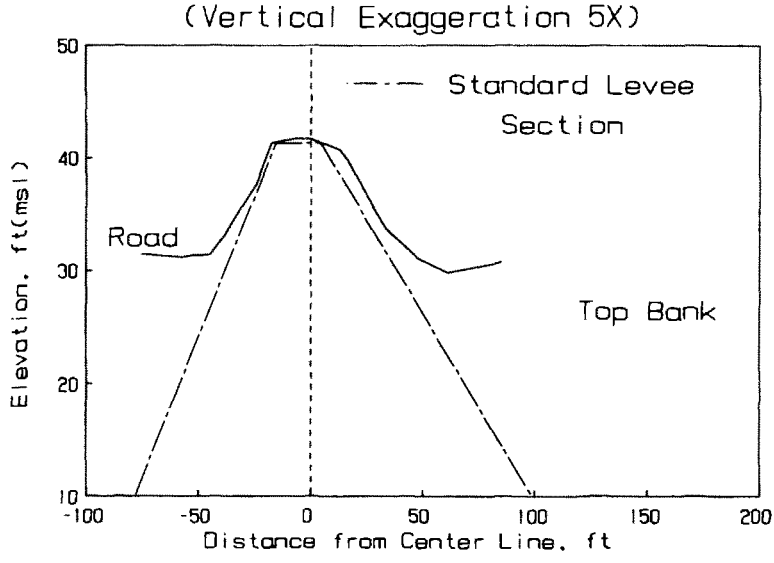


Figure 20. Levee cross-section profile, elderberry site (site 7)



Figure 21. Fissure in large clay clod or inclusion that has been permeated by a tree root

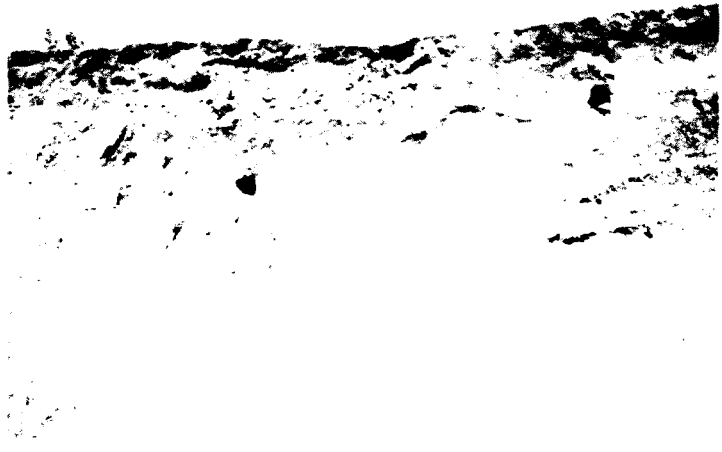


Figure 22. Example of vertical zonation or stratification on riverward levee slope caused by deposition of sediments during overbank flows

The Unified Soil Classification system design tion for the levee soil is SP. The gradation curves shown in Figure 23 for samples from site 3 are typical.

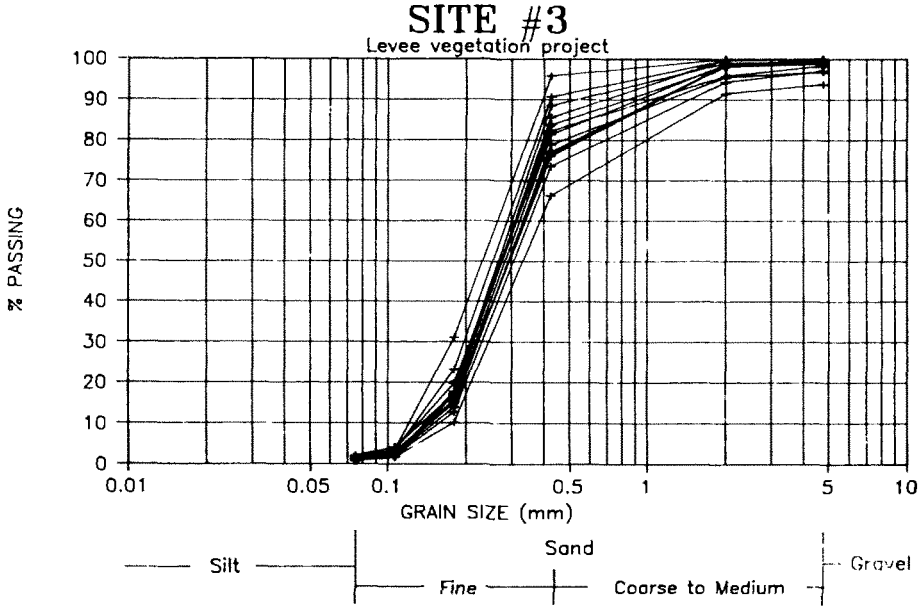


Figure 23. Grain size distribution curves for levee samples from site 3 (samples obtained from different boring locations and depths at site)

86. Field density. The sandy levee soil is generally in a fairly loose condition. The average dry density for all samples was 90 pcf. The site averages ranged from 85 to 92 pcf. Higher sample densities correlated or corresponded to sites that contained larger amounts of fines. No obvious or discernible relationship was observed between density and depth.

87. Permeability. The permeability of selected reconstituted samples of dry, sandy levee soil was determined using a gas permeameter. The permeability ranged from 0.03 to 0.07 cm/sec depending upon the void ratio. This permeability range is typical for a medium sand, and is consistent with the results of the gradation analyses. The sandy soil obeyed the Kozeny-Karman equation which predicts a linear relation between permeability (K) and $(e^3/1+e)$; where e is the void ratio. This functional relationship is shown plotted in Figure 24 for one of the samples that was tested.

88. Shear strength parameters. Effective shear strength parameters, namely, friction ($\emptyset'$) and cohesion (c'), were determined using an Iowa bore

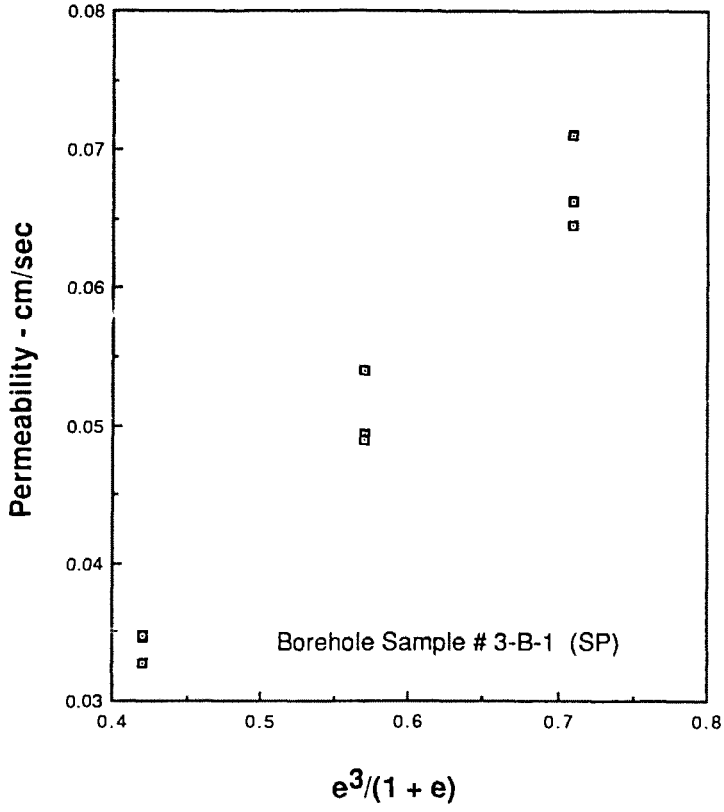


Figure 24. Typical functional relationship between permeability and void ratio for sandy levee samples

hole, direct shear device. Failure envelopes were obtained rapidly as a function of depth and checked on site. Typical failure envelopes for two depths in a test boring at Site 3 are shown in Figure 25.

89. The frequency distribution for both the cohesion and friction values from all borings are shown in Figures 26 and 27, respectively. The averages of all borings on the levee are:

Average friction angle = 31.6 deg
Average cohesion = 1.2 psi

The standard deviations were 3.7 deg and 0.62 psi for friction and cohesion, respectively. These results are reasonable for a medium, fine sand. The

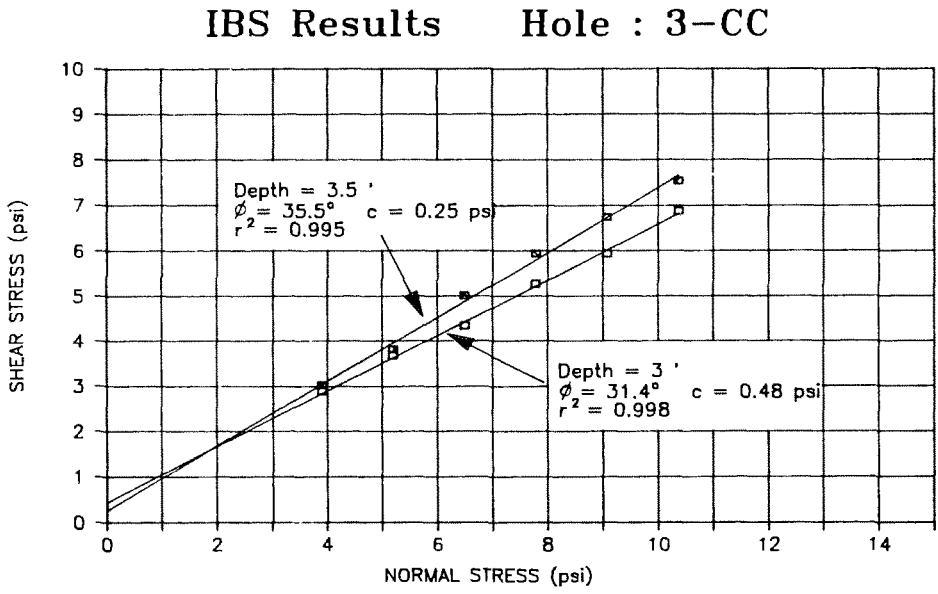


Figure 25. Example of failure envelopes obtained from Iowa borehole shear test borings at site 3

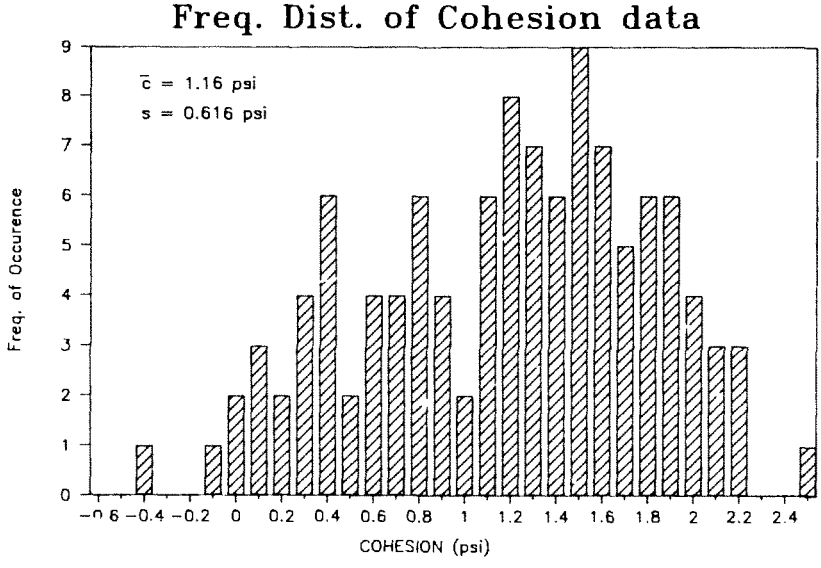


Figure 26. Frequency distribution of cohesion values obtained from all borehole shear test borings

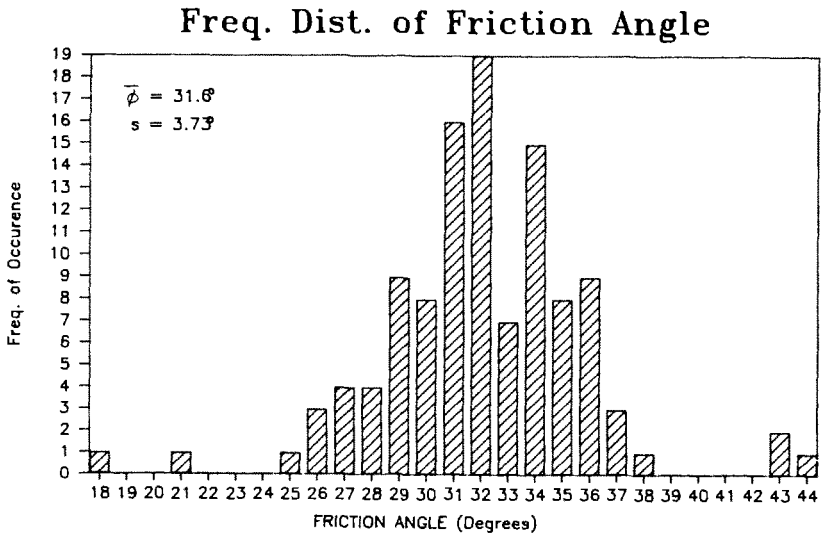


Figure 27. Frequency distribution of friction values obtained from all borehole shear test borings

general higher values of friction were observed where cohesion was low and vice versa. A plot of friction versus cohesion for all results (test borings) is shown in Figure 28. A linear regression analysis (R = 0.645) of this data yielded the following relationship.

$$\phi = 36.0 - 3.82c \quad (1)$$

where: ϕ = friction angle (degrees and c = cohesion (psi)

90. High cohesion values were associated with soil samples having a higher content of fines. As noted previously, these same samples also tended to have higher densities. Not surprisingly, therefore, a correlation was also observed between average site cohesion and average site density. Cohesion increases with increasing density as shown in Figure 29. The number above each point in the plot corresponds to the site number. The sites with large amounts of fines (sites 5, 7A, and 7B) exhibit the highest cohesion and soil density, whereas sites with lesser amounts of fines (sites 2, 3, and 4) have lower cohesions and densities.

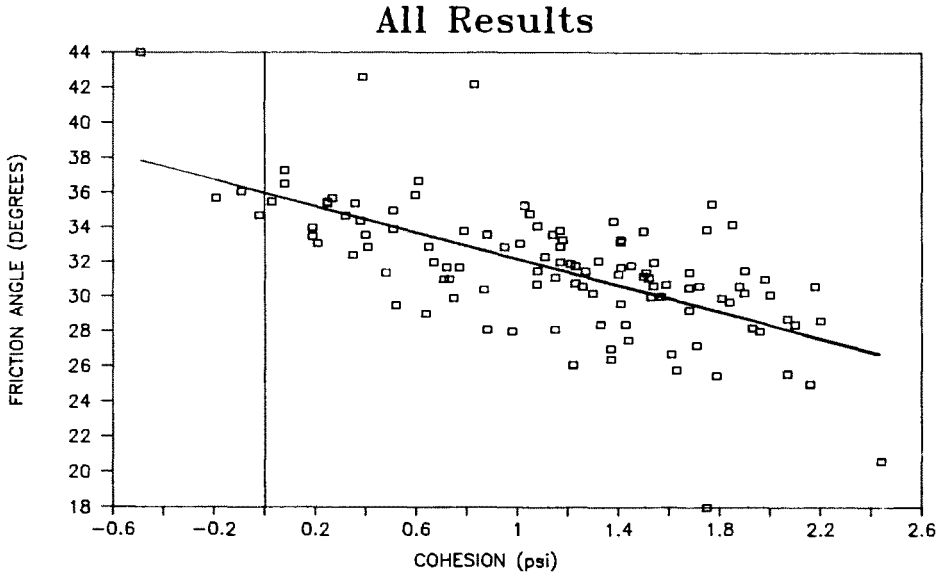


Figure 28. Friction vs. cohesion results for all test borings showing best-fit linear regression curve

91. Some evidence of root reinforcement was observed in the failure envelopes of a few test borings using the bore hole shear device. A photograph of a test boring site illustrating the extent of root permeation around the former bore hole is shown in Figure 30. The Iowa bore hole shear device is not ideally suited or designed to detect and measure root reinforcement influences on shear strength because the roots no longer penetrate fully across the failure surface after boring and reaming a hole to accommodate the shear head. Nevertheless, root/fiber reinforcement effects still manifested themselves in the form of bilinear or curved-linear failure envelopes in some instances, as illustrated in Figure 31. A distinct bilinear failure envelope was observed at a depth of 1 ft at this location (site 4).

92. Bilinear or curved-linear failure envelopes are typical of fiber reinforced sands as demonstrated by the work of Gray and Al-Refeai (1986); Gray and Maher (1989). Their work indicated that failure envelopes become strongly bilinear, as opposed to curved-linear, as the gradation and angularity of soil particles increase. The vertical displacement of the failure envelope above the reference or unreinforced envelope can be interpreted as a

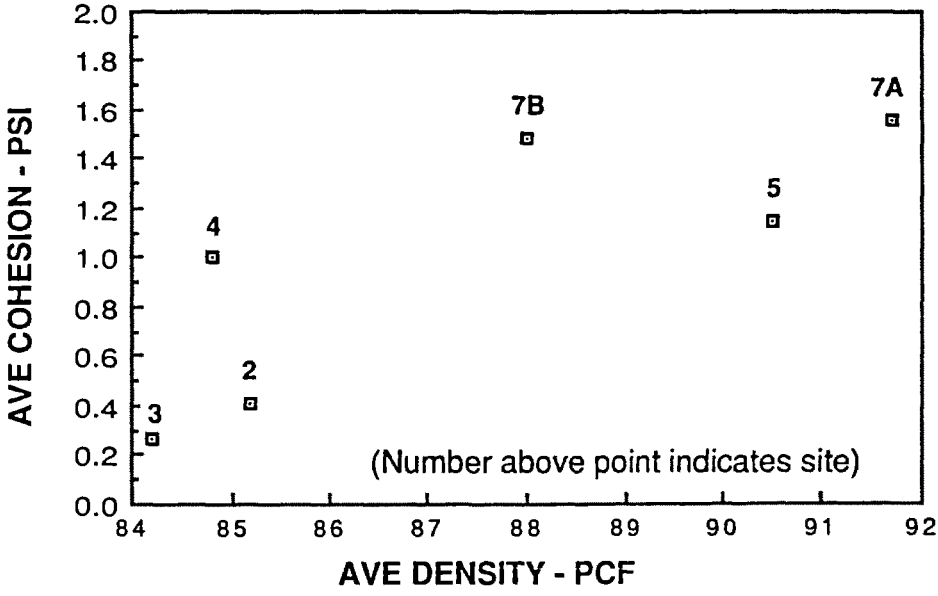


Figure 29. Average site cohesion versus average site soil density for in situ levee soils



Figure 30. Root permeation of sandy soil around former borehole location, site 4

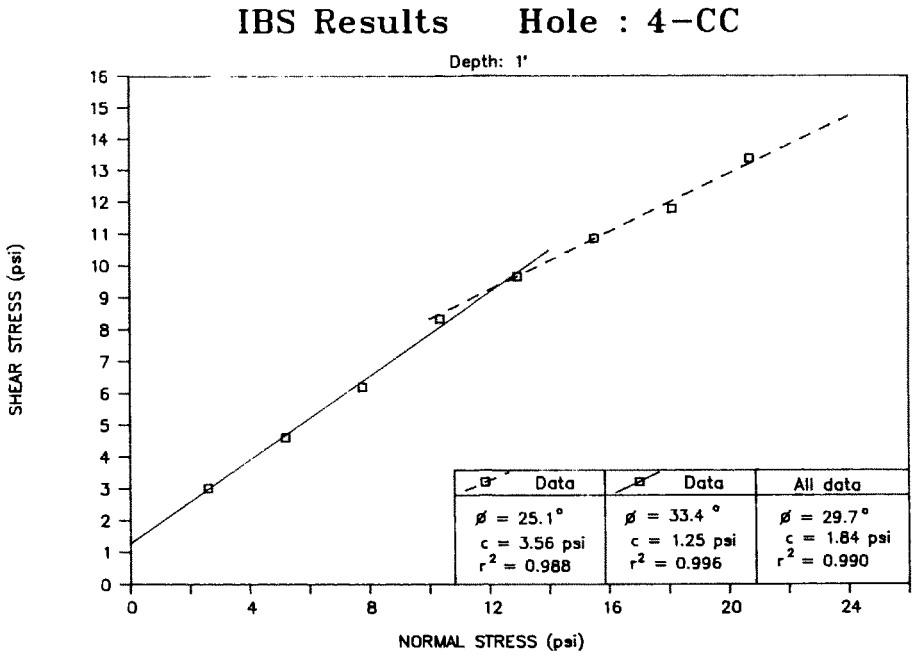


Figure 31. Bilinear failure envelope obtained in borehole shear test at site 4

measure of the additional shear strength or "fiber cohesion" imparted by the presence of the roots.

Botanical Data

Aboveground (vegetation)

93. Transect surveys. A total of seventeen 10-ft-wide transects were randomly selected (as described previously) for determination of the vegetation species composition and percent cover. The transect surveys showed that valley oak (*Quercus lobata*) and cottonwood (*Populus fremontii*) were the dominant tree species on the levee test section. Valley oak appeared well adapted to all levee environments and was the only arboreal species found growing on both landward and riverward slopes of the levee in addition to the levee crest area. All the other tree or shrub species, with the exception of California rose (*Rosa californica*) and licorice (*Glycyrrhiza* sp.), were found on the

riverward slopes only. Among the shrubs, licorice appeared to be particularly well adapted to all levee environments and vegetation management practices. This plant has an extensive root system and thrives on burning. A few weeks after firing the levee, licorice sprouted vigorously from its intact underground root system.

94. Vegetation cover for all transects by position on the levee, i.e., landward slope, crest area, and riverward slope, is summarized in Table 2. This summary table shows that ground cover (grasses and forbs) account for most of the plant cover, with shrubs occupying an insignificant proportion of the transect areas. Tree cover was 11 percent on the riverward slope, but less than 1 percent elsewhere.

Table 2

Summary of Vegetation Cover for All Transects by Location on the Levee Section

Levee Section Location	% Tree Cover	% Shrub Cover	% Ground Cover
Landward slope	0.44	0.08	48.1
Crest area	0.15	0.00	36.7
Riverward slope	11.00	0.10	40.4

95. Trench vegetation surveys. In addition to randomly selected transects, the species composition and cover were also determined at each of the trench sites as described previously. The location of different plants and the trace of their crowns, in the case of shrub or tree species, were superimposed on layout maps of each trench site. The absolute and relative cover for each major species were computed in this fashion. These results are summarized in Table 3. Percent cover pertains only to herbaceous plants, shrubs, and shrubby tree species (e.g., willow and black locust). The valley oak canopy was not included in these estimates.

"Belowground" vegetation

96. The profile-wall method (Bohm 1979) was adapted to determine the distribution and concentration of plant roots below ground. Sites with valley oak, black locust, willow, and elderberry were selected for root mapping in

Table 3

Species Composition and Plant Cover at Trench Sites

Species	Common Name	Absolute Cover (percent)					
		Control	Dead Oak	Live Oak	Willow	Elderberry	Black Locust
Grasses (various)	--	16.8	Burned	--	Burned	Burned	ND
Sedges (various)	--	6.7	--	<0.1	Burned	--	--
Rosa californica	California rose	31.6	--	5.9	--	3.7	2.1
Heterotheca grandiflora	Telegraph weed	1.5	--	--	--	--	--
Lotus purshianus	Lotus	0.2	--	--	--	--	--
Glycyrrhiza lepidota	Licorice	--	--	13.3	--	--	--
Sisymbrium officinale	Mustard	--	--	~4.7	--	--	0.4
Convolulus spp.	Bindweed	--	--	<0.1	--	--	--
Salix hindsiana	Willow	--	--	--	~10	--	--
Sambucus mexicana	Elderberry	--	--	--	--	72.0	--
Ribes spp.	Blackberry	--	--	--	--	1.7	--
Robinia pseudoacacia	Black locust	--	--	--	--	--	72.4

the field. At each site, mapping trenches were laid out running both parallel and perpendicular to the crest of the levee. In general the trenches were located tangentially at the crown edge or drip line of the tree species of interest. At the elderberry site the perpendicular trench was excavated through the approximate center of the clump or grove of elderberry bushes whereas the parallel trench was excavated tangentially to the crown edge.

97. Total area ratio profiles. The belowground mapping results are presented in several ways. Histograms or frequency distributions of all mapped features (roots, voids, pedotubules, and mineral inclusions) were prepared from the acetate overlay used in the field mapping program. The occurrence of these features is reported as an "area ratio," i.e., the percent of the trench face or cross-sectional area occupied by a particular feature. Typical histograms for the perpendicular and parallel trenches, respectively, showing the area ratios for different features as a function of depth at the elderberry site (site 7) are shown in Figures 32 and 33. Total area ratio histograms for the other sites are collected in Appendix A. An area ratio histogram for all features and depths as a function of position along the trench in the perpendicular trench arm at the elderberry site is shown in Figure 34. The bulge or peak in the histogram at mid-distance simply reflects the proximity of the plant stems at this position and the greater concentration of roots close to the stems.

98. Root area ratio (RAR) profiles. The fraction of the trench face or total cross-sectional area occupied by roots is referred to herein as "root area ratio (RAR)." This ratio is normally reported in percent. The RAR results can be presented in a variety of graphical and tabular formats which emphasize different aspects of the information. The RARs as a function of depth for all sites are summarized in Table 4. The RARs typically did not exceed more than 2 percent of the total cross-sectional area at any depth. The largest ratio was recorded at the control site at shallow depth due to the presence of abundant roots of herbaceous cover and California rose plants. The next highest root area ratio (1.1 percent) was measured at the elderberry site at a depth interval of 8-12 in. in the perpendicular trench. This trench passed close to the centers of the clump of elderberry bushes.

99. The RARs tended to decrease with depth in nearly every case. This trend is shown in Figures 35 through 37. Average RAR versus depth is shown in Figure 35 for the control, oak, and elderberry/willow/black locust sites.

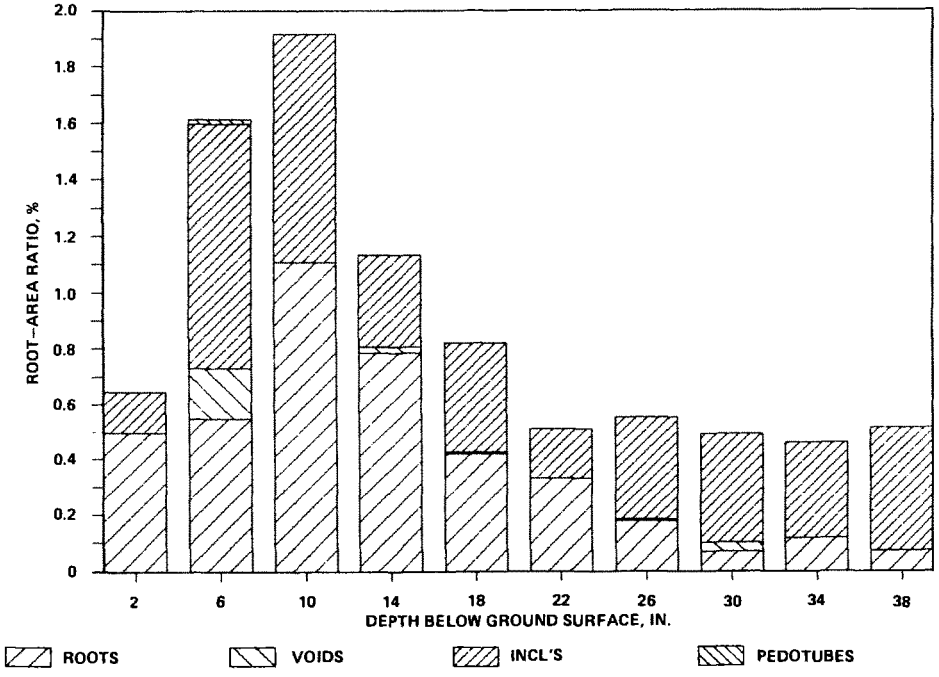


Figure 32. Total area ratio vs. depth, perpendicular trench, elderberry site (site 7)

Figures 36 and 37 show RAR-depth profiles for all sites (species) plotted on arithmetic and logarithmic scales, respectively. Average RARs decreased to less than 0.1 percent in all cases at depths greater than 40 in. These root distributions and concentrations are consistent with trends and values reported in the horticultural literature. A plot of RAR versus depth for the elderberry site at the parallel and perpendicular mapping trenches is shown in Figure 38. Root concentrations decreased approximately exponentially with depth at the perpendicular trench which passed close to the centers of the stems, whereas root concentrations tended to decrease linearly with depth in the parallel trench which was located at the drip line of the bushes. These root distributions were used later to estimate likely rooting contributions to shear strength.

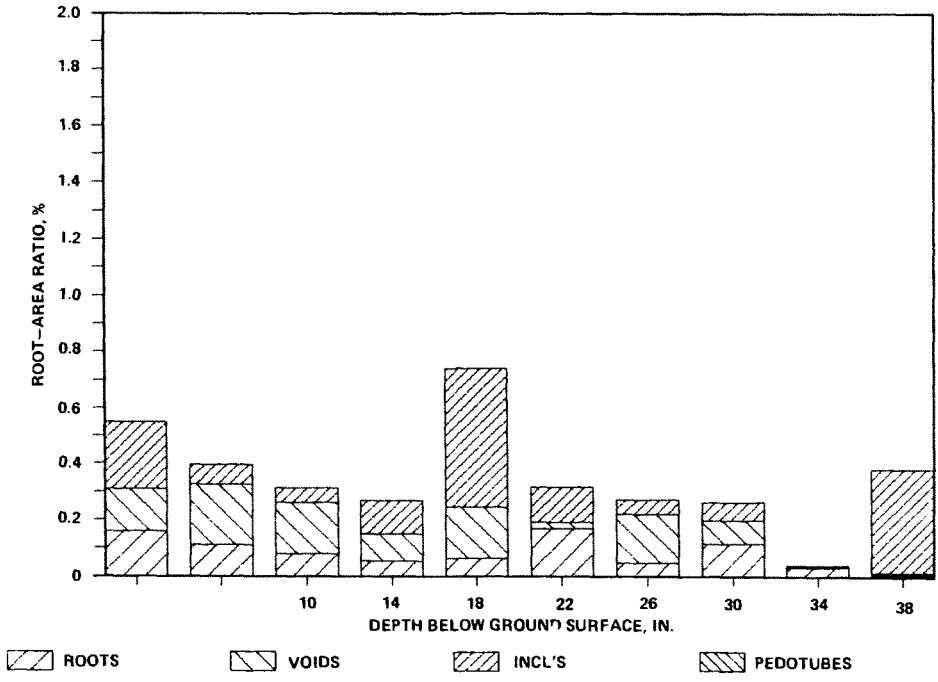


Figure 33. Total area ratio vs. depth, parallel trench, elderberry site (site 7)

100. The RAR is plotted versus species for different depth intervals in Figures 39 through 41. Flat, horizontal curves would indicate that no one species produces more roots than another. No consistent pattern or trend emerges from these plots...in the sense that one species can be said to have much higher root area ratios over its entire rooted depth compared to other species. The elderberry site tended to exhibit slightly higher ratios over its entire rooted depth compared to the other species but this result was biased somewhat by the location of the perpendicular trench close to the centers of the elderberry bush stems. Plots of RAR's versus species for different depth intervals for the other sites are collected in Appendix B.

101. Root size frequency distributions. The RAR is a useful, but highly aggregated parameter. Also of interest is the distribution of different size classes of roots with depth by species. This information was

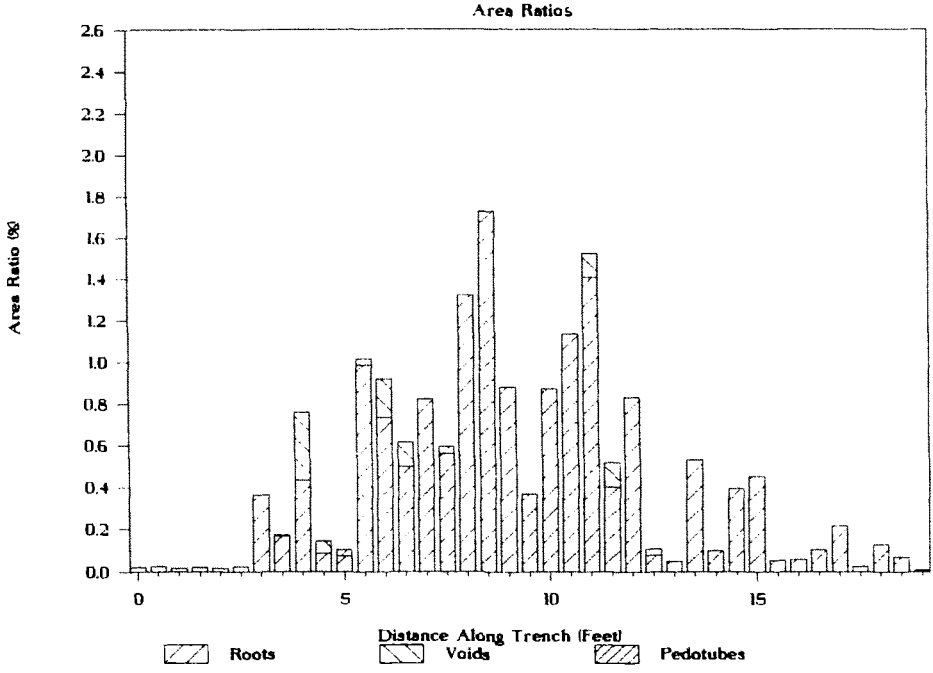


Figure 34. Total area ratio versus distance along trench, all depths, perpendicular trench, elderberry site

recorded directly on the acetate overlays during the field mapping program. Root size distribution plots are shown in a 3-D format in Figures 42 and 43 for parallel trenches at the live oak and elderberry sites, respectively. These two sites represent two extremes of woody vegetation, namely, large mature trees versus low shrubby bushes. Both trenches also were located at the drip line or crown edge. The root area ratio profiles for these two sites are similar in trend; however, the oak site has almost twice the total root area (summed over all depth intervals) as the elderberry site. This difference is due to the presence in general of larger roots at the oak site as can be seen by comparing Figures 42 and 43 and noting the greater number of roots in the larger size classes (classes 1-3) at the live oak site. Root size distribution plots for the other sites are collected in Appendix C.

102. Root architecture (structure). In order to gain some insights into root architecture or structure, a dead oak stump was completely excavated

Table 4

Root Area Ratios (Percent) Versus Depth at Trench Sites

	Control		Dead Oak		Live Oak		Willow		Elderberry		Black Locust	
Depth	Par.	Perp.	Par.	Perp.	Par.	Perp.	Par.	Perp.	Par.	Perp.	Par.	Perp.
0-4	2.02	0.10	0.04	0.001	0.32	0.01	0.03	0.20	0.16	0.50	0.03	0.85
4-8	0.02	0.62	0.02	0.01	0.23	0.04	0.10	0.18	0.11	0.55	0.12	0.07
8-12	0.01	0.18	0.40	0.01	0.28	0.01	0.36	0.26	0.08	1.11	0.07	0.62
12-16	0.10	0.12	0.11	0.003	0.25	0.01	0.01	0.20	0.05	0.78	0.02	1.02
16-20	0.19	0.01	0.04	0.01	0.15	0.02	0.01	0.10	0.06	0.42	0.02	0.87
20-24	ND	0.06	0.03	0.01	0.06	0.12	0.01	0.05	0.17	0.33	0.002	0.01
24-28	ND	0.39	1.06	0.001	0.09	0.02	0.01	0.03	0.05	0.18	0.001	0.02
28-32	ND	0.06	0.004	0.03	0.09	0.04	0.01	0.004	0.11	0.07	0.001	0.13
32-36	ND	0.10	0.09	0.24	0.13	0.02	0.001	0.06	0.03	0.12	0.001	0.01
36-40	ND	0.15	0.001	0.16	0.08	0.13	0.004	0.34	0.01	0.07	0.001	0.001

Depth below levee surface, inches (4 in. = 0.102 m)
ND: No data

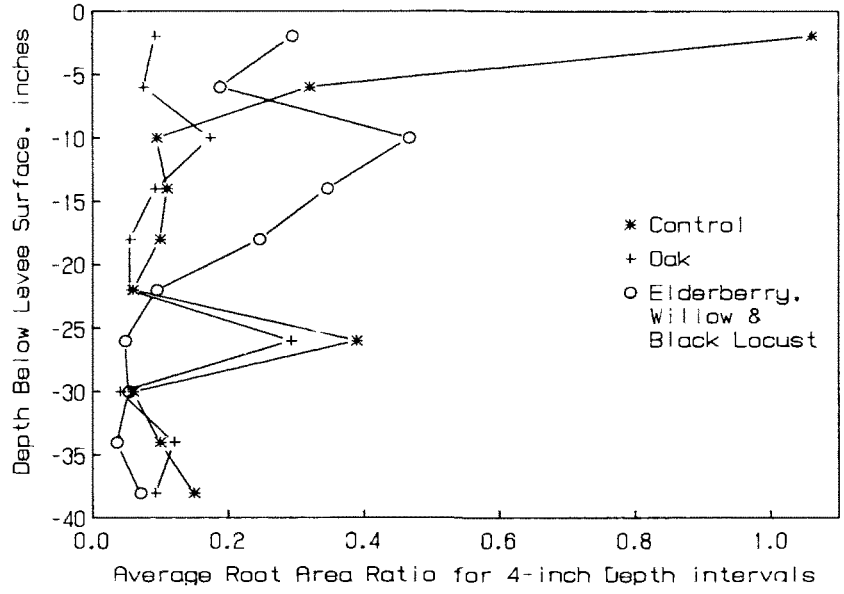


Figure 35. Average RAR profiles for control, oak and elderberry/willow/black locust trench sites

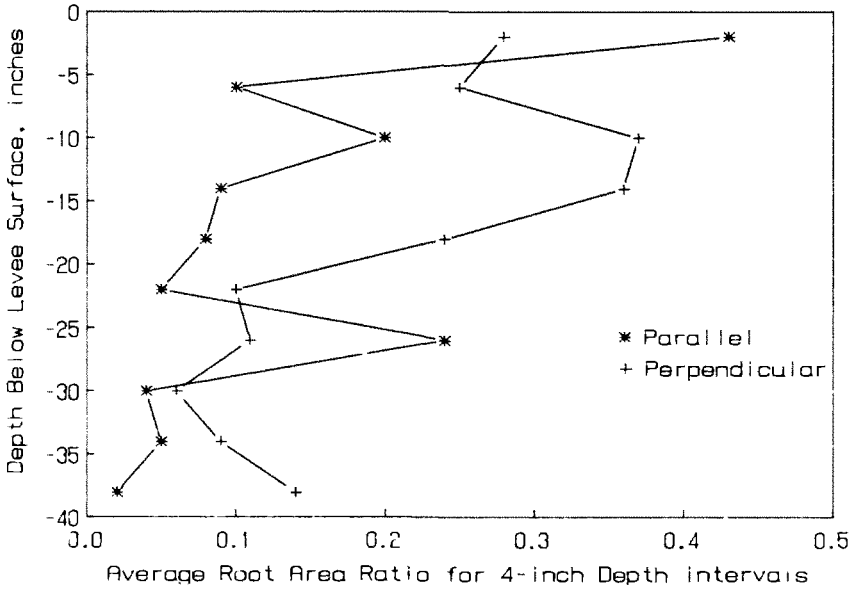


Figure 36. Average RAR profiles for parallel and perpendicular trenches, all sites, arithmetic scale

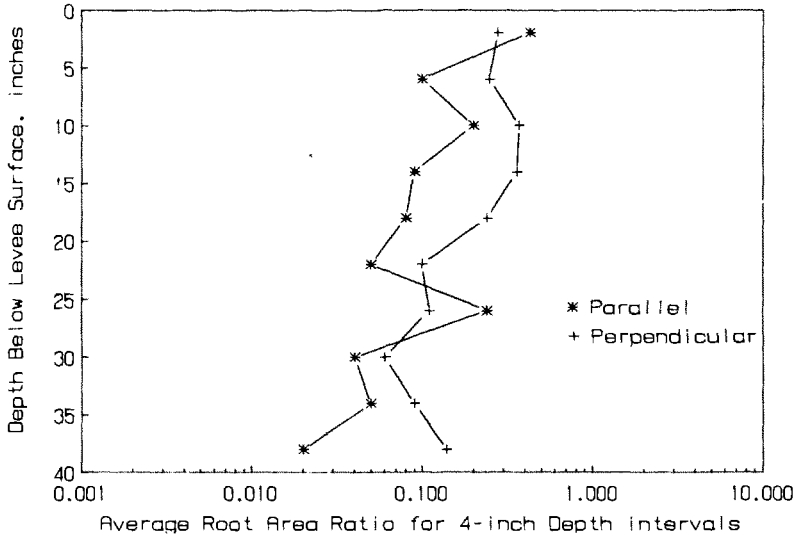


Figure 37. Average RAR profiles for parallel and perpendicular trenches, all sites, logarithmic scale

after trenching (site 2). The dead oak stump was located near the crest of the levee adjacent to the road on the riverward side. The stump was visible as a living tree in 1974 air photos and as a stump in 1982; therefore, it was felled sometime during the 8-year period between 1974 and 1982. Accordingly, the age of the stump when it was excavated in 1987 was somewhere between 5 and 13 years old. Based on a tree ring count, the age of the tree when it was cut was at least 37 years.

103. The root architecture of the oak was characterized by a massive, central tap root and a series of lateral roots radiating from the main tap root at a depth below the ground surface of approximately 0.6 to 1.2 m. A photograph of the excavated stump is shown in Figure 44. The most interesting and significant feature of the laterals was the angle at which they radiated away from the central tap root with respect to the ground surface. Most of these lateral roots angled down sharply rather than growing out in a quasi-horizontal attitude characteristic of lateral roots. This structure explains in part the paucity of roots exposed in the vertical mapping faces of the trenches around the oak trees at their drip lines. This structure is also consistent with the adaptability of the oaks to the levee environment and extreme droughtiness of the sandy soils that comprise the levee. The lateral

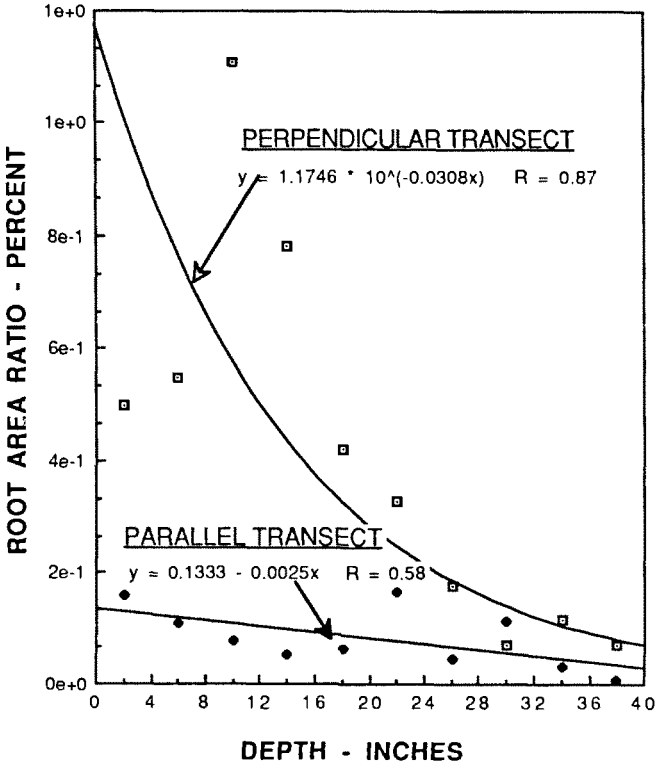


Figure 38. Functional relationship between RAR and depth in perpendicular and parallel transects, respectively, elderberry site (site 7)

roots are angling down sharply in order to reach the groundwater table at depth beneath the levee.

104. Vertical versus horizontal roots. Vertical or sinker roots are more likely to be effective in directly resisting downslope shearing forces on surfaces oriented parallel to the slope. The profile-wall method essentially maps horizontal or near horizontal roots exposed in a vertical face of a trench. The question that arises accordingly is, "Are RARs mapped on a vertical surface also representative of RARs in a horizontal plane which would be more representative of the vertical root system?" Reistenberg and Sovonick-Dunford (1983) conducted extensive root mapping of ash and ma[illegible]

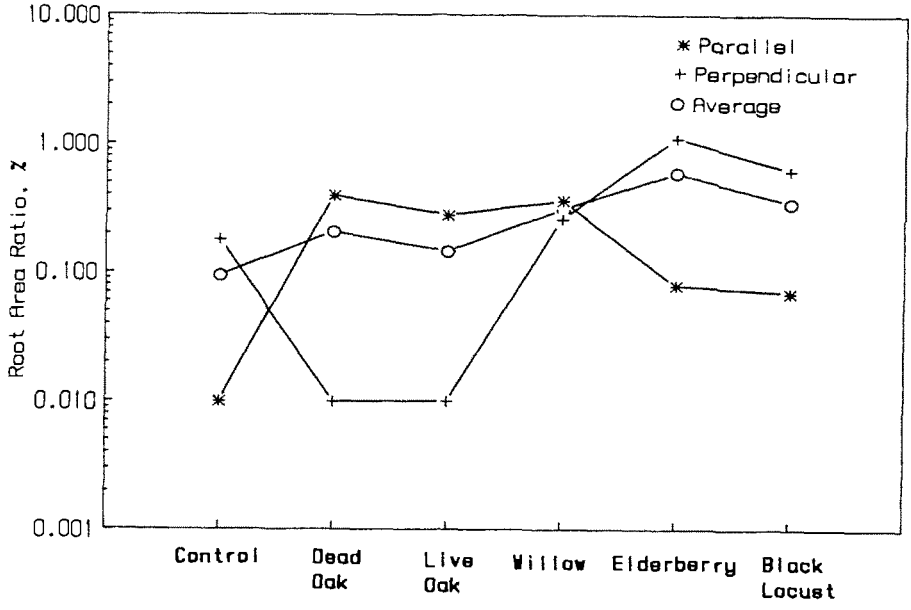


Figure 39. The RAR versus species for 8- to 12-in. depth interval

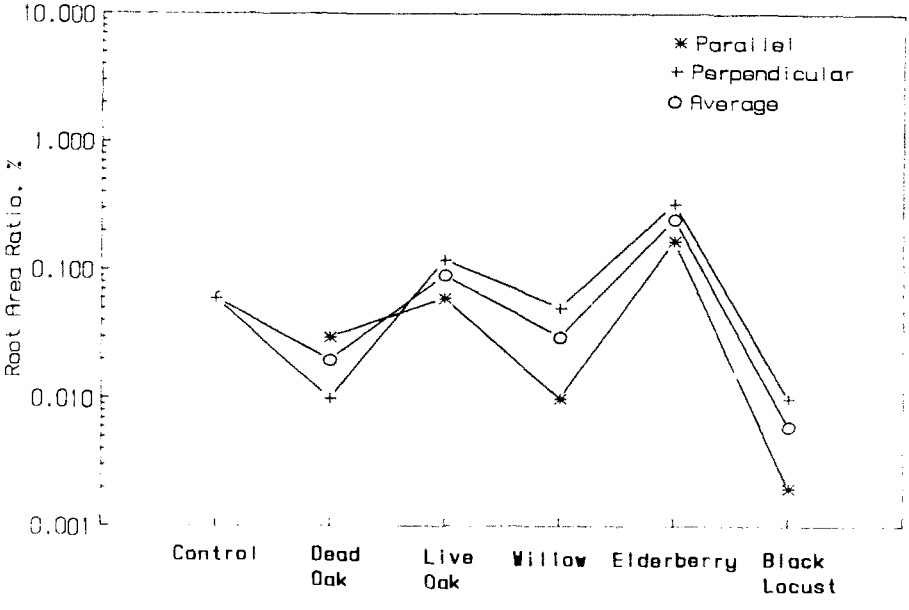


Figure 40. The RAR versus species for 20- to 24-in. depth interval

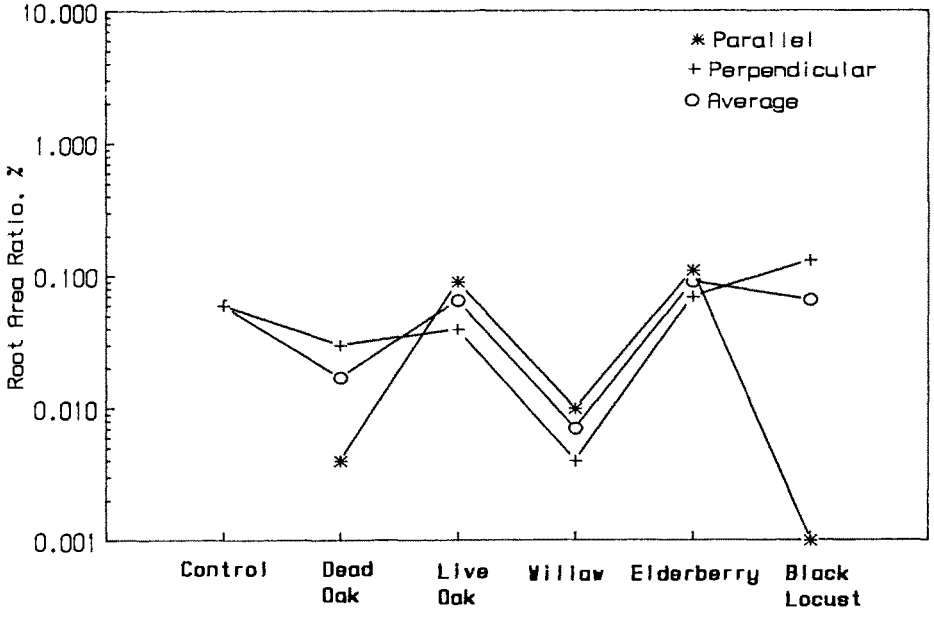


Figure 41. The RAR versus species for 28- to 32-in. depth interval

trees growing in a colluvial layer of soil on a steep, slide-prone slope. They hand-excavated the root systems and measured root areas in horizontal planes as a function of depth. Their root area ratio profiles were very similar to those obtained in the present study. This finding suggests that root distributions obtained by the profile-wall method should provide reasonable estimates of root area ratios (on horizontal surfaces) with depth as well. Further study is required on this point, however, in view of the root structure revealed during the excavation of the dead oak stump.

105. Void and pedotubule distribution. Voids and pedotubules that were exposed in the trench faces were also mapped along with roots. Unlike intact roots, open voids or conduits in a levee represent a clear and immediate danger from the point of view of a piping or internal erosion failure. Voids or holes created by burrowing rodents were easily identified in the trench faces by their size, shape, and form. An example of a ground squirrel burrow exposed in the trench face at site 4 is shown in Figure 45. These burrow holes occurred at all depths. A burrow hole located at the bottom of the

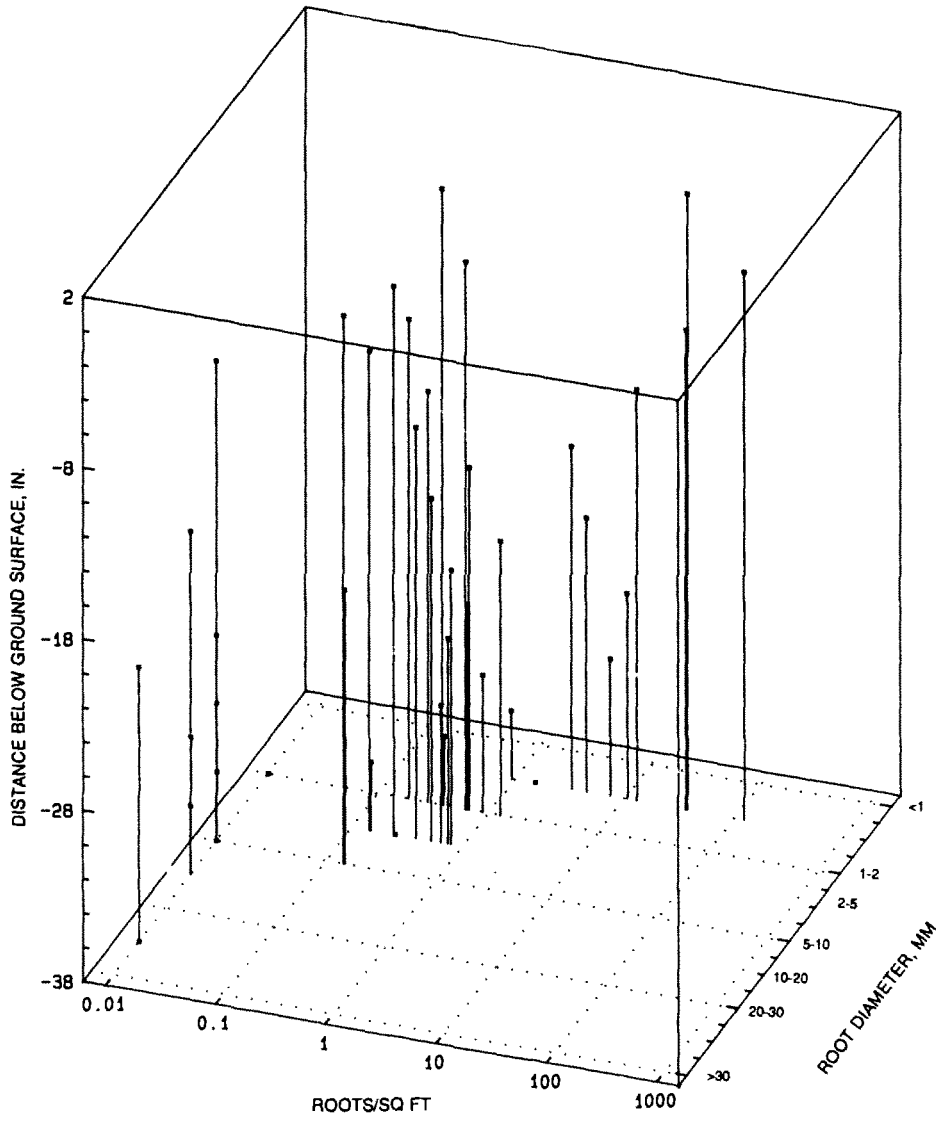


Figure 42. Root size frequency distribution, parallel trench, live oak site (site 4)

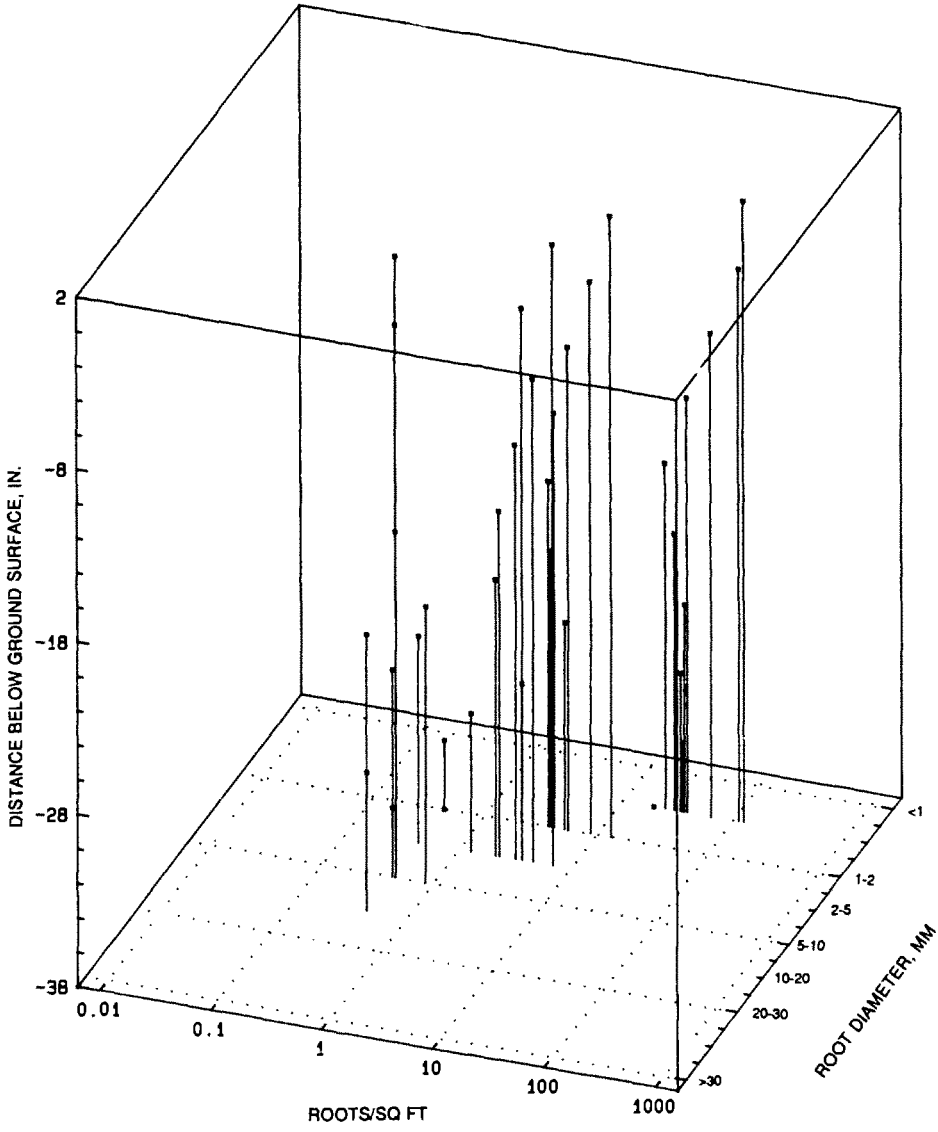


Figure 43. Root size frequency distribution, parallel trench, elderberry site (site 7)

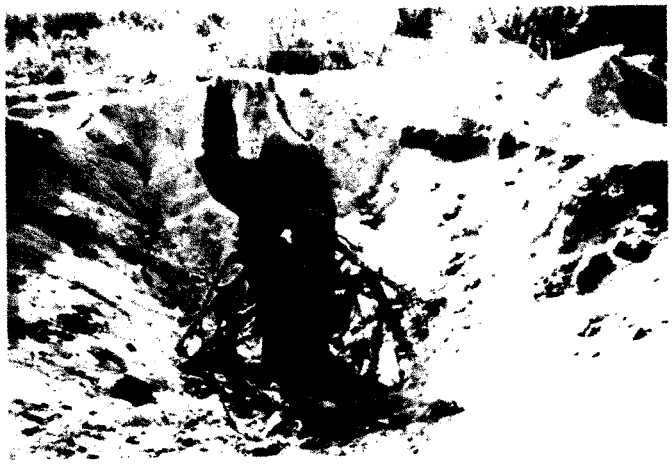


Figure 44. Photograph showing root structure and architecture of dead oak stump excavated in sandy levee, site 2



Figure 45. Photograph of ground squirrel burrows exposed in trench face at live oak site (site 3)

parallel trench face at the live oak site (site 4) is shown in Figure 46. Smaller diameter voids or holes caused by insects, e.g., ants, were also observed. These were very abundant in the parallel trench at the elderberry site (site 7).

106. No voids clearly attributable to decayed or rotted roots were observed. In a few cases voids were observed with residual root bark linings. However, these voids were all infilled with soil and hence, are more appropriately classified as pedotubules. An example of an infilled root hole is shown in Figure 47.

107. Void versus depth profiles were plotted for each site. The void density versus depth is shown plotted in Figure 48 for the elderberry and live oak sites. The average void count for all sites is also plotted on Figure 48.



Figure 46. Photograph of ground squirrel burrow exposed at bottom of trench parallel to levee crest at live oak site



Figure 47. Photograph of infilled root hole that has evolved into a pedotubule

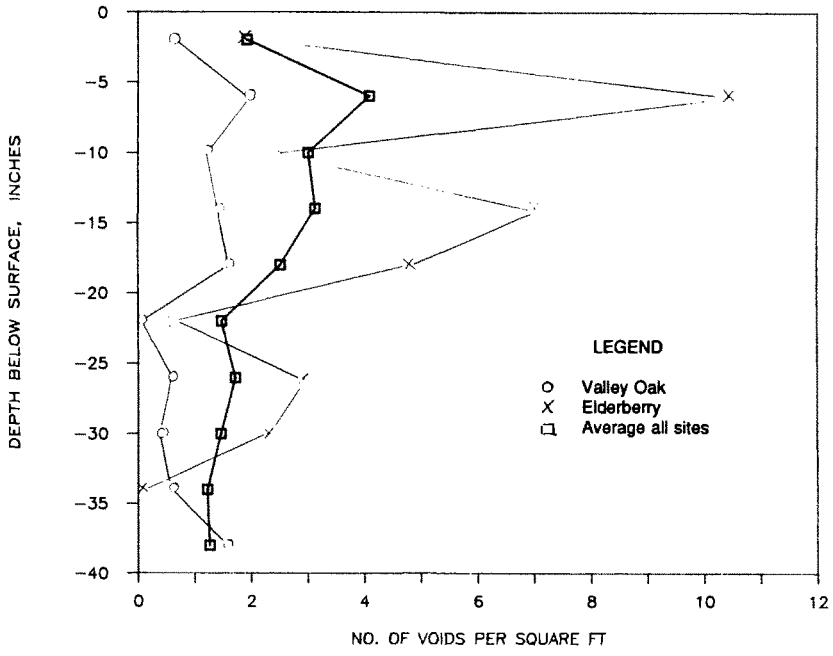


Figure 48. Void density versus depth for various trench sites

The number of voids per square foot reaches a maximum at a depth of 6 in. and then decreases with depth to some minimum value. The number of voids per square foot tends to exceed the average at the elderberry site, and drops below the average at the live oak site. This finding can be explained as follows: voids at the elderberry site are smaller and more numerous as a result of insect activity, whereas the voids at the live oak site tend to be larger and less numerous as a result of animal (ground squirrel) burrowing. An examination of the total area ratio profiles--which include void area ratios-reveals that the live oak site had a total or combined void area ratio of 4.7 percent versus 1.3 percent for the elderberry site. This finding also supports the position that voids are less numerous but much larger on average at the oak site compared to the elderberry site.

108. Good examples of pedotubules were observed in the perpendicular trench face at the live oak site. Some of these pedotubules had approximately circular or slightly elliptical cross sections with roughly the same diameters

as the squirrel burrows also observed in the same trench face. The pedotubules could be distinguished visually from the surrounding soil by differences in color and texture as shown in Figure 49. The soil from these pedotubules was analyzed further to determine if other soil properties might serve to distinguish them as well. One pedotubule (No. 1) was located approximately 9 m from the levee crest at an approximate depth of 2.2 ft, and the other (No. 2) at a depth of 0.5 ft approximately 13.5 m from the crest.

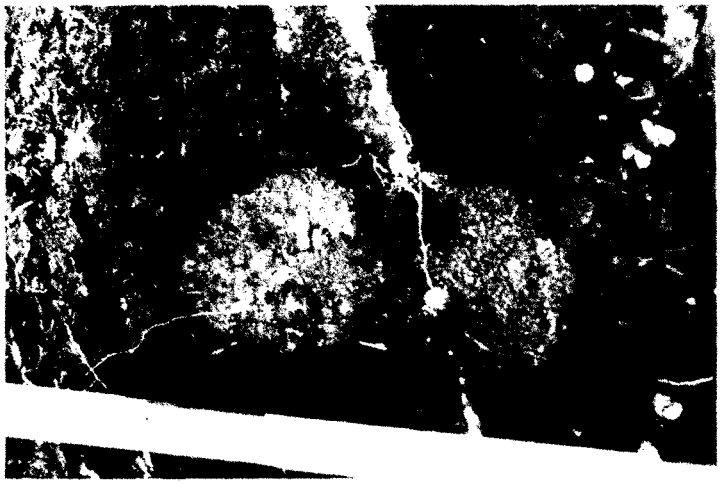


Figure 49. Example of pedotubule (No. 1) exposed in the perpendicular trench face at the live oak site (site 4)

109. The results of gradation analyses and field density tests performed on soil from the two pedotubules and the surrounding soil is summarized in Table 5. There is a pronounced difference in both gradation and density between the soil in the pedotubule and the surrounding soil at pedotubule 1. The lower density in the pedotubule suggests that this material was washed in and hydraulically deposited during a flood. The contrast in gradation and density for pedotubule 2 is marginal; only a visual or textural difference exists in this case. In any case, these findings indicate that voids do not persist long in these sandy levee soils; instead they evolve into pedotubules with time. Only rapidly formed holes of recent origin, namely, animal burrows or insect holes, are likely to be seen and mapped as voids at any given instant. Root holes form more slowly as roots gradually decay and are more likely to evolve directly into pedotubules and not persist long as voids.

Table 5

Gradation and Density Characteristics of Pedotubules

Pedotubule No.	Location	D30 mm	Unified Classification	Dry Density pcf
1	In pedotubule	.200	SP-SM or SC	71.2
	Around pedotubule	.069	SM or SC	80.1
2	In pedotubule	.07	SM or SC	81.8
	Around pedotubule	.10	SM or SC	78.7

PART V: GEOTECHNICAL AND HYDRAULIC ANALYSES

Seepage Analyses

110. Predictive approach. One of the goals of the study reported herein was to determine the likely influence of vegetation on the hydraulic flow regime in a levee. This goal essentially entails determining the distribution of hydraulic head and the location of the phreatic surface in a levee cross section, i.e., constructing a flow net.

111. The location and spacing of flow lines and equipotential lines in a flow net is particularly important with respect to the internal stability of a levee and its resistance to piping and seepage erosion. Closely spaced lines translate into high gradients and seepage velocities. If this condition occurs near the discharge face of the levee, piping and seepage erosion can occur.

112. Possible ways in which vegetation can influence the hydraulic regime of the levee include:

a. Modification of the hydraulic conductivity of the near-surface layer (top 3 ft) as a result of root permeation and disturbance.

b. Alteration of the hydraulic conductivity via changes in soil moisture content as a result of transpiration.

c. Creation of gross void volume defects such as pipes and conduits that pass or partially penetrate through a levee as a result of lateral root growth followed by decay.

113. Standard techniques are available to construct 2-D flow nets and determine hydraulic head distribution in earthen embankments. Permeability discontinuities and unusual embankment geometries complicate the analysis, but these techniques are adequate to investigate Items a. and b. cited above. An iterative, finite difference approach using an engineering spreadsheet was adopted for this purpose in the present study.

114. Suitable techniques are not presently available, on the other hand, to construct 3-D flow nets which are required to investigate Item c., namely, the influence of void volume defects or macropores in a pervious levee. In principle, an iterative, finite difference approach that links together spreadsheets in the third dimension could be developed. A total of six flow inputs, as opposed to four in the 2-D case, would be required at interior grid or nodal points in such an analysis.

Iterative finite difference solution

115. Steady state seepage flow through an earthen levee must satisfy the equation governing the distribution of hydraulic potential, viz., the LaPlace equation, at every point. The finite difference method essentially consists of subdividing the flow region into a series of nodes or grid points and determining the appropriate finite difference equation for the hydraulic head at each point. The head at each point can be expressed in terms of the heads at surrounding or adjoining nodal points. Typical nodal relationships or rules for calculating the head at interior nodes, nodes adjacent to or on a boundary, and nodes on an interface between material of different permeability, are summarized in Figure 50.

116. These equations can be solved simultaneously by an iterative relaxation technique (Kleiner 1985; Das 1983) using an engineering spreadsheet. The spreadsheet program EXCEL was used for this purpose in the present study. Calculated values of the hydraulic head at the node points were in turn used to plot the equipotential lines by means of an isopotential or contour plotting program.

Influence of entrance, discharge, and transfer conditions

117. The orientation of the phreatic surface in unconfined seepage through an embankment or levee depends upon a number of factors. The influence of entrance, discharge, and interface transfer conditions relevant to seepage flow through a levee are summarized in Figure 51.

118. The effect of a permeability discontinuity upon the change in direction of phreatic surface at the interface depends upon both the permeability ratio (K_1/K_2) and the orientation of the interface (W) as shown in Figure 51. The direction of the line of seepage must satisfy the Forcheimer relationship, viz.,

$$\frac{Tan\ (A)}{Tan\ (B)} = \frac{K_2}{K_1} \qquad (2)$$

where: A and B are angles of incidence and departure, respectively, of the seepage line with respect to the interface. In addition to the Forcheimer relationship, the direction of the line of seepage must also satisfy the condition B = 270 - A - W for the cases noted in Figure 51.

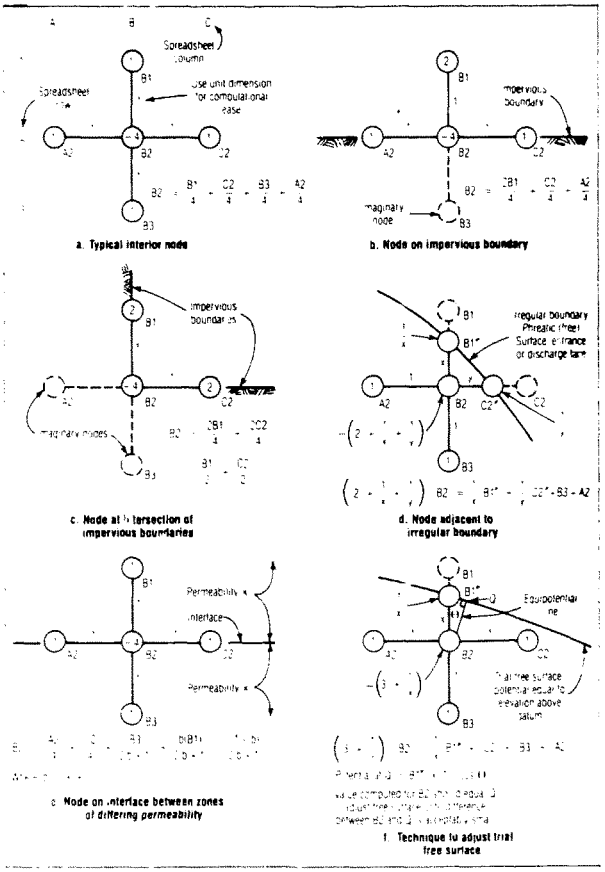
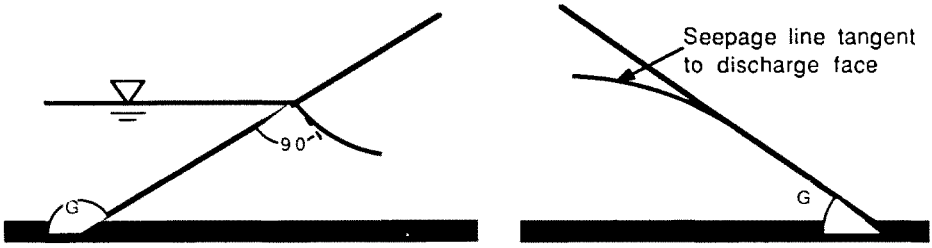


Figure 50. Summary of typical hydraulic head relationships for interior nodes, nodes adjacent to or on a boundary, and nodes on an interface between materials of different permeability (after Kleiner, 1985)

Equilibrium hydraulic head distributions

119. Standardized levee geometry. A standardized levee profile or geometry was adopted for the seepage analyses, as shown in Figure 52. The same side slopes and crest width specified in the standard levee sections shown in Figures 17 through 20 were retained for the seepage analyses. The embankment height was set at 20 ft. A 20-ft levee height with the use of 1-ft nodal spacings facilitated calculations in the seepage simulation. The actual

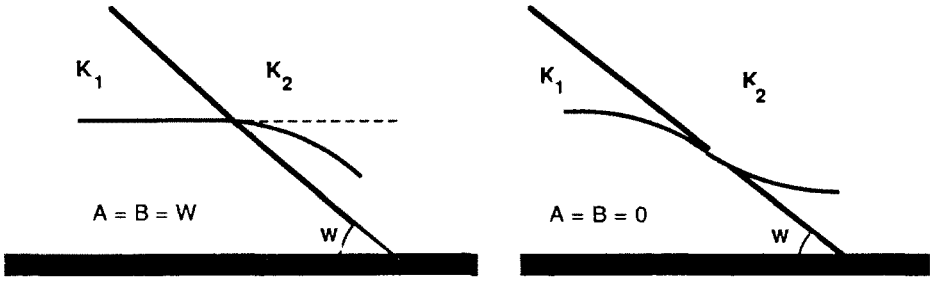
ENTRANCE/EXIT CONDITIONS



Entrance Condition (G>90)

Exit Condition (G<90)

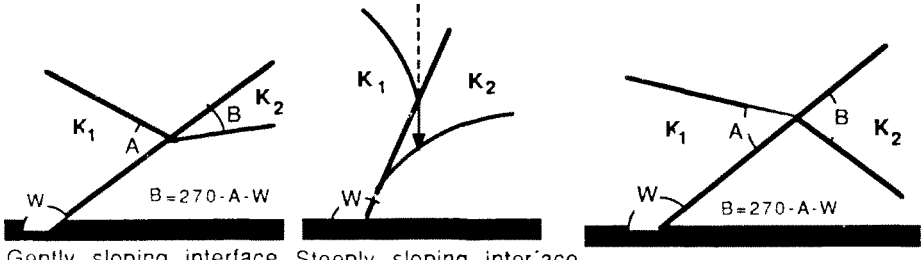
INTERFACE TRANSFER CONDITIONS (W<90)



$K_1 > K_2$

$K_1 < K_2$

INTERFACE TRANSFER CONDITIONS (W>90)



Gently sloping interface

$K_1 < K_2$

Steeply sloping interface

$K_1 < K_2$

$K_1 > K_2$

Figure 51. Entrance, discharge, and transfer conditions for phreatic surface during seepage flow through a levee

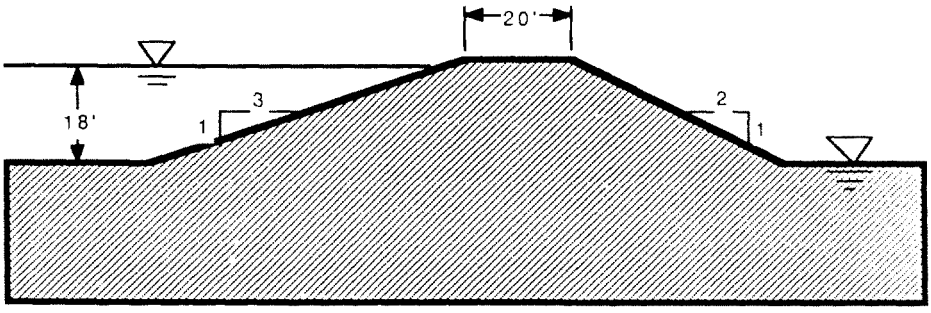


Figure 52. Standardized geometry adopted for seepage and stability analyses

levee dimensions (height) are less important if the main purpose of the seepage analysis is to compare behavior with and without a modified surface layer or skin.

120. The free water level on the channel or riverward side was set at 90 percent of the levee height for the seepage analyses. This level insured that the equilibrium phreatic surface intersected the landward face of the levee, and represents "worst case" scenario conditions.

121. Homogeneous cross section. Hydraulic head distributions for a homogeneous levee cross section were calculated on a spreadsheet using evenly spaced nodes with the iterative, finite difference method described previously. The phreatic surface or line of seepage was located with the aid of the rules and relationships shown in Figure 51 and according to procedures originally recommended by Casagrande (1938). The upstream face of the levee, up to its intersection with the free water surface, is considered an equipotential surface with a hydraulic head of 18 ft in the seepage analyses. This equipotential surface extends along the horizontal upstream boundary in front of the riverward toe of the levee. The discharge face of the levee, below the emergence point of the phreatic surface, is also treated as an equipotential surface with a hydraulic head value of zero. This equipotential surface likewise extends along the horizontal downstream boundary beyond the landward toe of the levee.

122. The spreadsheet output was converted to a data file that was used as the input to a contour or isopotential plotting program. The resulting equipotential map is shown in Figure 53 together with the location of the phreatic surface and the free water surface.

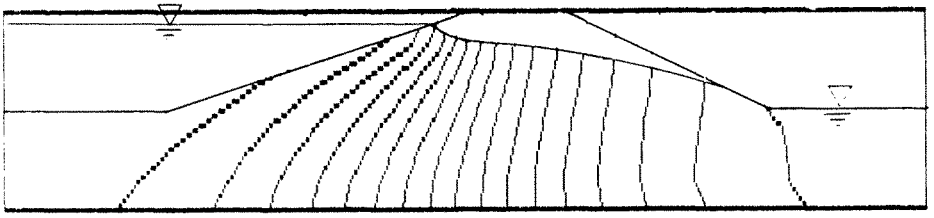


Figure 53. Equipotential lines and hydraulic head distribution for a homogeneous levee cross section

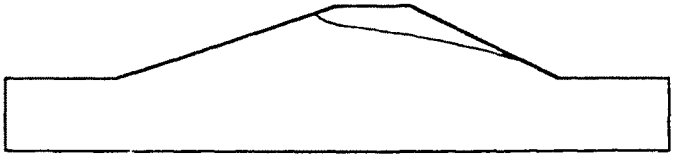
Composite levee with
modified surface layer

123. The impact of a modified surface layer or "skin" on either the riverward or landward slope with a different hydraulic conductivity (K_1) than the central core of the levee (K_2) was modelled by replacing the surface of a homogeneous levee with a 1-ft-thick modified layer. Most of the root biomass of plants is located very close to the surface, as shown in Figures 35 to 38.

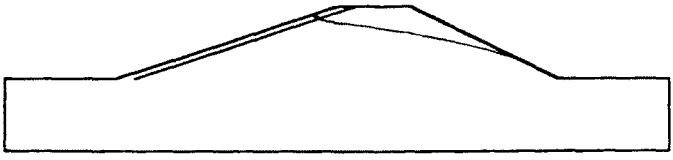
124. The first task was to determine the influence of a surface layer or skin on the location of the phreatic surface as shown schematically in Figure 54. This was accomplished by following the transfer condition rules summarized earlier in Figure 51. The "skin" was assumed to be either more or less permeable than the core by a factor of 10. The subsequent influence on the location and orientation of the phreatic surface as a result of this permeability contrast is depicted schematically in Figure 55.

125. The location of the phreatic surface is not greatly influenced by a modified surface on the upstream slope. Nor are the consequences of the change very significant. This is not the case, however, on the downstream side. A less permeable layer elevates the phreatic surface and increases the area of discharge on the downstream face whereas a more permeable layer depresses the phreatic surface and lowers the emergence point relative to the homogeneous case. A detailed view showing the influence of a permeability contrast between a surface layer and core at the upstream and downstream faces, respectively, is presented in Figure 55.

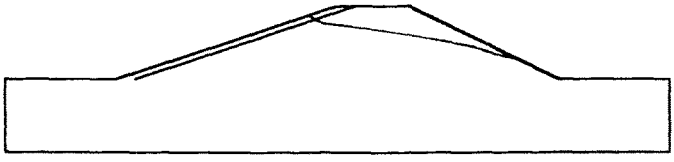
126. The spreadsheet program EXCEL was again used to obtain the hydraulic head distribution for a levee with a modified surface layer or skin with a different permeability. The resulting equipotential lines and hydraulic head distribution for the two cases of "more" and "less" permeable skin, respectively, are plotted and compared with the results for the homogeneous case in



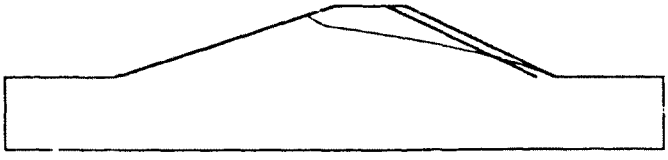
a) levee with constant permeability , k_2



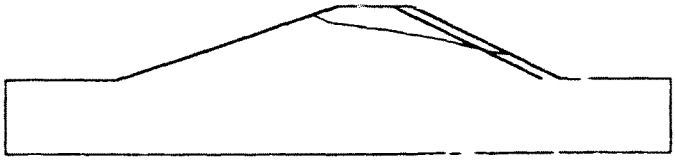
b) levee with a 1-ft layer of permeability , k_1 and $k_1 / k_2 = 10$



c) levee with a 1-ft layer of permeability , k_1 and $k_1 / k_2 = 0.1$

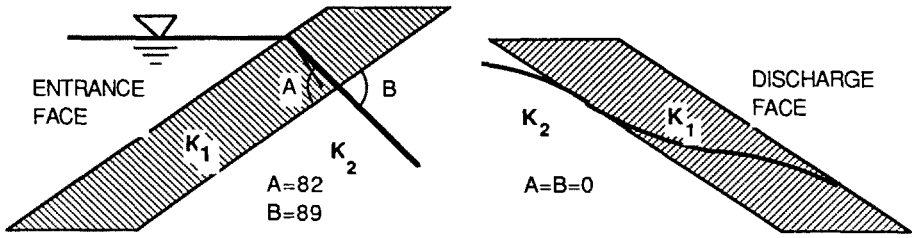


d) levee with 1-ft layer of permeability , k_1 and $k_1 / k_2 = 10$

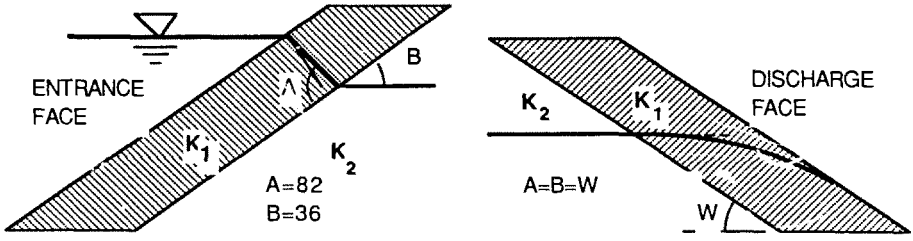


e) levee with 1-ft layer of permeability , k_1 and $k_1 / k_2 = 0.1$

Figure 54. Schematic illustration showing influence of a modified surface permeability on the line of seepage



(A) MORE PERMEABLE "SKIN" (K1 = 10 K2)



(B) LESS PERMEABLE "SKIN" (K1 = 0.1 K2)

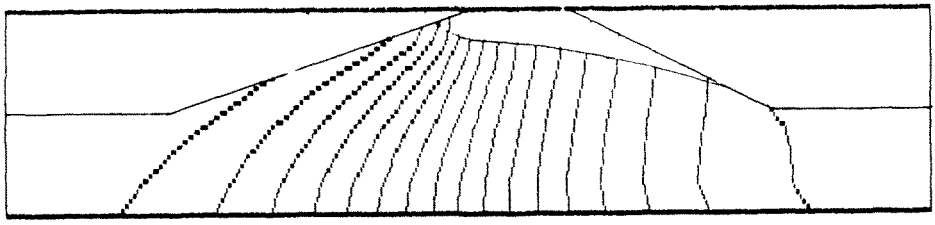
Figure 55. Influence of permeability contrast between facing or "skin" and core of levee on line of seepage

Figure 56. The following tentative conclusions can be drawn from the results of the comparison shown in Figure 56:

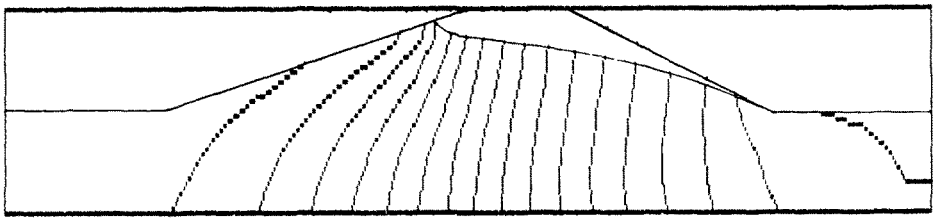
a. A less permeable skin elevates the phreatic surface and increases the discharge area or seepage zone on the downstream face.

b. A less permeable skin results in considerably higher exit gradients (closely spaced equipotential lines) at the discharge face near the toe.

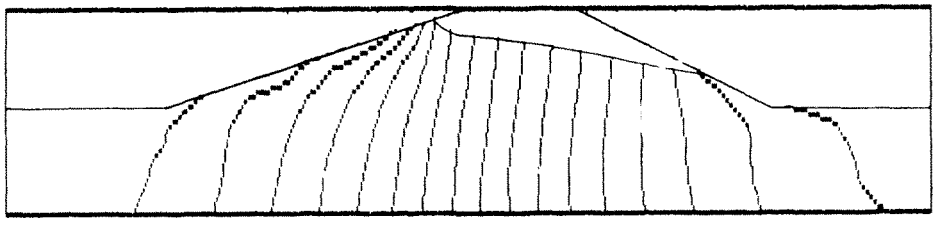
127. Some distortion of the equipotential lines resulted from the relative coarseness of the grid or nodal spacing used in the spreadsheet analysis. A nodal spacing of 1 ft was used in the present study. The fidelity of the equipotential lines and hydraulic head distribution could be improved by using



HOMOGENEOUS LEVEE



MORE PERMEABLE SKIN (K1 = 10 X K2)



LESS PERMEABLE SKIN (K1 = 0.1 X K2)

Figure 56. Equipotential lines and hydraulic head distribution for homogenous levee and levees with a surface layer having a different permeability on the landward face

more closely spaced nodal points or more cells in the spreadsheet. This improvement can be achieved, however, only at considerable expense in computing time due to the large number of iterations required for an equilibrium solution.

Unsteady state flow

128. Both the seepage and stability analyses described herein are based upon steady seepage. In other words, it was assumed that elevated free water levels (FWL) on the channel side would be present for sufficiently long times to develop an equilibrium phreatic surface. Furthermore, the FWL in the channel was purposely set high in the analyses so that the phreatic surface or line of seepage would intersect the downstream face of the levee above the toe. The FWL was set at 80 to 90 percent of the levee crest elevation in both the seepage and mass stability analyses. Both these conditions, i.e., assumed level and duration, are part of a worst case scenario that may never occur in practice.

129. Flood stage duration records for the reach of levee in question along the Sacramento River indicate that (a) the peak flood levels have not risen more than 6-7 ft above the base of the levee, and (b) the duration of the near peak levels is not more than a few hours. A typical flood stage duration record is shown in Figure 57.

130. Huang (1986) has presented a simple method for locating the unsteady state or transient phreatic surfaces in an earth dam or levee. The phreatic surface progresses over time from the upstream to downstream face, with the upper end fixed at the pool (free water) elevation and the lower end moving along the base of the levee. Huang derived an equation to predict the distance (x) from the heel of the levee as a function of time (t). A plot of dimensionless distance (x/h) versus dimensionless time (T) is shown in Figure 58. The dimensionless time T is defined as follows:

$$T = (k\ t)/(n_e\ h) \tag{3}$$

where

k = hydraulic conductivity, ft/min

t = elapsed time, min

n_e = effective porosity

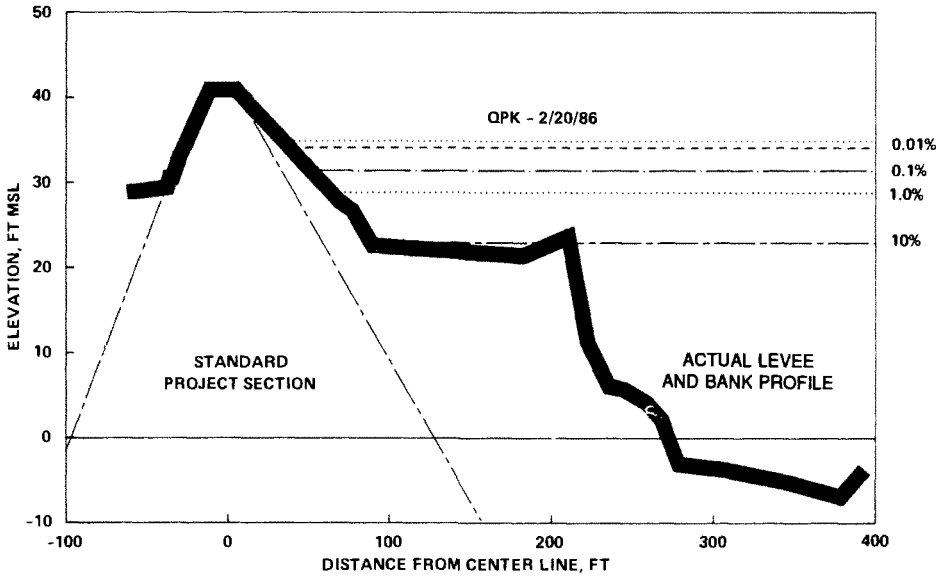


Figure 57. Typical flood-duration record for a levee site, Sacramento River channel levee (percentages represent the amount of time during the 1986 winter period during which these stages were equalled or exceeded, based on daily discharge values and supplemented by hourly values for the 1986 flood above 0.1 percent)

h = free water elevation above base of levee, ft

131. At any given time, t , the distance x can be determined from Figure 58 and the phreatic surface located. The relationship in Figure 58 is, strictly speaking, only valid for cases involving an upstream slope of 2:1 and an impervious horizontal base. Flatter slopes can be handled using a procedure described by Huang, and the presence of a permeable foundation beneath the levee leads to conservative estimates.

132. Huang's method was used to plot the location of the transient phreatic surfaces for both a "low" (6-ft) and "high" (12-ft) flood stage. The results are shown in Figure 59. The time required for the phreatic surface to reach the toe of the levee under a low and high flood, respectively, are approximately 20 and 12 hr. Accordingly, not only are actual, maximum FWLs less than those assumed in the analyses described herein, they are also of

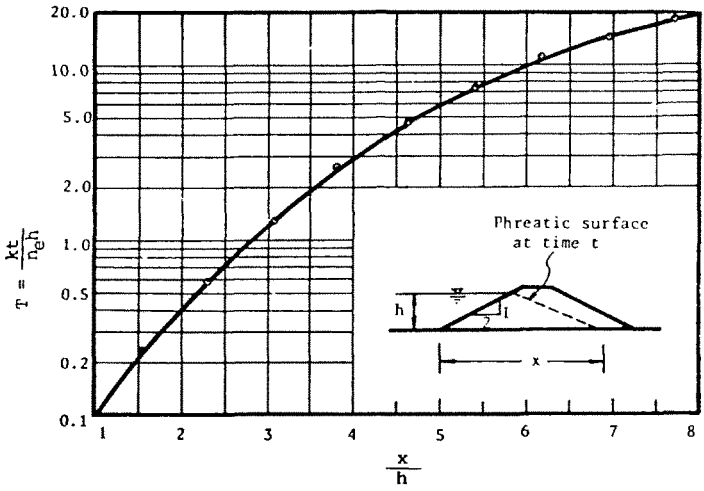


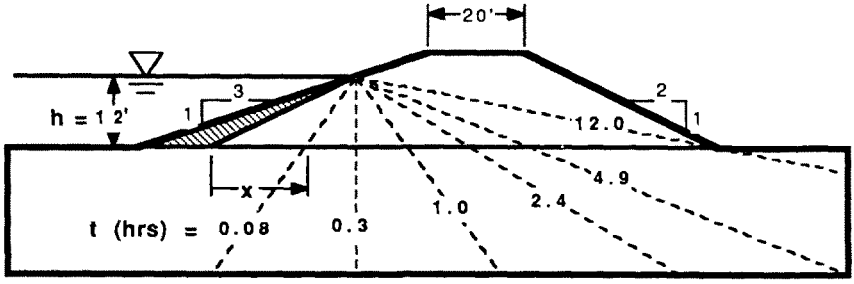
Figure 58. Plot of dimensionless time (T) versus dimensionless distance (x/h) for determining location of transient phreatic surface (from Huang 1986)

insufficient duration to develop an equilibrium phreatic surface under normal conditions, i.e., a levee having a relatively homogeneous cross section consisting of a uniform, medium sand with a hydraulic conductivity of 0.05 cm/sec measured at an average dry density of 90 pcf. The same conclusion would not hold for other conditions such as a vastly different average hydraulic conductivity or the demonstrable presence of gross hydraulic nonhomogeneities, e.g., a greatly modified surface layer (e.g., K1 >> K2) or conduits/pipes which penetrate through the levee. Little or no evidence was observed in the present field study to indicate that vegetation growing on the levee led to either of the latter conditions.

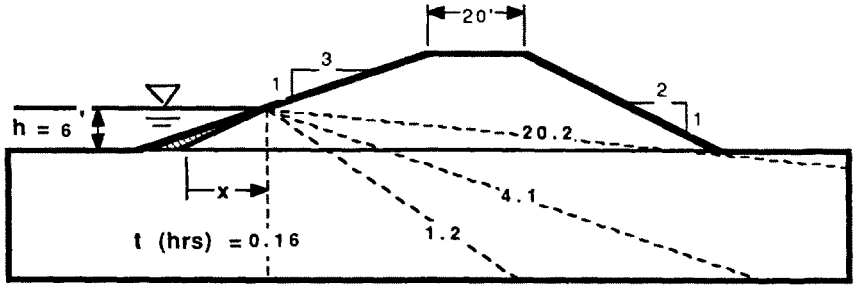
Mass Stability Analyses

General considerations

133. The relative security or factor of safety of an earthen slope is normally expressed as the ratio of the shear strength to the shear stress along a critical surface. A slope fails when the shear stress on this critical surface exceeds the shear strength.



(A) HIGH FLOOD STAGE - 12 FT ABOVE BASE OF LEVEE



(A) LOW FLOOD STAGE - 6 FT ABOVE BASE OF LEVEE

Figure 59. Development of transient phreatic surfaces with time in a sandy levee for two different flood stage elevations (assumed permeability = 0.05 cm/sec)

134. The type of failure (slide or flow) and failure mechanism (planar or rotational movement) depends upon a number of soil, slope, and hydrologic variables. Different types of mass stability analyses have been developed (see Huang 1983) to predict the factor of safety. These analyses take into account the influence of these variables.

135. The so-called infinite slope model is appropriate for analyzing planar slides in which the failure surface is planar and parallel to the slope over most of its length. The infinite slope model is generally applicable for sandy slopes subject to shallow sloughing and for slopes in which stratigraphic or geologic controls restrict sliding to a plane of weakness parallel

to the slope, e.g., a colluvial soil layer overlying an inclined bedrock contact.

136. A circular arc analysis is appropriate to rotational sides in which the failure surface is curved and can be modelled by the arc of a circle. Uniform clay slopes generally fail by deep-seated movement along a curved surface. More sandy slopes, on the other hand, tend to fail along shallow curved surfaces passing through the toe of the slope.

137. Both types of failure models, infinite slope and circular arc, are depicted schematically in Figure 60. In the case of a levee embankment or dam, both the upstream and downstream slopes are vulnerable to a mass stability failure. The upstream slope can fail as a result of rapid drawdown, e.g., a rapidly subsiding flood crest, and the downstream slope as a result of steady seepage (either parallel to or emerging from the face of the levee).

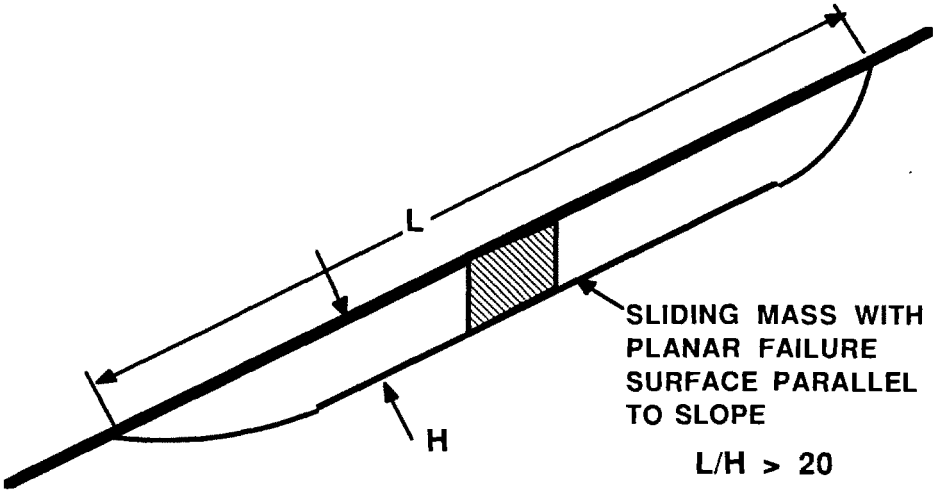
138. The stability of the levee described herein was determined for both the steady seepage and drawdown cases, respectively. Both infinite slope and circular arc analyses were employed. The influence of vegetation was investigated by introducing a thin surface layer or skin with different shear strength properties as a result of root permeation and modification of the soil.

Effect of plant roots
on soil shear strength

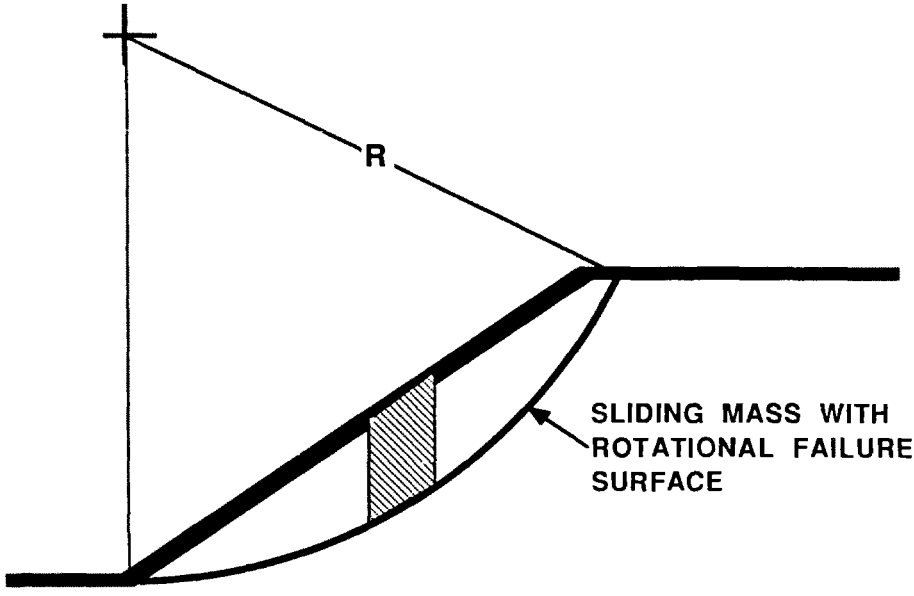
139. The main effect of the presence of fibers (roots) in a soil, insofar as shear strength is concerned, is to provide a measure of apparent cohesion. This fiber or root cohesion can make a significant difference in the resistance to shallow sliding or shear displacement in sandy soils with little or no intrinsic cohesion.

140. A number of studies have been reported in the technical literature on the contribution of woody roots to increased shear strength or root cohesion (c_R). Results and findings of these studies are summarized in Table 6. Contributions to increased shear strength can be estimated from either root biomass concentrations or from RARs. Actual shear tests in the laboratory and field on root/fiber permeated sands (Ziemer 1981; Gray and Ohashi 1983) indicate a shear strength increase per unit fiber concentration ranging from 7.4 to 8.7 psi/lb root/cf soil. This translates into an average value of 3.2 psi/percent RAR (assuming a root unit weight of 40 pcf).

141. RAR-versus-depth curves shown in Figure 38 for the elderberry site were used to estimate the likely root cohesion (c_R) as a function of depth.



(A) INFINITE SLOPE MODEL



(B) CIRCULAR ARC FAILURE MODEL

Figure 60. Slope failure models for mass stability analysis ((a) = infinite slope model; (b) = circular arc model)

TABLE 6. SUMMARY OF ROOT/FIBER CONTRIBUTIONS TO SOIL SHEAR STRENGTH

FIBER OR ROOT SYSTEM	MAXIMUM FIBER OR ROOT BIOMASS CONC			SHEAR STRENGTH INCREASE PER UNIT FIBER CONC.		MAX SHEAR STRENGTH INCR MEASURED IN TESTS		REFERENCE
	AREA RATIO (%)	WT. CONC. (= 40 PCF) lbs root cf soil	kg root cu m soil	PSI lb/cf	kPa kg/cu m	(PSI)	(kPa)	
HORIZONTAL SURFACE, VERTICAL ROOTS:								
Tree roots (spruce, hemlock) Horizontal shear surface, silty sand (interface between "B" and "C" Horizons) Live roots <13 mm diameter In-situ analysis	0.037	0.015	0.24	57.3	24.6	0.86	5.9	Wu, 1976
Tree roots (sugar maple) Horizontal shear surface, silty clay colluvium (interface between colluvium/bedrock) Live roots <25 mm diameter In-situ analysis	0.025	0.010	0.16	83.0	35.7	0.83	5.7	Riestenberg et al., 1983
Grass roots In-situ direct shear tests	0.050	0.020	0.33	34.6	15.0	0.70	5.0	CIRIA, 1987
AVERAGES:	0.037	0.015	0.24	58.4	25.1	0.80	5.5	
VERTICAL SURFACE, LATERAL ROOTS:								
Tree roots (Rocky Mtn. Douglas fir) Vertical surface, sandy loam Live roots <10 mm diameter In-situ analysis	0.046	0.018	0.29	68.9	29.6	1.24	8.6	Burroughs & Thomas, 1977
Tree roots (pinus contorta) Vertical shear surface, coastal sand Liver roots <17 mm diameter In-situ direct shear test	0	0.312	5.00	7.4	3.2	2.32	16.0	Ziemer, 1981
AVERAGES:	0.413	0.165	2.65	38.2	16.4	1.78	12.3	
LAB TESTS ON FIBER PERMEATED SANDS:								
Reed fibers (phragmites communis) Natural fibers: diameter = 2.0 mm Uniform sand Direct shear test	1.700	0.680	10.90	8.7	3.7	5.90	40.3	Gray & Ohashi, 1983
OVERALL AVERAGES	0.440	0.176	2.82	43.4	18.6	2.0	13.6	

The perpendicular transect data were used as representative of a "high" root concentration and the parallel transect, a "low" root concentration. These root concentrations and corresponding root cohesions were used in the stability analyses to investigate the likely influence of levee vegetation on the mass stability of a sandy levee with the properties and characteristics described previously.

Infinite slope analyses

142. Infinite slope analyses were conducted on both the upstream (3:1) slope and downstream (2:1) slope. Factors of safety were computed as a function of vertical depth (H) and seepage direction (θ) with respect to a horizontal plane. The static factor of safety is given by the following relationships (Huang 1983):

$$F = A\,[Tan(\phi)/Tan(\beta)] + B\,[(c + c_R)/\gamma H)] \tag{4a}$$

$$A = [1 - r_u/Cos^2(\beta)] \tag{4b}$$

$$B = [1/Cos^2(\beta)\,Tan(\beta)] \tag{4c}$$

$$r_u = [\gamma/\gamma_w)\ \{1/(1 + Tan(\beta)\,Tan(\theta)\}] \tag{4d}$$

where: ϕ = angle of internal friction

β = slope angle

c = soil cohesion

c_R = root cohesion

γ = soil density

γ_w = density of water

143. The infinite slope equation was programmed into a spreadsheet. The results of the analyses are tabulated in Tables 7 and 8 for a 2:1 slope and different assumed values of soil friction (ϕ), and amounts of root cohesion (c_R). Root cohesion was computed as a function of RAR which, in turn, varied with depth as explained in the previous section. The intrinsic soil

TABLE 7. EFFECT OF PLANT ROOTS ON STABILITY AGAINST SLOUGHING (SHALLOW FACE SLIDING) IN LEVEE SLOPES AS A RESULT OF SEEPAGE OR SUDDEN DRAWDOWN (2:1 SLOPE, PHI = 36 DEG)

2:1 SLOPE (26.6 DEG)
NO ROOTS (Ar/A = 0)

DEPTH TO FAILURE SURFACE H (FT)	SATD SOIL DENSITY ((PCF)	SOIL COHESION C (PSI)	SOIL FRICTION ANGLE ∅ (DEG)	ROOT COHESION Cr (PSI)	FACTOR OF SAFETY FOR VARIOUS SEEPAGE DIRECTIONS - THETA				
					THETA = 0 (DEG)	THETA = 26.6 (DEG)	THETA = 30 (DEG)	THETA = 60 (DEG)	THETA = 90 (DEG)
0.5	118	0	36	0	0.49	0.68	0.71	0.94	1.46
1.0	118	0	36	0	0.49	0.68	0.71	0.94	1.46
1.5	118	0	36	0	0.49	0.68	0.71	0.94	1.46
2.0	118	0	36	0	0.49	0.68	0.71	0.94	1.46
2.5	118	0	36	0	0.49	0.68	0.71	0.94	1.46
3.0	118	0	36	0	0.49	0.68	0.71	0.94	1.46
3.5	118	0	36	0	0.49	0.68	0.71	0.94	1.46
4.0	118	0	36	0	0.49	0.68	0.71	0.94	1.46

2:1 SLOPE (26.6 DEG)
LOW ROOT CONC (Ar/A = 0.1333 - 0.03 x H)

DEPTH TO FAILURE SURFACE H (FT)	SATD SOIL DENSITY ((PCF)	SOIL COHESION C (PSI)	SOIL FRICTION ANGLE ∅ (DEG)	ROOT COHESION Cr (PSI)	FACTOR OF SAFETY FOR VARIOUS SEEPAGE DIRECTIONS - THETA				
					THETA = 0 (DEG)	THETA = 26.6 (DEG)	THETA = 30 (DEG)	THETA = 60 (DEG)	THETA = 90 (DEG)
0.5	118	0	36	0.38	2.80	3.00	3.02	3.25	3.78
1.0	118	0	36	0.33	1.50	1.70	1.72	1.95	2.47
1.5	118	0	36	0.28	1.07	1.26	1.29	1.52	2.04
2.0	118	0	36	0.23	0.85	1.05	1.07	1.30	1.82
2.5	118	0	36	0.19	0.72	0.92	0.94	1.17	1.69
3.0	118	0	36	0.14	0.64	0.83	0.85	1.08	1.61
3.5	118	0	36	0.09	0.57	0.77	0.79	1.02	1.55
4.0	118	0	36	0.04	0.53	0.72	0.74	0.98	1.50

TABLE 7 (CONTINUED)

2:1 SLOPE (26.6 DEG)
HIGH ROOT CONC (Ar/A = 1.1746 X 10^(-0.3696 x H))

DEPTH TO FAILURE SURFACE H (FT)	SATD SOIL DENSITY ((PCF)	SOIL COHESION C (PSI)	SOIL FRICTION ANGLE ϕ (DEG)	ROOT COHESION Cr (PSI)	FACTOR OF SAFETY FOR VARIOUS SEEPAGE DIRECTIONS - THETA				
					THETA = 0 (DEG)	THETA = 26.6 (DEG)	THETA = 30 (DEG)	THETA = 60 (DEG)	THETA = 90 (DEG)
			1	2		3			
0.5	118	0	36	2.46	15.48	15.67	15.70	15.93	16.45
1.0	118	0	36	1.60	5.39	5.58	5.61	5.84	6.36
1.5	118	0	36	1.05	2.63	2.82	2.84	3.08	3.60
2.0	118	0	36	0.69	1.54	1.73	1.76	1.99	2.51
2.5	118	0	36	0.45	1.04	1.23	1.26	1.49	2.01
3.0	118	0	36	0.29	0.79	0.99	1.01	1.24	1.76
3.5	118	0	36	0.19	0.66	0.85	0.88	1.11	1.63
4.0	118	0	36	0.12	0.59	0.78	0.81	1.04	1.56

NOTES:

1. ϕ (deg) = 36 - 3.82 x C (psi). Correlation from levee BHS test results
2. Cr (psi) = 3.2 (Ar/A) (%). Correlation based on direct shear tests on root/fiber/soil composites (Gray & Ohashi, 1983; Ziemer 1981)
3. Seepage parallel to slope and "sudden drawdown" cases

TABLE 8. EFFECT OF PLANT ROOTS ON STABILITY AGAINST SLOUGHING (SHALLOW FACE SLIDING) IN LEVEE SLOPES AS A RESULT OF SEEPAGE OR SUDDEN DRAWDOWN(2:1 SLOPE, PHI = 28 DEG)

2:1 SLOPE (26.6 DEG)
NO ROOTS (Ar/A = 0)

DEPTH TO FAILURE SURFACE H (FT)	SATD SOIL DENSITY ((PCF)	SOIL COHESION C (PSI)	SOIL FRICTION ANGLE ∅ (DEG)	ROOT COHESION Cr (PSI)	FACTOR OF SAFETY FOR VARIOUS SEEPAGE DIRECTIONS - THETA				
					THETA = 0 (DEG)	THETA = 26.6 (DEG)	THETA = 30 (DEG)	THETA = 60 (DEG)	THETA = 90 (DEG)
0.5	118	0	28	0	0.36	0.50	0.52	0.69	1.07
1.0	118	0	28	0	0.36	0.50	0.52	0.69	1.07
1.5	118	0	28	0	0.36	0.50	0.52	0.69	1.07
2.0	118	0	28	0	0.36	0.50	0.52	0.69	1.07
2.5	118	0	28	0	0.36	0.50	0.52	0.69	1.07
3.0	118	0	28	0	0.36	0.50	0.52	0.69	1.07
3.5	118	0	28	0	0.36	0.50	0.52	0.69	1.07
4.0	118	0	28	0	0.36	0.50	0.52	0.69	1.07

2:1 SLOPE (26.6 DEG)
LOW ROOT CONC (Ar/A = 0.1333 - 0.03 x H)

DEPTH TO FAILURE SURFACE H (FT)	SATD SOIL DENSITY ((PCF)	SOIL COHESION C (PSI)	SOIL FRICTION ANGLE ∅ (DEG)	ROOT COHESION Cr (PSI)	FACTOR OF SAFETY FOR VARIOUS SEEPAGE DIRECTIONS - THETA				
					THETA = 0 (DEG)	THETA = 26.6 (DEG)	THETA = 30 (DEG)	THETA = 60 (DEG)	THETA = 90 (DEG)
0.5	118	0	28	0.38	2.67	2.81	2.83	3.00	3.38
1.0	118	0	28	0.33	1.37	1.51	1.53	1.70	2.08
1.5	118	0	28	0.28	0.94	1.08	1.09	1.26	1.65
2.0	118	0	28	0.23	0.72	0.86	0.88	1.05	1.43
2.5	118	0	28	0.19	0.59	0.73	0.75	0.92	1.30
3.0	118	0	28	0.14	0.50	0.64	0.66	0.83	1.21
3.5	118	0	28	0.09	0.44	0.58	0.60	0.77	1.15
4.0	118	0	28	0.04	0.39	0.54	0.55	0.72	1.11

TABLE 8 (CONTINUED)

2:1 SLOPE (26.6 DEG)
HIGH ROOT CONC (Ar/A = 1.1746 X 10^(-0.3696 x H))

DEPTH TO FAILURE SURFACE H (FT)	SATD SOIL DENSITY ((PCF)	SOIL COHESION C (PSI)	SOIL FRICTION ANGLE Ø (DEG)	ROOT COHESION Cr (PSI)	FACTOR OF SAFETY FOR VARIOUS SEEPAGE DIRECTIONS - THETA				
					THETA = 0 (DEG)	THETA = 26.6 (DEG)	THETA = 30 (DEG)	THETA = 60 (DEG)	THETA = 90 (DEG)
			1	2		3			
0.5	118	0	28	2.46	15.35	15.49	15.50	15.67	16.06
1.0	118	0	28	1.60	5.26	5.40	5.42	5.59	5.97
1.5	118	0	28	1.05	2.49	2.64	2.65	2.82	3.21
2.0	118	0	28	0.69	1.41	1.55	1.57	1.74	2.12
2.5	118	0	28	0.45	0.91	1.05	1.07	1.24	1.62
3.0	118	0	28	0.29	0.66	0.80	0.82	0.99	1.37
3.5	118	0	28	0.19	0.53	0.67	0.69	0.86	1.24
4.0	118	0	28	0.12	0.46	0.60	0.62	0.79	1.17

NOTES:

1. "Worst case" scenario...minimum friction angle and negligible cohesion
2. Cr (psi) = 3.2 (Ar/A) (%). Correlation based on direct shear tests on root/fiber/soil composites (Gray & Ohashi, 1983; Ziemer 1981)
3. Seepage parallel to slope and "sudden drawdown" cases

cohesion was assumed to be zero, and the friction angle set to either 36° (the maximum value measured on the levee) or 28° (the lowest recorded value). The latter represents a "worst-case" scenario, i.e., combination of lowest recorded friction coupled with absence of any cohesion. The average friction and cohesion values measured from in situ borehole shear tests were 31.6° and 1.16 psi, respectively.

144. Sudden drawdown in an infinite slope analysis is equivalent to saturated, steady seepage when the seepage direction is parallel to the slope, i.e., ($\theta = \beta$). A factor of safety for this condition was computed in every case.

145. Results from the spreadsheet analyses are presented graphically in Figures 61 through 64 for the case of soil friction angle equal to 36°. Factor of safety is plotted as a function of depth and seepage direction for the case of no root cohesion ($c_R = 0$) for the 2:1 and 3:1 slope, respectively, in Figures 61 and 62. The factor of safety drops below one when the seepage either parallels or emerges from the slope face for the 2:1 slope. The corresponding factor of safety for the case of low root concentrations is plotted in Figures 63 and 64. The factor of safety exceeds unity for all depths and seepage directions in this case (except for low seepage angle directions in the 2:1 slope).

146. The results show that both the seepage direction (θ) and presence of root cohesion (c_R) have a significant effect on the factor of safety. Even a small amount of root cohesion can increase the factor of safety substantially. This influence is very pronounced at shallow depths where root concentrations are highest and reinforcement effects, therefore, greatest. In this regard grass roots appear to be just as effective as tree and shrub (woody) roots because of their high concentration at shallow depths. The RARs measured at the control site, for example, exceeded all other sites at depths under 6 in. (see Figures 35 and 36) because of the abundance of grasses and herbaceous ground cover at this location. In the presence of root cohesion, even for low root concentrations, the factor of safety exceeds unity at all depths up to 2.0 ft even for worst case scenario conditions of low friction angle ($\phi = 28°$) and seepage emerging from the slope ($\theta = 0°$).

147. One effect of the roots is to displace the critical shear surface (surface where F = 1.0) downward. The further downward the critical surface is displaced, the less prone the slope is to surface sloughing or ravelling. If the critical surface is displaced too far, however, the infinite slope

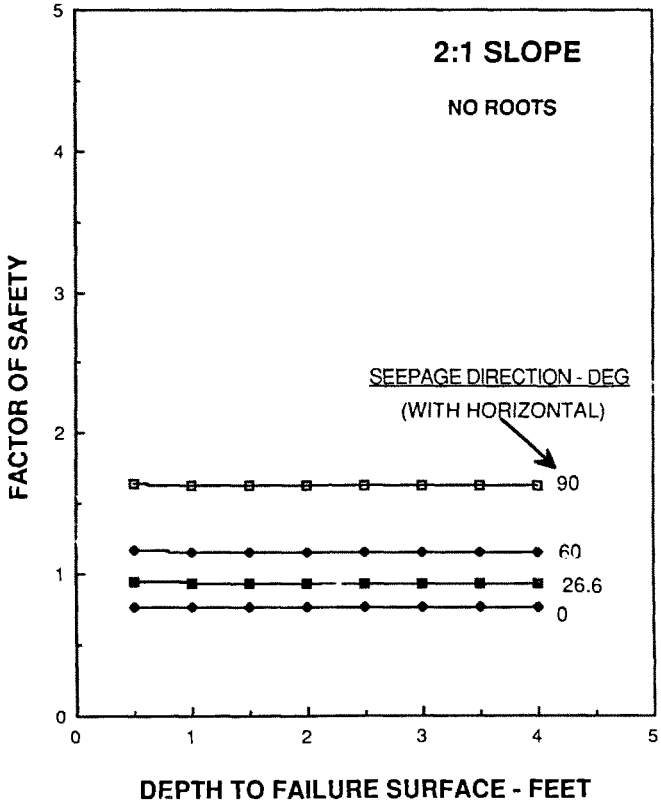


Figure 61. Infinite slope analysis of saturated (2:1) downstream slope of levee without roots (friction angle = 36°)

model is no longer valid. This analysis assumes that the length of the sliding mass is large relative to its thickness (L > 20 H) as shown in Figure 60. For a 15-ft-high sandy levee, this criteria translates to a thickness of 1.7 and 2.4 (or vertical depth to the sliding plane of 1.9 and 2.5) for 2:1 and 3:1 slopes, respectively. At sufficiently large depths (H > 4 ft) the root concentrations and reinforcement will decrease to zero. At these depths the sliding mass will not have the dimensions or aspect ratio required by the infinite slope model. When this condition is no longer observed, then another type of analysis, either a circular arc or log spiral failure analysis, should be used as well.

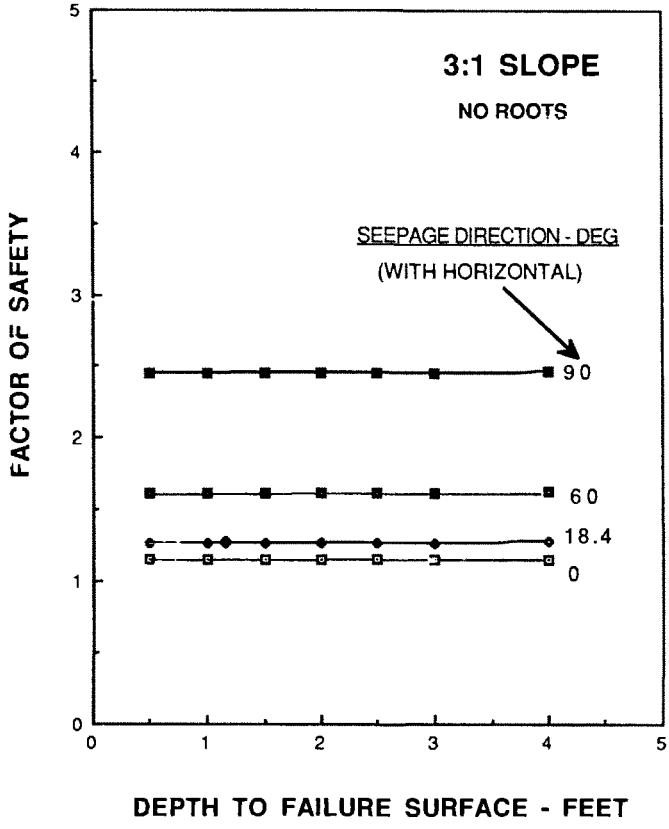


Figure 62. Infinite slope analysis of saturated (3:1) downstream slope of levee without roots (friction angle = 36°)

148. The effect of seepage direction (θ) on stability deserves some comment. Downward seepage (θ = 90°) greatly increases the factor of safety. This condition, in fact, yields the same factor of safety as a dry slope. Accordingly, to the extent that slope vegetation and plant roots promote downward seepage and infiltration, they also enhance stability.

Circular arc analyses

149. Curved failure surfaces in sandy slopes are log spiral shaped and pass through the toe of the slope. A circular arc analysis was used to simulate this failure condition. Critical circles in sandy slopes are generally

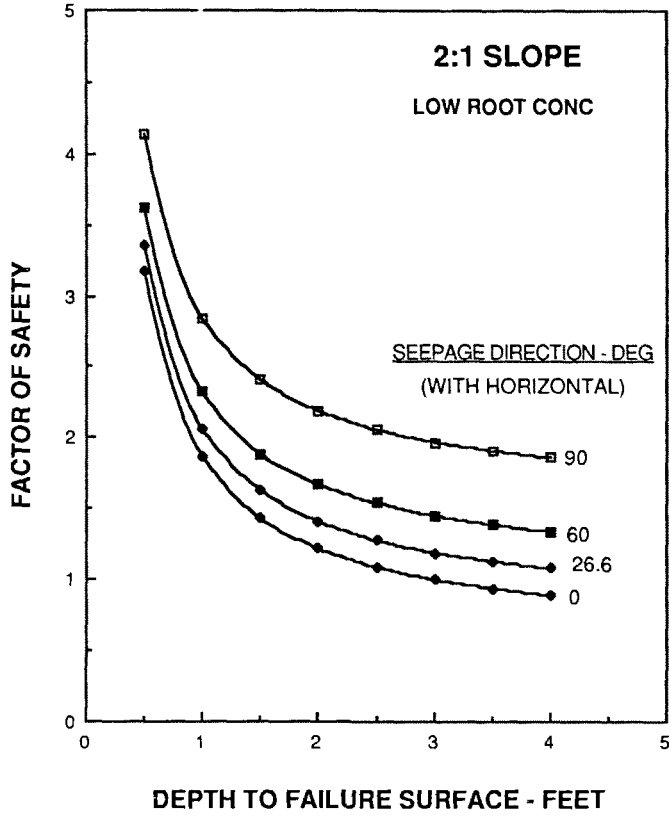


Figure 63. Infinite slope analysis of saturated (2:1) downstream slope of levee with roots (friction angle = 36°)

quite flat and shallow; this is one reason that the infinite slope model with its assumption of a planar failure surface is also a good approximation.

150. There are several variants of circular arc stability analyses. One approach is to subdivide the failure mass, defined by the intersection of a trial failure circle with the slope, into a series of vertical elements or "slices." The factor of safety against rotational sliding is determined by calculating the static force and moment equilibrium of the slices. The Modified (or Bishop) Method of slices was used in this study. This method assumes that the vertical forces of the sides of the slices are opposite and equal, which in turn means that the resultant of the side forces on a slice acts

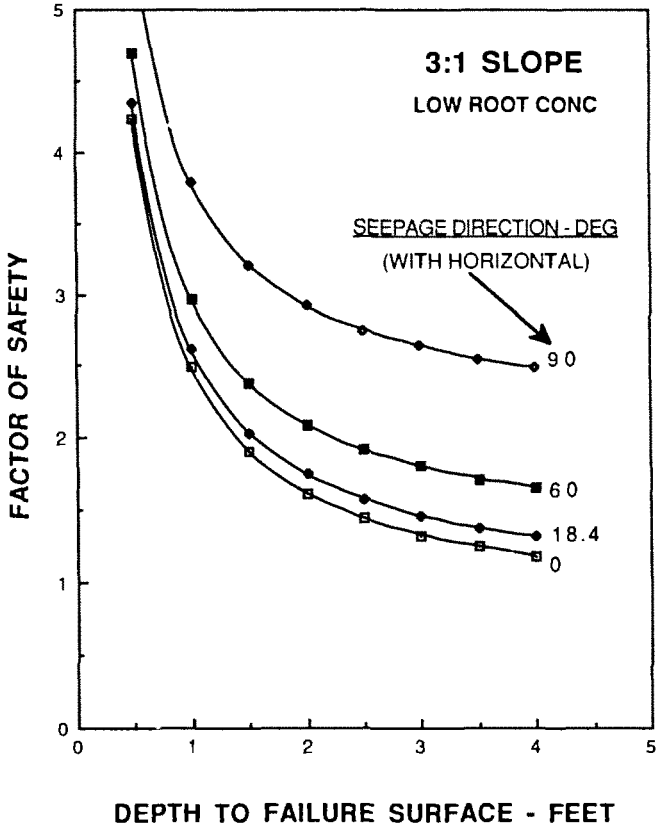


Figure 64. Infinite slope analysis of saturated (3:1) downstream slope of levee with roots (friction angle = 36°)

horizontally. The assumption of equal and opposite vertical side forces on the slices is reasonable if sufficiently narrow slides are used in the analysis.

151. The factor of safety computed by the Modified Method of slices is given by the following equation (Huang 1983):

$$F = \frac{\sum\left[\left\{-c'\Delta x + \left(W_i - u_i\Delta x_i\right)\right\} Tan\phi'\right]\left(1/m_\alpha\right)}{\sum W_i \, Sin\alpha_i} \qquad (5a)$$

$$m_a = [Cos\alpha \{1 + (1/F) (Tan\phi' Tan\alpha)\}] \quad (5b)$$

where: c', ϕ' = effective shear strength parameters

Δx_i = slice width

W_i = slice weight

u_i = pore water pressure at base of slice

α_i = inclination of base of a slice

152. This equation must be solved by iteration because the factor of safety (F) appears on both sides of the equation. The usual procedure is to select several trial circles until the critical circle with the lowest factor of safety is identified. The calculations are tedious and best performed on a high-speed computer. The program SB-SLOPE (distributed by VonGunten Engineering, Fort Collins, CO) was used for this purpose.

153. The factor of safety was computed for several trial circles for both steady seepage (2:1 slope) and sudden drawdown (3:1 slope) conditions, respectively, as shown in Figures 65 and 66. Successively deeper circles passing through the toe (or heel) were selected. The most critical circles were the shallow ones in both cases.

154. The influence of root cohesion was investigated by assigning a cohesion value as a function of depth as described in the previous section. Results of safety factor calculations for the steady seepage and sudden drawdown cases are shown graphically in Figures 67 and 68, respectively, for the same failure circles used previously in Figures 65 and 66. The thin soil layers (6 in. thick) shown in the cross-section diagram of the slope represent soils with different cohesion based on a "low" root concentration in the soil.

155. Results of the circular arc analysis show that in the unreinforced (no root) case, the critical failure circle ($F < 1$) is quite shallow. The presence of roots, even at low concentration, completely reverses this trend. Now the shallow circles (where root concentrations are highest) have the highest factor of safety, whereas the deeper circles are relatively unaffected. Since the deeper circles are not critical in the first place ($F > 1$), the influence of plant roots is less important.

Comparison of safety factors

156. Safety factors computed by the circular arc and infinite slope analyses, respectively, were compared for steady seepage and sudden drawdown

SB-SLOPE

Simplified Bishop Slope Stability Analysis

PROJECT: Stability Analysis of Downstream Face , w/o Roots

LOCATION: Sacramento River Channel Levee

ANALYSIS DONE ON FILE SSD3
FAILURE CIRCLES AND FACTORS OF SAFETY

No. 1	X= 134.7	Y= 45	R= 31.5	FS= 0.65
No. 2	X= 125.6	Y= 31.5	R= 16.6	FS= 0.79
No. 3	X= 124.9	Y= 33.8	R= 18.8	FS= 0.86
No. 4	X= 123.6	Y= 41.3	R= 26.4	FS= 0.98
No. 5	X= 122.4	Y= 47.5	R= 32.5	FS= 1.04

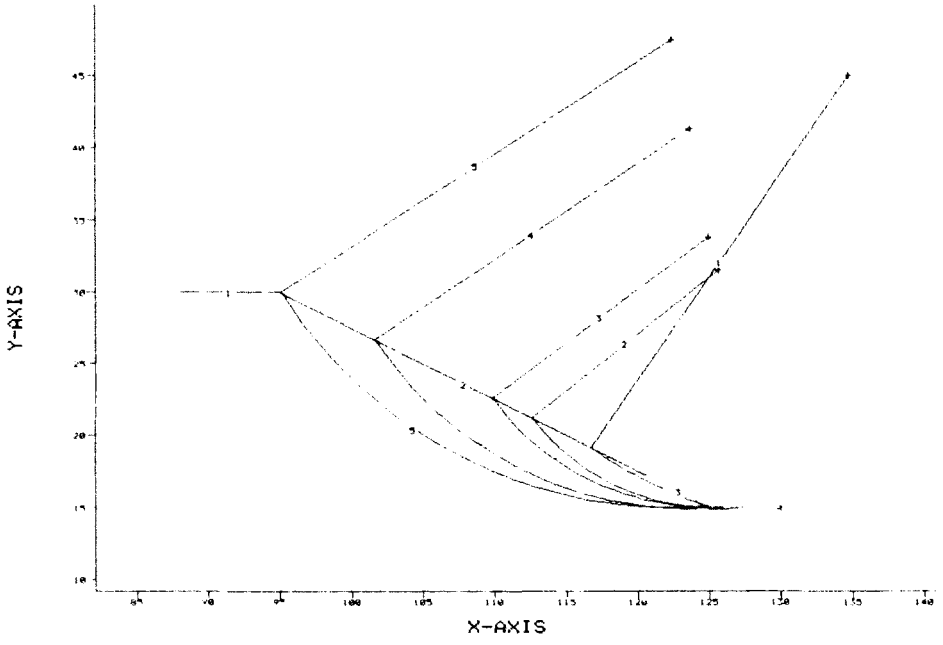


Figure 65. Circular arc stability analysis of (2:1) landward slope of levee under steady seepage conditions. No roots are present (friction angle = 30°)

SB-SLOPE

Simplified Bishop Slope Stability Analysis

PROJECT: Stability Analysis of Upstream Face , w/o Roots

LOCATION: Sacramento River Channel Levee

ANALYSIS DONE ON FILE SS1
FAILURE CIRCLES AND FACTORS OF SAFETY

No. 1	X= 30	Y= 23.9	R= 8.6	FS= 0.72
No. 2	X= 30	Y= 37.6	R= 22.3	FS= 0.72
No. 3	X= 30	Y= 51.1	R= 35.8	FS= 0.73
No. 4	X= 30	Y= 76.4	R= 61.4	FS= 0.74
No. 5	X= 30	Y= 83	R= 68.1	FS= 0.77

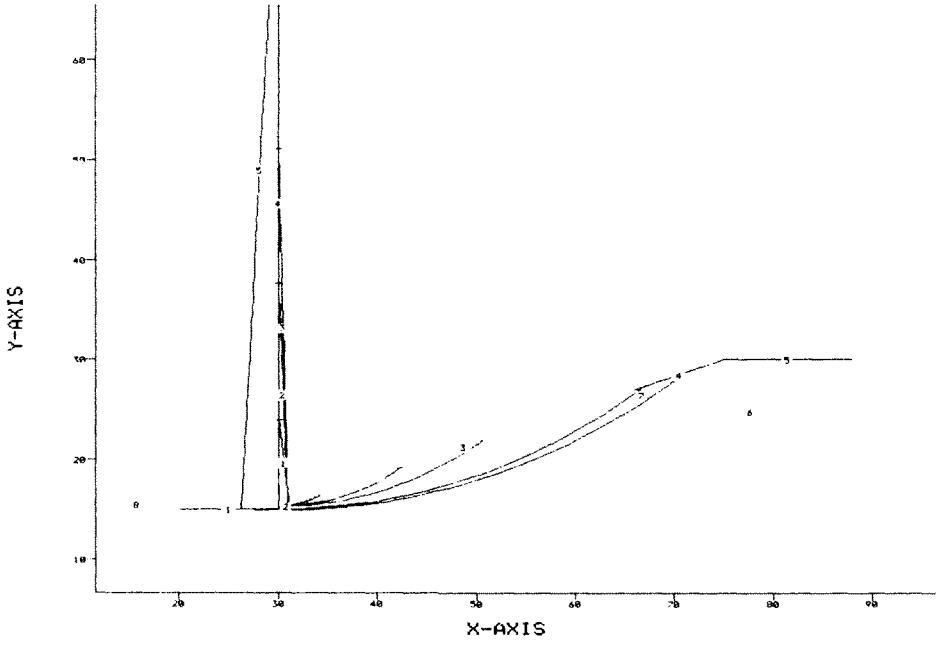


Figure 66. Circular arc stability analysis of (3:1) riverward slope of levee under sudden drawdown conditions. No roots are present (friction angle = 30°)

SB-SLOPE

Simplified Bishop Slope Stability Analysis

PROJECT: Stability Analysis of Downstream Face , with Roots

LOCATION: Sacramento River Channel Levee

ANALYSIS DONE ON FILE SSD3R
FAILURE CIRCLES AND FACTORS OF SAFETY

No. 1	X= 134.7	Y= 45	R= 31.5	FS= 5.57
No. 2	X= 125.6	Y= 31.5	R= 16.6	FS= 1.75
No. 3	X= 124.9	Y= 33.8	R= 18.8	FS= 1.54
No. 4	X= 123.6	Y= 41.3	R= 26.4	FS= 1.23
No. 5	X= 122.4	Y= 47.5	R= 32.5	FS= 1.16

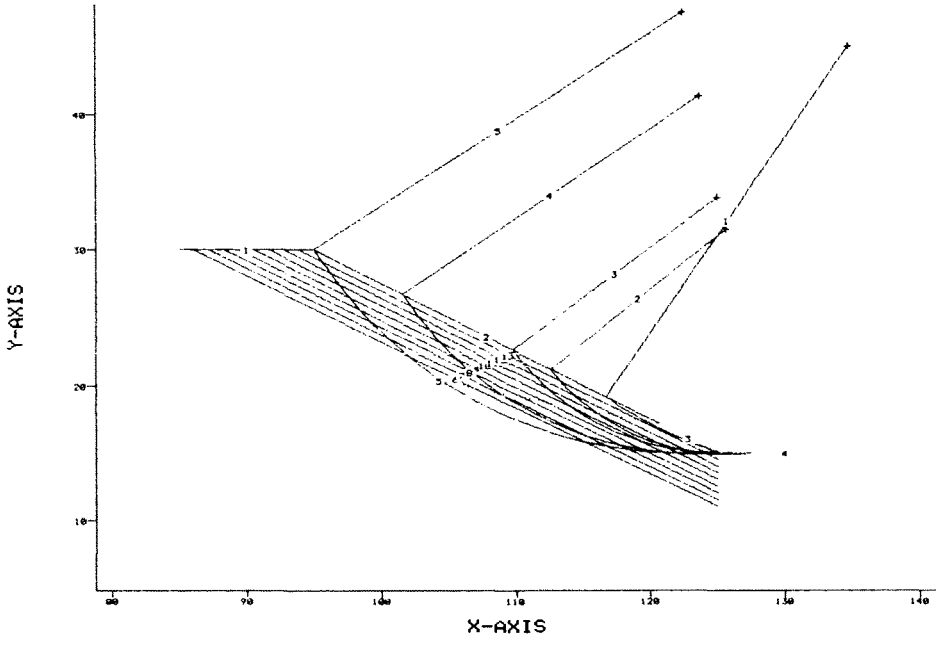


Figure 67. Circular arc stability analysis of (2:1) landward slope of levee under steady seepage conditions. Low root concentration (friction angle = 30°)

SB-SLOPE

Simplified Bishop Slope Stability Analysis

PROJECT: Stability Analysis of Upstream Face , with Roots

LOCATION: Sacramento River Channel Levee

ANALYSIS DONE ON FILE SS1R
FAILURE CIRCLES AND FACTORS OF SAFETY

No. 1	X= 30	Y= 23.9	R= 8.6	FS= 16.5
No. 2	X= 30	Y= 37.6	R= 22.3	FS= 3.40
No. 3	X= 30	Y= 51.1	R= 35.8	FS= 2.01
No. 4	X= 30	Y= 76.4	R= 61.4	FS= 1.16
No. 5	X= 30	Y= 83	R= 68.1	FS= 1.10

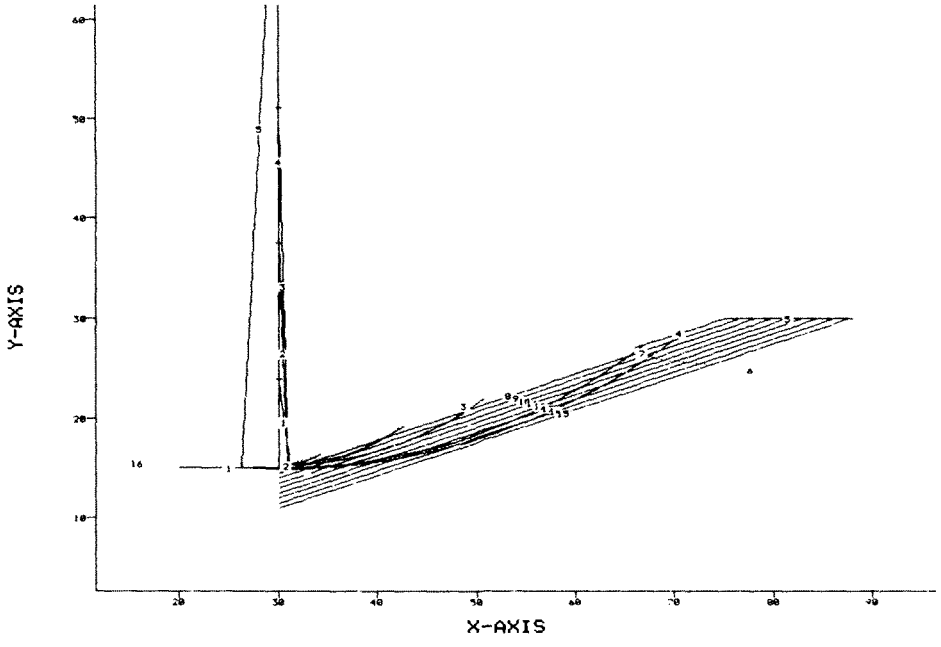


Figure 68. Circular arc stability analysis of (3:1) riverward slope of levee under sudden drawdown conditions. Low root concentration (friction angle = 30°)

conditions. The results of this comparison are shown in Tables 9 and 10 for both the "no root" and "low root" concentration cases, respectively. The presence of roots, even at low concentrations, more than doubles the critical factor of safety in both cases.

157. The circular arc analyses were conducted with $\phi = 30°$, whereas the infinite slope analyses were run at 28° and 36° -- the minimum and maximum values measured in the borehole shear tests. The average friction angle for all tests was 31.6°. The agreement between circular arc and infinite slope analyses is excellent for the steady seepage case--both with and without root cohesion. Factors of safety computed by the circular arc analyses lie within the values computed by the infinite slope method for $28<\phi<36$ and $0<\theta<b$. Agreement between the two methods for the sudden drawdown case is less satisfactory, with the infinite slope method giving lower estimates.

TABLE 9. COMPARISON OF FACTORS OF SAFETY - NO ROOTS

METHOD OF ANALYSIS	FACTOR OF SAFETY	
	STEADY SEEPAGE (2:1 SLOPE)	SUDDEN DRAWDOWN (3:1 SLOPE)
CIRCULAR ARC: (CRITICAL CIRCLE) PHi = 30 DEG	0.65	0.72
INFINITE SLOPE:		
PHI = 36 DEG THETA = 0 DEG	0.76	N/A
THETA = BETA	0.94	1.27
PHI = 28 DEG THETA = 0 DEG	0.56	N/A
THETA = BETA	0.68	0.93

TABLE 10. COMPARISON OF FACTORS OF SAFETY - LOW ROOT CONCENTRATION, SHALLOW FAILURE SURFACE

METHOD OF ANALYSIS	FACTOR OF SAFETY	
	STEADY SEEPAGE (2:1 SLOPE)	SUDDEN DRAWDOWN (3:1 SLOPE)
CIRCULAR ARC: (SHALLOW CIRCLE, H = 1 FT) PHI = 30 DEG	1.75	3.4
INFINITE SLOPE: (H=1 FT)		
PHI = 36 DEG THETA = 0 DEG	1.87	N/A
THETA = BETA	2.00	2.62
PHI = 28 DEG THETA = 0 DEG	1.64	N/A
THETA = BETA	1.78	2.28

PART VI: SUMMARY AND CONCLUSIONS

Summary

158. Woody vegetation growing on the side slopes of levees modifies the top surface layer and this in turn can affect the hydraulic regime and stability of the levee. A field study was conducted to determine the distribution and concentration of roots, voids, and pedotubules along transects both perpendicular and parallel to the crest of a sandy levee. The results of the field study together with the findings of seepage and stability analyses described herein lead to the following conclusions:

Levee vegetation
composition and distribution

a. An analysis of random vegetation transects showed that the dominant tree species growing on the 6-mile study reach of channel levee along the Sacramento River are valley oak (*Quercus lobata*) and cottonwood (*Populus fremontii*). Valley oak appeared well adapted to all levee environments and was the only arboreal species found growing on both landward and riverward slopes of the levee in addition to the levee crest.

b. The principal shrub species were licorice (*Glyclyrrhiza* sp.), rose (*Rosa californica*), elderberry (*Sambucus* sp.), and willow (*Salix* sp.). Among the shrubs, licorice appeared to be particularly well adapted to all levee environments and vegetation management practices. This plant has an extensive root system and thrives on burning.

c. Apart from valley oak, rose, and licorice, all other tree and shrub species were found on the riverward slope only.

Root distribution in
sandy channel levees

a. The profile method was adapted successfully to determine the distribution and concentration of roots and biopores in a sandy channel levee.

b. Lateral plant roots are restricted to and modify mainly the first few feet beneath the surface of a levee. Root area ratios did not exceed 2 percent and generally decreased approximately exponentially with depth. Most of the root biomass is concentrated in the top 2 ft.

c. The only valley oak that was fully excavated had a deep, vertical, central tap root. Laterals radiating away from this central tap root tend to angle down sharply in order to reach moisture in a sandy, and hence droughty, levee. This root architecture means that lateral roots are much less likely to penetrate across or through a levee.

d. All tree/shrub species investigated had similar lateral root area ratio profiles. A comparison of root area ratios at different depth intervals indicated that no one species exhibited a higher root area ratio than another over the entire rooting depth. An exception was the "control" or grass and herbaceous ground cover site, which exhibited high root area ratios at very shallow depths (less than 6 in.).

Occurrence, probable cause, and influence of voids and pedotubules

a. Voids and pedotubules (infilled holes or conduits) were mapped in the vertical faces of the trenches at each site. The average number of voids per unit area reached a maximum at a depth of 6 in. and then decreased with depth to a minimum value.

b. Voids or holes were created by burrowing animals or insects. Voids created by burrowing animals, namely the California ground squirrel, were easily identified by their size, shape, and form. These burrow holes occurred at all depths including one hole which was exposed at a depth of 4 ft.

c. No voids clearly attributable to plant roots were observed. Only rapidly formed holes of recent origin, namely, animal burrows or insect holes, are likely to be observed at any given instant. Root holes which form more slowly, as roots gradually decay, are more likely to evolve directly into pedotubules and not persist long as voids.

d. Pedotubules could be distinguished visually from the surrounding soil by differences in color and texture and in some cases by differences in gradation and density as well. These pedotubules appeared to form as a result of soil washed in during overbank flows or floods.

e. Unlike intact roots, open voids or conduits in a levee represent an immediate danger from the point of view of a piping or internal erosion failure. These features could affect internal stability as a result of high seepage velocities and gradients associated with them.

f. Other factors in addition to the presence of biopores are responsible for internal erosion or piping failure in a levee. The role of hydraulic fracturing, which can occur independently of the existence of such macropores, must be considered as well.

Influence of roots on hydraulic regime

a. The influence of a modified surface layer or skin (with a different hydraulic conductivity) on hydraulic head distribution and line of seepage was determined for both the case of a less- and more permeable skin. A less permeable skin resulted in enlargement of the exposed seepage area and greater exit gradients near the toe.

b. There was no evidence in the field study that vegetation affected the hydraulic conductivity one way or the other either by modification of microscopic or macroscopic porosity.

c. The results of a transient seepage analysis showed that the maximum flood of record was of insufficient magnitude, in stage elevation and/or duration, to cause the line of seepage or phreatic surface to reach the landward toe of a design levee with a homogenous cross section. The presence or absence of vegetation should not alter this conclusion provided the vegetation does not greatly change the hydraulic conductivity of the levee soils (see preceding conclusion).

d. A 3-D seepage analysis should be developed to study the influence of pipes or pedotubules that penetrate or partially penetrate through a levee. There was little or no evidence from limited excavation and trenching conducted during the field study itself to indicate that fully penetrating conduits actually exist.

Influence of roots on mass stability

a. Roots reinforce the soil and increase the shear strength in a measurable manner. A shear strength increase or root cohesion can be estimated from the root biomass per unit volume or alternatively from the RAR. A value of root cohesion (cR) of 3.2 psi/% RAR was calculated in the study. This root cohesion can greatly improve the mass stability, particularly in a sandy loam with little or no intrinsic cohesion.

b. Both infinite slope and circular arc stability analyses were performed on the landward and riverward slope for steady seepage and sudden drawdown conditions, respectively. These analyses showed that even low root concentrations as measured along selected transects in the sandy levee sufficed to make the slope more secure under "worst case" scenario conditions (i.e., high free water level, low shear strength, etc).

c. Results of the circular arc analyses show that in the unreinforced (no root) case the critical failure circles ($F < 1$) are quite shallow. The presence of roots, even at low concentrations, completely reversed this trend. Shallow circles (where root concentrations are highest) now have the highest factor of safety whereas deeper circles are relatively unaffected. Since the deeper circles are not critical in the first place ($F > 1$) the influence of plant roots is less important in this instance.

d. Grassed slopes exhibited relatively high root area ratios at very shallow depths (under 6 in.) compared to woody sites. Consequently, grass or herbaceous cover appears to be just as effective in preventing shallow sloughing or surface ravelling. Woody plants, on the other hand, are more deeply rooted and therefore more effective in preventing deeper seated sliding. Shrubs and bushes provide the benefits of woody roots without the possible liabilities associated with large trees such as wind-throwing.

Conclusions

159. Based on the results of preliminary field studies conducted on a sandy channel levee, it does not appear that woody vegetation adversely affects the structural integrity of a levee. No open voids or conduits clearly attributable to plant roots were observed. The presence of plant roots reinforced the soil and increased the shear strength of the surface layers in a measurable manner.

160. Grasses and herbaceous ground cover provided greater amounts of roots at very low depths (under 6 in.) than did woody plants. Consequently, this type of vegetation appears to be just as effective as woody plants in preventing shallow sloughing or surface ravelling. Woody roots, on the other hand, are stronger and tend to penetrate more deeply; therefore, they are more effective in preventing deeper seated slope failures. Low-lying shrubs and bushes provide the benefits of woody roots without possible liabilities associated with large trees growing on a levee.

161. The profile wall method and other techniques described in the report can be adapted successfully to determine the distribution and concentration of roots and biopores in a levee structure. These techniques should be used to investigate the effects of vegetation on other types of levees and in regions with different climatic conditions.

PART VII: RECOMMENDATIONS FOR FUTURE RESEARCH

162. As a result of the research described herein, the following topics have been identified as useful areas for future research:

a. Root architecture and distribution.

1. Conduct additional full excavations around trees to determine if vertical rooting is the predominant orientation in sandy levees. Very few large, lateral roots were exposed in the trench faces at the live oak site.

2. Conduct gravimetric root biomass assays in conjunction with the profile-wall surveys to see if the latter adequately accounts for the presence of root fibers less than 1 mm in diameter. The latter size class is probably underestimated in the profile-wall survey method.

b. Hydraulic studies.

1. Conduct in situ hydraulic conductivity testing with large, double ring infiltrometers in order to determine if near surface portions of a levee are modified by the presence of vegetation. Permeability/density tests on small volume samples do not adequately reflect macroscopic hydraulic properties of levee soils, i.e., the influence of large void volume defects such as animal burrows, pedotubules, root holes, etc.

2. Develop a 3-D seepage analysis technique to model adequately the effects of pipes, holes, large voids, etc., on the seepage regime and the danger of internal erosion.

c. General.

1. Conduct similar field studies in levees made of cohesive soils and compare results with those obtained for sandy levees.

2. Conduct studies in regions where climatic conditions are more humid and the vegetation spectrum is different from the semi-arid conditions of central California.

REFERENCES

ASTM. 1977. "Dispersive Clays, Related Piping and Erosion in Geotechnical Projects," ASTM STP 623, J. L. Sherard and R. S. Decker, eds., Amer. Soc. for Testing and Materials.

ASTM. 1985. "Standard Method for Particle-Size Analysis of Soils-ASTM D422," Annual Book of ASTM Standards, Sec. 4, Vol 04.08, *Soil and Rock; Building Stones*, American Society for Testing and Materials.

Beven, K. and German, P. 1982. "Macropores and Water Flow in Soils," Water Resources Research, Vol 18, pp 1311-1325.

Bohm, W. 1979. Methods of Studying Root Systems, Springer-Verlag, New York.

Brenner, R. P. 1973. "A Hydrologic Model Study of a Forested and a Cutover Slope," Bulletin of Hydrologic Sciences, Vol 18, No. 26, pp 125-143.

Brewer, R. and Sleeman, J. R. 1963. "Pedotubules: Their Definition, Classification, and Interpretation," Journal of Soil Science, Vol 14, pp 156-166.

California Reclamation Board. 1967. "Levee Encroachment: Guide for Vegetation on Project Levees," California Department of Water Resources, Sacramento, CA.

_____. 1982. Guide for Vegetation on Project Levees. California Department of Water Resources, Sacramento, CA.

Carter, L. W., and Anderson, G. L. 1984. "Riparian Vegetation on Flood Control Levees: Constraints and Opportunities," California Riparian Systems Conference, University of California, Davis, CA.

Casagrande, A. 1938. "Seepage Through Earth Dams," Contributions to Soil Mechanics: 1925-1940, Boston Society of Civil Engineers, Boston, MA, pp 295-335.

Cedergren, H. R. 1967. Seepage, Drainage and Flow Nets, 1st ed., John Wiley and Sons, New York.

Daar, S. Klitz, W., and Olkowski, W. 1984. "The Role of Vegetation in an Integrated Pest Management Approach to Levee Management," California Riparian Systems Conference, University of California, Davis, CA.

Das, B. M. 1983. Advanced Soil Mechanics, McGraw-Hill Book Co., New York.

Davis, L. C., Ito, S. I., and Zwanch, P. T. 1967. "Pilot Levee Maintenance Study," Bulletin no. 167, California Department of Water Resources, Sacramento, CA.

Endo, T., and Tsuruta, T. 1969. "The Effect of Tree Roots Upon the Shearing Strength of Soil," Annual Report of the Hokkaido Branch, Tokyo Forest Experiment Station, Vol 18, pp 168-179.

Fitzgerald, W. S., and Marsh, R. E. 1986. "Potential of Vegetation Management for Ground Squirrel Control," Proceedings, Twelfth Vertebrae Pest Conference, University of California, Davis.

Fogel, R. 1980. "Mycorrhizae and Nutrient Cycling in Natural Forest Ecosystems," New Phytology, Vol 86, pp 199-212.

Gray, D. H., and Leiser, A. T. 1982. Biotechnical Slope Protection and Erosion Control, Van Nostrand Reinhold, New York.

Gray, D. H., and Ohashi, H. 1983. "Mechanics of Fiber Reinforcement in Sand," Journal of Geotechnical Engineering, ASCE, Vol 109, No. 3, pp 335-353.

Gray, D. H., and Al-Refeai, T. 1986. "Behavior of Fabric- versus Fiber-Reinforced Sand," Journal of Geotechnical Engineering, ASCE, Vol 112, No. GT8, pp 804-820.

Gray, D. H., and Maher, H. 1989. "Admixture Stabilization of Sands with Random Fibers," Proceedings, XII International Conference on Soil Mechanics and Foundation Engineering, ICSMFE.

Greenway, D. R. 1987. "Vegetation and Slope Stability," Slope Stability, John Wiley and Sons, New York.

Handy, R. L. 1986. "Borehole Shear Test and Slope Stability," Proceedings, ASCE-GT Specialty Conference, Blacksburg, VA, pp 161-175.

Hermann, R. K. 1977. "Growth and Production of Tree Roots: A Review," The Below Ground Ecosystem: A Synthesis of Plant-Associated Processes, Scientific Series No. 26, J. K. Marshall, ed., Range Science Department, Colorado State University, Ft. Collins, pp 7-28.

Hewlett, H. W., Boorman, L. A., and Bramley, M. E. 1987. "Design of Reinforced Grass Waterways," CIRIA Report No. 116, Construction Industry Research and Information Association, London, England.

Hynson, J. R., Elmer, J. O., and Shields, F. D. 1985. "Environmental Features for Streamside Levee Projects," Technical Report E-85-7, Center for Natural Areas, South Gardiner, ME, and US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Huang, Y. H. 1983. Stability Analysis of Earth Slopes, Van Nostrand Reinhold Co., New York.

Huang, Y. H. 1986. "Unsteady State Phreatic Surface in Earth Dams," Journal of Geotechnical Engineering, Vol 112, No. 1, pp 93-98.

Jones, J. A. 1981. The Nature of Soil Pipes, Geo Books, Norwich, England.

Keller, E. A., and Brookes, A. 1984. "Considerations of Meandering in Channelization Projects: Selected Observations and Judgements," Proceedings of the Conference Rivers '83, pp 384-397.

Kenney, T. C., and Lau, D. 1985. "Internal Stability of Granular Filters," Canadian Geotechnical Journal, Vol 22, pp 215-225.

Kleiner, D. E. 1985. "Engineering with Spreadsheets," Civil Engineering, ASCE, Vol 55, No. 10, pp 55-57.

Klingeman, P. C., and Bradley, J. B. 1976. "Willamette River Basin Streambank Stabilization by Natural Means," Water Resources Research Institute, Oregon State University, Corvallis, OR.

Kouwen, N., and Li, R. M. 1980. "Biomechanics of Vegetative Channel Linings," Journal of Hydraulic Engineering, ASCE, Vol 106, No. 6, pp 1085-1103.

McGinn, D. R. 1963. "Characteristics of Douglas Fir Root Systems, Canadian Journal of Botany, Vol 4, pp 105-122.

Nolan, M. F. 1981. "Vegetation on Corps of Engineers Project Levees in the Sacramento-San Joaquin Valley, California," California Riparian Systems Conference, University of California, Davis, CA.

Gray, D. H., and Ohashi, H. 1983. "Mechanics of Fiber Reinforcement in Sand," Journal of Geotechnical Engineering, ASCE, Vol 109, No. 3, pp 335-353.

Gray, D. H., and Al-Refeai, T. 1986. "Behavior of Fabric- versus Fiber-Reinforced Sand," Journal of Geotechnical Engineering, ASCE, Vol 112, No. GT8, pp 804-820.

Gray, D. H., and Maher, H. 1989. "Admixture Stabilization of Sands with Random Fibers," Proceedings, XII International Conference on Soil Mechanics and Foundation Engineering, ICSMFE.

Greenway, D. R. 1987. "Vegetation and Slope Stability," Slope Stability, John Wiley and Sons, New York.

Handy, R. L. 1986. "Borehole Shear Test and Slope Stability," Proceedings, ASCE-GT Specialty Conference, Blacksburg, VA, pp 161-175.

Hermann, R. K. 1977. "Growth and Production of Tree Roots: A Review," The Below Ground Ecosystem: A Synthesis of Plant-Associated Processes, Scientific Series No. 26, J. K. Marshall, ed., Range Science Department, Colorado State University, Ft. Collins, pp 7-28.

Hewlett, H. W., Boorman, L. A., and Bramley, M. E. 1987. "Design of Reinforced Grass Waterways," CIRIA Report No. 116, Construction Industry Research and Information Association, London, England.

Hynson, J. R., Elmer, J. O., and Shields, F. D. 1985. "Environmental Features for Streamside Levee Projects," Technical Report E-85-7, Center for Natural Areas, South Gardiner, ME, and US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Huang, Y. H. 1983. Stability Analysis of Earth Slopes, Van Nostrand Reinhold Co., New York.

Huang, Y. H. 1986. "Unsteady State Phreatic Surface in Earth Dams," Journal of Geotechnical Engineering, Vol 112, No. 1, pp 93-98.

Jones, J. A. 1981. The Nature of Soil Pipes, Geo Books, Norwich, England.

Keller, E. A., and Brookes, A. 1984. "Considerations of Meandering in Channelization Projects: Selected Observations and Judgements," Proceedings of the Conference Rivers '83, pp 384-397.

Kenney, T. C., and Lau, D. 1985. "Internal Stability of Granular Filters," Canadian Geotechnical Journal, Vol 22, pp 215-225.

Kleiner, D. E. 1985. "Engineering with Spreadsheets," Civil Engineering, ASCE, Vol 55, No. 10, pp 55-57.

Klingeman, P. C., and Bradley, J. B. 1976. "Willamette River Basin Streambank Stabilization by Natural Means," Water Resources Research Institute, Oregon State University, Corvallis, OR.

Kouwen, N., and Li, R. M. 1980. "Biomechanics of Vegetative Channel Linings," Journal of Hydraulic Engineering, ASCE, Vol 106, No. 6, pp 1085-1103.

McGinn, D. R. 1963. "Characteristics of Douglas Fir Root Systems, Canadian Journal of Botany, Vol 4, pp 105-122.

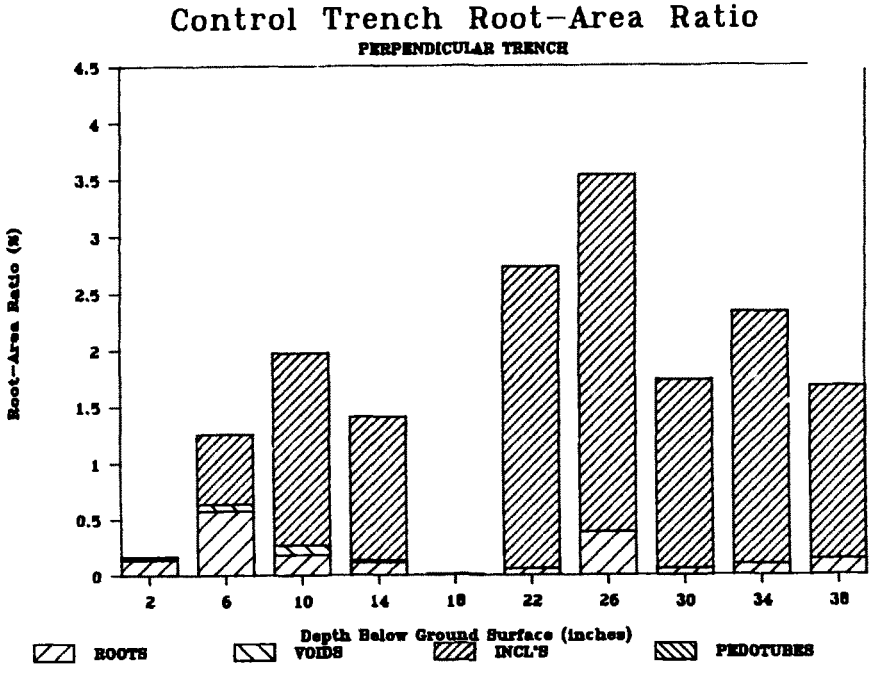
Nolan, M. F. 1981. "Vegetation on Corps of Engineers Project Levees in the Sacramento-San Joaquin valley, California," California Riparian Systems Conference, University of California, Davis, CA

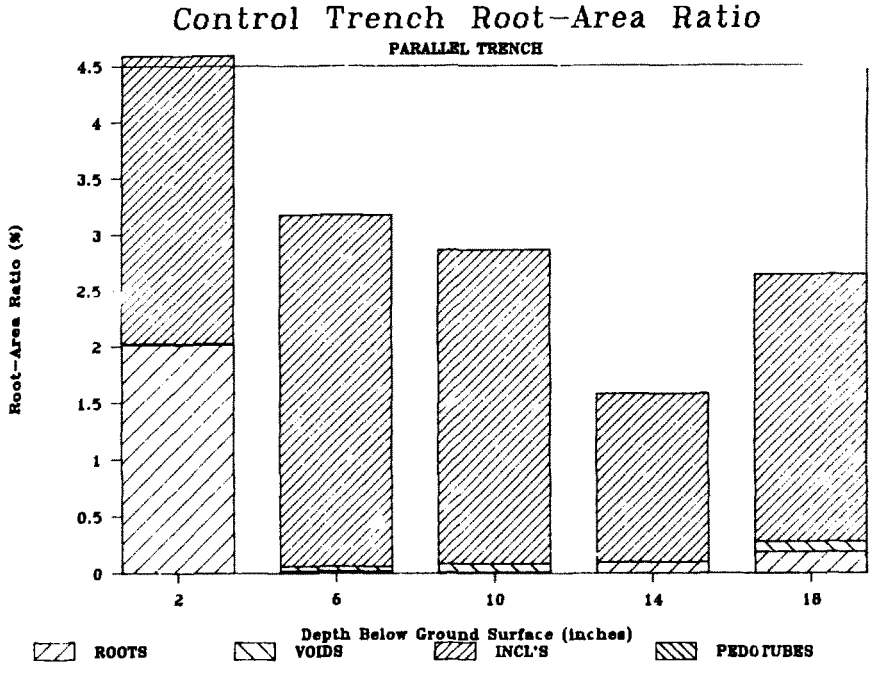
Whitlow, T. H., and Bahre, C. J. 1984. "Plant Succession on Merced River Dredge Spoils," California Riparian Systems, R. E. Warner and K. M. Hendrix, eds., University of California Press, Berkeley.

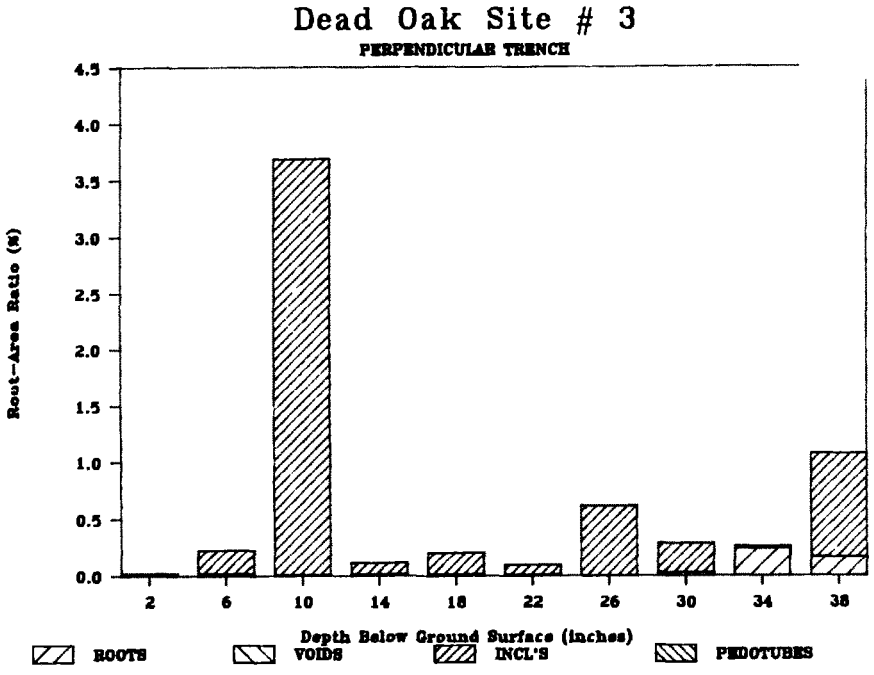
Wineland, J. D. 1975. "Borehole Shear Device," Proceedings, ASCE-GT Specialty Conference, Raleigh, NC, Vol 1, pp 511-535.

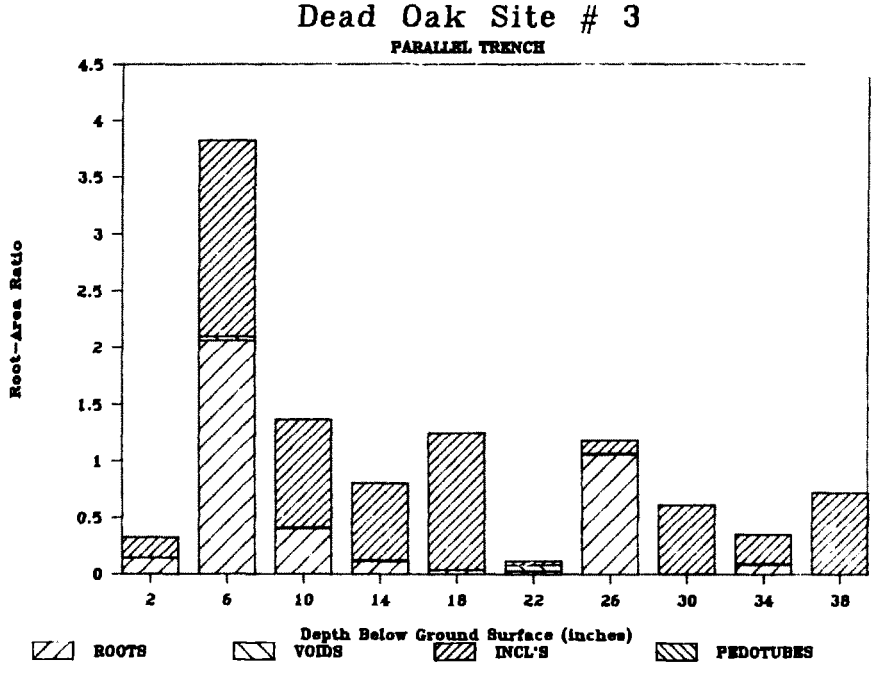
Ziemer, R. 1981. "Roots and Shallow Stability of Forested Slopes," International Association of Hydrological Sciences, No. 132, pp 343-361.

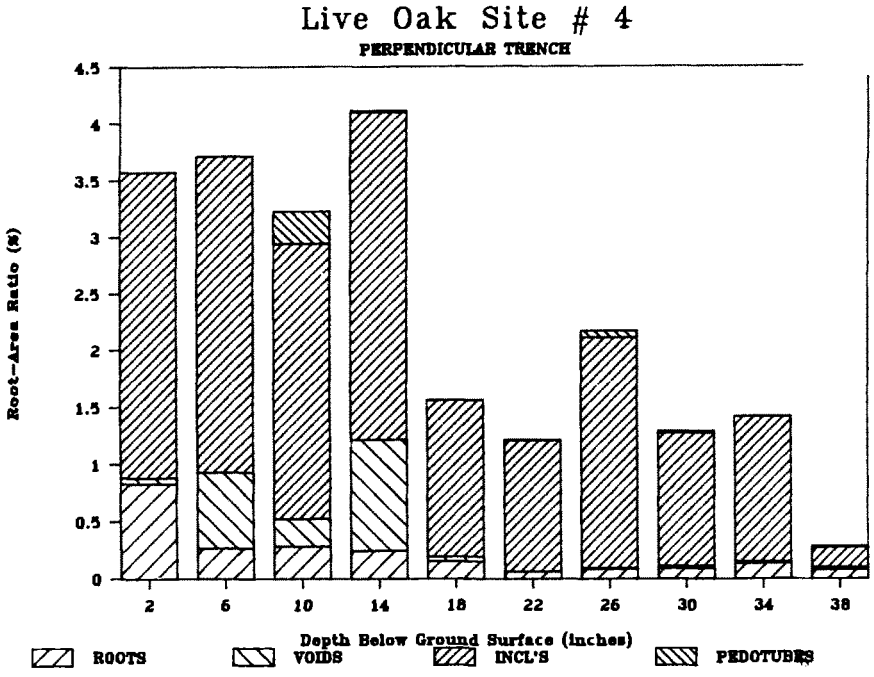
APPENDIX A: TOTAL AREA RATIO HISTOGRAMS FOR LEVEE TRENCH SITES

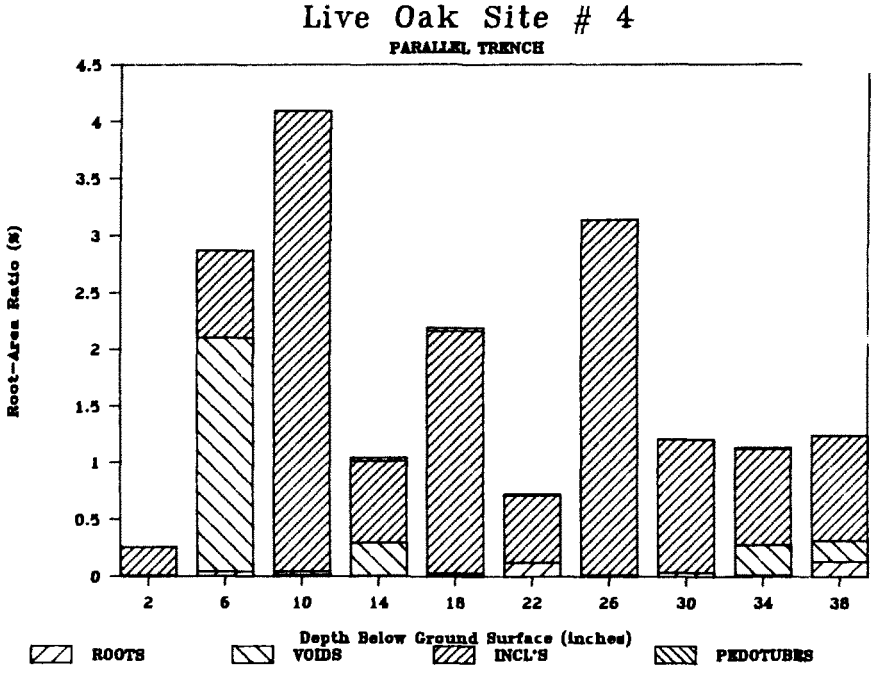

Control Trench Root-Area Ratio
PERPENDICULAR TRENCH
Root-Area Ratio (%)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2
6
10
14
18
22
26
30
34
38
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES

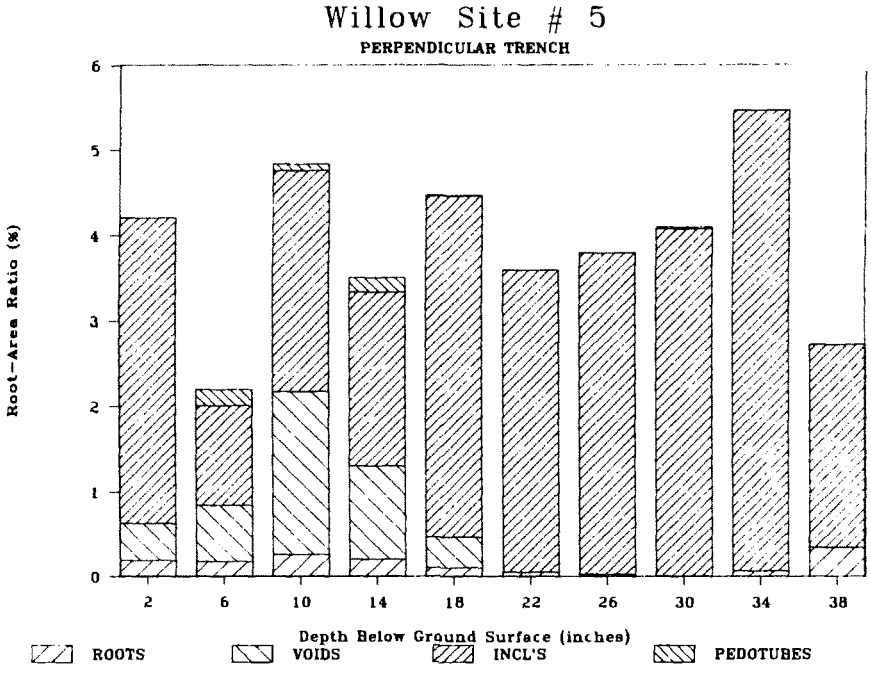

Control Trench Root-Area Ratio
PARALLEL TRENCH
Root-Area Ratio (%)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2
6
10
14
18
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES

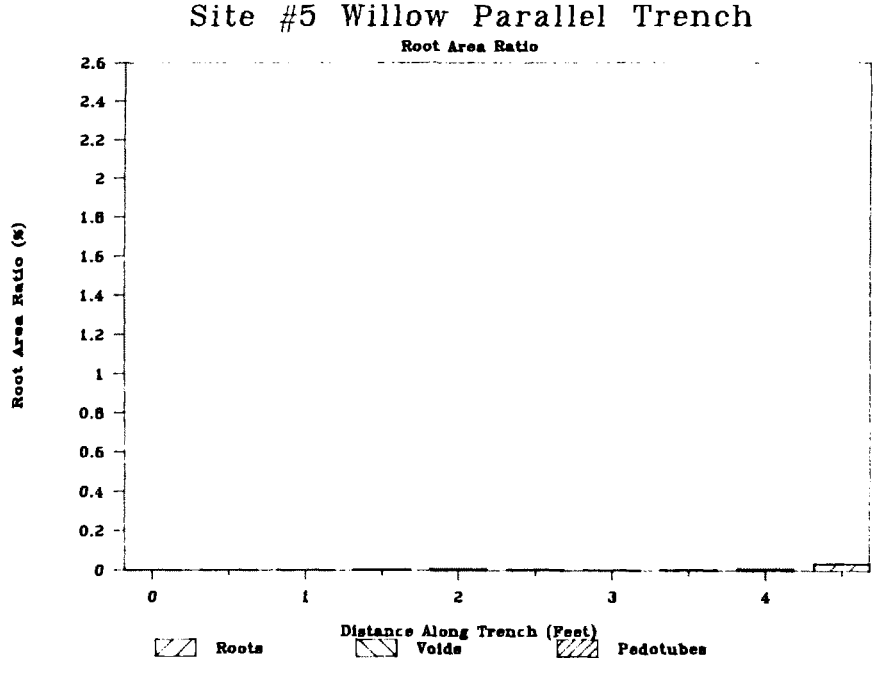

Dead Oak Site # 3
PERPENDICULAR TRENCH
Root-Area Ratio (%)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2
6
10
14
18
22
26
30
34
38
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES

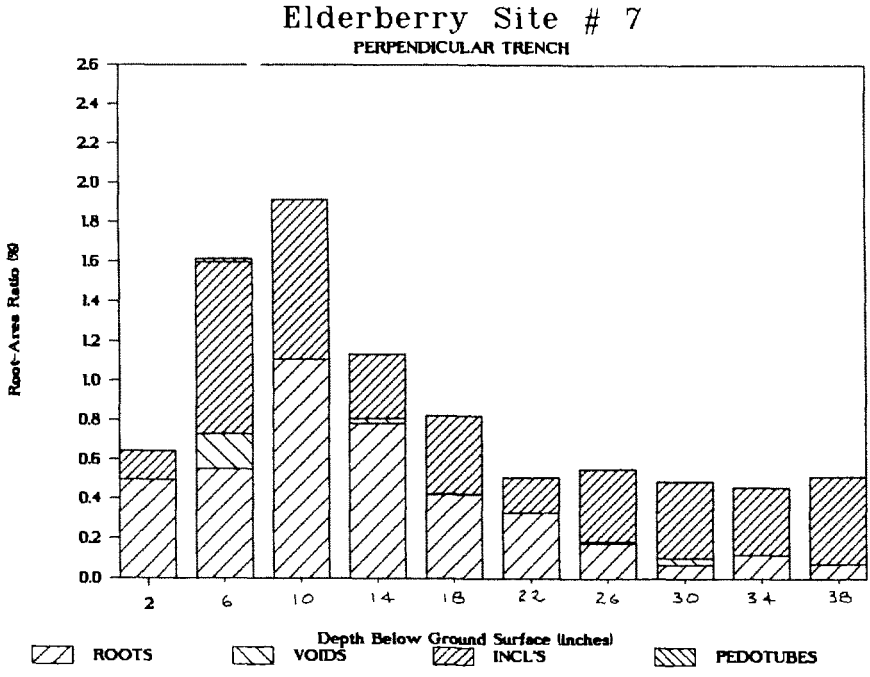

Dead Oak Site # 3
PARALLEL TRENCH
Root-Area Ratio
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2
6
10
14
18
22
26
30
34
38
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES

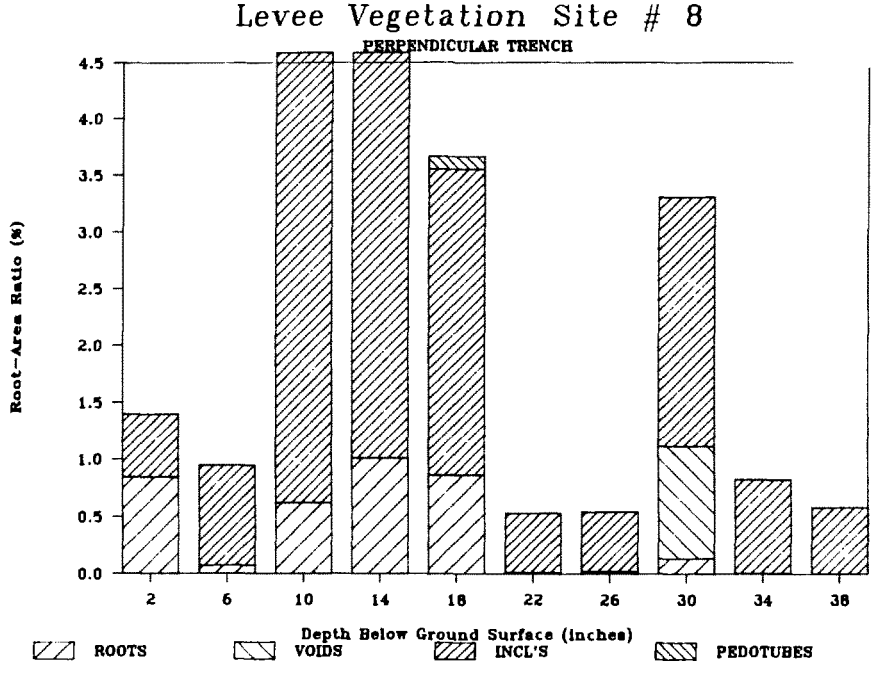

Live Oak Site # 4
PERPENDICULAR TRENCH
Root-Area Ratio (%)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2
6
10
14
18
22
26
30
34
38
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES

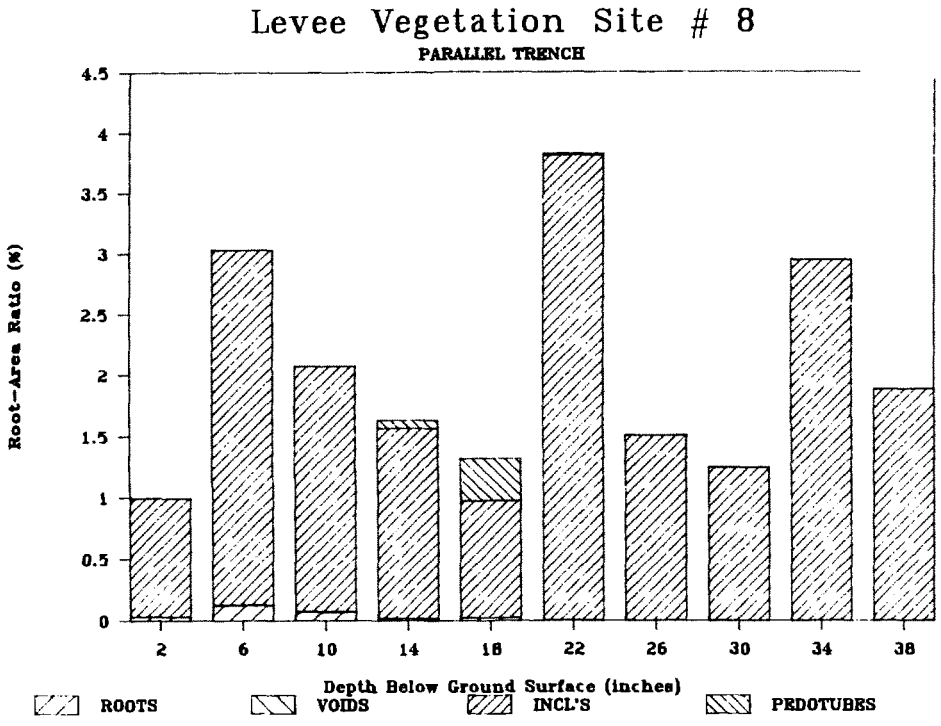

Live Oak Site # 4
PARALLEL TRENCH
Root-Area Ratio (%)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2
6
10
14
18
22
26
30
34
38
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES


Willow Site # 5
PERPENDICULAR TRENCH
Root-Area Ratio (%)
0
1
2
3
4
5
6
2
6
10
14
18
22
26
30
34
38
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES

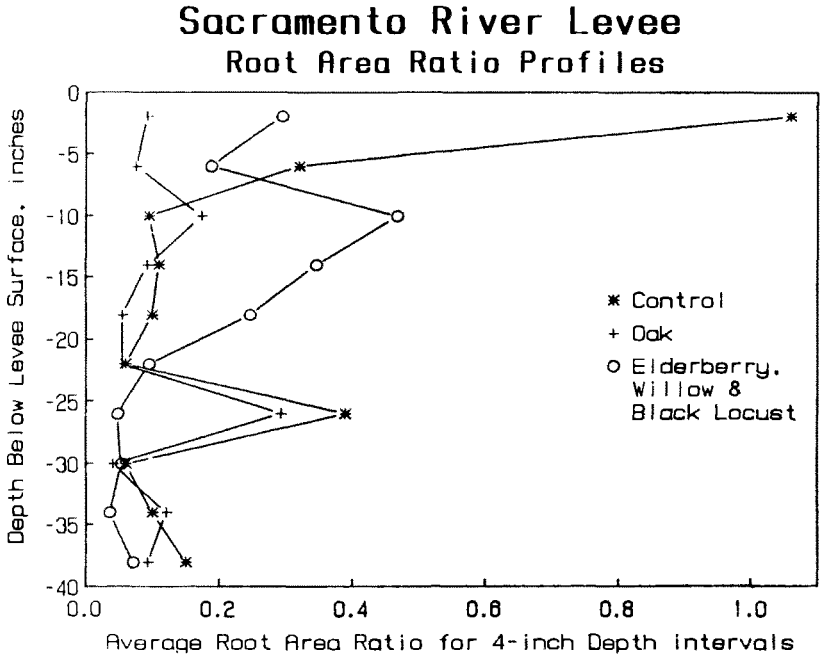

Site #5 Willow Parallel Trench
Root Area Ratio
Root Area Ratio (%)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
0
1
2
3
4
Distance Along Trench (Feet)
Roots
Voids
Pedotubes

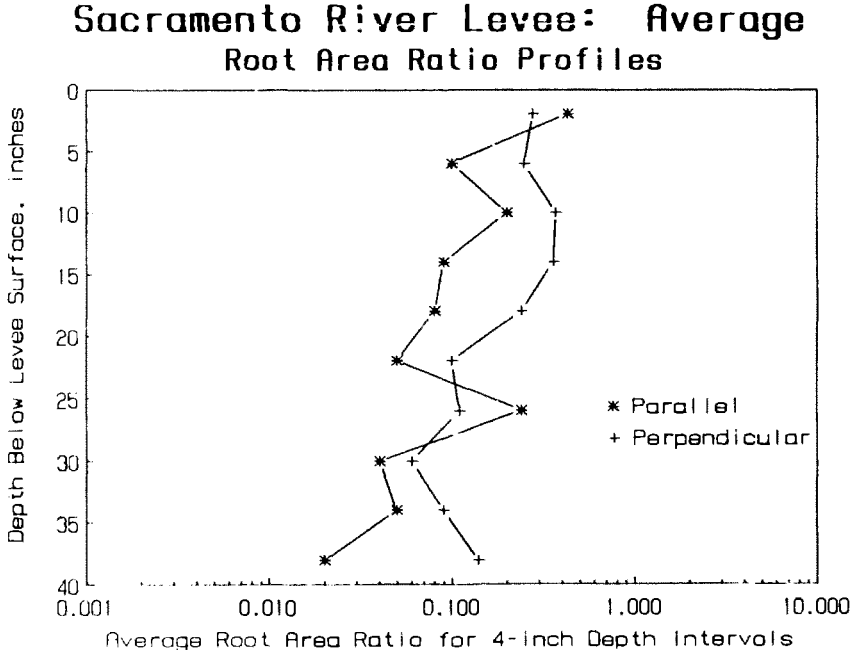

Elderberry Site # 7
PERPENDICULAR TRENCH
Root-Area Ratio (%)
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2
6
10
14
18
22
26
30
34
38
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES

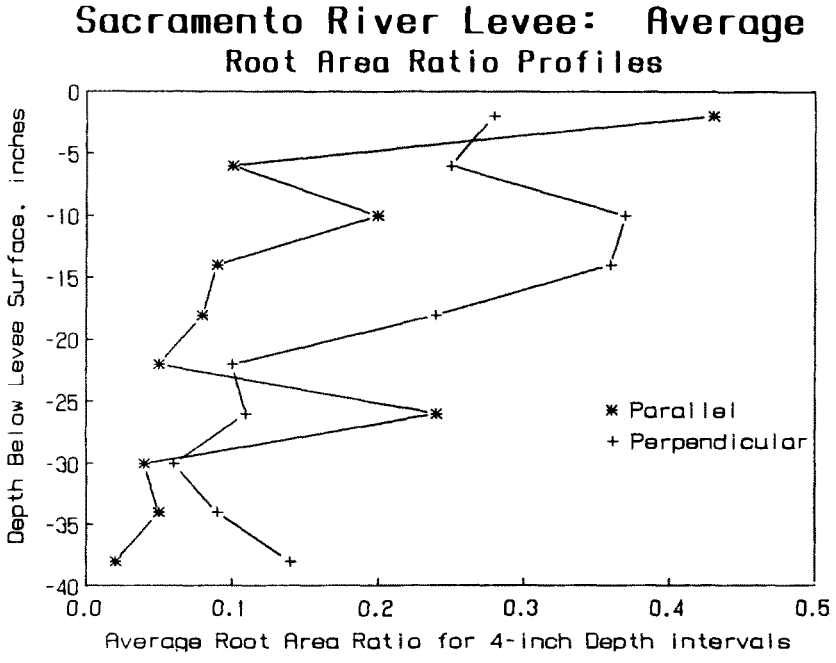

Levee Vegetation Site # 8
PERPENDICULAR TRENCH
Root-Area Ratio (%)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2
6
10
14
18
22
26
30
34
38
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES

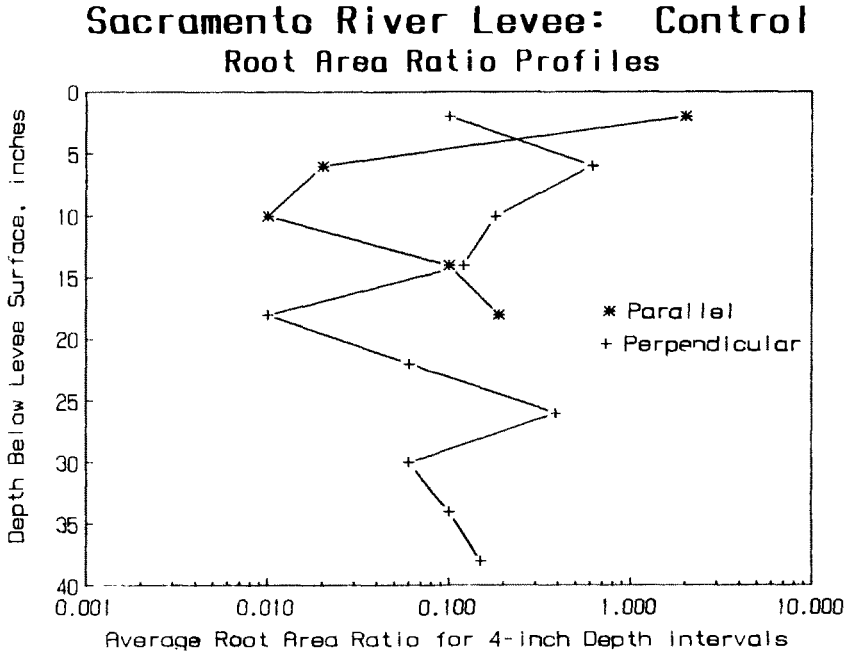

Levee Vegetation Site # 8
PARALLEL TRENCH
Root-Area Ratio (%)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2
6
10
14
18
22
26
30
34
38
Depth Below Ground Surface (inches)
ROOTS
VOIDS
INCL'S
PEDOTUBES

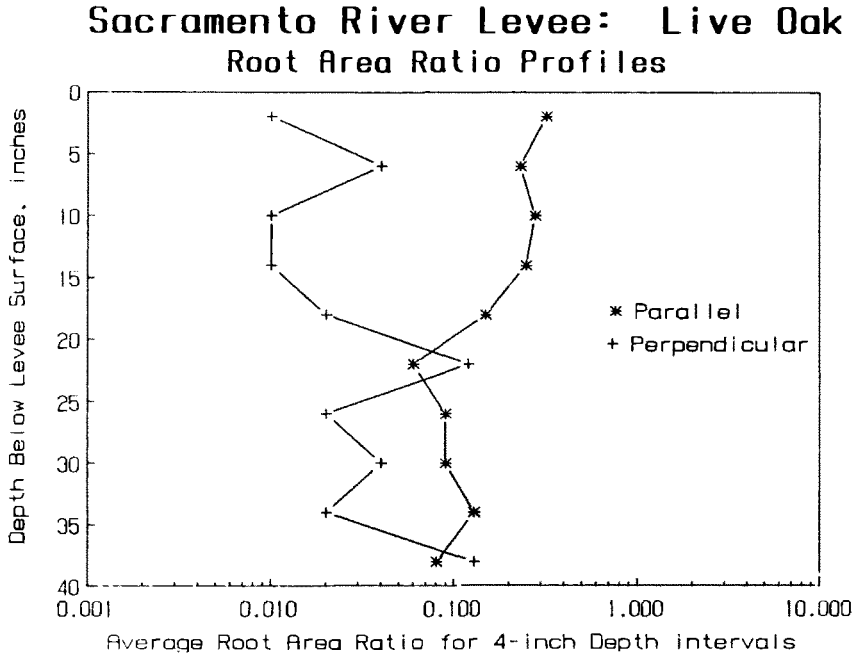
APPENDIX B: ROOT AREA RATIO PROFILES FOR LEVEE TRENCH SITES

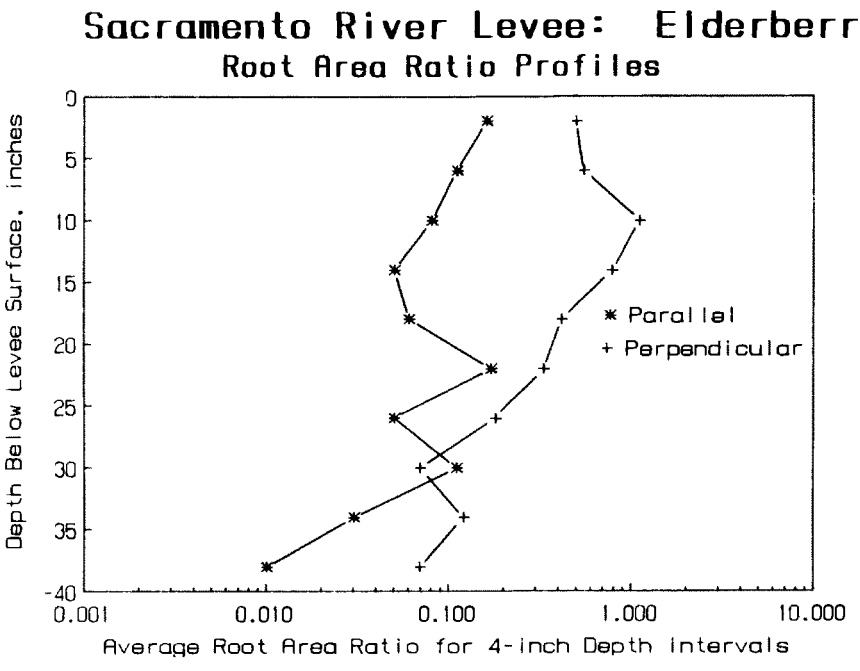

Sacramento River Levee
Root Area Ratio Profiles
Depth Below Levee Surface, inches
0
-5
-10
-15
-20
-25
-30
-35
-40
0.0
0.2
0.4
0.6
0.8
1.0
Average Root Area Ratio for 4-inch Depth intervals
* Control
+ Oak
o Elderberry, Willow & Black Locust

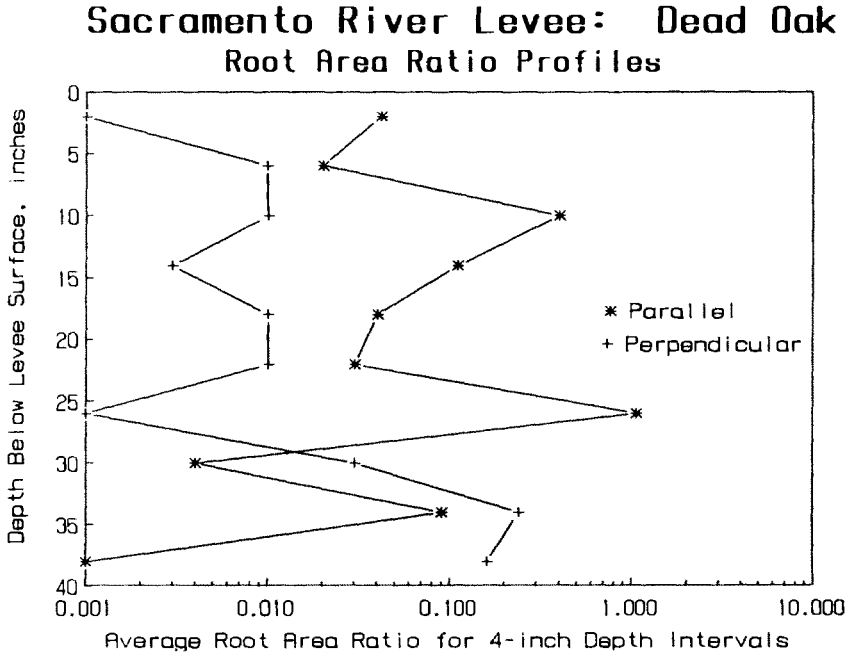

Sacramento River Levee: Average
Root Area Ratio Profiles
Depth Below Levee Surface, inches
0
5
10
15
20
25
30
35
40
0.001
0.010
0.100
1.000
10.000
Average Root Area Ratio for 4-inch Depth intervals
* Parallel
+ Perpendicular

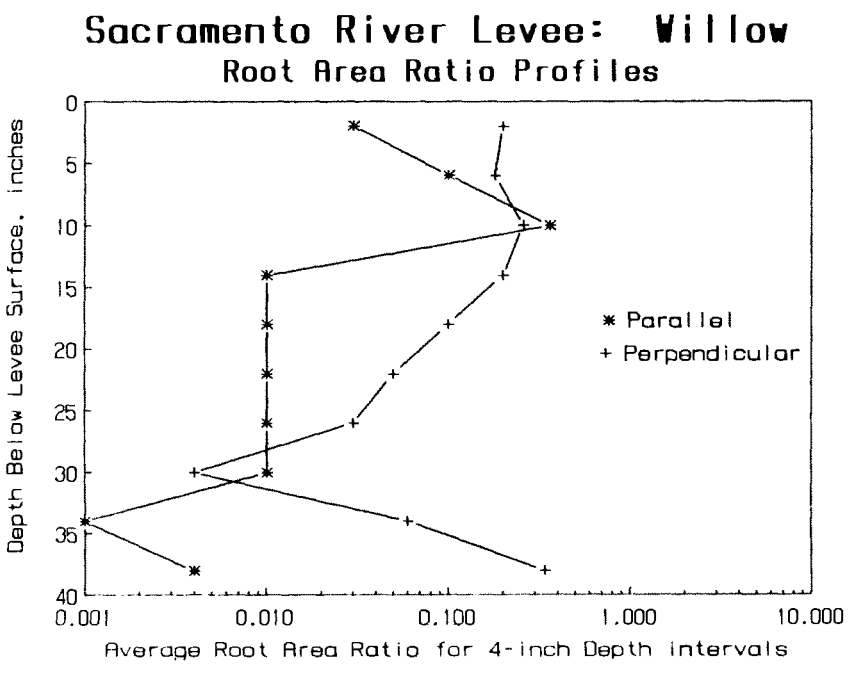

Sacramento River Levee: Average
Root Area Ratio Profiles
Depth Below Levee Surface, inches
0
-5
-10
-15
-20
-25
-30
-35
-40
0.0
0.1
0.2
0.3
0.4
0.5
* Parallel
+ Perpendicular
Average Root Area Ratio for 4-inch Depth intervals

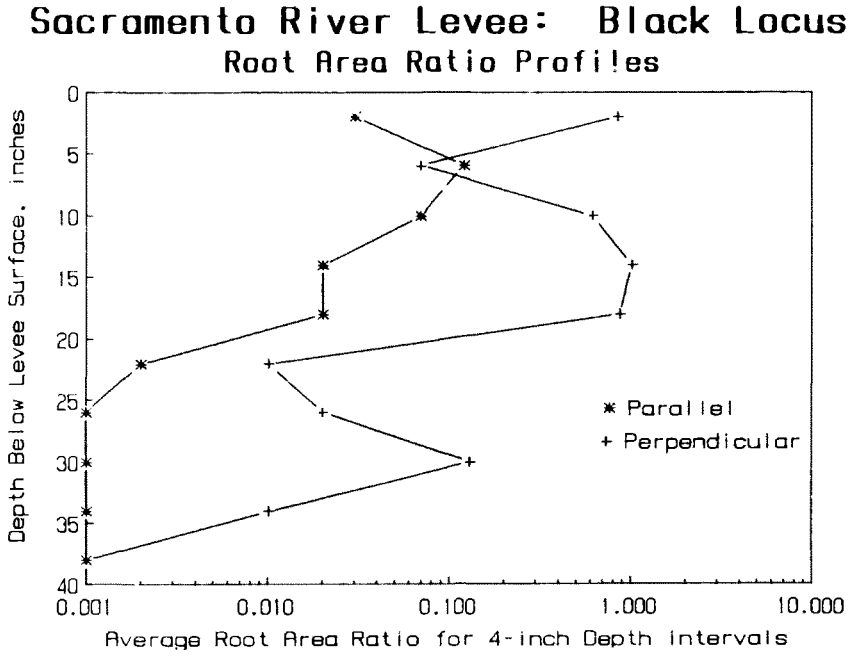

Sacramento River Levee: Control
Root Area Ratio Profiles
Depth Below Levee Surface, inches
0
5
10
15
20
25
30
35
40
0.001
0.010
0.100
1.000
10.000
* Parallel
+ Perpendicular
Average Root Area Ratio for 4-inch Depth intervals

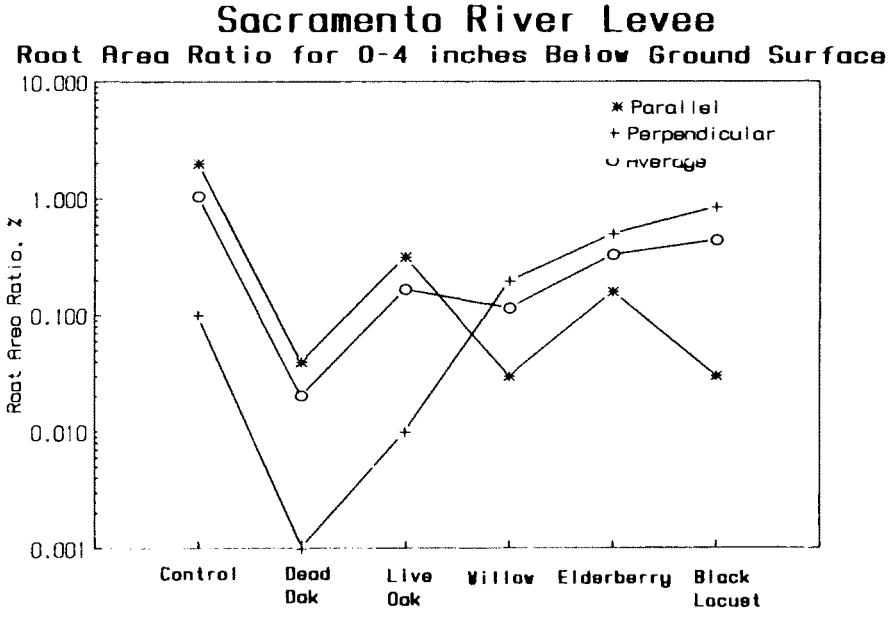

Sacramento River Levee: Live Oak
Root Area Ratio Profiles
Depth Below Levee Surface, inches
0
5
10
15
20
25
30
35
40
* Parallel
+ Perpendicular
0.001
0.010
0.100
1.000
10.000
Average Root Area Ratio for 4-inch Depth intervals

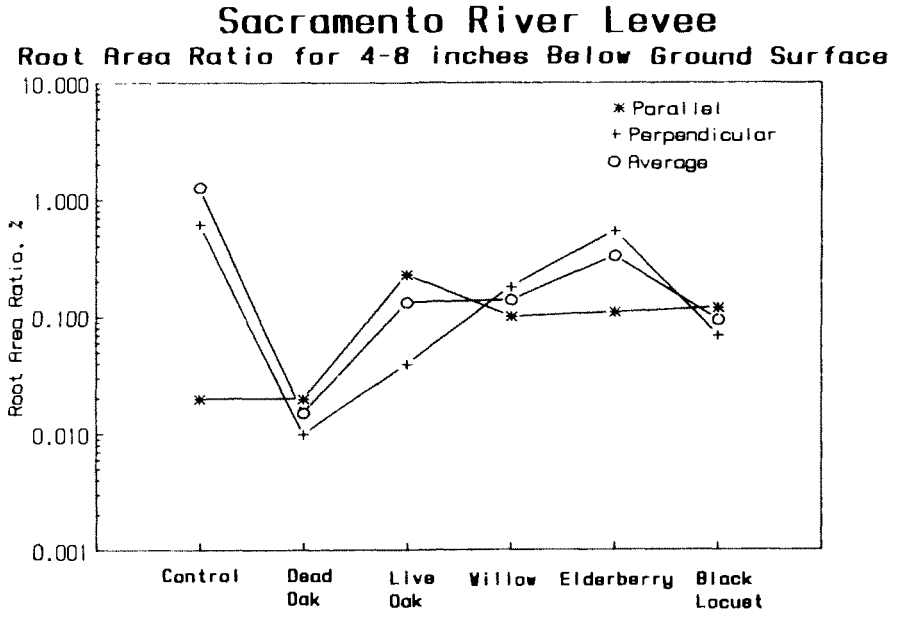

Sacramento River Levee: Elderberry
Root Area Ratio Profiles
Depth Below Levee Surface, inches
0
5
10
15
20
25
30
35
-40
* Parallel
+ Perpendicular
0.001
0.010
0.100
1.000
10.000
Average Root Area Ratio for 4-inch Depth intervals

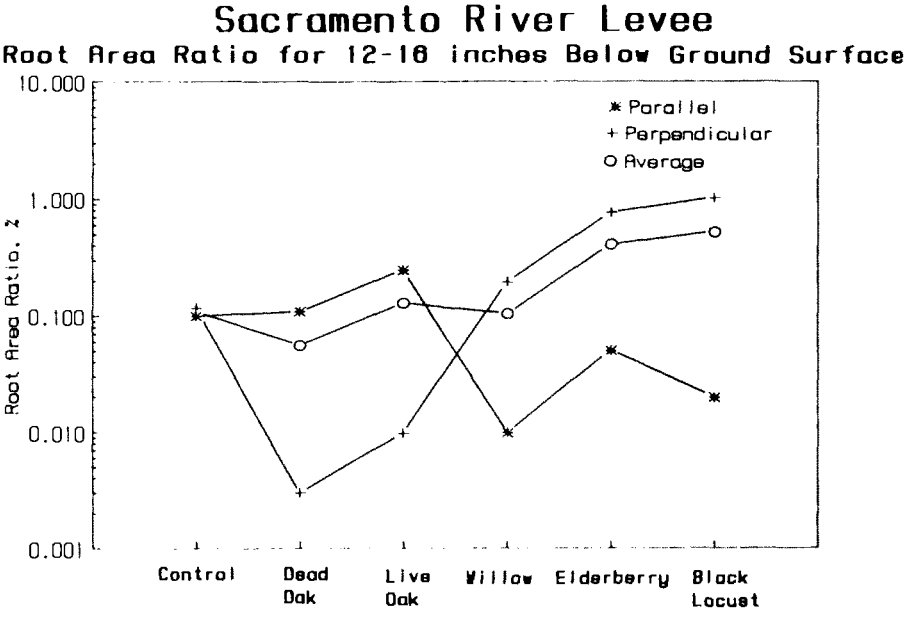

Sacramento River Levee: Dead Oak
Root Area Ratio Profiles
Depth Below Levee Surface, inches
0
5
10
15
20
25
30
35
40
* Parallel
+ Perpendicular
0.001
0.010
0.100
1.000
10.000
Average Root Area Ratio for 4-inch Depth Intervals

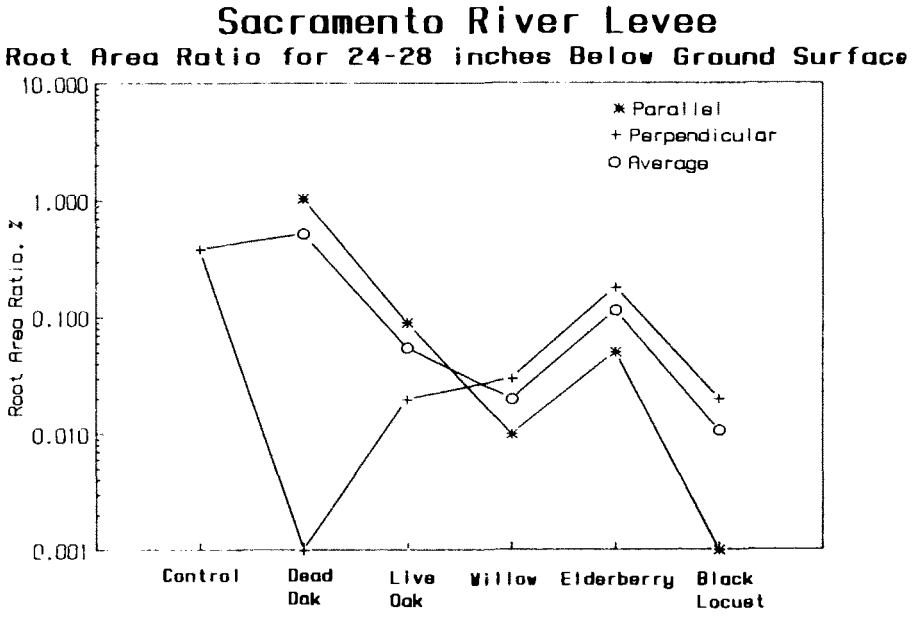

Sacramento River Levee: Willow
Root Area Ratio Profiles
Depth Below Levee Surface, inches
0
5
10
15
20
25
30
35
40
* Parallel
+ Perpendicular
0.001
0.010
0.100
1.000
10.000
Average Root Area Ratio for 4-inch Depth Intervals

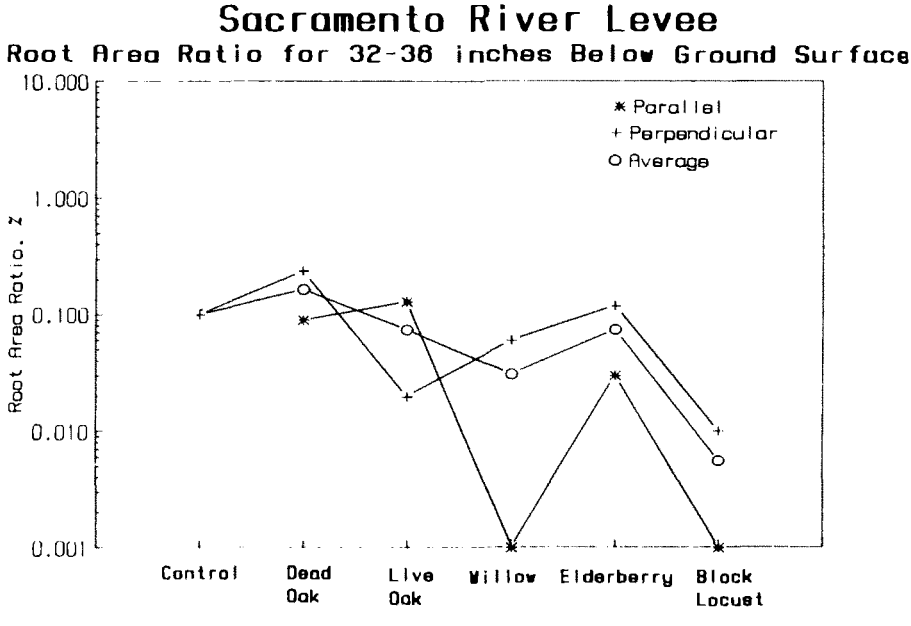

Sacramento River Levee: Black Locust
Root Area Ratio Profiles
Depth Below Levee Surface, inches
0
5
10
15
20
25
30
35
40
* Parallel
+ Perpendicular
0.001
0.010
0.100
1.000
10.000
Average Root Area Ratio for 4-inch Depth Intervals

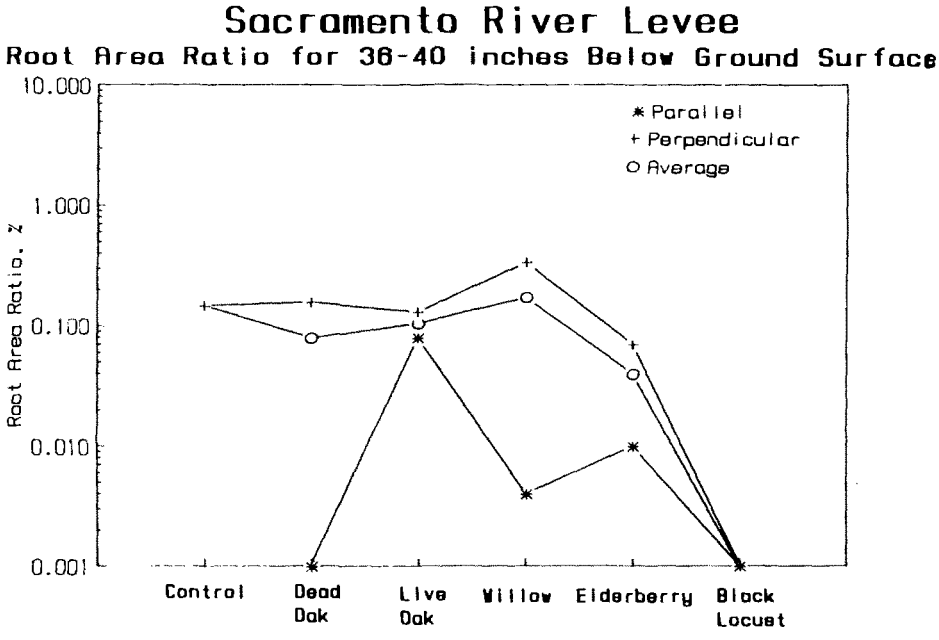

Sacramento River Levee
Root Area Ratio for 0-4 inches Below Ground Surface
Root Area Ratio, %
10.000
1.000
0.100
0.010
0.001
* Parallel
+ Perpendicular
Average
Control
Dead Oak
Live Oak
Willow
Elderberry
Black Locust


Sacramento River Levee
Root Area Ratio for 4-8 inches Below Ground Surface
10.000
1.000
0.100
0.010
0.001
Root Area Ratio, %
* Parallel
+ Perpendicular
O Average
Control
Dead Oak
Live Oak
Willow
Elderberry
Black Locust


Sacramento River Levee
Root Area Ratio for 12-16 inches Below Ground Surface
10.000
1.000
0.100
0.010
0.001
Root Area Ratio, %
* Parallel
+ Perpendicular
O Average
Control
Dead Oak
Live Oak
Willow
Elderberry
Black Locust


Sacramento River Levee
Root Area Ratio for 24-28 inches Below Ground Surface
10.000
1.000
0.100
0.010
0.001
Root Area Ratio, %
* Parallel
+ Perpendicular
O Average
Control
Dead Oak
Live Oak
Willow
Elderberry
Black Locust


Sacramento River Levee
Root Area Ratio for 32-36 inches Below Ground Surface
10.000
1.000
0.100
0.010
0.001
Root Area Ratio, %
* Parallel
+ Perpendicular
O Average
Control
Dead Oak
Live Oak
Willow
Elderberry
Black Locust


Sacramento River Levee
Root Area Ratio for 36-40 inches Below Ground Surface
10.000
1.000
0.100
0.010
0.001
Root Area Ratio, %
* Parallel
+ Perpendicular
O Average
Control
Dead Oak
Live Oak
Willow
Elderberry
Black Locust

APPENDIX C: ROOT SIZE DISTRIBUTION PLOTS FOR LEVEE TRENCH SITES

Explanation of Three-dimensional Plots

X axis--log of number of roots per square foot.

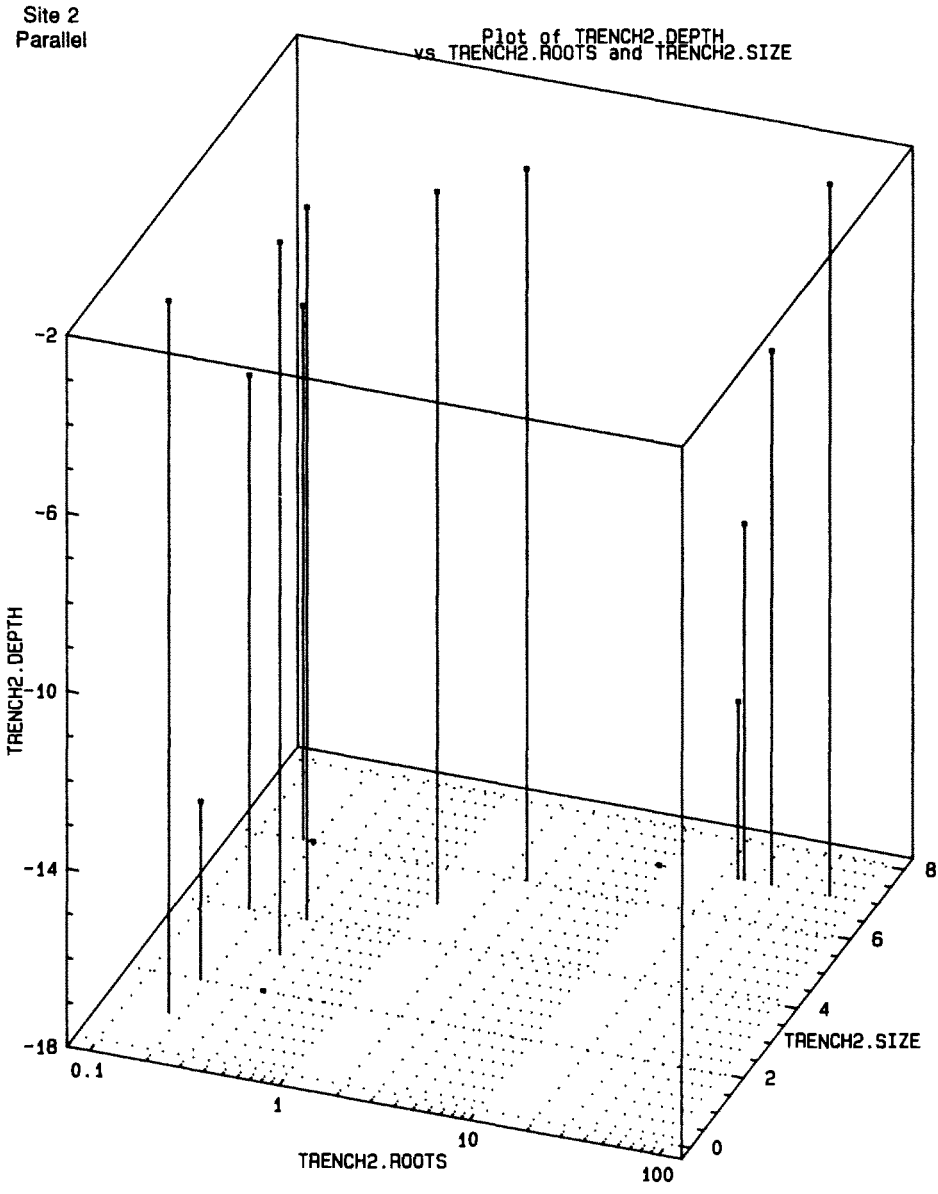
Y axis--root size class.

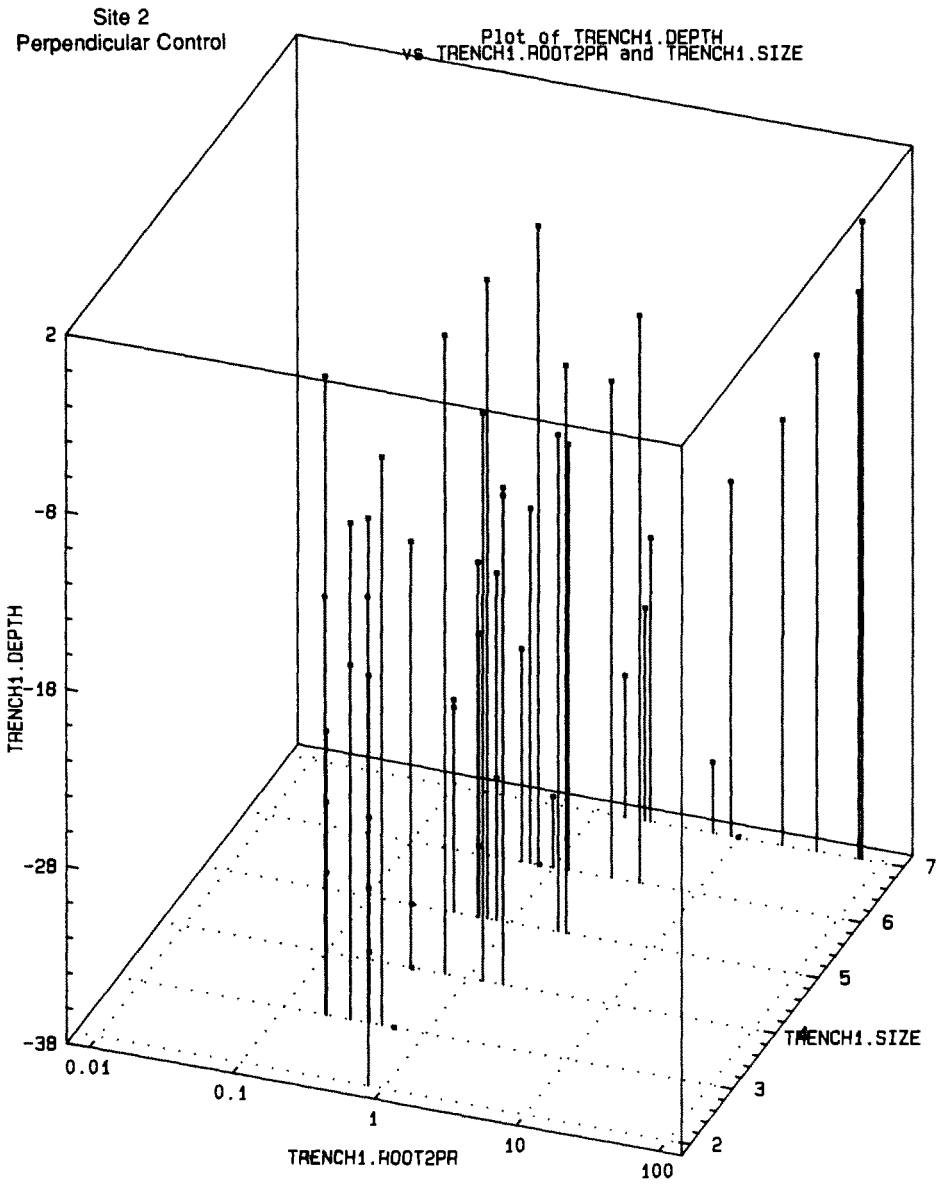
1	> 30 mm
2	20-30 mm
3	10-20 mm
4	5-10 mm
5	2-5 mm
6	1-2 mm
7	< 1 mm

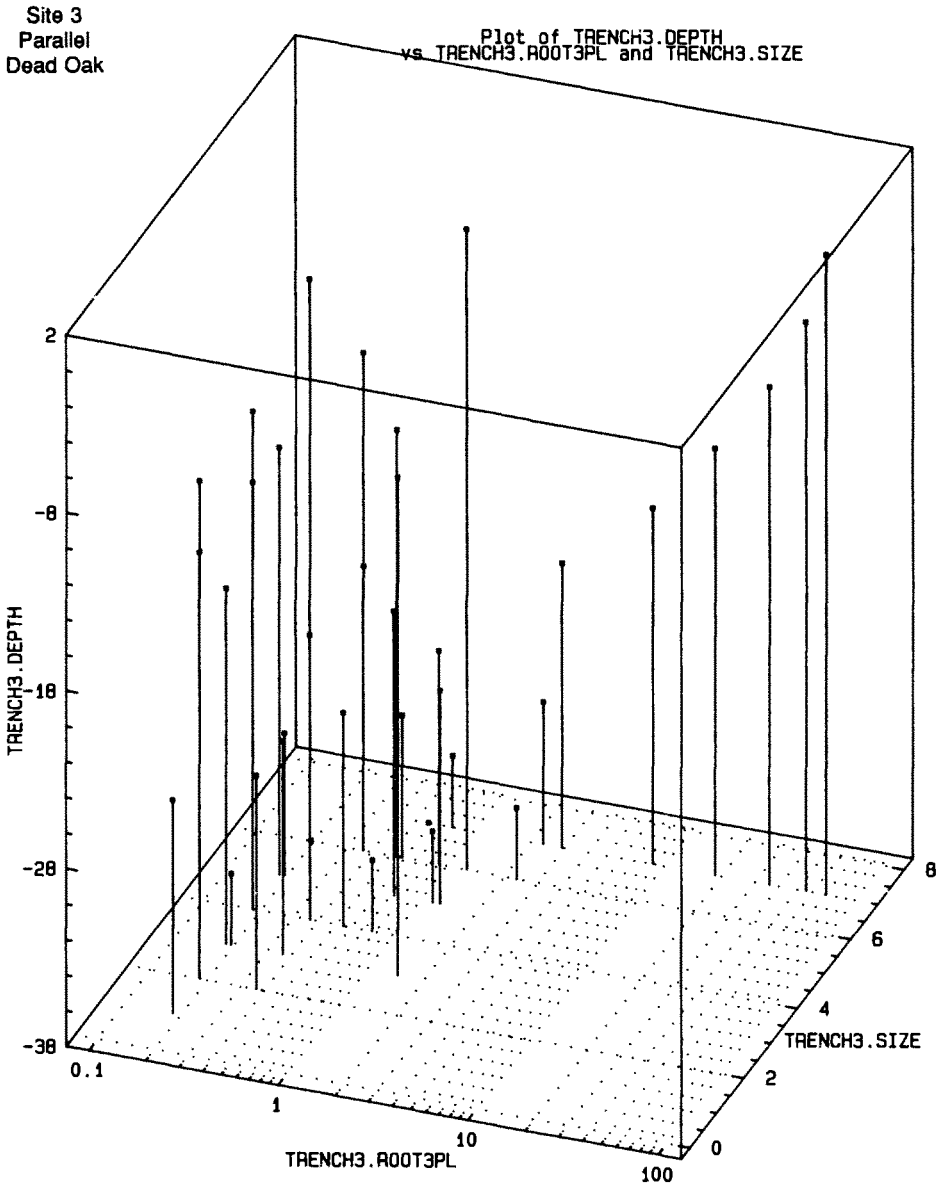
Most of the Y scales range from 0 to 8, but a few have smaller ranges. Scales were set automatically by the plot package.

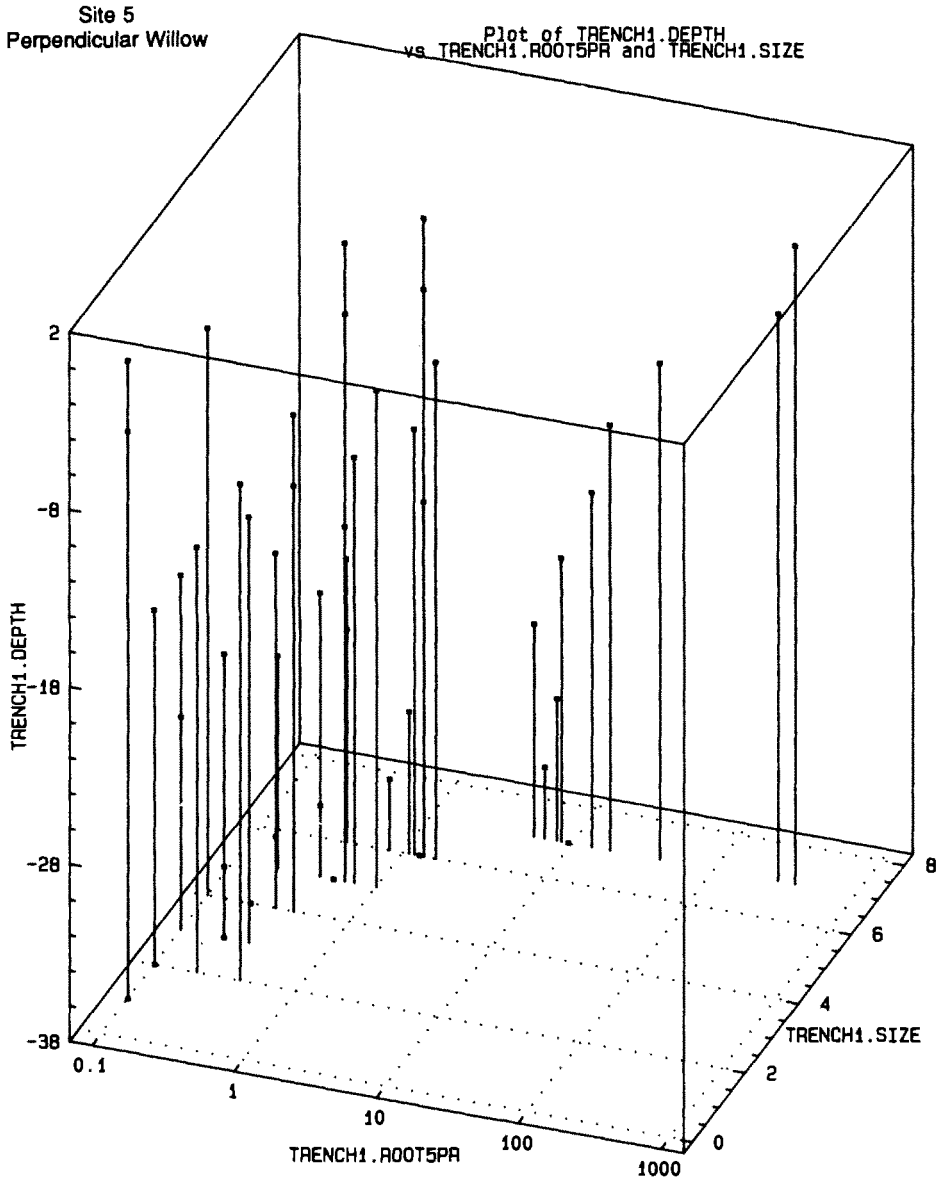
Z (vertical) axis--depth below surface in inches times -1. The upper limit of +2 was set by the automatic scaling routine in the plot software--there has been some trouble with the software when attempts are made to manually set the scales. Note that all plots have Z axes scaled from +2 to -38, except site 2 (parallel) and site 3 (perpendicular).

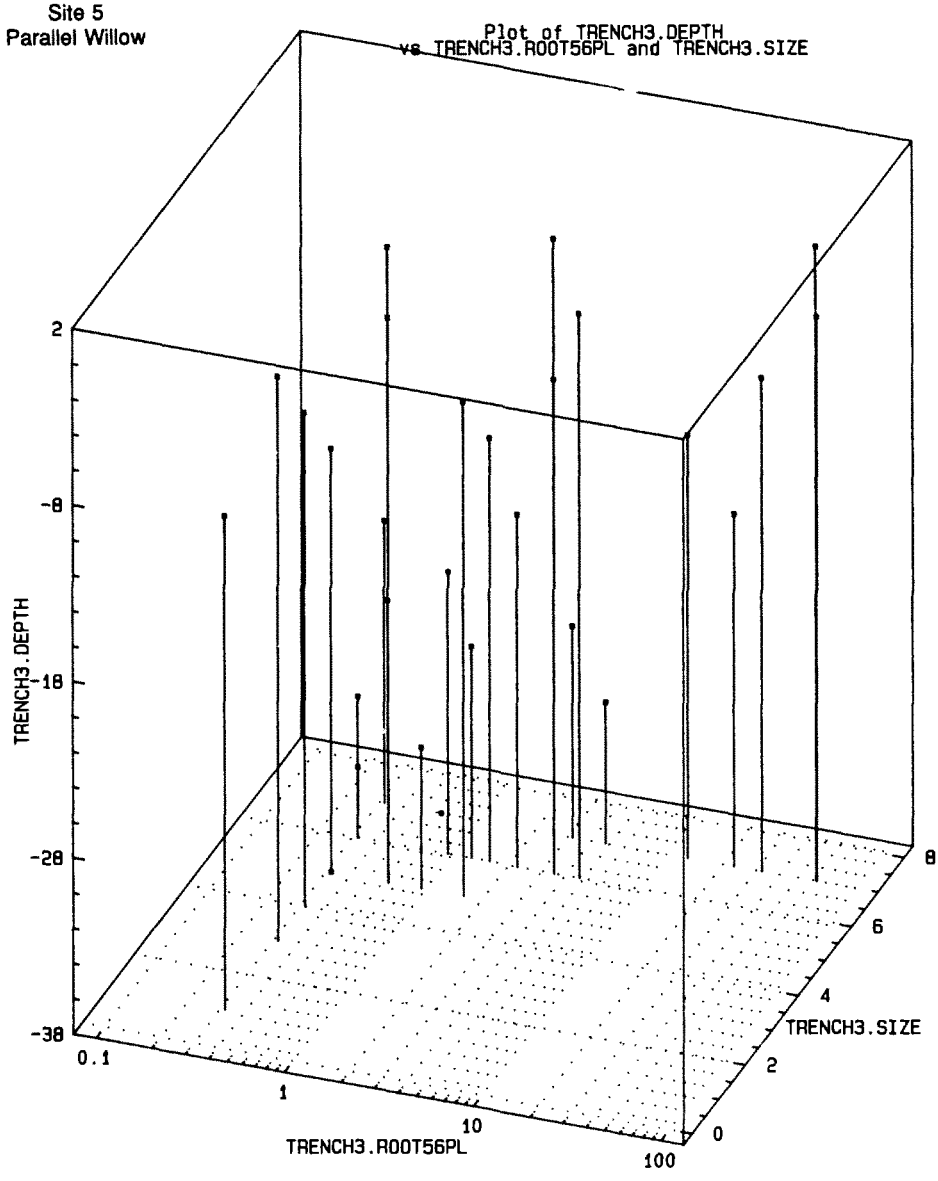
To use all of the plots in the report, the software could probably be forced to use uniform scales, with a little more effort. The authors are not advocating inclusion of these plots in the report, however. They were produced only to facilitate examination of the data.

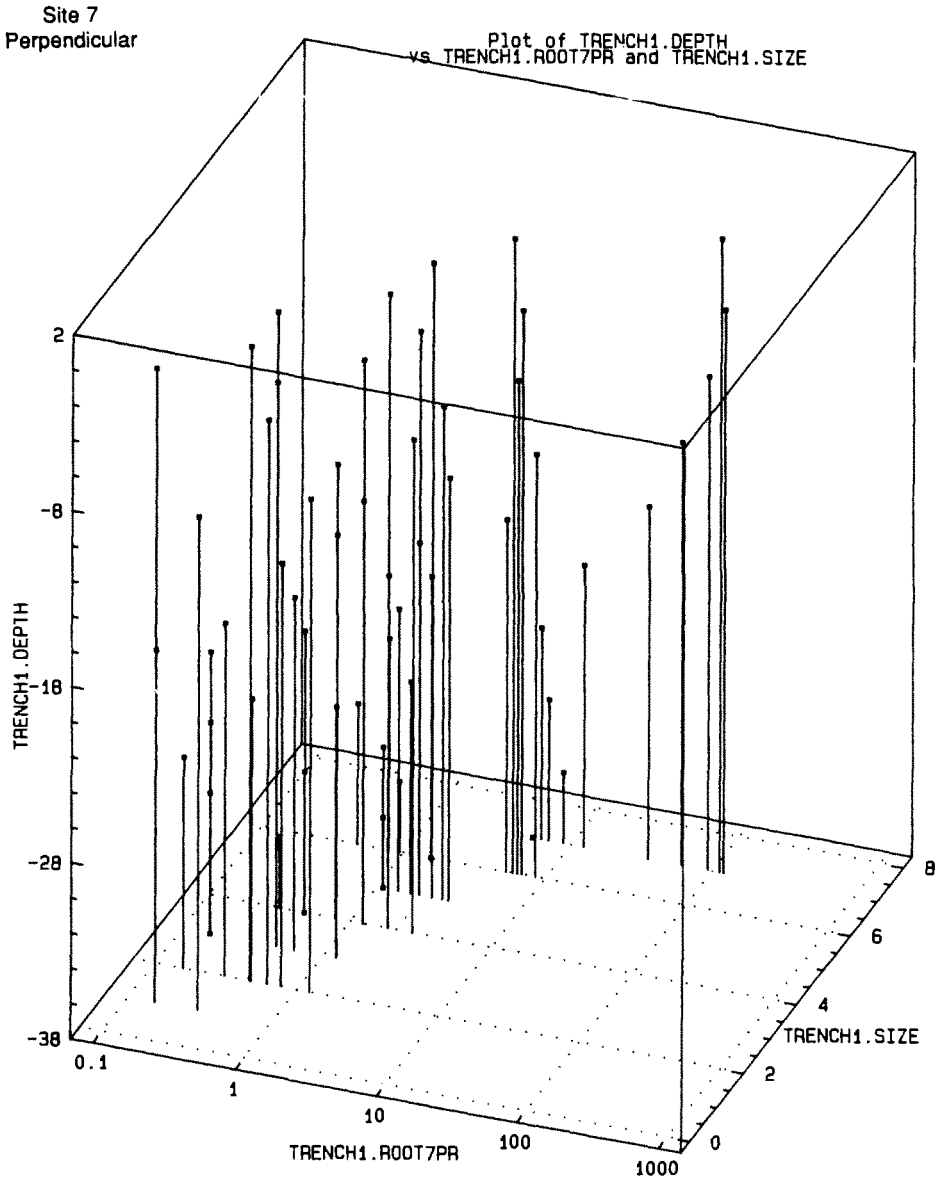

Site 2
Parallel
Plot of TRENCH2.DEPTH
vs TRENCH2.ROOTS and TRENCH2.SIZE
TRENCH2.DEPTH
-2
-6
-10
-14
-18
0.1
1
10
100
TRENCH2.ROOTS
0
2
4
6
8
TRENCH2.SIZE

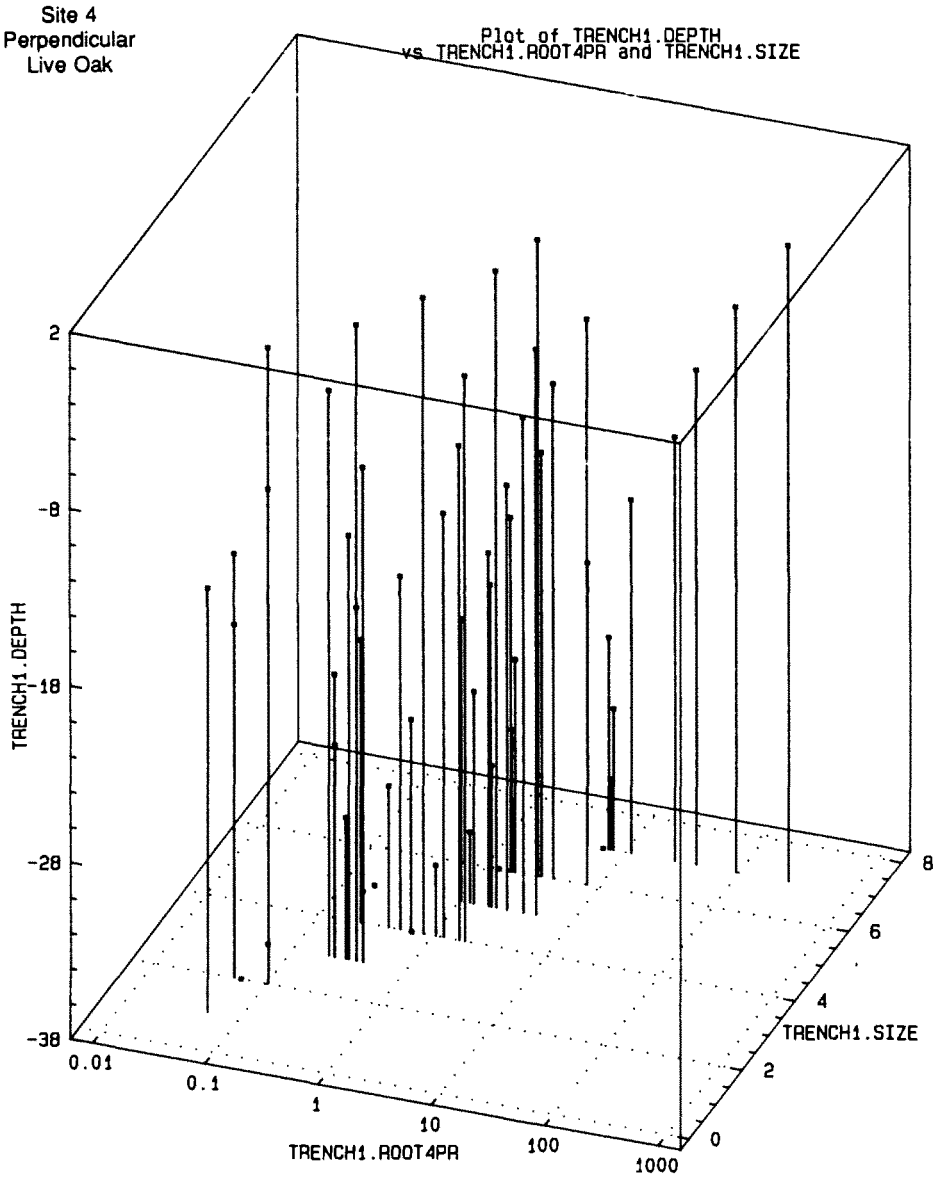

Site 2
Perpendicular Control
Plot of TRENCH1.DEPTH
vs TRENCH1.ROOT2PR and TRENCH1.SIZE
2
-8
-18
-28
-38
TRENCH1.DEPTH
0.01
0.1
1
10
100
TRENCH1.ROOT2PR
2
3
4
5
6
7
TRENCH1.SIZE

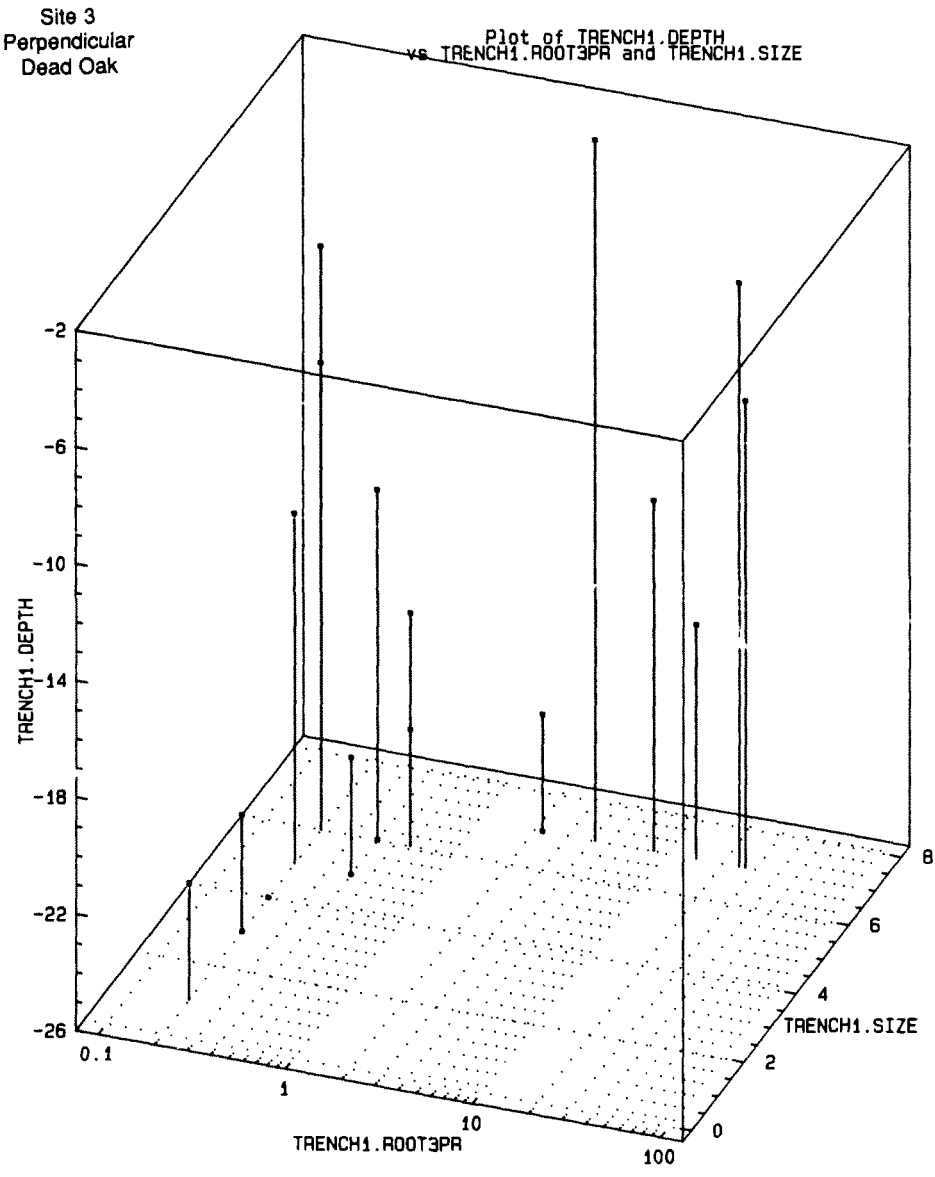

Site 3
Parallel
Dead Oak
Plot of TRENCH3.DEPTH
vs TRENCH3.ROOT3PL and TRENCH3.SIZE
TRENCH3.DEPTH
2
-8
-18
-28
-38
0.1
1
10
100
TRENCH3.ROOT3PL
0
2
4
6
8
TRENCH3.SIZE

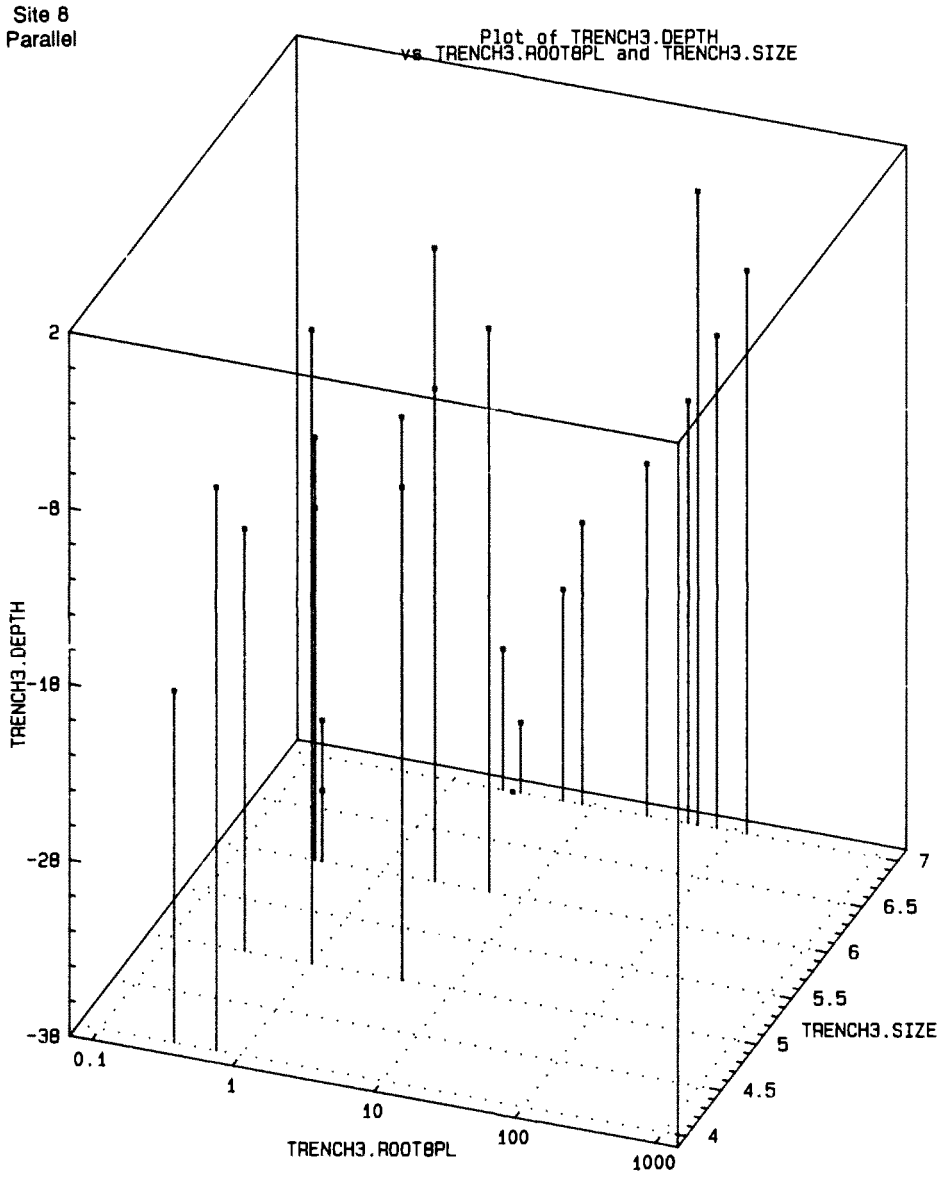

Site 5
Perpendicular Willow
Plot of TRENCH1.DEPTH
vs TRENCH1.ROOT5PR and TRENCH1.SIZE
TRENCH1.DEPTH
2
-8
-18
-28
-38
TRENCH1.ROOT5PR
0.1
1
10
100
1000
TRENCH1.SIZE
0
2
4
6
8

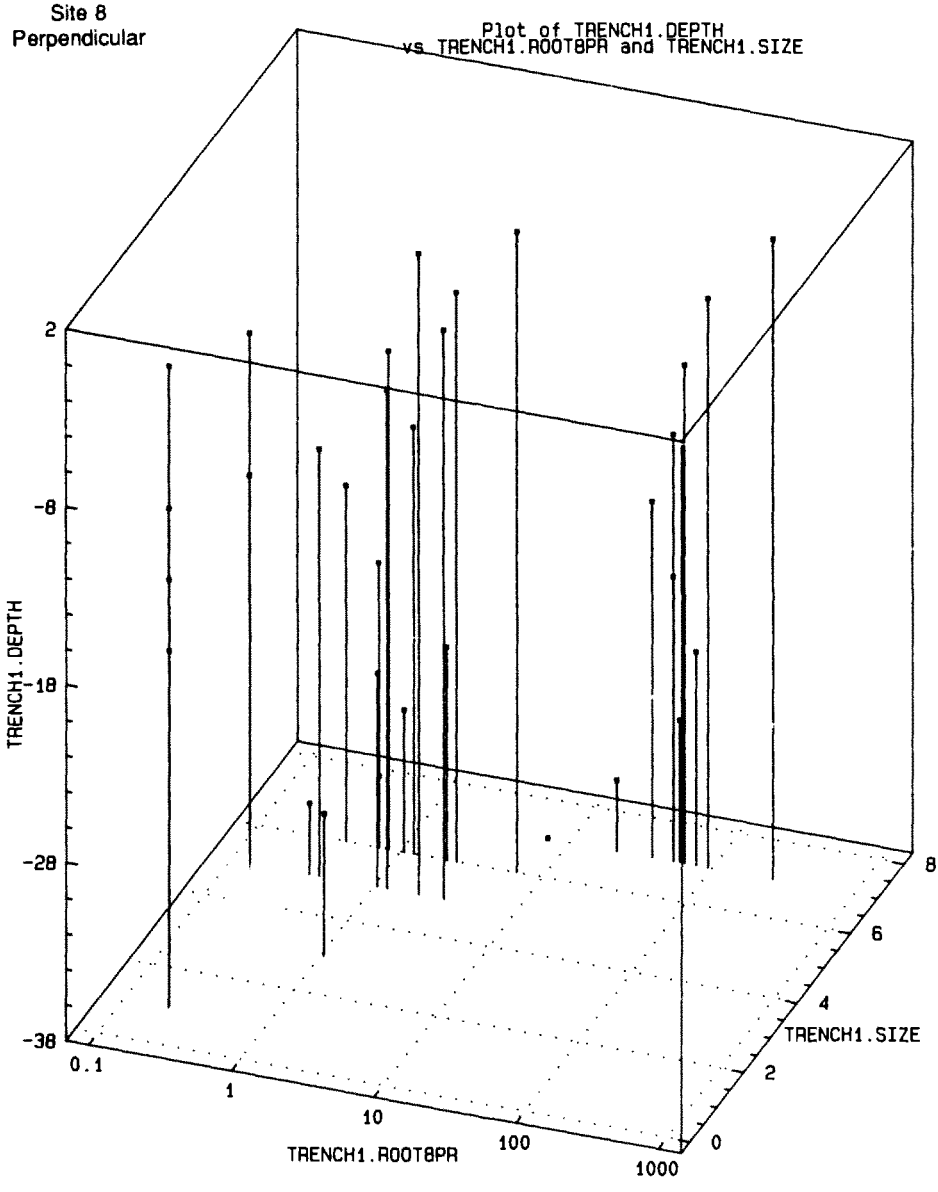

Site 5
Parallel Willow
Plot of TRENCH3.DEPTH
vs TRENCH3.ROOT56PL and TRENCH3.SIZE
2
-8
-18
-28
-38
TRENCH3.DEPTH
0.1
1
10
100
TRENCH3.ROOT56PL
0
2
4
6
8
TRENCH3.SIZE


Site 7
Perpendicular
Plot of TRENCH1.DEPTH
vs TRENCH1.ROOT7PR and TRENCH1.SIZE
TRENCH1.DEPTH
2
-8
-18
-28
-38
TRENCH1.ROOT7PR
0.1
1
10
100
1000
TRENCH1.SIZE
0
2
4
6
8


Site 4
Perpendicular
Live Oak
Plot of TRENCH1.DEPTH
vs TRENCH1.ROOT4PR and TRENCH1.SIZE
TRENCH1.DEPTH
2
-8
-18
-28
-38
0.01
0.1
1
10
100
1000
TRENCH1.ROOT4PR
0
2
4
6
8
TRENCH1.SIZE


Site 3
Perpendicular
Dead Oak
Plot of TRENCH1.DEPTH
vs TRENCH1.ROOT3PR and TRENCH1.SIZE
TRENCH1.DEPTH
-2
-6
-10
-14
-18
-22
-26
0.1
1
10
100
TRENCH1.ROOT3PR
0
2
4
6
8
TRENCH1.SIZE


Site 8
Parallel
Plot of TRENCH3.DEPTH
vs TRENCH3.ROOT8PL and TRENCH3.SIZE
2
-8
-18
-28
-38
TRENCH3.DEPTH
0.1
1
10
100
1000
TRENCH3.ROOT8PL
4
4.5
5
5.5
6
6.5
7
TRENCH3.SIZE


Site 8
Perpendicular
Plot of TRENCH1.DEPTH
vs TRENCH1.ROOT8PR and TRENCH1.SIZE
TRENCH1.DEPTH
2
-8
-18
-28
-38
TRENCH1.ROOT8PR
0.1
1
10
100
1000
TRENCH1.SIZE
0
2
4
6
8

APPENDIX C

Kleinfelder Report: Letter to Larry Aksland Regarding
Twin Creeks Subdivision in Stockton, California

KLEINFELDER

File No. 20-1739-02
March 9, 1989

Larry Aksland
8282 E. Veritas
Manteca, CA 95336

Subject: ADDENDUM TO OUR LETTER DATED FEBRUARY 14, 1989
TWIN CREEKS ESTATE SUBDIVISION
STOCKTON, CALIFORNIA

Gentlemen:

Following our conference discussion with David LeBeouf and representatives of Michael Baker Engineers, we understand that additional information has been requested regarding Item 5 of our February 14, 1989 letter. We understand that this is the last item of concern before a LOMR can be issued. In summary, Michael Baker Engineers continues to be concerned regarding the presence of trees on the water side of the Mosher Creek Levee as well as the placement of new trees required by the Corps of Engineers and Department of Fish and Game. Computer analyses have been requested showing the effect on levee stability should some of the existing trees fall over. Even though such an event would technically require a three dimensional analysis we have continued to use the two dimensional FSTAB program since it would provide conservative solutions.

In our evaluation of the root zone depth to include in our levee profile, we have used the actual measurements of a downed 24 inch diameter oak tree that exists at the site as shown on photograph R2-6. This photograph is one of many taken along the water side slope adjacent to Mosher Slough. Reference is also made to the cross section presented opposite to each photograph showing surveying measurements of the slope and tree location. We point out that every tree has been numbered and marked in the field. The measured root zone in photograph R2-6 was approximately 2 feet in depth and had a plan dimension of approximately 3 by 5 feet. We understand that survey measurements taken in the hole left by the toppled tree indicate a ground elevation

above the theoretical levee profile.

Presented on Plates I through III are the profiles analyzed. Considering the fact that existing trees are located near the top of slope, at the base of slope, and in clusters we have accordingly removed portions of the water side slope at these locations. The observed two foot root zone depth is consistant with normal growth patterns where tree roots seldom extend into saturated soil. For the benefit of representatives of FEMA and Michael Baker Engineers, we point out that Larry Aksland has owned and operated as much as 280 acres of almond trees and has never observed extensive root development below the groundwater table. In order to evaluate the effect of a deeper root zone, such as may occur for a tree near the top of slope we have also performed our analysis with a root depth of 3 feet. The results of the computed Factors of Safety for these six analyses are presented in Table I. As can be shown there is little impact to the previously computed Factors of Safety. As additional justification for leaving the existing trees in place, we have included a letter dated March 3, 1989 by the Corps of Engineers. This letter describes the requirement to revegetate the levee along Mosher Slough. Since the Corps of Engineers have not only insisted on leaving the existing trees in place but have required additional trees to be planted, it is implied that levee stability would not be adversely effected.

We have included along with this letter to FEMA and Michael Baker Engineers a revised revegetation plan showing the locations of 14 new trees, all located at approximate elevation 5 feet. This elevation is approximately 2 feet above the normal tide level. It was originally intended to locate new trees on the water side as far away from the hinge point of levee as possible, however, the Corps of Engineers and Department of Fish and Game have insisted that several of the bare spots along the creek be covered. Reference is made specifically to that area between Trees No. 26 and 27. As noted the lots are relatively high at this location varying from elevation 5.5 to 9.8 feet. At these locations as well as all other locations where new trees are planned, the elevation of the new trees will be substantially below the adjacent pad elevation. We also note that the fallen 24 inch Oak tree shown on photograph R2-6 is

required to remain in place to provide fish habitat by the State Department of Fish and Game.

A photo album with corresponding cross sections describes the relationship between location and landscaping has been provided with this report. A master plan showing cross sections of the levee with survey locations and elevations of existing trees along this portion of the project has also been attached to this report. For the benefit of FEMA and representatives of Michael Baker Engineers any further questions on the revegetation requirements can be directed to the following individuals who all have met with Larry Askland at the site;

Lou Cadwell of the Corps of Engineers - 916/551-2263

Tom Skordal of the Corps of Engineers - 916/551-2262

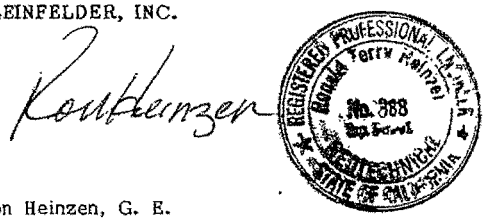
Kay Goodie of Department of Interior, Fish and Wildlife Service - 916/978-4613

Peggy Coal or James Messersmith of State of California Fish and Game Department - 916/355-0922

We trust that the information presented sufficiently addresses the last concern expressed by FEMA and representatives of Michael Baker Engineers. We understand that Mr. LeBeouf will be in Washington some time during the week of March 13 through 18 to review this report with FEMA and Michael Baker Engineers. In the mean time if you have any questions regarding the information attached, please contact us.

Respectfully submitted,

KLEINFELDER, INC.



Ron Heinzen, G. E.
Regional Manager

RTH:sfa
MD#73

File No. 20-1739-02
March 9, 1989

Summary of Factors of Safety
Waterside - Falling Trees
Table I

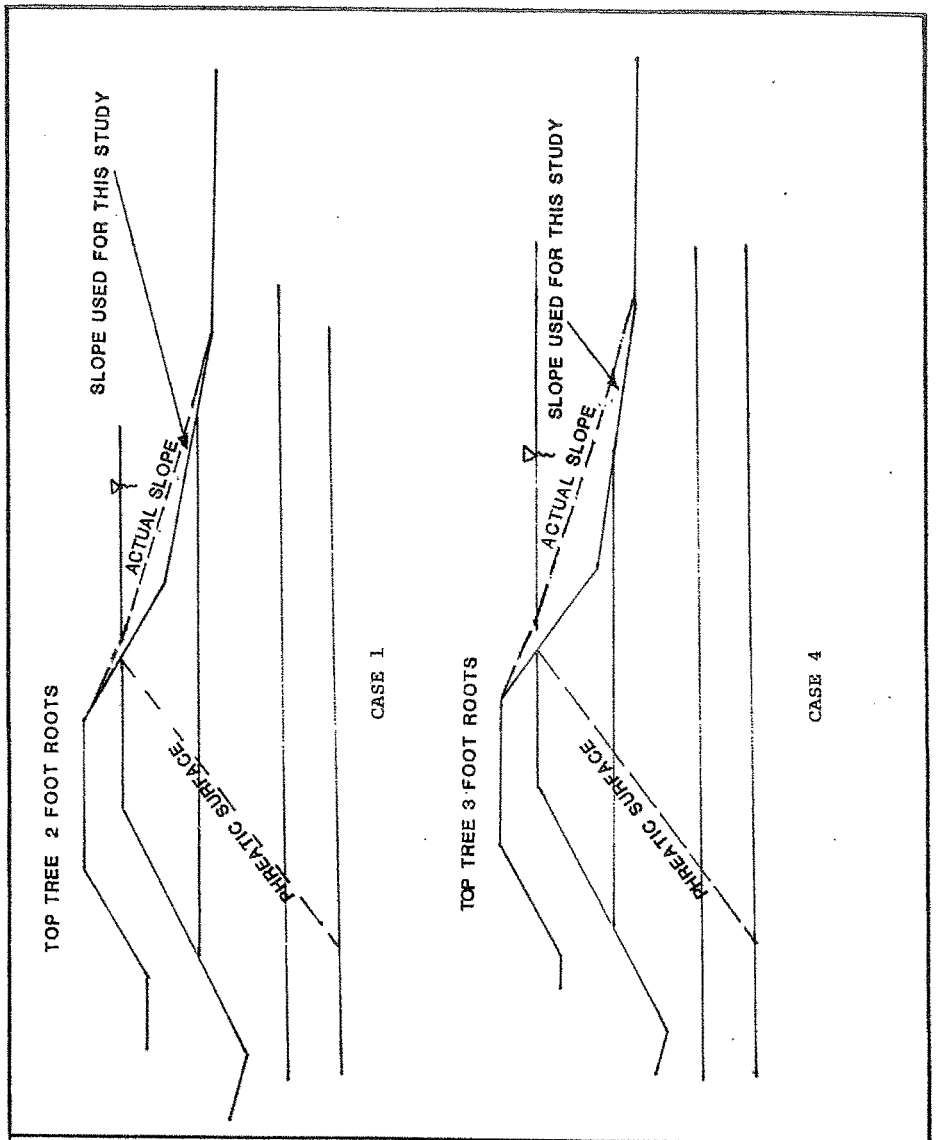
2 Feet Roots:

Case #	Description	Factors of Safety
1	Top Tree	2.4
2	Bottom Tree	2.3
3	Top and Bottom Trees	2.4

3 Feet Roots:

Case #	Description	Factors of Safety
4	Top Tree	2.4
5	Bottom Tree	2.3
6	Top and Bottom Tree	2.4

MD#73



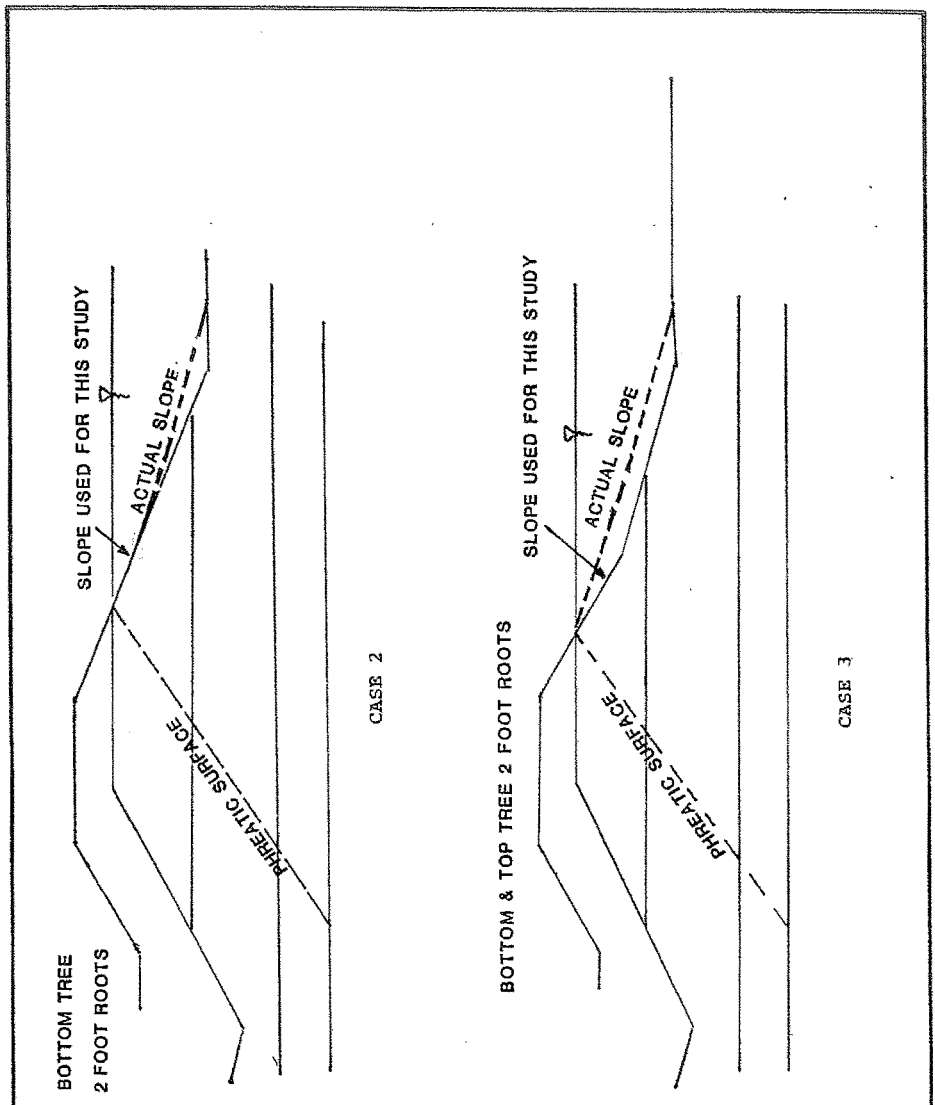
KLEINFELDER

TWIN CREEKS LEVEE PROFILES

PLATE I.

PROJECT NO. 20-1739-02

M-6



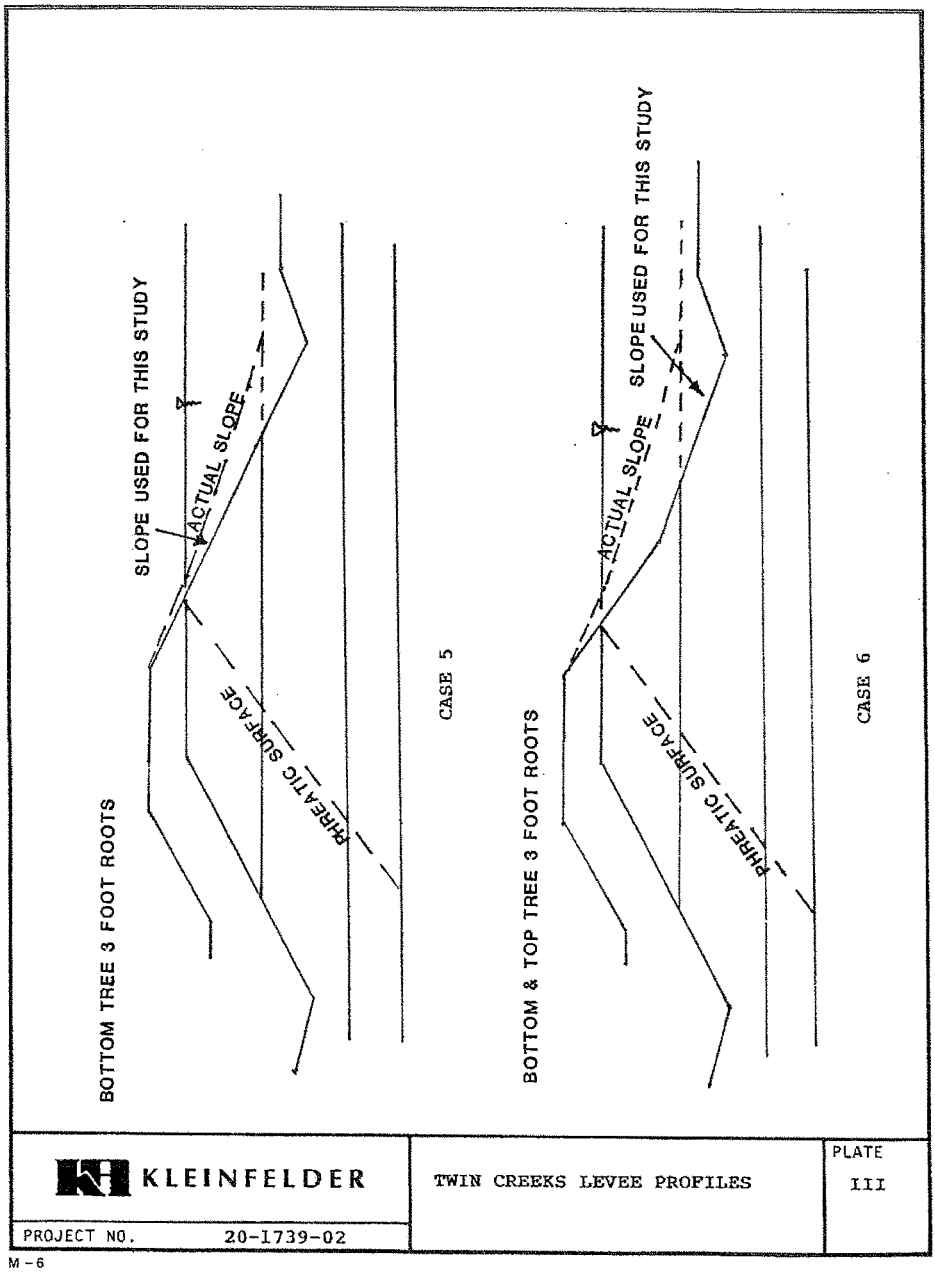
KLEINFELDER

TWIN CREEKS LEVEE PROFILES

PLATE
11

PROJECT NO. 20-1739-02

M-6


BOTTOM TREE 3 FOOT ROOTS
SLOPE USED FOR THIS STUDY
ACTUAL SLOPE
PHREATIC SURFACE
CASE 5
BOTTOM & TOP TREE 3 FOOT ROOTS
SLOPE USED FOR THIS STUDY
ACTUAL SLOPE
PHREATIC SURFACE
CASE 6
KLEINFELDER
TWIN CREEKS LEVEE PROFILES
PLATE
III
PROJECT NO. 20-1739-02

M-6

C

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT CORPS OF ENGINEERS
650 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814-4794

REPLY TO
ATTENTION OF

March 3, 1989

Regulatory Section (9665)

Mr. Larry W. Aksland
8282 East Veritas Avenue
Manteca, California 95336

Dear Mr. Aksland:

This letter is to verify a conversation between you and Lou Cadwell of my staff. As Mrs. Cadwell pointed out to you the revegetation of the levee along Mosher Slough is a condition of your Department of the Army Permit Number 9665.

The planting of additional vegetation along the Mosher Slough levee is a mitigation measure for the loss of riparian vegetation caused by allowing you to place fill across the mouth of a tidal irrigation canal.

I am enclosing for your information and assistance in planning your revegetation a list of desirable plant species and undesirable plant species and a drawing which is a guide to spacing of plants on levees. This information was copied from a "Guide for Vegetation on Project Levees" adopted by the State Reclamation Board on December 1, 1967. It has been revised several times, most recently on December 18, 1981. In choosing your plant species, please select native plant species from the list of desirable plants.

If you have any questions, please contact Mrs. Cadwell at the above letterhead address, or telephone (916) 551-2263.

Sincerely,

Tom Skordal
Chief, Regulatory Unit 1

Enclosure

TABLE 1

Desirable and Undesirable Plant Species for Levees

Desirable Trees

Ash, Arizona
Fraxinus velutina

Ash, flowering
Fraxinus ornus

Ash, Modesto
Fraxinus velutina
'Modesto' NATIVE

Ash, Oregon NATIVE
Fraxinus latifolia

California bay NATIVE
Umbellularia californica

California pepper tree
Schinus molle

Chinese pistache
Pistacia chinensis

Coast beefwood
Casuarina stricta

Common catalpa
Catalpa bignonidides

Crape myrtle
Lagerstroemia indica

Eucalyptus, flooded box
Eucalyptus microtheca

Eucalyptus, red ironbark
Eucalyptus sideroxylon

Evergreen pear
Pyrus kawakamii

Fremont cottonwood (male tree) NATIVE
Populus fremontii

Goldenrain tree
Koelreuteria paniculata

Hackberry, Chinese
Celtis sinenis

Hackberry, common
Celtis occidentalis

Hackberry, European
Celtis australis

Maidenhair tree (male tree only)
Ginkgo biloba

Montezuma cypress
Taxodium mucrontum

Oak, coast live NATIVE
Quercus agrifolia

Oak, valley NATIVE
Quercus lobata

Pagoda tree
Sophora japonica

Redtwig dogwood NATIVE
Cornus stolonifera

Desirable Trees (continued)

Sawleaf zelkova
Zelkova serrata

Silk tree
Albizia julibrissin

Tallow tree
Sapium sebiferum

Thornless honey locust
Gleditsia triacanthos
var. inermis

Tupelo
Nyssa sylvatica

Wattle, golden
Acacia longifolia

Wattle, water
Acacia retinoids

Willow, black NATIVE
Salix goodingii
var. goodingii and
var. variabilis

Desirable Shrubs

Bladder pod NATIVE
Isomeris arborea

Bottlebrush
Callistemon citrinus

Bush germander
Teucrium fruticans

Buttonwillow NATIVE
Cephalanthus occidentalis

Cleveland sage NATIVE
Salvia clevelandii

Coyote bush NATIVE
Baccharis pilularis
var. consanguinea

Dwarf oleander
Nerium oleander 'Petite
Pink or Petite Salmon'

False willow NATIVE
Baccharis glutinosa

Fremont silktassel NATIVE
Garrya fremonti

Greasewood NATIVE
Sarcobatus vermiculatus

Heavenly bamboo
Nandina domestica

Hop bush
Dodonaea viscosa

Japanese boxwood
Buxus microphylla
var. japonica

Mugho pine
Pinus mugo mugo

Mugwort NATIVE
Artemisia douglasiana

Myrtle
Myrtus communis

Noel grevillea
Grevillea noellii

Desirable Shrubs (continued)

Photina
Photina fraseri

Redbud, Western NATIVE
Cercis occidentalis

Redbud, Eastern
Cercis canadensis

Rockrose, sageleaf
Cistus salviifolius

Rockrose, white
Cistus hybridus

Saltbush, four-wing NATIVE
Atriplex canescens

Saltbush, quaibush NATIVE
Atriplex lentiformis

Spice bush NATIVE
Calycanthus occidentalis

Strawberry tree (dwarf)
Arbutus unedo
var. compacta

Toyon NATIVE
Heteromeles arbutifolia

Willow, arroyo NATIVE
Salix lasiolepis

Willow, sandbar NATIVE
Salix hindsiana

Desirable Ground Covers

Australian saltbush
Atriplex semibaccata

Basket-of-gold
Aurinia saxatile

Bermuda Grass NATURALIZED ~~NATIVE~~
Cynodon dactylon 'tifgreen'
Cynodon dactylon 'coastal'
Cynodon dactylon 'Tufcote'

Blue-eyed grass NATIVE
Sisyrinchium bellum

Cape weed
Arctotheca calendula

Creeping wild rye NATIVE
Elymus triticoides

Dwarf coyote brush (male plant)
Baccharis pilularis
'Twin Peaks No. 2' NATIVE

Dwarf rosemary
Rosmarinus officinalis
'Prostratus'

Garden lippia
Phyla nodiflora
(Lippia nodiflora)

Green carpet
Herniaria glabra

Horsetail NATIVE
Equisetum hyemale

Indian mock strawberry
Duchesnea indica

Lavender cotton
Santolina
chamaecyparissus

Desirable Ground Covers (continued)

Mexican evening primrose
Oenothera berlandieri

Palestine orchardgrass
Dactylis glomerata 'Palestine'

Perla koleagrass
Phalaris tuberosa var. *hirtiglumis*

Prostrate germander
Teucrium chamaedrys 'Prostratium'

Reed canary grass
Phalaris arundinacea

Salt grass NATIVE
Distichlis spicata

Stonecrop NATIVE
Sedum - spp

Trailing African daisy
Osteospermum frutilosum

Wheatgrass, fairway crested
Agropyron cristatum

Wheatgrass, intermediate
Agropyron intermedium

Wheatgrass, pubescent
Agropyron trichophorum

Wheatgrass, sodar NATIVE
Agropyron riparium

Wheatgrass, tall
Agropyron elongatum

Yellow-eyed grass NATIVE
Sisyrinchium californicum

Undesirable Trees

Acacia, Bailey
Acacia baileyana

Acacia, kangaroo thorn
Acacia armata

Almond, edible
Prunus dulcis

Apple, crabapple, edible
Malus - spp

Undesirable Trees (continued)

Apricot, edible
Prunus armeniaca

Blue gum
Eucalyptus globulus

Cedar[1/]
Cedrus - spp

Cherry, edible
Prunus avium

Chinese jujube
Zizyphus jujube

Chinese wingnut
Pterocarya stenoptera

Citrus, edible
Citrus - spp

Coast redwood
Sequoia sempervirens

Colorado spruce
Picea pungens

Cypress[1/]
Cupressus - spp

Date palm
Phoenix - spp

Elm
Ulmus - spp

English walnut
Juglans regia

Fan palm
Washingtonia - spp

Fig, edible
Ficus carica

Fir[1/]
Abies - spp

Giant sequoia
Sequoiadendron giganteum

Hawthorn
Crataegus -

Incense cedar[1/]
Calocedrus decurrens

Locust
Robinia - spp

Loquat
Eriobotrya - spp

Magnolia
Magnolia - spp

Mayten tree
Maytenus boaria

Olive
Olea europaea

Osage orange
Maclura pomifera

Peach and nectarine
Prunus perica

1/ Conifers, whose normal mature height is 50 feet or less, may be considered desirable under maintenance conditions that (1) protect the tree from drought and (2) will assure proper pruning of the lower branches.

Undesirable Trees (continued)

Pecan
Carya illinoinensis

Persimmon
Diospyros - spp

Pine[1/]
Pinus - spp

Plum and prune, edible
Prunus domestica, salicina

Pomegranate, edible
Punica granatum

Quince, edible
Cydonia oblonga

Russian olive
Elaegnus augustifolia

Silver maple
Acer saccharinum

Tree of heaven
Ailanthus altissima

Yew[1/]
Taxus - spp

Undesirable Shrubs

Bamboo
Bambusa - spp

Barberry
Berberis - spp

Berry
Rubus - spp

Broom
cytisus - spp

Cactus
Cactaceae (Many general)

Camellia
Camellia japonica

Cane
Arundinaria - spp

Cape plumbago
Plumbago auriculata

Century plant
Agave americana

Firethorn
Pyracantha - spp

Flowering quince
Chaenomeles

Fuchsia - Flowering gooseberry
Ribes speciosum

Holly
Ilex - spp

Hydrangea
Hydrangea - spp

1/ Conifers, whose normal mature height is 50 feet or less, may be considered desirable under maintenance conditions that (1) protect the tree from drought and (2) will assure proper pruning of the lower branches.

Undesirable Shrubs (continued)

Jasmine
Jasminum - spp

Kumquat
Fortunella margarita

New Zealand flax
Phormium tenax

Oleander 1/
Nerium oleander

Oregon grape
Mahonia aquifolium

Pampas grass
Cortaderia selloana

Pfitzer juniper
Juniperus chinensis
'Pfitzrana'

Rose
Rosa - spp

Siberian peashrub
Caragana arborescens

Spanish broom
Genista hispanica

Undesirable Ground Covers

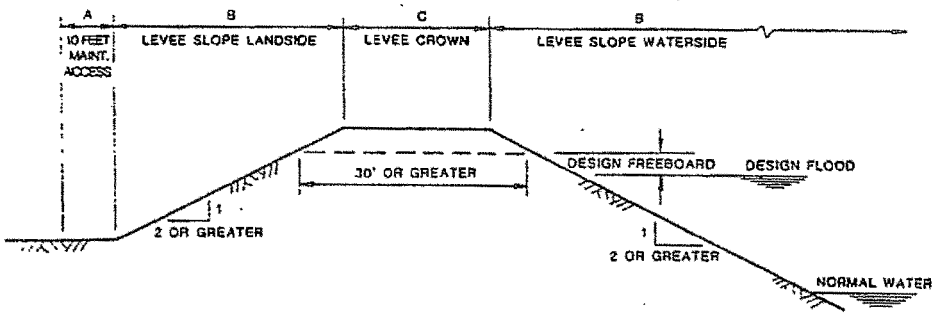
Honeysuckle
Lonicera - spp

Ivy
Hedera - spp

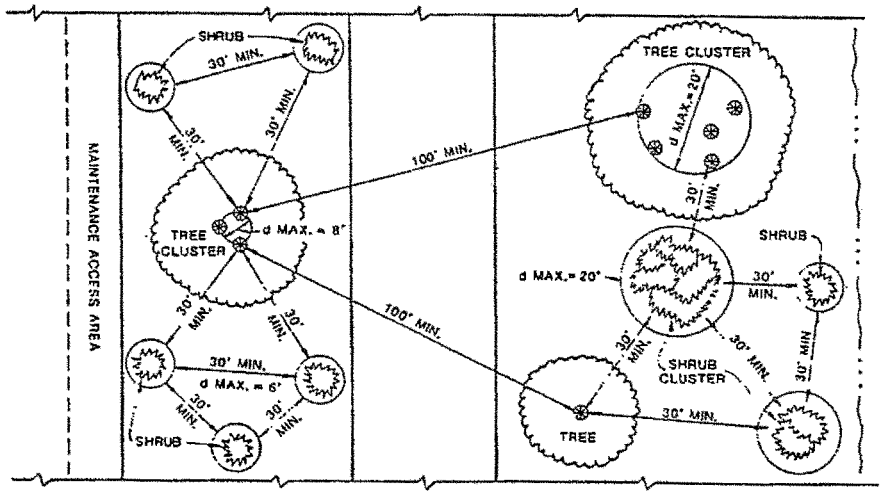
Periwinkle
Vinca - spp

1/ Except dwarf varieties 'Petite Pink' and 'Petite Salmon', which are desirable.

FIGURE 1
GUIDE FOR PLANT SPECIES
ON LEVEES



REQUIRED LEVEE DIMENSIONS FOR TREES
(Section View)



MINIMUM SPACING REQUIREMENTS FOR TREES AND SHRUBS
(Plan View)

ROBERT C. DIXON ▫ AGRO ENVIRONMENTAL SERVICES

ROOT PATTERN INVESTIGATION
NATIVE RIPARIAN VEGETATION ON MOSHER SLOUGH LEVEE
TWIN CREEK ESTATES SUBDIVISION
STOCKTON, CALIFORNIA

Supplement To Response Letter
Dated February 14, 1989

PREPARED FOR: LARRY AKSLAND, INC.
8282 EAST VERITAS
MANTECA, CALIFORNIA 95336

BY: ROBERT C. DIXON
AGRO ENVIRONMENTAL SERVICES
STOCKTON, CA 95207

DATE: APRIL 14, 1989

Consultant to Agriculture ▫ Certified Professional Agronomist
2719 Sheridan Way ▫ Stockton, California 95207 ▫ (209) 474-1492

Reference: Twin Creek Estates
Subdivision
Stockton, California

FEMA Case No. 89-09-02R

Date Of This Report: April 14, 1989

BACKGROUND

The Federal Emergency Management Agency (FEMA) has requested additional data to support a conditional Letter of Map Revisions (LOMR) for the project referenced above. In part, FEMA has expressed concern that the presence of native riparian vegetation along the water-side of the Mosher Slough levee could impair stability of this levee. Additionally, FEMA has questioned revegetation of certain sections of this levee with desirable plant species. Pursuant to the issuance of Army Permit Number 9665, the Corps of Engineers has required that desirable plant species be replanted as a mitigation measure for the loss of riparian vegetation at another location in this project. Furthermore, the Corps has provided a list of desirable plant species -- "A Guide for Vegetation on Project Levees" -- adopted by the State Reclamation Board (California) on December 1, 1967. This list has been revised and updated several times, most recently on December 18, 1981.

Based on an inspection of the levee vegetation on June 3, 1987, a biologist of the United States Department of Interior, Fish and Wildlife Service, concluded that the waters of Mosher Slough and the native riparian vegetation that line its banks are a crucial habitat to a variety of important migratory birds and fish of concern to the Service. Many unique native species are found in the Sacramento - San Joaquin River Delta in which Mosher Slough is located. For these reasons, the Service desires that this native riparian vegetation be protected.

SCOPE AND PURPOSE OF THIS REPORT

Agro Environmental Services, Stockton, California, was retained by Mr. Larry Aksland, Larry Aksland, Inc. to: 1) determine the root system patterns of this riparian vegetation established along the northern levee of Mosher Slough, and 2) report as to the potential for seepage or other detrimental conditions which could result from the roots of existing trees or trees to be planted as part of the revegetation requirement.

DISCUSSION

Root Development - In native ecosystems, woody vegetation germinating from seed produces a taproot that will grow vertically downward 3 to 7 feet or until oxygen levels or other physical conditions become limiting. However, the vertical taproot is usually choked out by lateral roots and is generally absent in most mature trees. Lateral roots radiate out from the base of the trunk. They rapidly decrease in diameter within 3 to 10 feet from the trunk to form an extensive network of long, rope-like roots one to two inches in diameter. Few large lateral roots are found beyond 10 feet from the trunk. In undisturbed clay soil, these roots are 8-12 inches below the surface. Multiple rebranching of the lateral roots produces a mat or fan of fine, short, non-woody absorbing roots, commonly called "feeder roots", that grow up into the surface soil as conditions are favorable. This root network is short-lived and constantly being replaced (Figure 2-1).

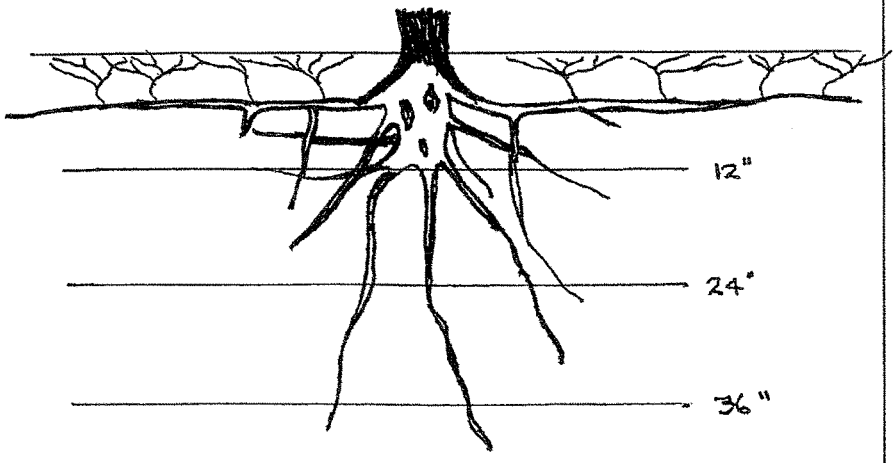


Fig 2-1. Schematic representation of a typical root system of a mature tree

Root Depth and Distribution - A common misconception about roots is that they grow vertically downward in response to gravity. This is only true for a very short period of time in the growth of very young trees. Roots do not grow to or toward anything, rather they grow where soil conditions allow. Roots grow where there is sufficient oxygen, moisture, nutrients, and where the physical structure of the soil does not restrict root elongation and growth. Most roots grow radially outward from the trunk and largely horizontal to the soil surface. **Ninety (90) percent or more of the roots of a tree are found within the first three feet of soil. Up to 70% of the roots are found in the top foot of soil** (Figure 3-1).

Vertical growing roots are commonly found close to and under the tree. Small roots lateral to large roots grow at many angles to the vertical, and some grow up into the surface soil.

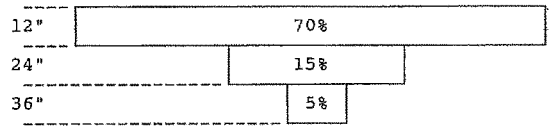
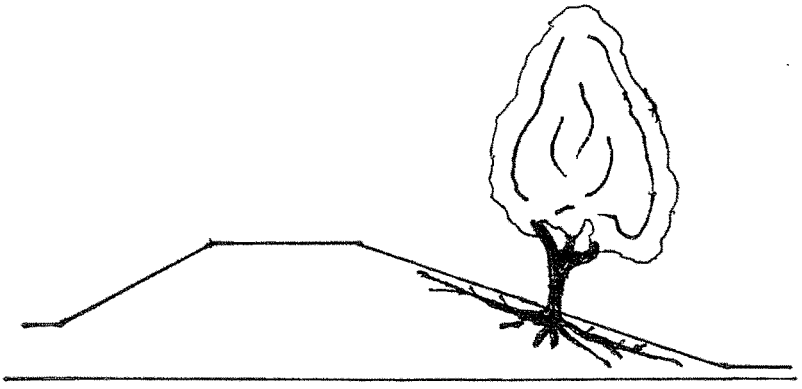


Fig 3-1. Typical root system distribution with depth.

Under conditions where the soil is not disturbed by cultivation and a mulch of leaves, weeds, and other plant debri covers the surface of the soil, surface rooting is a common phenomenon. Generally, an extensive network of small diameter and fine roots (feeder roots) are confined to the first 8-12 inches of soil where water and oxygen can readily penetrate.

Fig 4-1. Large roots tend to grow at about the same soil depth regardless of the slope of the soil surface.



Oxygen Starvation - Oxygen availability is a key component of root growth and function. **Poor oxygen availability is associated with compacted, waterlogged, heavy clay, paved over and filled (raised) soils. The mixing of soil or the addition of off-site soil, greatly reduces oxygen availability.**

Undisturbed soils contain approximately 50 percent pore space in the surface layer (upper 8 to 12 inches) allowing air, water and roots to penetrate. As soil depth increases, the number of soil pores and available oxygen decreases while resistance to root penetration increases. Soil compaction effectively eliminates pore space.

Most land plants will not survive long with the root system submerged in water or surrounded by a soil that is water-soaked. Notable exceptions are rice, various swamp and marsh plants, and the bald cypress (Taxodium distichum).

Air in the pore spaces of the soil is displaced when the spaces become filled with water either from flooding, seepage, or a static, fluctuating or perched water table. Roots will not grow into a water-saturated or oxygen depleted environment. Once the oxygen supply is depleted and anaerobic conditions prevail, roots disfunction and can be killed within 1 to 3 or 4 days of anaerobiosis.

Decreased levels of soil oxygen can result in soils of high clay content, from compaction, and from raising the soil grade or mixing of soils. The latter condition is common with levees and construction sites.

PROCEDURE

A previous study by Aksland provided detailed drawings of the levee cross section at every item of native riparian vegetation along the Mosher Slough levee. Each respective cross section showed the surveyed elevations of the vegetation, the levee, and the normal water level in the slough. From this data, four of the largest and most representative trees of the woody riparian vegetation were selected.

The slope of the levee and the presence of vegetation prevented the use of a backhoe to dig a series of slit-trenches to assess rooting patterns. Furthermore, trenching would have caused greater damage to the integrity of the levee and to any roots which might have been encountered.

Therefore, a portable, 6-inch diameter power auger was used to drill a series of vertical inspection holes into the levee to visually determine the presence of roots, their size and their depth relative to the surface of the soil or the face of the levee. Borings were made ranging in depth from 6 to 8 feet. Depending on the configuration of the leaf canopy of the tree selected for evaluation, borings were made at distances ranging from 5 to 18 feet from the respective tree trunk to the land-side of the levee. **See APPENDIX A-1 through A-4.**

FINDINGS

Groundwater was not encountered in any of the borings. When roots were encountered, small diameter to fine feeder roots (1/8 inch or less in diameter) were found in the upper 2 feet of soil. At one site (Bore-2, Item #2, a 30" diameter willow), feeder roots were visible to a depth of 4.5 feet. When encountered, larger diameter lateral roots were found at a depth of 2 to 2.5 feet. None were found below this depth. **See Logs APPENDIX B-1 through B-4.**

CONCLUSIONS

Established Native Vegetation - The depth of roots observed in the representative bore holes is consistent with root patterns of trees described in the literature and actually seen under "field" conditions. It is also concluded that the root patterns seen in the bore holes are representative of the root patterns of all native vegetation along the levee.

The constant waterlogged conditions on the water-side of the levee and the concurrent oxygen deficient soil at the water-bank interface precludes any root growth or development into the water or below the waterline as established by the normal water level in the slough. In other words, roots will not grow or function in water-logged soil.

Horizontal root growth into the interior part of the levee is likewise restricted due to the compacted, high density of the levee soil. Geophysical assessments made by Kleinfelder indicate that the soil of the original levee is compacted to greater than 85 percent. The improved levee has an average compaction of 93 percent. In soils compacted to this density, there is insufficient pore space to provide adequate moisture and aeration (oxygen) to sustain root activity. Therefore, it is concluded that the root pattern of the native vegetation, particularly of the large trees, occupies the upper 2.5 feet of soil with a network of fine roots predominantly in the top 24 inches of soil. The roots lie in a plain that is parallel to the slope of the surface soil

(Figure 4-1). From the root pattern of a large wind-fallen oak on the levee and a large tree that was removed from the levee for construction purposes, the roots of this native vegetation has not penetrated deeper than 3 feet into the soil.

It is further concluded that because the roots are in the surface soil of the levee, loss of any vegetation and the subsequent decay of any roots would not impair the integrity of the levee even if water rose to the designed flood level. Evidence at the site indicates that any uprooting of trees along the levee will only disturb the upper to 2 to 3 feet of soil on the levee slope and in most cases this would be above a 3:1 slope configuration of the levee.

Another key element is a ledge that is evidence of the original levee. By the obvious age of the trees and shrubs which line the bank of Mosher Slough, this native vegetation has established its roots in this soil matrix and not in soil that has been added to build-up the levee to its present height of 11.5 feet. Observation of the bank shows numerous large roots which are visible just above the water line. These roots run parallel with the levee and the water course. They do not grow into the water-logged soil on the water-side of the levee and they do not grow horizontally into the levee to any great distance because of a lack of oxygen. According to Kleinfelder, borings into this original levee reveal that it consists primarily of cohesive silt and clay materials in a medium-stiff to stiff condition. Therefore, the root pattern of vegetation along the levee is shallow, parallel to the levee and slough, and confined to that soil where the conditions of moisture and aeration favor root activity. Such conditions do not prevail in the interior of the levee or in the water-logged soil of the slough.

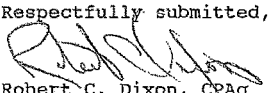
Revegetation - It is my opinion that planting of desirable plant species, as required by the Corps of Engineers and as desired by the Fish and Wildlife Service, will not impair the integrity of the levee or necessarily set the conditions for seepage (Department of Army letter, March 3, 1989, Guide For Plant Species On Levees). This opinion is given based on the information on rooting patterns presented in the discussion section of this report and on visual evidence obtained at the site. Trees and shrubs planted near the normal waterline of the slough where favorable conditions of moisture and aeration occur will become established on their own without much supplement care. This would be a preferred planting area.

However, it is my opinion that plantings higher on the slopes of the levee may require periodic watering until they become fully established. In drought years, supplemental irrigation may have to be provided even for these trees and shrubs if they are to maintain minimum levels of health and vigor.

* * * * * * *

I trust that this report adequately addresses the concerns expressed in various correspondence from FEMA. If you have any further questions, please contact me.

Respectfully submitted,



Robert C. Dixon, CPAg
Certified Professional Agronomist
ARCPACS #354

RCD/md

REFERENCES

1. Tree Roots - Major Considerations For The Developer, January 1989, B. W. Hagen, Staff Forester, California Department of Forestry and Fire Protection.

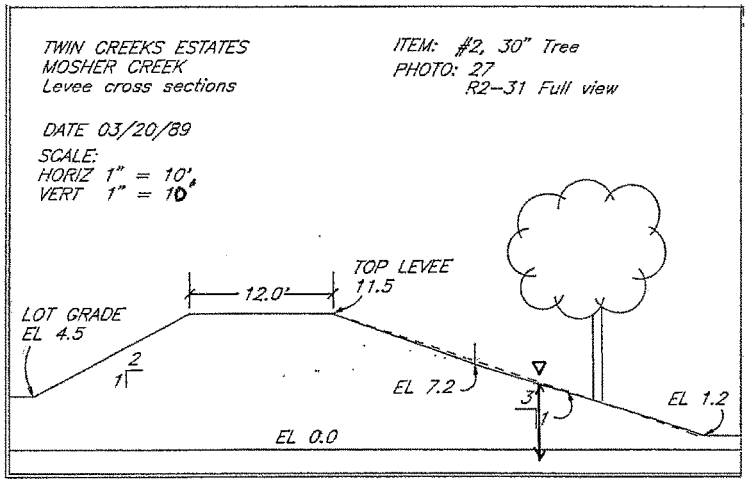
2. Tree Notes - Roots Function, Distribution and Depth, B. W. Hagen, Staff Forester, California Department of Forestry and Fire Protection.

3. Vegetation Management On Reservoir Recreation Sites, Summary Report -- 1966-1971, Department of Environmental Horticulture, University of California, Davis.

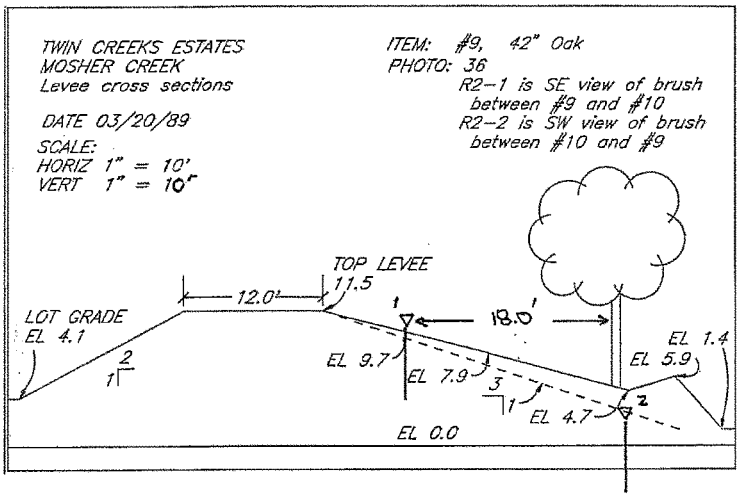
4. Tree Tolerance to Inundation, Progress Report, July 1, 1973, R. W. Harris et. al., Department of Environmental Horticulture, University of California, Davis.

5. Arboriculture, R. W. Harris, pages 42-47.

6. Private technical reference library, Agro Environmental Services.

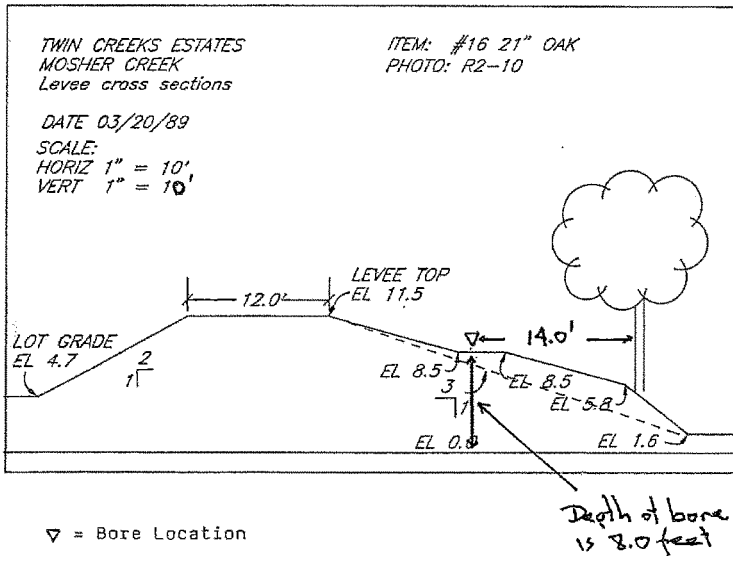


▽= Bore Location

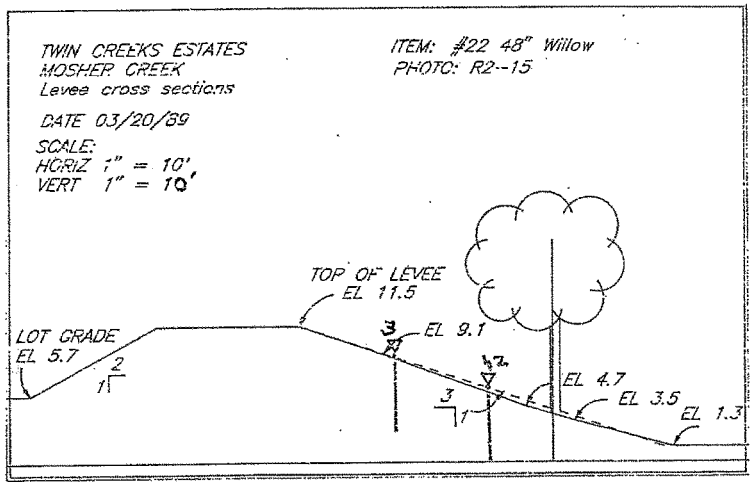


▽ = Bore Location

APPENDIX A-2
Agro Environmental Services



APPENDIX A-3
Agro Environmental Services



▽ = Bore Location

APPENDIX A-4
Agro Environmental Services

LOG DESIGNATION Item #2, 30" dia Willow Tree

Date: 4-05-89
Logged by: RCD
Elevation:
Water Level: No groundwater encountered
Equipment: One-man power auger, 6" bore

Job: Aksland - Mosher Slough
Reference: Item #2, 30" dia willow tree

Depth	Description Soil Profile	Notes
0 to 3"	Surface roots 1" dia or less.	Bore-1, 5 feet to the levee side of tree trunk.
2.5'	Large diameter root - auger could not pass.	
0 to 4.5'	Fine surface and feeder roots length of auger hole.	Bore-2, moved slightly to side of Bore-1.
4.5' to 6.0'	No roots visible. Moist clay at 6 feet, auger would not clear, drilling stopped.	

The log shows subsurface conditions at the date and location indicated, and it is not warranted that they are representative of subsurface conditions at other locations.

LOG DESIGNATION Item #9, 42" dia Oak Tree

Date: 4-05-89 Job: Aksland - Mosher Slough
Logged by: RCD Reference: Item #9, 42" dia oak tree
Elevation:
Water Level: No groundwater encountered
Equipment: One-man power auger, 6" bore

Depth	Description Soil Profile	Notes
0 to 6'	No roots visible. Soil uniformly moist.	Bore-1, 18 feet to levee side of tree trunk. Approximate dripline of the leaf canopy.
0 to 6'	A few small surface roots in upper 12 inches of soil. Uniform soil moisture.	Bore-2, 12 feet west of tree trunk and 8 feet from water edge.

The log shows subsurface conditions at the date and location indicated, and it is not warranted that they are representative of subsurface conditions at other locations.

LOG DESIGNATION Item #16, 21" dia Oak Tree

Date: 4-05-89
Logged by: RCD
Elevation:
Water Level: No groundwater encountered
Equipment: One-man power auger, 6" bore

Job: Aksland - Mosher Slough
Reference: Item #16, 21" dia oak tree

Depth	Description Soil Profile	Notes
0 to 8'	No roots visible.	Bore-1, 14 feet to levee side of tree trunk. Approximate dripline of the leaf canopy.

The log shows subsurface conditions at the date and location indicated, and it is not warranted that they are representative of subsurface conditions at other locations.

LOG DESIGNATION Item #22, 48" dia Willow Tree

Date: 4-05-89 Job: Aksland - Mosher Slough
Logged by: RCD Reference: Item #22, 48" dia
Elevation: willow tree
Water Level: No groundwater encountered
Equipment: One-man power auger, 6" bore

Depth	Description Soil Profile	Notes
- 0 - to - 24"	Small roots 1/8 inch or less in diameter.	Bore-1, 5.5 feet to levee side of tree trunk.
- 24"	Large root, auger could not pass.	
- 0 - to - 24"	Small diameter roots to 24 inches, large root encountered at 24 inches, auger could not pass.	Bore-2, 5.5 feet to levee side of trunk, approx. 2 feet west of Bore-1.
- 0 - to - 84" -	No visible roots.	Bore-3, 13.5 feet to levee side of trunk, approx 2 feet west of Bore-2.

The log shows subsurface conditions at the date and location indicated, and it is not warranted that they are representative of subsurface conditions at other locations.

VITA
ROBERT C. DIXON
Consulting Agronomist

Experience

Mr. Dixon has 30 years of agronomic experience with responsibilities in sales, marketing, management, and technical functions. As the principal in Agro Environmental Services, he provides agronomic and agriculturally related environmental services to industry, agribusiness, and large-scale mechanized and small-holder irrigated farming systems.

These services include technical, management, and hands-on agronomic and pest management responsibilities for over 1500 acres of diversified crops including alfalfa. Mr. Dixon has provided soil and crop agronomic expertise for projects involving the recycling of industrial waste water to land/crop systems and the conversion of liquid rocket fuel into fertilizer. He is currently Project Manager and Consultant involving the treatment of agricultural wash water for cropland disposal. This project also involves a multidisciplinary team effort to assess the impact on soil and groundwater resulting from previous, long-term wash water discharges. Mr. Dixon is functioning in a similar capacity for an industrial site assessment of soil and groundwater which could impact adjacent prime agricultural land.

Mr. Dixon is the author of the "Crop Nutrient News" column which appears monthly in the Agribusiness Fieldman. He has also authored trade journal articles and numerous technical papers on fertilizer-use, plant nutrition, and salinity and sodic soil management. He is a frequent speaker at industry technical conferences and university workshops.

Education

Mr. Dixon is a graduate of the University of California at Davis. He holds a B.S. degree in Plant Science (Agronomy) with emphasis in soil chemistry and plant nutrition. Mr. Dixon is a Certified Professional Agronomist, a Pest Control Advisor licensed by the State of California, and holds a certificate in Hazardous Materials Management from the University of California Extension. He is recognized as a Certified Professional Agronomist by the American Registry of Certified Professionals in Agronomy, Crops, and Soils (ARCPACS). He is a Certified Member of the American Society of Agricultural Consultants, and a member of the American Society of Agronomy, Soil Science Society of America, the California Agricultural Production Consultants Association (CAPCA), and the California Fertilizer Association.

APPENDIX C-1
Agro Environmental Services

Evidence of Experience

Mr. Dixon has been or is currently responsible for the following projects:

Crop Production

Deseret Farms of California (1250 acres - walnuts)
Ohm Ranch (200 acres - sugar beets)
Thompson Ranch (1200 acres - walnut, sugarbeets, wheat, corn, and alfalfa)

Agricultural Land Evaluation

Neumiller & Beardslee, Attorneys & Counselors
Nichols & Berman, Environmental Planners
RLC Associates, Civil Engineers
Jake Weststeyn

Agronomic Assistance and Training

Agro Tech
Arcadian Corp.
California Agricultural Resources Inc.
California Ammonia Co.
City of Piedmont, California
Earth Resource Data Corp. (Verde Technologies)
Kerley Ag Products Inc.
SoilServ Inc.
Willoughby Farms Inc.

Crop Loss and Damage (Forensic Agronomy)

Angelakis Vineyards
CGG Land Seismic
Franchetti & Franchetti, Attorneys at Law
Mazzera, Snyder & DeMartini, Attorneys at Law
R. C. Farms
Scoular Grain Inc.
South San Joaquin Irrigation District
Stammer, McKnight, Barnum & Bailey, Attorneys at Law

Environmental Agronomy

All Pure Chemical Co.
Diablo Ag Chemical Co.
Snow Commodities Inc.
Triple E Produce Corp.
Vandenberg Air Force Base/Dowell Schlumberger
Western Farm Service Inc.

APPENDIX C-2
Agro Environmental Services

Product Development and Marketing Studies

Alpine Plant Foods, Inc.
Arcadian Corp.
Domtar Gypsum America Inc.
Foster Farms
J.R. Simplot Co.

Writing and Publishing

California Ammonia Co.
Kerley Ag Products Inc.
Western Agricultural Publishing Co.

References

1. Mr. Carl Spiva, Agronomist/Consultant
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2. John H. Sammons, Ph.D.
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Novato, CA 94945-1702 (415) 892-0022

3. Dr. Roland E. Meyer
Extension Soil Specialist
University of California
129 Hoagland Hall
Davis, CA 95616 (916) 752-2531

4. Terry L. Prichard
Area Soils and Water Specialist
University of California, Cooperative Extension
420 South Wilson Way
Stockton, CA 95205 (209) 944-3711

DRAFT 2/8/2010

Alison M. Berry, PhD
611 I Street
Davis, CA 95616
February 6, 2010

TO: Mr. Tim Washburn, Director of Planning, Sacramento Area Flood Control Agency
1007 7th Street, 7th Floor, Sacramento, CA 95814

FROM: Alison M. Berry, PhD

Dear Mr. Washburn:

In response to your request of 1/29/2010, I have reviewed the documents that were emailed to me on Jan 29, 2010, regarding assessment of trees and tree roots along the Mosher Creek Levee, Stockton, California, with particular attention to the methods, results and interpretations presented in the report by Robert C. Dixon.

I received copies of 3 documents, which I will briefly describe:
Document 1: An addendum dated March 9, 1989, and stamped by Ronald Heinzen, Regional Manager of Kleinfelder, Inc., containing results of 2D modeling of levee profile impacts of root systems either 2' or 3' deep. The root depth dimensions were based on field observations of the root system of a downed oak tree that fell over along the water side slope adjacent to Mosher Slough, and on personal observations of a local almond-tree farmer. The tree was 24" in diameter, with a root plate that was 2' deep, and 3' – 5' in horizontal extent. Photos of the tree were not included in this copy of the document. One conclusion was that the shallow root plate indicates a high water table. This evaluation appears to be reasonable and accurate. Factors of Safety were calculated using the 2D profile data, and did not differ greatly among the cases considered.

Document 2: A cover letter dated March 3, 1989, and accompanying tables, from Tom Skordal, Chief, Regulatory Unit 1 of the Department of the Army, Sacramento District Corps of Engineers. The tables contain lists of desirable and undesirable plant species for planting on levees, including trees, shrubs and ground cover. Included also are levee sections indicating locations on the levee slopes where trees and shrubs should be planted. The list of desirable trees includes many species observed on or adjacent to levees I have visited in the Sacramento and Delta region. Many, but not all of the tree species indicated as desirable on this list are native California riparian species.

Document 3: Supplement dated April 14, 1989, to a previous letter dated Feb 14, 1989. Supplement titled: Root Pattern Investigation: Native Riparian Vegetation on Mosher

Slough Levee, Twin Creeks Estate Subdivision, Stockton, CA. Author: Robert C. Dixon, Consultant to Agriculture, Agro Environmental Services, Stockton, CA 95207. Mr. Dixon carried out a field study of root system depth and extent of 4 trees located on or adjacent to the Mosher Slough Levee, with respect to potential for seepage or other detrimental effects of the tree root systems on the levee.

Assessment:
Mr. Dixon first presents a discussion of tree root system architecture, root depth and distribution (pp. 2-3). The discussion is generally accurate, except that estimates of rooting depth are somewhat too shallow to apply to all soil conditions, and estimates of percent of roots in the top 12" of the soil horizon (70%; Fig. 3-1) are only accurate for trees with root systems within 12-24" of the water table. In deeply-drained, sandy soils adjacent to levees in Sacramento, I have measured somewhat deeper rooting patterns, i.e. major structural roots of one oak tree were found at 4-5' depth (Mayhew Levee), and a taproot on another oak tree extended beyond 6' of depth (Pocket Levee).
The pattern of root growth observed by Mr. Dixon to follow below the grade of the levee slope, depicted in Fig. 4, has also been observed by us at the Pocket Levee.
Mr. Dixon's description of oxygen availability in soils and the consequences for tree roots (p. 5) is generally correct.
The method used by Mr. Dixon to assess the depth and extent of tree root systems without causing major damage to the levee structure seems reasonable, although with some limitations, as described below. A 6-inch diameter power auger was used to drill vertical inspection holes at distances from the trunks of 4 trees – 2 willows and 2 oaks (shown in Appendices A1-A4). The trees were selected as representative of the Mosher Levee vegetation based on survey data previously acquired.
Information on soil particle distribution and other soil characteristics at the site was not provided in the report I received. Photos were taken of the trees measured, but these were not part of the report I received.
The results, summarized in the text, p. 6, and presented in Appendices B1-B4, showed:
1. that roots were present in bore holes near the tree trunks, but that no major roots were identified in bore holes at or beyond a horizontal distance of 12' from the center of the trees sampled.
2. in terms of root depth in bore holes made closer to the tree trunks (distances of 5' and 5.5' from the trunk), in two cases (B-1-1, B-4), large roots were encountered at 2'-2.5' depth, at which time augering was stopped. It was not possible to auger through the roots, and therefore it was not possible to determine the depth of the root systems beyond 2'-2.5'. In one bore-hole at 5' from a willow trunk (B-1-2), no roots were encountered to a depth of 6'.
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General Summary Comments:
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References

Barnes, BV, Zak DR, Denton SR, Spurr SH. 1997. Forest Ecology, 4th ed., Wiley, New York.
Harris RW, Clark JR, Matheny NP. 2004. Arboriculture, Integrated Management of Landscape Trees, Shrubs and Vines, 4th ed. Prentice Hall, New Jersey.
Kramer PJ, Kozlowski TT. 1979. Physiology of Woody Plants, Academic Press, Orlando.
Lyford WH. 1980. Development of the root system of northern red oak (Auercus rubra L.). Harvard Forest Paper 21, Harvard University.
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APPENDIX D

Research in Progress on the Root Structure of
Trees Found on Loire River Sandy Dike

Caroline Zanetti is a doctoral student currently evaluating root structures found in trees growing on the waterside of a sandy dike on the Loire River in France. As part of this effort, Zanetti has participated in excavating and examining several trees of a similar species, size, and relationship to the dike and the river as those found in the Project Area. Zanetti's observations, along with photos of some of the excavated trees, are attached. She notes that the trees in dikes along the Loire River bank produce a mass of shallow lateral roots that grow in the surface soil of the dike structure (upper 3 to 4 feet) parallel to the levee slope. These trees also produce a smaller number of vertical roots (including tap roots in the case of oak trees) that may extend up to 5 feet down.

The following is a list of sources for Zanetti's research in progress:

Zanetti, C. et al. In prep. *Trees – Structure and function*. Root systems architecture on dikes: a typology purpose.

———. In prep. *Plant and Soil*. Trees Root systems structure on dikes.

———. In prep.*Regulated Rivers : Research and Managemen*t. Tree roots growth and development on earth dikes.

———. In prep. Woody vegetation on earth dikes: risks assessment and management solutions. *European Journal of Environnemental and Civil Engineering*.

The table below displays Zanetti's findings on the root structures of four tree species (i.e., oak, willow, ash, and acer negundo [boxelder]) found on the Loire River sandy dyke.

Root Structure of Trees Found on Loire River Sandy Dike

	Tree			
	Oak	**Willow**	**Ash**	**Acer negundo (boxelder)**
Taproot	Yes or no	Yes or no	No	No
Depth	1.5 m	1 m	0.75 m	0.5 m
Horizontal extent (radius)	3 m	6 m	3 m	4 m

Notes: On sandy dike (in the case of Loire dike in France):
Taproot: yes/no (depends on tree position: top or dike foot)
Depth of majority of the root system (let us say, 75–80% of root system): (1 m, 2 m, etc.)
Horizontal extent of the majority of the root system (~80%): (radius)

Source: Zanetti et al. in prep.

Contact :

Caroline Zanetti, Cemagref, Hydraulics and Hydrology Research Unit, 3275 route de Cézanne – CS 40061, 13182 Aix-en-Provence Cedex 5, France.

University of Provence, Aix Marseille 1, 29 avenue Robert Schuman, 13100 Aix-en-Provence, France.

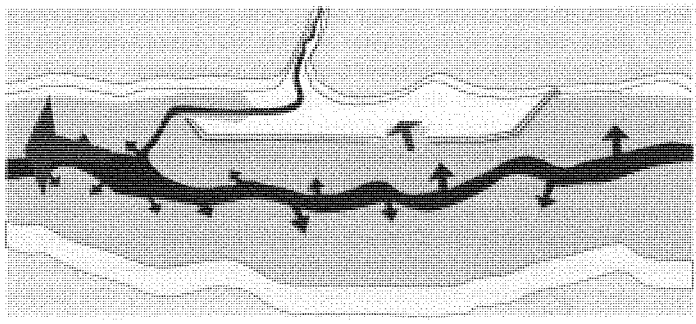


Figure 3c. Spillway operation

1.3 Composition of dikes

1.3.1 Fill dikes

The majority of dikes in France are earthfill embankment constructions made with materials ranging from silt to sand and occasionally gravel. Their composition can largely be explained by the history of their construction.

– Very often they were built in stages during different periods as the use of rivers and the need for defences changed (Fig. 4).

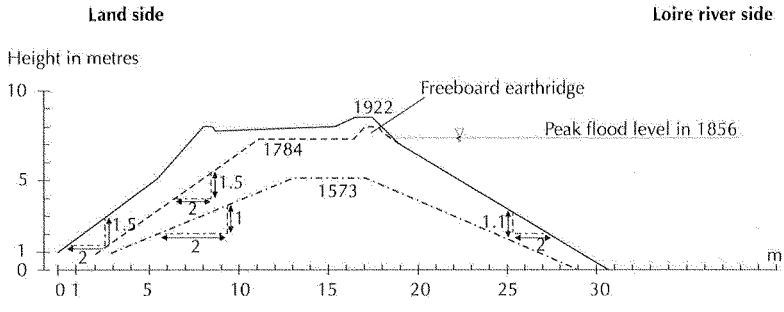


Figure 4. Typical cross-sections of River Loire levees before recent upgrading work

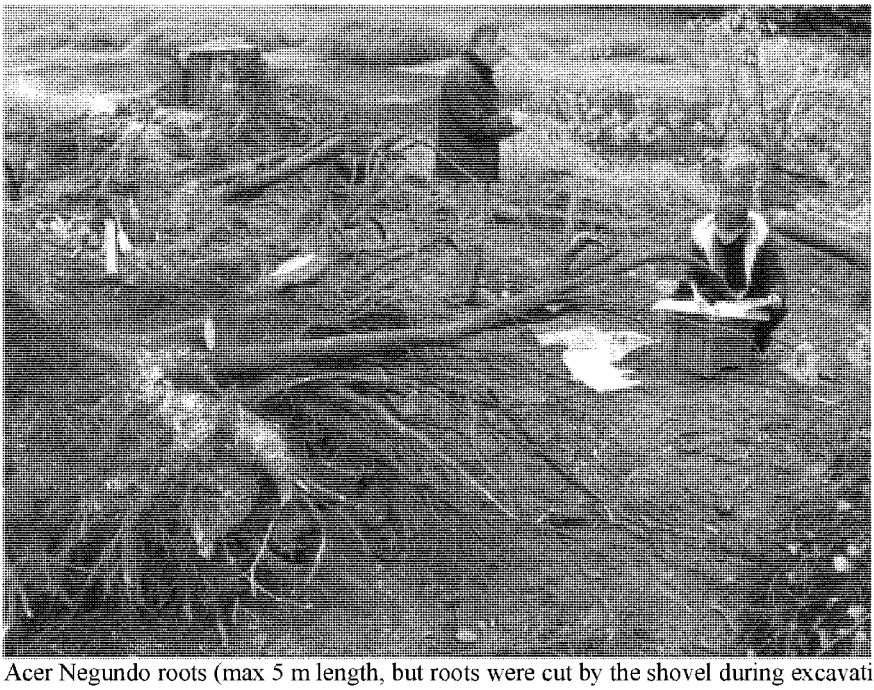
– Since powerful earth-moving equipment was not available at the time, dike embankments were generally built with materials taken from the immediately surrounding area; the remains of old borrow pits can still be seen at the toe of some dikes.

The nature of earthfill materials may therefore vary widely, even along the same river (sandy in the middle reaches and silty nearer the mouth). Generally, however, single sections are of a homogeneous nature with no zoning and no special internal drainage system (Fig. 5).

Root systems on Loire dike (sandy and silty levee) near Cosne-sur-Loire (58 Nièvre)



Acer Negundo (shallow root system)



Acer Negundo roots (max 5 m length, but roots were cut by the shovel during excavation)



Salix Alba (very big root system, with very long and large roots – it was growing at the foot bottom, so with a very good water access)



Poplar hybrida (little root system, with a taproot of 1m length)



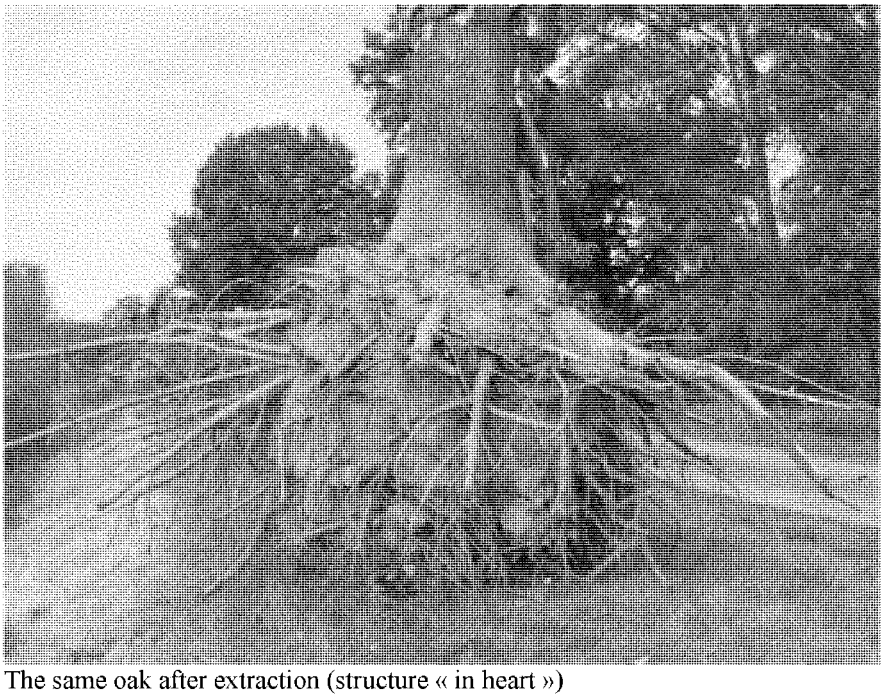
Another poplar root system (the shallow roots went to river direction)



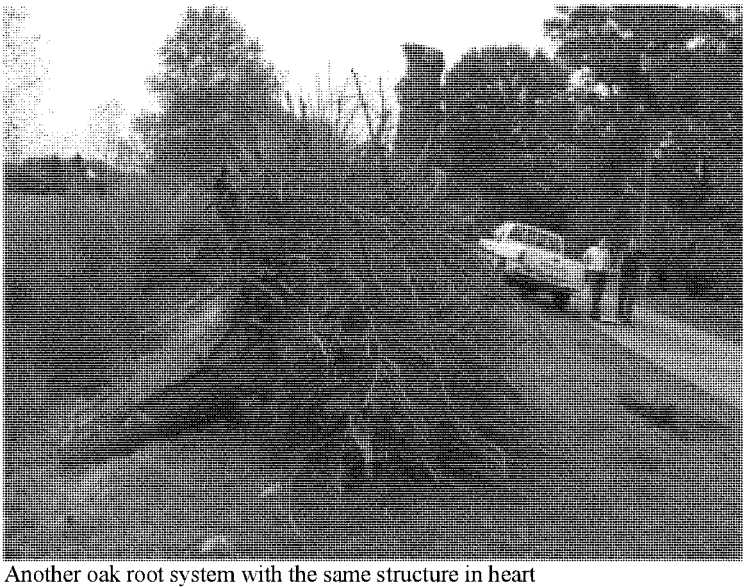
Root system of the same poplar (shallow and deep roots)



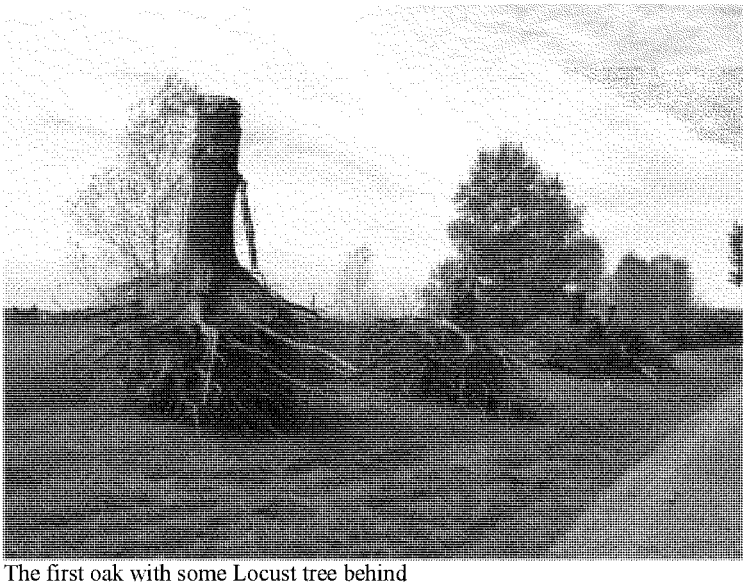
Oak root system (on this part of the dike materials were more sandy)



The same oak after extraction (structure « in heart »)



Another oak root system with the same structure in heart



The first oak with some Locust tree behind

Caroline Zanetti, 3/02/2010

Cemagref
Science, water & land management

APPENDIX E

Kleinfelder Letter Report: Levee Seepage and Stability Analysis

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April 8, 2010
File: 94582

Mr. Tim Washburn, Esq.
Sacramento Area Flood Control Agency
1007 7th Street, 7th Floor
Sacramento, California 95814

Subject: Vegetation Variance Geotechnical Evaluation
Natomas Levee Improvement Program (NLIP)
Sacramento and Sutter Counties, California

Dear Mr. Washburn:

At the request of SAFCA, Kleinfelder performed analyses of potential seepage and stability impacts associated with the presence of vegetation along the waterside slope/base of existing Natomas levees.

Kleinfelder conducted a series of analyses that evaluated:

- Steady-state seepage exit gradients and riverside sudden drawdown stability after a hypothetical complete loss (erosion) of a vegetative zone on the waterside face of the levee. The vegetative zone was assumed to be 15 feet wide at the base, measured at the riverside toe of the levee, with a backslope of 3H:1V (horizontal:vertical) or steeper, as required to maintain a 20-foot-wide levee crown width.
- Sudden drawdown slope stability to evaluate impact of local scour on slope stability. This analysis was based on scour analyses conducted by Northwest Hydraulic Consultants (nhc) for specific trees judged to be critical in terms of location and depth of scour.
- Sudden drawdown slope stability due to loss of the riverside face due to tree fall in the upper one-third of the waterside slope. The zone of erosion is defined as a 10-foot-thick wide zone measured perpendicular to the existing slope face at the riverside levee crown hinge point with a 2H:1V backslope. A widened levee section will be constructed on the landside slope to provide a minimum 20-foot crown width. Landside slopes will vary between 2H:1V and 3H:1V.

The 15-foot-wide vegetative zone is based on eight representative levee geometries (Index Sections) selected by AECOM, SAFCA's environmental consultant. These sections were judged to be critical in terms of impacts of vegetation on the NLIP levees. Kleinfelder selected seven representative cross sections from previous and ongoing studies judged to have similar geometry to AECOM Index Sections.

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The impact of scour of selected trees is based on studies by nhc. Nhc was retained by SAFCA to conduct an evaluation of the riverside vegetation to identify trees that could have the greatest impact to levee stability if tree fall and erosion (scour) should occur. Ten sites were selected by nhc for scour analyses, and their analyses identified two locations where the depth of scour could potentially impact the levee template[1]: one on the Natomas Cross Canal (NCC) and the second on the upper portion of the Sacramento River East Levee (SREL). The location (levee slope or toe) and size (depth and width) of the resulting scour holes were provided to Kleinfelder. Seven cross sections were selected from previous or ongoing analyses to evaluate the sudden drawdown stability due to the presence of a scour hole (defined herein as the remnant scour section).

The impact of vegetation within the upper one-third of slope was conducted for two sections along the Sacramento and American Rivers. The levee geometry was also checked to confirm that nhc scour estimates for tree fall scour within the upper one-third of the levee did not impact the levee template.

AECOM INDEX SECTIONS

AECOM identified eight Index Sections with corresponding post-remediation levee geometries where a vegetation variance will be required to allow trees to remain. The locations of these sections, referenced by both levee acronym and levee mile (LM) are discussed below and shown in Table 1. Kleinfelder reviewed the most current levee models that have been completed for the basin and selected cross sections that best matched the Index Section geometries. The locations of these sections with respect to the Index Sections are summarized in Table 1.

For this analysis it was assumed that, for an extreme condition, a 15-foot-wide section, measured horizontally from the levee waterside toe, would erode leaving a levee remnant section. This section was modeled to have a waterside slope inclination of 3H:1V or steeper to maintain a 20-foot-wide crown. Steady state seepage analysis was then conducted to check that exit gradients at the toe of the remnant levee section did not exceed USACE design criteria of 0.5 for the design water surface elevation (WSE). For the NLIP project, a 200-year WSE has been selected for design of the project. The results of this analysis are described in more detail below.

Location of Analysis

Vegetation variance analysis was performed by Kleinfelder at seven representative locations selected by AECOM. Information regarding these Index Sections are summarized below and in Table 1.

[1] *Levee template taken as waterside slope no steeper than 2H:1V, landside slope no steeper than 3H:1V, and a levee crown width of 20 feet.*

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Table 1 – AECOM Index Cross Sections and Kleinfelder Representative Cross Section Summary Table

Index Cross Section Number	Levee Section	Section Levee Mile[1]	Representative Length (miles)[1]	Feature[1]	Kleinfelder Representative Model Station	Kleinfelder Report Reference Number[2]	Date Published
I-1	SREL 2	5.8	13.8	Raised adjacent levee alone, or with a seepage cutoff wall or seepage berm	320+00	1	January 15, 2010
I-2	SREL 4	15.2	3.4	Adjacent levee alone, or with a seepage cutoff wall or seepage berm	838+00	2	November 6, 2009
I-3	SREL 4	17.0	2	Adjacent levee alone, or with a seepage cutoff wall or seepage berm	904+50	2	November 6, 2009
I-4	ARNL	1.1	2.2	Over-built levee	47+98	3	November 2, 2009
I-5	NEMDC South	0.0	0.3	Over-built levee	Anp[3]	4	November 2, 2009
I-6	NEMDC South	0.3	4.6	Typical section	58+00	4	November 2, 2009
I-7	NCC	0.7	4.3	Standard levee	183+00	5	January 21, 2009
I-8	NCC	3.6	1	Expanded levee	21+00	5	January 21, 2009

Note: 1. Source: AECOM
2. A "Reference" page is attached to this report.
3. anp = analysis not performed on this section because no remediation is planned for this section and the section had an 85-foot crown.

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Index 1 - SREL from the NCC downstream to about Powerline Road: This levee segment is characterized by a new adjacent levee constructed landward of the existing hydraulic-fill sand levee. Remediation measures planned along this reach include seepage berms and soil-bentonite (SB) seepage cutoff walls.

Index 2 - SREL downstream of Powerline Road to about Reach 19: This levee segment is characterized by a widened levee section constructed landward of the existing levee. Remediation measures planned along this reach include seepage berms and SB seepage cutoff walls.

Index 3 - SREL from Reach 19 to confluence of the American River North Levee (ARNL): Because of existing development at/near the landside levee toe, this segment will have neither adjacent nor widened levee construction. However, this segment has a relatively wide crown due to the presence of both the multi-lane Garden Highway and adjacent improvements. Remediation measures planned along this segment include SB cutoff walls.

Index 4 - ARNL from the confluence with Sacramento River extending to about Northgate Boulevard: Because of existing development at/near the landside levee toe, this segment will have neither adjacent nor widened levee construction. However, this reach has a relatively wide crown due to the presence of Garden Highway. Remediation measures planned along this segment include SB cutoff walls.

Index 5 - Natomas East Main Drainage Canal (NEMDC) from Northgate Boulevard upstream to the Arden-Garden Connector bridge structure: This levee segment has a wide crown width due to the presence of the multiple-lane Garden Highway. No remediation measures are currently planned along this segment, and no analyses were performed due to the 85-foot-wide crown.

Index 6 - NEMDC from the Arden-Garden Connector bridge structure upstream to the County of Sacramento Pumping Plant: No additional levee width is proposed along this alignment. Proposed remediation measures include SB cutoff walls and relief wells.

Index 7 - NCC from about Station 54+00 to Pleasant Grove Creek Canal levee: This levee segment consists of a conventional levee with 3H:1V waterside and landside slopes with a 20-foot crown width. Completed levee remediation along this alignment includes a SB seepage cutoff wall.

Index 8 - NCC from the confluence with the Sacramento River to about Station 54+00: This levee segment consists of a conventional crown width embankment with a waterside slope generally flatter than about 3H:1V. Completed levee remediation along this alignment includes a soil-cement-bentonite (SCB) seepage cutoff wall.

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Kleinfelder selected cross sections previously analyzed as part of Alternatives Analysis or Basis of Design Reports. The cross sections selected are near the selected levee mile or judged to be close to the typical levee section as developed by AECOM. Table 1 summarizes the station of the model used for each section and the Kleinfelder report it was taken from. Specific details concerning analysis methods and input parameters for strength and permeability are contained in the respective reports.

ANALYSES

Kleinfelder analyzed the potential effects of vegetation presence along the waterside slope/toe by evaluating the levee with removal of a portion of the waterside slope, referenced herein as the remnant levee configuration. All analyses were conducted using the 200-year WSE. In areas where there was existing/proposed excessive crown width, a 15-foot-wide section of levee (measured horizontally) was removed. The resulting waterside slope analyzed ranged from about 1.7H:1V to 3.5H:1V. In most cases, this resulted in a remaining crown width greater than 20 feet. This condition is expressed in Kleinfelder Model Stations SREL 320+00, SREL 838+00, and ARNL 47+98 (AECOM I-1, I-2, and I-4), attached.

For Kleinfelder Model Stations SREL 904+50, NEMDC 58+00, NCC 21+00, and NCC 183+00 (AECOM I-3, I-6 through I-8), a 15-foot-wide portion of the levee (measured at the base width) was removed. If the crown width was at least 20 feet, the levee slope was projected from the resulting theoretical levee toe to the top of a 20-foot-wide crown. If the existing crown width was 20 feet or less, the levee slope was projected from the bottom of the slope (with a 15-foot-wide portion removed) to the levee crown.

As stated above, no analyses were performed at AECOM Section I-5.

MATERIAL VARIABILITY

Kleinfelder reviewed existing analyses for other levee cross sections modeled by Kleinfelder for the NLIP project. By inspection, these cross sections were comprised of and had geometric configurations represented by the Index Sections. Kleinfelder believes these cross sections will perform similarly in terms of steady-state seepage and sudden drawdown stability as the sections modeled, as described in the following section.

INDEX SECTION RESULTS

Regarding waterside sudden drawdown conditions, Kleinfelder performed analyses on the waterside slopes with and without the erosion of the levee waterside embankment. The results are shown in Table 2. For Sections I-2, I-3, I-6 through I-8, a decrease in Factor of Safety (FOS) between 0.16 and 0.58 is shown. Despite the decrease in FOS in some of the sections, the remnant levee configuration exceeds USACE criteria for the sudden drawdown loading condition (FOS >1.1).

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Underseepage was also evaluated in each cross section with the remnant levee configuration. The seepage gradients at the landside levee toe are less than USACE maximum criteria in all cases. Results of all the analyses are presented in Table 2 and on Plates 1 through 21.

Table 2 –Vegetation Variance Seepage and Stability Results Summary

Index Cross Section Number	Levee Section	Station Number	Seepage Gradient at Landside Levee Toe (200-Year WSE) Remnant Levee Configuration	Sudden Drawdown Factor of Safety	
				Existing Configuration	Remnant Levee Configuration
I-1	SREL 2	320+00	<0.10	1.67	1.86
I-2	SREL 4	838+00	0.20	1.64	1.35
I-3	SREL 4	904+50	0.10	3.08	2.50
I-4	ARNL	47+50	<0.10	1.25	1.42
I-5	NEMDC	N/A	anp[1]	anp[1]	anp[1]
I-6	NEMDC	58+00	0.29	1.86	1.42
I-7	NCC	183+00	<0.10	1.60	1.35
I-8	NCC	21+00	0.46	1.65	1.56

Note: 1. anp = analysis not performed on this section because no remediation is planned for this section and the section had an 85-foot crown.

nhc SCOUR REMNANT SECTIONS

SECTION SELECTION

As documented in nhc's March 2010 report, site selection for scour analysis was based on the following:

- Identify at least one site in each NLIP levee segment and for each of the different proposed improvements along the SREL where there is greatest potential for erosion to penetrate the levee;
- Where the existing waterside levee slope was close to the existing minimum levee template and where large trees were observed on the section; and
- Where local river velocities were judged to be highest along the bank or levee slope.

A total of ten sites were selected by nhc for analysis, summarized in Table 3.

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Table 3 – Summary of nhc Selected Cross Sections

nhc Cross Section ID (LM)	Levee Section	Section River Mile (Station)[1]	nhc Vegetation Description	Feature
Sac 1 (0.3)	SREL	78.5 (17+00)	Large trees on the lower bank and waterside slope	Raised adjacent levee, alone or with a seepage cutoff wall or seepage berm
Sac 2 (5.3)	SREL	74.8 (280+00)	A large tree on the berm	Raised adjacent levee, alone or with a seepage cutoff wall or seepage berm
Sac 3 (12.0)	SREL	61.3 (917+44)	A large tree on the berm	Adjacent levee alone or with a seepage cutoff wall or seepage berm
Sac 4 (13.3)	SREL	66.5 (631+63.5)	A very large tree about 20 feet from the levee toe at a location of greatest river velocities	Raised adjacent levee, alone or with a seepage cutoff wall or seepage berm
Sac 5 (14.9)	SREL	63.9 (788+10)	A large tree located on the riverside berm about 15 feet from the toe	Adjacent levee, alone or with a seepage cutoff wall or seepage berm
Sac 6 (17.4)	SREL	65.5 (710+72)	A large tree located on the levee slope	Raised adjacent levee, alone or with a seepage cutoff wall or seepage berm
NEMDC (1.3)	NEMDC	-- (67+71)	Large tree at toe of levee opposite Arcade Creek	Seepage cutoff wall
NCC1 (3.7)	NCC	-- (35+00)	Large tree on either the levee slope or near the toe	Raised levee with seepage cutoff wall
ARNL 1 (0.7)	ARNL	35+50	Large tree in upper one-third of slope	Wide levee with seepage cutoff wall
ARNL 2 (1.7)	ARNL	-- (92+68)	Large tree on either the levee slope or berm near the toe	Wide levee with seepage cutoff wall

Note: [1] Source: nhc

LOCATION OF ANALYSIS

The vegetation variance scour analysis was performed at seven of the ten locations summarized in a report published by nhc on April 1, 2010. Kleinfelder selected cross sections previously analyzed as part of Alternatives Analysis or Basis of Design Reports. The cross sections selected are near the selected levee station, as developed by nhc.

Table 4 summarizes the station of the model used for each nhc section and the Kleinfelder report from which it was taken. Specific details concerning analysis methods and input parameters for strength and permeability are contained in the respective reports. The results of nhc scour analyses are summarized in Table 5. Analyses were not conducted for nhc locations Sac 4, Sac 6, and ARNL 1, since the depth of scour is less than 3 feet and does not penetrate the levee template. Based on the model results for the other sections, this small amount of scour is judged to have little impact on the global stability of the levee and was not modeled.

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Table 4 – nhc Scour Analysis Cross Section and Kleinfelder Model Station Summary Table

nhc Cross Section ID (LM)	Section Station[1]	Levee Section	Kleinfelder Representative Model Station	Kleinfelder Report Reference Number[2]	Date Published
Sac 1 (0.3)	17+00	SREL 1	27+00	7	January 30, 2009
Sac 2 (5.3)	280+00	SREL 2	287+00	1	January 15, 2010
Sac 3 (12.0)	631+63.5	SREL 3	640+00	6	September 23, 2009
Sac 4 (13.3)	710+72	SREL 3	--	--	--
Sac 5 (14.9)	788+10	SREL 4	789+00	2	November 6, 2009
Sac 6 (17.4)	917+44	SREL 4	--	--	--
NEMDC (1.3)	67+71	NEMDC South	58+00	4	November 2, 2009
NCC1 (3.7)	35+00	NCC	21+00	5	January 30, 2009
ARNL 1 (0.7)	35+50	ARNL	--	--	--
ARNL 2 (1.7)	92+68	ARNL	96+65	3	November 2, 2009

Notes: [1] Source: nhc
[2] A "Reference" page is attached to this report
-- not analyzed

Table 5 – Summary of nhc Scour Analysis Results

Site (LM)	200-year WSE (NAVD88 ft)	Elevation of Tree (NAVD88 ft)	Maximum Scour Depth for Event (ft)
Sac 1 (0.3)	43.1	31	11.8
Sac 2 (5.3)	41.3	35	11.6+
Sac 3 (12.0)	36.4	27	11.7
Sac 4 (13.3)	35.7	33.7	2.4
Sac 5 (14.9)	34.4	27	11.7
Sac 6 (17.4)	34.9	31	0.1
NEMDC (1.3)	36.1	30	7.3
NCC1 (3.7)	42.3	31	9.6
ARNL 1 (0.7)	35.4	34.4	3.9
ARNL 2 (1.7)	35.8	25	11.7

ANALYSES

Kleinfelder analyzed the potential effects of scour holes caused by tree falls on the waterside slope/toe by evaluating sudden drawdown stability with the scour remnant levee configuration. The geometry of this portion was based off of the nhc drawings provided to Kleinfelder on March 11, 2010, and are included in the April 8, 2010, nhc report. All analyses were conducted using the 200-year WSE. Nhc also defined a scour envelope for the eight AECOM Index Sections. Based on the area defined by the scour envelope, a supplemental analysis was performed on the NEMDC index cross (I-5). The scour envelope in the NEMDC index section is defined by a 1.7H: 1V slope

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starting at the waterside crown hinge point and extending to the toe of the waterside slope. In the NEMDC model, all material not contained within the 1.7H:1V waterside slope was removed and a sudden drawdown analysis was performed. Supplemental analysis was not performed on the other six AECOM Index Sections since the scour envelope defined by nhc for these sections did not extend into the remnant levee geometry.

RESULTS

Regarding waterside sudden drawdown conditions, Kleinfelder performed analyses on the waterside slopes with the removal of the scour hole on the waterside slope and with the scour envelope removed for the NEMDC Index Section. The results are shown in Table 6. All scour remnant sections were found to have a sudden drawdown FOS greater that 1.1, the USACE minimum criteria.

Results of these analyses are presented in Table 6 and on Plates 22 through 29.

Table 6 –Scour Analysis Stability Results Summary

nhc Cross Section ID	Analysis Type	Levee Section	Kleinfelder Representative Station (Model)	Sudden Drawdown FOS With Scour Configuration
Sac 1	Scour Hole	SREL 2	27+00	1.34
Sac 2	Scour Hole	SREL 2	287+00	1.27
Sac 3	Scour Hole	SREL 3	640+00	2.23
Sac 5	Scour Hole	SREL 4	789+00	1.58
NEMDC	Scour Hole	NEMDC	58+00	1.29
NEMDC	Scour Envelope	NEMDC	58+00	1.18
NCC1	Scour Hole	NCC	21+00	1.19
ARNL 2	Scour Hole	ARNL	96+65	1.15

TREE FALL WITHIN THE UPPER ONE-THIRD OF SLOPE

From discussions with SAFCA and the USACE, tree fall within the upper one-third of the levee is a concern. It is Kleinfelder's current understanding that, to allow existing trees to remain in the upper one-third of the levee, there has to be a stable remnant levee section. For this case, the remnant levee is defined as a levee section with a waterside slope no steeper than 2H:1V, a 3H:1V landside slope (or stable existing slope if steeper than 3H:1V), and a 20-foot crown width. The location of the remnant levee 2H:1V waterside slope is determined by offsetting the existing waterside slope by projecting a 10-foot line perpendicular to the existing waterside slope. Kleinfelder conducted sudden drawdown slope stability analyses for two cross sections where trees on the upper one-third of the levee are of particular concern, SREL Station 838+00 and ARNL Station 47+98, presented on Plates 30 and 31. The analysis for SREL 838+00 (Plate 30) requires widening the adjacent levee slope to achieve a total crown width of

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approximately 44 feet with a resulting remnant crown width of 20 feet. The analysis for ARNL 47+98 (Plate 31) does not require an adjacent levee to provide the levee remnant section. Both of these analyses show that the remnant levee section have a calculated FOS of greater than USACE minimum of 1.1.

CONCLUSIONS AND RECOMMENDATIONS

Kleinfelder evaluated both the effects of steady state seepage and sudden drawdown stability for the remnant levee configurations. Since all levee segments include through seepage remediation, Kleinfelder has concluded that the loss of a 15-foot-wide zone of the levee waterside slopes or the inclusion of scour holes as calculated by nhc would not impact the effectiveness of proposed remedial measures.

Although the remnant levee conditions resulted in a decrease in waterside stability, the FOS for representative cross sections exceeds USACE criteria.

As shown in Table 2, representative cross sections I-1 and I-4 had increased FOS, indicating that waterside stability is improved when a section of the waterside is removed. The reason for improved stability is likely due to the failure surface moving landward into the existing levee granular fill material combined with flattening of the waterside slope to 3H:1V. It is important to note that the removal of this material should not be seen as a means of improving overall levee performance.

As shown in Table 6, the NEMDC section had the lowest FOS of all the scour analyses but meets USACE design criteria.

For trees located within the upper one-third of the existing waterside slope, the width of the widened levee section within the SREL will need to be increased to provide the minimum 20-foot crown width and a 2H:1V waterside remnant levee slope. The sudden drawdown stability of the remnant levee for SREL and ARNL models exceed the minimum USACE FOS criteria of 1.1.

LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions, and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

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This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report.

The work performed was based on project information provided by Client. If Client does not retain Kleinfelder to review any plans and specifications, including any revisions or modifications to the plans and specifications, Kleinfelder assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, Client must obtain written approval from Kleinfelder's engineer that such changes do not affect our recommendations. Failure to do so will vitiate Kleinfelder's recommendations.

Recommendations contained in this report are based on Kleinfelder's field observations, subsurface explorations completed by Kleinfelder and others, laboratory tests, and Kleinfelder's present knowledge of the existing levee conditions. It is possible that soil conditions could vary between or beyond the points explored.

We appreciate the opportunity of providing our services for this project. If you have questions regarding this report or if we may be of further assistance, please contact the undersigned.

Respectfully,

KLEINFELDER WEST, INC.

Elizabeth Roesler, EIT
Geotechnical Professional

Mark Stanley, PE, GE
Senior Principal Engineer

REGISTERED PROFESSIONAL ENGINEER
MARK H. STANLEY
No. GE 002397
Exp. 9-30-10
GEOTECHNICAL
STATE OF CALIFORNIA

Lynn M. O'Leary, PE, PMP
Project Manager

Attachments:

References
Plates 1-31

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REFERENCES

1. Kleinfelder, Inc. "Geotechnical Basis of Design Report, Sacramento River East Levee Phase 2 (Reaches 5 through 9) Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 15, 2010.

2. Kleinfelder, Inc. "Draft Alternatives Analysis Report, Sacramento River East Levee Phase 4 (Reaches 16 through 20) Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 6, 2009.

3. Kleinfelder, Inc. "Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

4. Kleinfelder, Inc. "Draft Alternatives Analysis Report, Natomas East Main Drainage Canal – South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

5. Kleinfelder, Inc. "Geotechnical Basis of Design, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

6. Kleinfelder, Inc. "Draft Basis of Design Report, Sacramento River East Levee, SREL 3 (Reaches 10 through 15), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated September 23, 2009.

7. Kleinfelder, Inc. "Geotechnical Basis of Design Report, Sacramento River East Levee, Phase 1 (Reaches 1 through 4a), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

8. Northwest Hydraulics Consultants, Inc. "NLIP Vegetation Variance Request Tree Fall Levee Erosion Studies", March 30, 2010.

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File Name: SREL_320+00_200YR_AJ31_COW-73_2-17-10_VWR.gsz
Last Saved Date: 2/17/2010
Analysis Type: Steady-State
Analysis View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

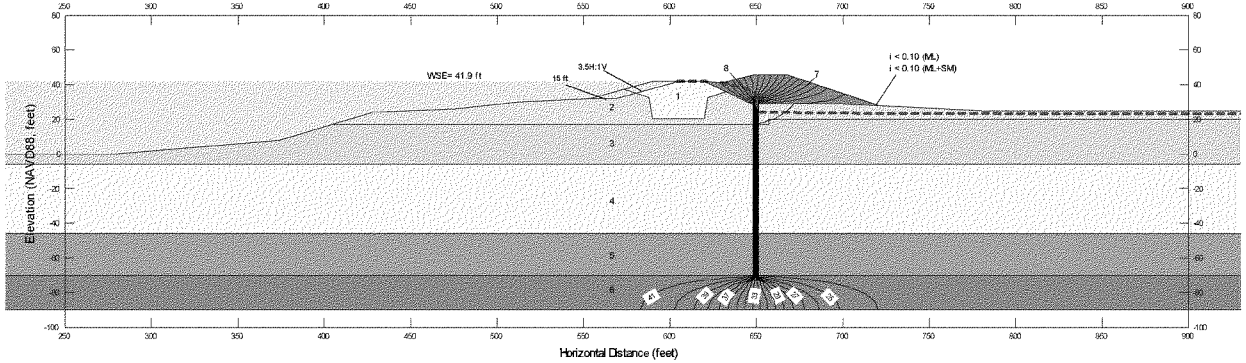
Material #1: Levee Fill - PG Sand; Sand with Silt 0-7% fines, Ks=14 ft/day (5.0x10E-3 cm/s); K-Ratio: 1
Material #2: Silt; Silt, Non-Plastic Fines PI<4 Ks=0.14 ft/day (5.0x10E-5 cm/s); K-Ratio: 0.25
Material #3: Interbedded Silty Sand, Silt, and Clay; Silty Sand 30-49% fines, Ks=0.28 ft/day (1.0x10E-4 cm/s); K-Ratio: 0.1
Material #4: PG Sand; Sand with Silt 0-7% fines, Ks=14 ft/day (5.0x10E-3 cm/s); K-Ratio: 1
Material #5: PG Gravel; Gravel with Silt 0-12% fines, Ks=28 ft/day (1.0x10E-2 cm/s); K-Ratio: 1
Material #6: Clay, Pleistocene Clay Ks=0.00028 ft/day (1.0x10E-7 cm/s); K-Ratio: 0.25
Material #7: Adjacent Levee; Clay - Levee Embankment Fill Ks=0.0028 ft/day (1.0x10E-6 cm/s); K-Ratio: 0.25
Material #8: Cutoff Wall; SB Cutoff Wall Ks=0.00028 ft/day (1.0x10E-7 cm/s); K-Ratio: 1

Top of Adjacent Levee Elevation: 45.5 ft
Adjacent Levee Toe Elevation: 28 ft
Cutoff Wall Tip Elevation: -73 ft

200-Year WSE: 41.9 ft

Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=WSE

Results
Average Gradient at Adjacent Levee Toe: < 0.10



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed followed a 3.5H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, soil stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 320+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 15, 2010.

INDEX CROSS SECTION #1 - SREL
ADJACENT LEVEE WIDTH: 20 FT
EXISTING LEVEE WIDTH: 15 FT
200-YEAR WSE
TOTAL HEAD CONTOURS
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VWR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

SREL STATION 320+00
SEEPAGE ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
1

File Name: SREL_Sta 320+00_SDD_AJ31_COW-75_R1.gsz
Last Saved Date: 1/9/2010
Analysis Type: Spencer
Analysis View: 2D

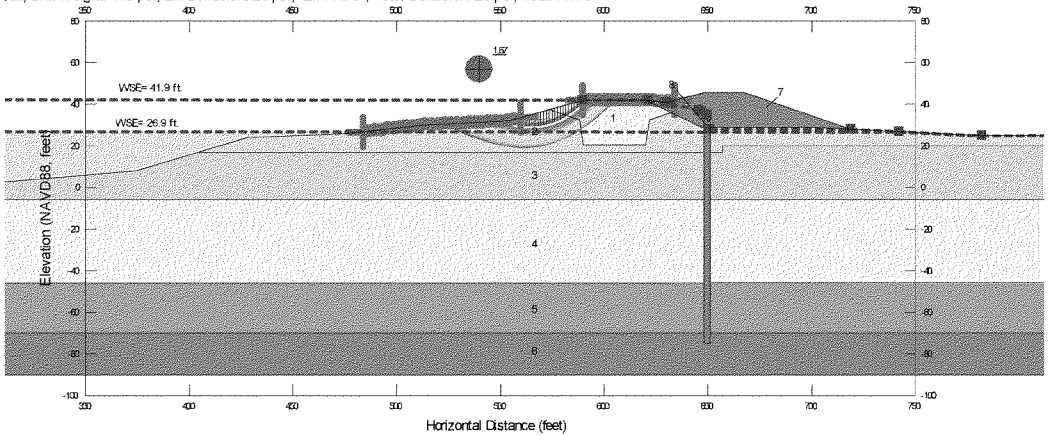
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Levee Fill - PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #2: Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #3: Interbedded Silty Sand, Silt, and Clay; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #5: PG Gravel; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #7: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Adjacent Levee Elevation: 45.5 ft
Adjacent Levee Toe Elevation: 28 ft
Cutoff Wall Tip Elevation: -75 ft

Sudden Drawdown: WSE from 41.9 ft to 26.9 ft

Results
Factor of Safety: 1.67



Notes:
1) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 320+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 15, 2010.

INDEX CROSS SECTION #1 - SREL
ADJACENT LEVEE WIDTH: 20 FT
EXISTING LEVEE WIDTH: 30 FT
WSE: 41.9 FT to 26.9 FT
SUDDEN DRAWDOWN
EXISTING LEVEE CONFIGURATION

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2.1 — 1.6
Factor of Safety Spectrum

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CHECKED BY:	R. Costa
FILE NAME:	

SREL STATION 320+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
2

File Name: SREL_Sta 320+00_SDD_AJ31_COW-75_R1_2-17-10_VVR.gsz
Last Saved Date: 2/15/2010
Analysis Type: Spencer
Analysis View: 2D

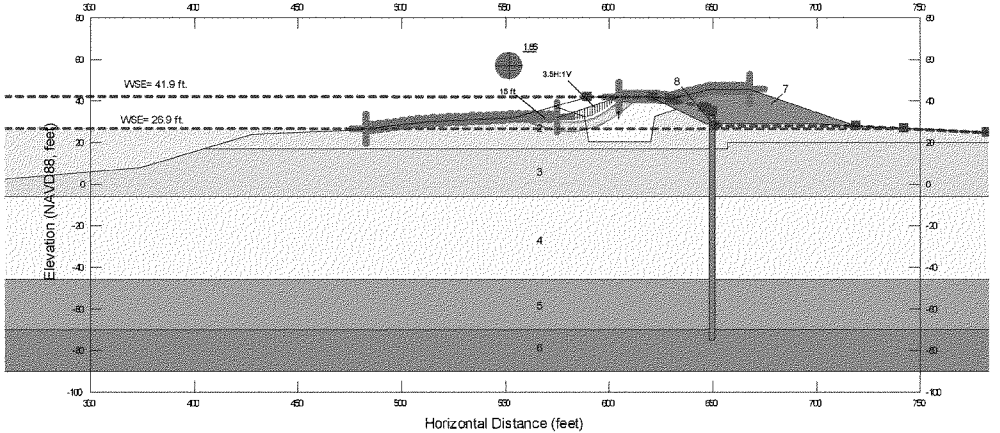
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

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Material #2: Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #3: Interbedded Silty Sand, Silt, and Clay; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #5: PG Gravel; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #7: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Adjacent Levee Elevation: 45.5 ft
Adjacent Levee Toe Elevation: 28 ft
Cutoff Wall Tip Elevation: -75 ft

Sudden Drawdown WSE from 41.9 ft to 26.9 ft

Results
Factor of Safety: 1.86



Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 3.5H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 320+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 15, 2010.

INDEX CROSS SECTION #1 - SREL
ADJACENT LEVEE WIDTH: 20 FT
EXISTING LEVEE WIDTH: 15 FT
WSE: 41.9 FT to 26.9 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION

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2.3 — 1.8
Factor of Safety Spectrum

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CHECKED BY:	R. Costa
FILE NAME:	

SREL STATION 320+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
3

File Name: SREL_838+00_200YR_31AJ15_2-17-10-VVR2.gsz
Last Saved Date: 4/2/2010
Analysis Type: SEEP/W
Analysis View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

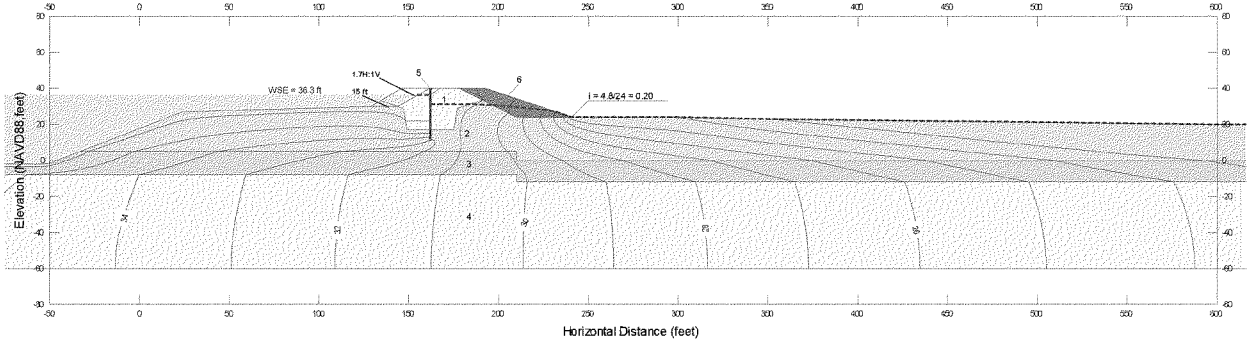
Material #1: PG Sand (Levee Fill); Sand w/ 3-7% ML or 0-2% CL, Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #2: Silt; Silt Ks=0.56 ft/day (2x10E-4 cm/s); K-Ratio: 0.25
Material #3: Silty Sand; Sand w/ 28-49% ML, Ks= 1.12 ft/day (4x10E-4 cm/s); K-Ratio: 0.25
Material #4: PG Sand; Sand w/ 3-7% ML or 0-2% CL, Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #5: Existing Cutoff Wall; Cutoff Wall Ks=0.0028 ft/day (1x10E-6 cm/s); K-Ratio: 1
Material #6: Adjacent Levee; Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25

Top of Levee Elevation: 40 ft
Widened Adjacent Levee: 15 ft
Landside Toe Elevation: 24 ft
Existing Cutoff Wall Tip Elevation: 11 ft

200-Year WSE: 36.3 ft

Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H = WSE

Results
Average Gradient at Landside Toe: 0.20



Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 1.7H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, soil stratigraphy, permeability and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 838+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 6, 2009.

INDEX CROSS SECTION #2 - SREL
ADJACENT LEVEE WIDTH: 15 FT
EXISTING LEVEE WIDTH: 17 FT
200-YEAR WSE
TOTAL HEAD CONTOURS
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

SREL STATION 838+00
SEEPAGE ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
4

File Name: SREL_838+00_200YR_31AJ15_RD_10-16-09.gsz
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Analysis Type: Spencer
Analysis View: 2D

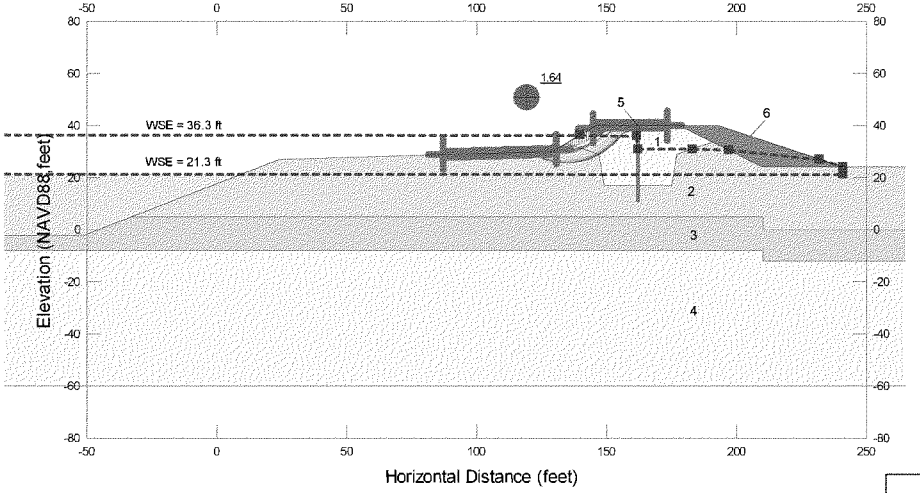
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

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Material #2: Silt; Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #5: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #6: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Levee Elevation: 40 ft
Widened Adjacent Levee: 15 ft
Landside Toe Elevation: 24 ft
Existing Cutoff Wall Tip Elevation: 11 ft

Sudden Drawdown WSE from 36.3 ft to 21.3 ft

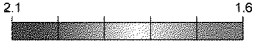
Results
Factor of Safety: 1.64



INDEX CROSS SECTION #2 - SREL
ADJACENT LEVEE WIDTH: 15 FT
EXISTING LEVEE WIDTH: 32 FT
WSE: 36.3 FT to 21.3 FT
SUDDEN DRAWDOWN
EXISTING LEVEE CONFIGURATION

Notes:
1) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 838+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 6, 2009.

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DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

SREL STATION 838+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
5

File Name: SREL_838+00_200YR_31AJ15_RD_2-17-10-VVR2.gsz
Last Saved Date: 2/24/2010
Analysis Type: Spencer
Analysis View: 2D

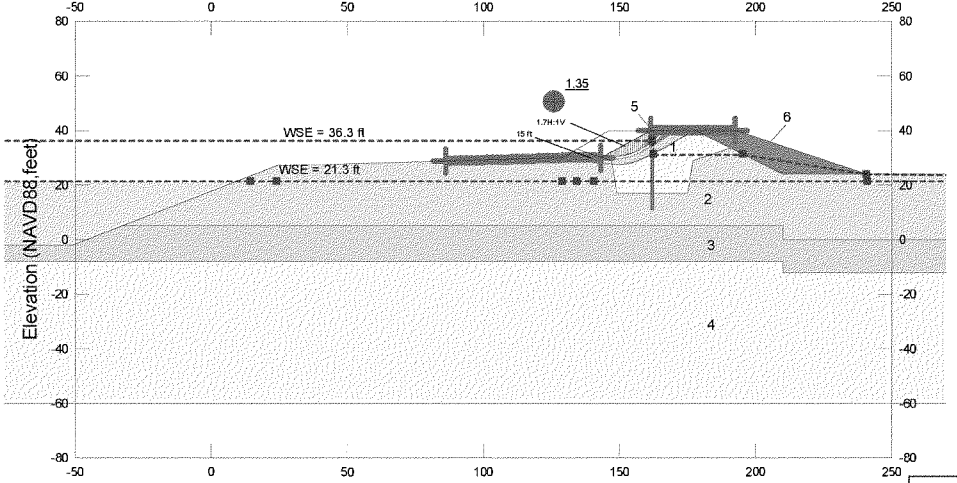
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Material #2: Silt; Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #5: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #6: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Levee Elevation: 40 ft
Widened Adjacent Levee: 15 ft
Landside Toe Elevation: 24 ft
Existing Cutoff Wall Tip Elevation: 11 ft

Sudden Drawdown WSE from 36.3 ft to 21.3 ft

Results
Factor of Safety: 1.35



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed followed a 1.7H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 838+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 6, 2009.

INDEX CROSS SECTION #2 - SREL
ADJACENT LEVEE WIDTH: 15 FT
EXISTING LEVEE WIDTH: 17 FT
WSE: 36.3 FT to 21.3 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION

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1.8 — 1.3
Factor of Safety Spectrum

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DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

SREL STATION 838+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
6

File Name: SREL_904+50_200YR_CW-37_2-17-10_VVR.gsz
Last Saved Date: 2/25/2010
Analysis Type: Steady-State
Analysis View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

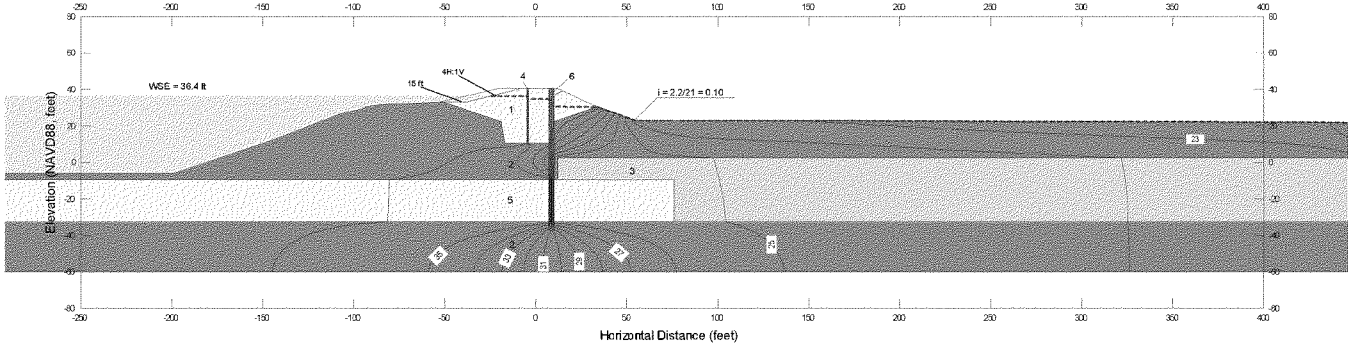
Material #1: PG Sand (Levee Fill); Sand w/ 0-2% CL or 3-7% ML, Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #2: Clay; Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #3: Silty Sand; Sand w/ 3-12% CL or 8-27% ML, Ks=2.8 ft/day (1x10E-3 cm/s); K-Ratio: 0.25
Material #4: Existing Cutoff Wall; Cutoff Wall Ks=0.0028 ft/day (1x10E-6 cm/s); K-Ratio: 1
Material #5: PG Sand; Sand w/ 0-2% CL or 3-7% ML, Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #6: Proposed Cutoff Wall; Cutoff Wall Ks=0.0028 ft/day (1x10E-6 cm/s); K-Ratio: 1

Top of Existing Levee Elevation: 40.5 ft
Landside Toe Elevation: 23 ft
Existing Cutoff Wall Tip Elevation: 11 ft
Proposed Cutoff Wall Tip Elevation: -37 ft

200-Year WSE: 36.4 ft

Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=WSE

Results
Average Gradient at Adjacent Levee Toe: 0.10



Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 4H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) A levee width of 20 feet was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevations are based off of the seepage model for the 200-year WSE, at Station 904+50 presented in Kleinfelder's "Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California." dated November 6, 2009.

INDEX CROSS SECTION #3 - SREL
EXISTING LEVEE WIDTH: 20 FT
200-YEAR WSE
TOTAL HEAD CONTOURS
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

SREL STATION 904+50
SEEPAGE ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
7

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File Name: SREL_904+50_200YR_RD_CW-37_2-16-10.gsz
Last Saved Date: 2/25/2010
Analysis Type: Spencer
Analysis View: 2D

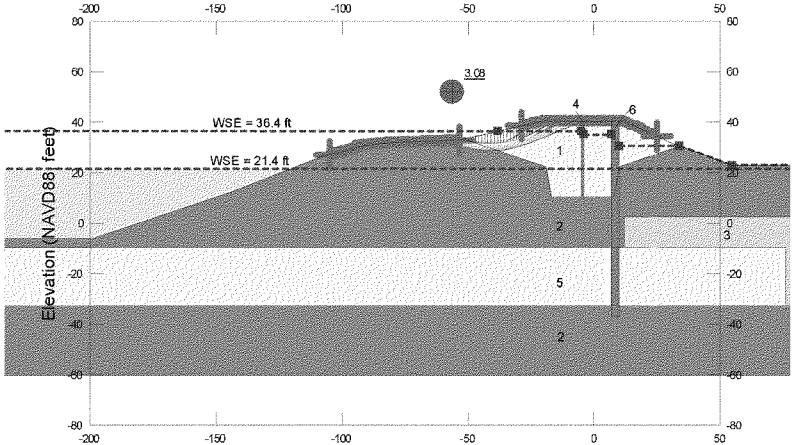
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Clay; Unit Weight: 112 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #5: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #6: Proposed Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Levee Elevation: 40.5 ft
Landside Toe Elevation: 23 ft
Existing Cutoff Wall Tip Elevation: 11 ft
Proposed Cutoff Wall Tip Elevation: -37 ft

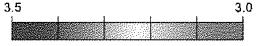
Sudden Drawdown WSE from 36.4 ft to 21.4 ft

Results
Factor of Safety: 3.06



INDEX CROSS SECTION #3 - SREL
EXISTING LEVEE WIDTH: 32 FT
WSE: 36.4 FT to 21.4 FT
SUDDEN DRAWDOWN
EXISTING LEVEE CONFIGURATION

Notes:
1) WSE, stratigraphy, strength parameters, and cutoff wall elevations are based off of the sudden drawdown model for the 200-year WSE, at Station 904+50 presented in Kleinfelder's "Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and SutterCounties, California," dated November 6, 2009.



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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

SREL STATION 904+50
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
8

File Name: SREL_904+50_200YR_RD_CW-37_2-16-10_VVR.gsz
Last Saved Date: 2/25/2010
Analysis Type: Spencer
Analysis View: 2D

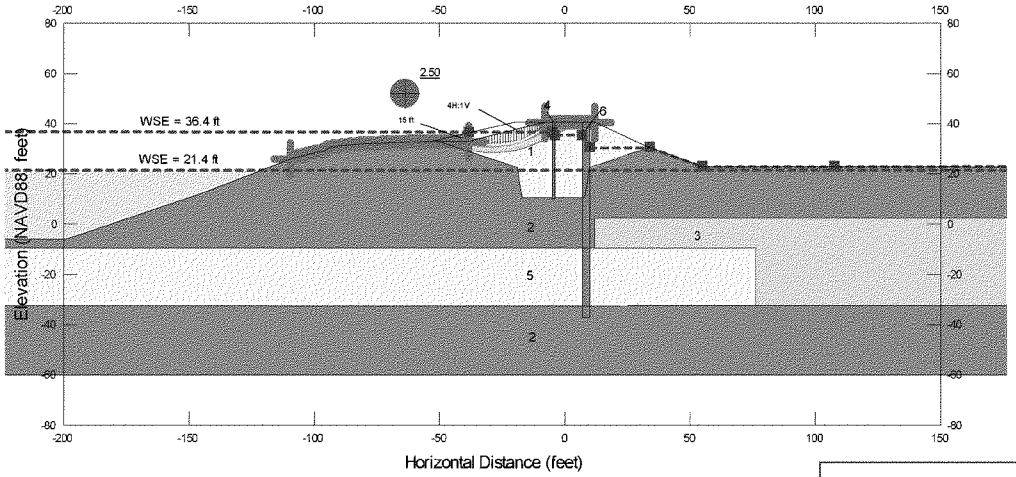
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Clay; Unit Weight: 112 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #5: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #6: Proposed Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Levee Elevation: 40.5 ft
Landside Toe Elevation: 23 ft
Existing Cutoff Wall Tip Elevation: 11 ft
Proposed Cutoff Wall Tip Elevation: -37 ft

Sudden Drawdown WSE from 36.4 ft to 21.4 ft

Results
Factor of Safety: 2.50



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed followed a 4H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) A levee width of 20 feet was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevations are based off of the sudden drawdown model for the 200-year WSE, at Station 904+50 presented in Kleinfelder's "Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 6, 2009.

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3.0 2.5
Factor of Safety Spectrum

INDEX CROSS SECTION #3 - SREL
EXISTING LEVEE WIDTH: 20 FT
WSE: 36.4 FT TO 21.4 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

SREL STATION 904+50
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
9

File Name: ARNL_47+98_200YR_SS&RDD_CW0_2-17-10_VVR.gsz
Last Saved Date: 2/24/2010
Analysis Type: Steady-State
Analysis View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

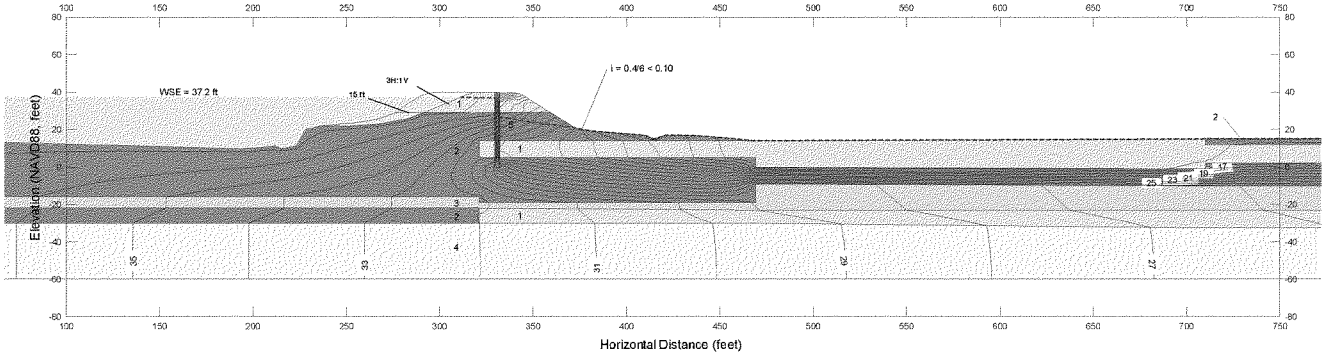
Material #1: Silt (ML); Silt Ks=0.56 ft/day (2x10E-4 cm/s); K-Ratio: 0.25
Material #2: Clay (CL); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #3: Silty Sand (SM); Sand w/ 13-27% ML, Ks=2.8 ft/day (1x10E-3 cm/s); K-Ratio: 0.25
Material #4: Poorly Graded Sand (SP); Sand w/ 0-2% CL, Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #5: Proposed Cutoff Wall; Cutoff Wall Ks=0.0014 ft/day (5x10E-7 cm/s); K-Ratio: 1

Top of Existing Levee Elevation: 40 ft
Landside Toe Elevation: 20 ft
Blanket Thickness at Landside Toe: 6 ft
Proposed Cutoff Wall Tip Elevation: 0 ft

200-Year WSE: 37.2 ft

Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=WSE

Results
Average Gradient at Landside Toe < 0.10



Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 3H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 47+98 presented in Kleinfelder's "Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

INDEX CROSS SECTION #4 - ARNL
EXISTING LEVEE WIDTH: 20 FT
200-YEAR WSE
TOTAL HEAD CONTOURS
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

ARNL STATION 47+98
SEEPAGE ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
10

File Name: ARNL_47+98_200YR_SS_CW0_2-16-10.gsz
Last Saved Date: 2/25/2010
Analysis Type: Spencer
Analysis View: 2D

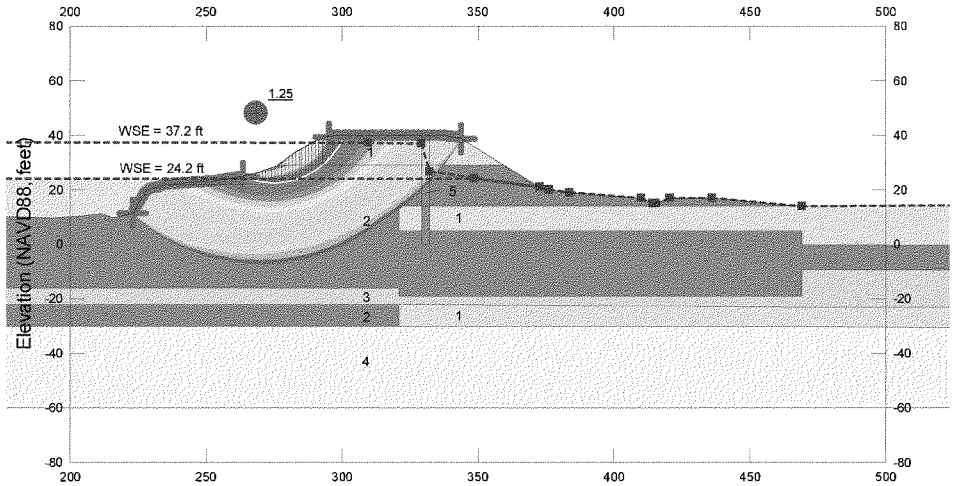
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Silt (ML); Unit Weight: 115 pcf; Eff Cohesion: 50 psf; Eff Phi: 30 degrees; Total Cohesion: 100 psf; Total Phi: 20 degrees
Material #2: Clay (CL); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28 degrees; Total Cohesion: 200 psf; Total Phi: 15 degrees
Material #3: Silty Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #4: Poorly Graded Sand (SP); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #5: Proposed Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0 degrees; Total Cohesion: 20 psf; Total Phi: 0 degrees

Top of Existing Levee Elevation: 40 ft
Landside Toe Elevation: 20 ft
Proposed Cutoff Wall Tip Elevation: 0 ft

Sudden Drawdown WSE from 37.2 ft to 24.2 ft

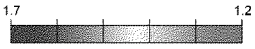
Results
Factor of Safety: 1.25



Notes:

1) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 47+98 presented in Kleinfelder's "Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

INDEX CROSS SECTION #4 - ARNL
EXISTING LEVEE WIDTH: 40 FT
WSE: 37.2 FT to 24.2 FT
SUDDEN DRAWDOWN
EXISTING LEVEE CONFIGURATION



Factor of Safety Spectrum

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

ARNL STATION 47+98
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
11

File Name: ARNL_47+98_200YR_SS&RDD_CW0_2-17-10_VVR.gsz
Last Saved Date: 2/24/2010
Analysis Type: Spencer
Analysis View: 2D

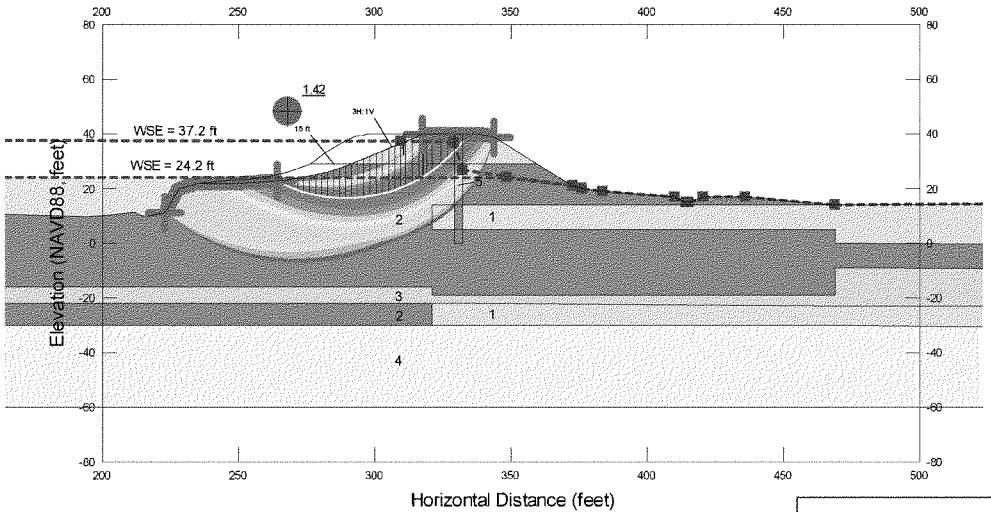
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Silt (ML); Unit Weight: 115 pcf; Eff Cohesion: 50 psf; Eff Phi: 30 degrees; Total Cohesion: 100 psf; Total Phi: 20 degrees
Material #2: Clay (CL); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28 degrees; Total Cohesion: 200 psf; Total Phi: 15 degrees
Material #3: Silty Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #4: Poorly Graded Sand (SP); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #5: Proposed Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0 degrees; Total Cohesion: 20 psf; Total Phi: 0 degrees

Top of Existing Levee Elevation: 40 ft
Landside Toe Elevation: 20 ft
Proposed Cutoff Wall Tip Elevation: 0 ft

Sudden Drawdown WSE from 37.2 ft to 24.2 ft

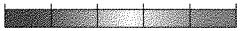
Results
Factor of Safety: 1.42



INDEX CROSS SECTION #4 - ARNL
EXISTING LEVEE WIDTH: 20 FT
WSE: 37.2 FT to 24.2 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 3H:1V slope starting 15 feet from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 47+98 presented in Kleinfelder's "Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California." dated November 2, 2009.

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

ARNL STATION 47+98
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
12

File Name: NEMDC_Sta 58+00_SP_CW-9_200YR_Rev3_2-17-10_VEG2.gsz
Last Saved Date: 2/22/2010
Analysis Type: Steady-State
Analysis View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

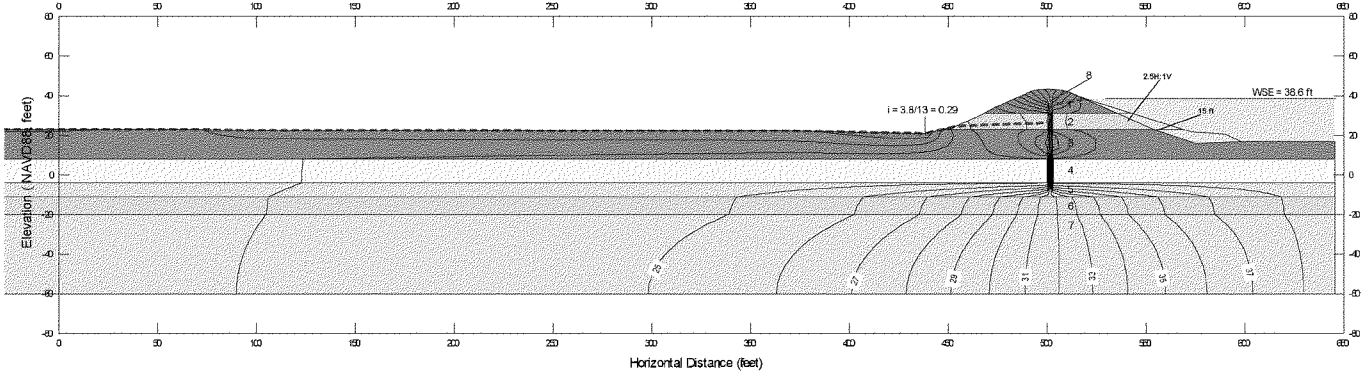
Material #1 Clay Kx=0.028 ft/day (1x10E-5 cm/s) K-Ratio: 0.25
Material #2 Sand w/ 13-27% CL or 28-49% ML, Kx=1.12 ft/day (4x10E-4 cm/s) K-Ratio: 0.25
Material #3 Clay Kx=0.028 ft/day (1x10E-5 cm/s) K-Ratio: 0.25
Material #4 Sand w/ 0-2% CL or 3-7% ML, Kx=14 ft/day (5x10E-3 cm/s) K-Ratio: 0.25
Material #5 Silt Kx=0.028 ft/day (1x10E-5 cm/s) K-Ratio: 0.25
Material #6 Sand Kx=0.28 ft/day (1x10E-4 cm/s) K-Ratio: 0.25
Material #7 Silt Kx=0.028 ft/day (1x10E-5 cm/s) K-Ratio: 0.25
Material #8 Slurry Wall Kx=0.0028 ft/day (1x10E-6 cm/s) K-Ratio: 1

Top of Levee Elevation: 43.4 ft
Landside Toe Elevation: 21 ft
Cutoff Wall Tip Elevation:-9 ft

200-Year WSE: 38.6 ft

Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=WSE

Results
Average Gradient at Landside Toe: 0.29



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed followed a 2.5H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) The entire levee width of 18 feet was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 58+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

INDEX CROSS SECTION #6 - NEMDC
EXISTING LEVEE WIDTH: 18 FT
200-YEAR WSE
TOTAL HEAD CONTOURS
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

NEMDC STATION 58+00
SEEPAGE ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
13

File Name: NEMDC_Sta 58+00_RD_CW-9_200YR_Rev3_3-31-10.gsz
Last Saved Date: 3/31/2010
Analysis Type: Spencer
Analysis View: 2D

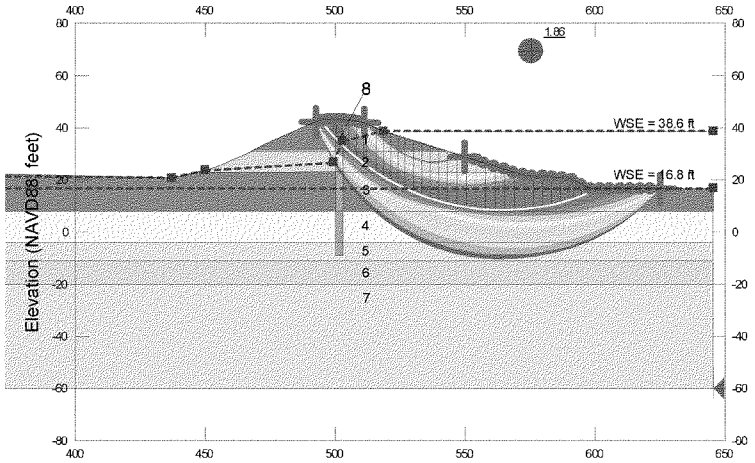
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (CL); Unit Weight: 120 pcf; Eff Cohesion: 150 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #2: Silty Clayey Sand (SC-SM); Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #3: Clay (CL) (2); Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 24°
Material #4: Sand (SP-SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #5: Sand (SP); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Silt (ML) (2) Unit Weight: 110 pcf, Eff Cohesion: 50 psf, Eff Phi: 32 °, Total Cohesion: 200 psf, Total Phi: 24 °
Material #8: Slurry Wall Unit Weight: 100 pcf, Eff Cohesion:50 psf, Eff Phi:0 °, Total Cohesion: 50 psf, Total Phi: 0 °

Top of Levee Elevation: 43.4 ft
Landside Toe Elevation: 21 ft
Cutoff Wall Tip Elevation: -9 ft

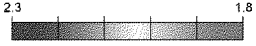
Sudden Drawdown WSE from 38.6 ft to 16.8 ft

Results
Factor of Safety = 1.86



Notes:
1) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

INDEX CROSS SECTION #6 - NEMDC
EXISTING LEVEE WIDTH: 18 FT
WSE: 38.6 FT to 16.8 FT
SUDDEN DRAWDOWN
EXISTING LEVEE CONFIGURATION



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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

NEMDC STATION 58+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
14

File Name: NEMDC_Sta 58+00_RD_CW-9_200YR_Rev3_3-31-10_VWR.gsz
Last Saved Date: 4/1/2010
Analysis Type: Spencer
Analysis View: 2D

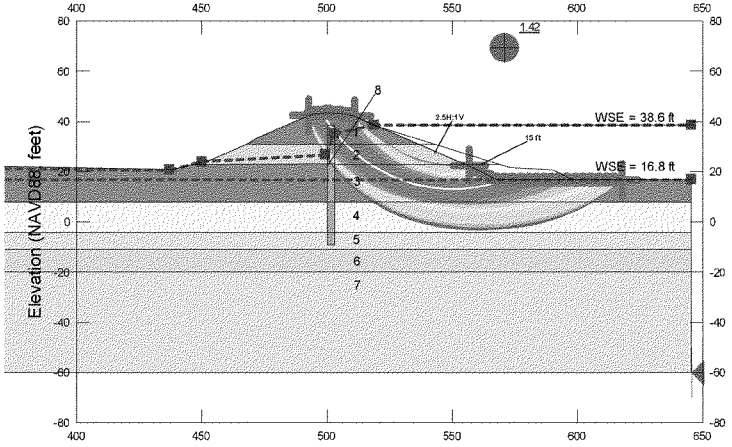
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (CL); Unit Weight: 120 pcf; Eff Cohesion: 150 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #2: Silty Clayey Sand (SC-SM); Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #3: Clay (CL) (2); Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 24°
Material #4: Sand (SP-SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #5: Sand (SP); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Silt (ML) (2) Unit Weight: 110 pcf, Eff Cohesion: 50 psf, Eff Phi: 32 °, Total Cohesion: 200 psf, Total Phi: 24 °
Material #8: Slurry Wall Unit Weight: 100 pcf, Eff Cohesion:50 psf, Eff Phi:0 °, Total Cohesion: 50 psf, Total Phi: 0 °

Top of Levee Elevation: 43.4 ft
Landside Toe Elevation: 21 ft
Cutoff Wall Tip Elevation: -9 ft

Sudden Drawdown WSE from 38.6 ft to 16.8 ft

Results
Factor of Safety : 1.42



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed followed a 2.5H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) The entire levee width of 18 feet was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

INDEX CROSS SECTION #6 - NEMDC
EXISTING LEVEE WIDTH: 18 FT
WSE: 38.6 FT to 16.8 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION

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1.9 — 1.4
Factor of Safety Spectrum

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PROJECT NO.	VWR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

NEMDC STATION 58+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
15

File Name: NCC_183+00_200YR_SP_COW75_3-31-10_VVR.gsz
Last Saved Date: 4/1/2010
Analysis Type: Steady-State
Analysis View:View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

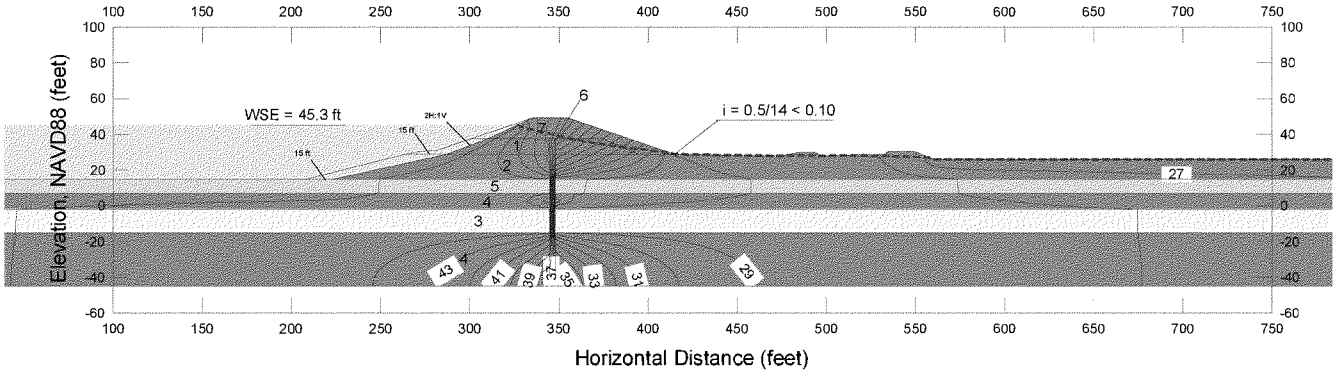
Material #1: Clay (Existing Levee); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #2: Clay (Blanket); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #3: Sand with Silt; Sand w/ 3-7% ML or 0-2% CL Ks=14 ft/day (5x10E-3 cm/s); K-Ratio: 0.25
Material #4: Clay; Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #5: Silty Sand; Sand w/ 8-27% ML or 3-12% CL Ks=2.8 ft/day (1x10E-3 cm/s); K-Ratio: 0.25
Material #6: Cutoff Wall; Slurry Wall Ks=0.0028 ft/day (1x10E-6 cm/s); K-Ratio: 1
Material #7: Clay (Levee Raise); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25

Top of Raised Levee Elevation: 49 ft
Landside Levee Toe Elevation: 29 ft
Cutoff Wall Bottom Elevation: -38 ft

200-Year WSE: 45.3 ft

Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=Flood Elevation

Results
Average Gradient at Landside Toe: <0.10



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed followed a 2H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) The entire levee width of 20 feet was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 183+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

INDEX CROSS SECTION #7 - NCC
EXISTING RAISED LEVEE WIDTH: 20 FT
200-YEAR WSE
TOTAL HEAD CONTOURS
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	4.1.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Shindler
FILE NAME:	

NCC STATION 183+-00
SEEPAGE ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
16

File Name: NCC_183+00_200YR_RD_COW75_3-8-10.gsz
Last Saved Date: 4/1/2010
Analysis Type: Spencer
Analysis View: 2D

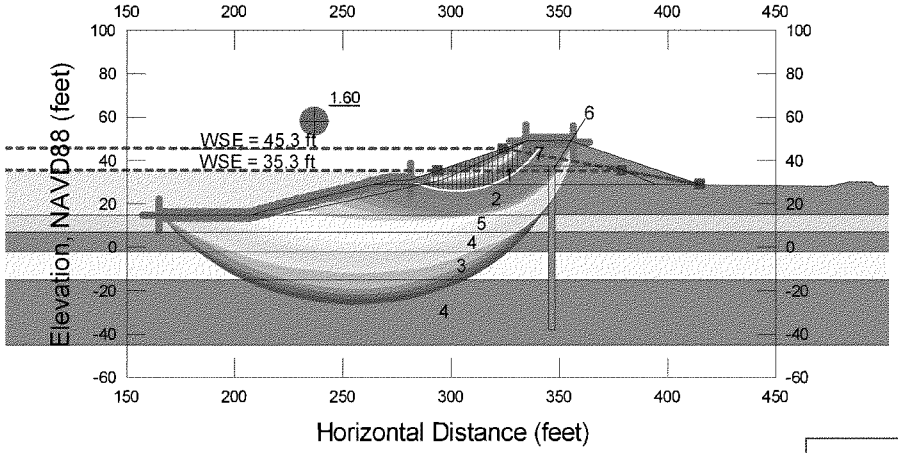
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Sand with Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 30°; Total Cohesion: 0 psf; Total Phi: 30°
Material #4: Clay; Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #5: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #6: Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Raised Levee Elevation: 49 ft
Landside Levee Toe Elevation: 29 ft
Cutoff Wall Tip Elevation: -38 ft

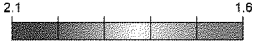
Sudden Drawdown WSE from 45.3 ft to 35.3 ft

Results
Factor of Safety: 1.60



Notes:
1) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 183+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter, California," dated January 30, 2009.

INDEX CROSS SECTION #7- NCC
EXISTING RAISED LEVEE WIDTH: 20 FT
WSE: 45.3 FT to 35.3 FT
SUDDEN DRAWDOWN
EXISTING LEVEE CONFIGURATION



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PROJECT NO.	VVR DSGN
DATE:	4.1.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Shindler
FILE NAME:	

NCC STATION 183+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
17

File Name: NCC_183+00_200YR_RD_COW75_3-8-10.gsz
Last Saved Date: 4/1/2010
Analysis Type: Spencer
Analysis View: 2D

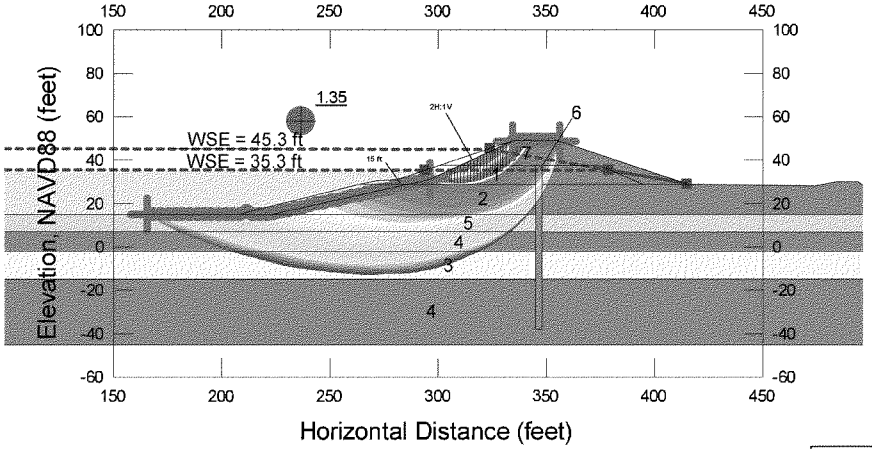
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Sand with Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 30°; Total Cohesion: 0 psf; Total Phi: 30°
Material #4: Clay; Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #5: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #6: Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Raised Levee Elevation: 49 ft
Landside Levee Toe Elevation: 29 ft
Cutoff Wall Tip Elevation: -38 ft

Sudden Drawdown WSE from 45.3 ft to 35.3 ft

Results
Factor of Safety: 1.35



Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 2H:1V slope starting 15 feet (horizontally) from the waterside toe projected to the crest of the levee.
2) The entire levee width of 20 feet was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 183+00 presented in Kleinfelder's "Draft Final Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

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1.8 — 1.3
Factor of Safety Spectrum

INDEX CROSS SECTION #7 - NCC
EXISTING RAISED LEVEE WIDTH: 20 FT
WSE: 45.3 FT to 35.3 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	4.1.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

NCC STATION 183+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
18

File Name: NCC_21+00_200YR_SP_CW_2-17-10.gsz
Last Saved Date: 2/25/2010
Analysis Type: Steady-State
Analysis View: View: 2D

Horizontal Hydraulic Conductivity (Ks) and Anisotropy Ratio (K-Ratio)

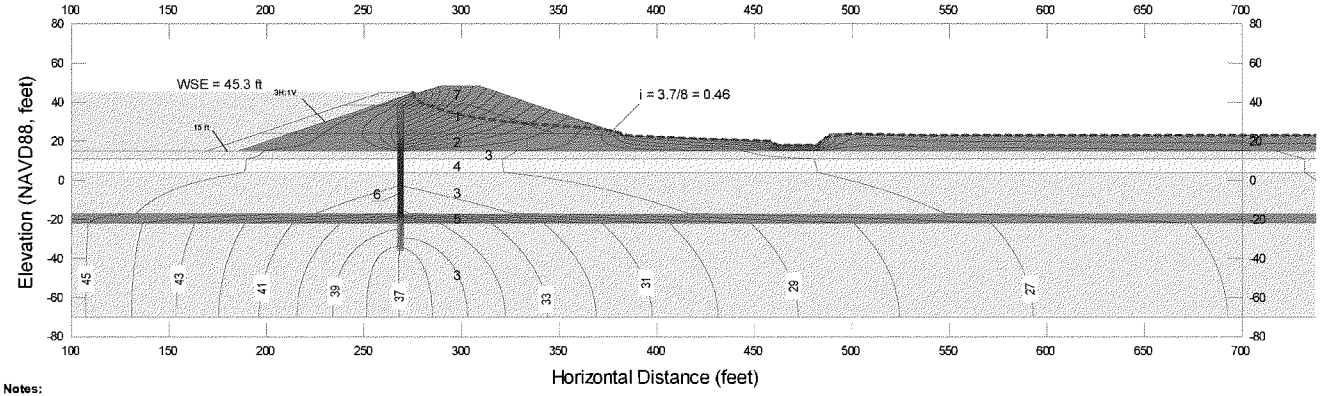
Material #1: Clay (Existing Levee); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #2: Clay (Blanket); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #3: Silt; Silt Ks=0.56 ft/day (2x10E-4 cm/s); K-Ratio: 0.25
Material #4: Sand; Sand Ks=28 ft/day (1x10E-2 cm/s); K-Ratio: 0.25
Material #5: Clay; Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25
Material #6: Cutoff Wall; Slurry Wall Ks=0.0028 ft/day (1x10E-6 cm/s); K-Ratio: 1
Material #7: Clay (Levee Raise); Clay Ks=0.028 ft/day (1x10E-5 cm/s); K-Ratio: 0.25

Top of Raised Levee Elevation: 48.3 ft
Landside Levee Toe Elevation: 23 ft
Cutoff Wall Tip Elevation: -36 ft

200-Year WSE: 45.3 ft

Landside Edge Boundary Condition: No Flow (Q=0)
Waterside Edge Boundary Condition: H=Flood Elevation

Results
Average Gradient at Landside Levee Toe: 0.46



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed followed a 3H:1V slope starting 15 feet (horizontally) from the waterside toe to the crest of the levee.
2) The entire levee width of 20 feet was retained.
3) WSE, stratigraphy, permeability, and cutoff wall elevation are based off of the seepage model for the 200-year WSE, at Station 21+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

INDEX CROSS SECTION #8 - NCC
EXISTING RAISED LEVEE WIDTH: 20 FT
200-YEAR WSE
TOTAL HEAD CONTOURS
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	4.1.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

NCC STATION 21+00
SEEPAGE ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
19

File Name: NCC_21+00_200YR_RD_CW_2-17-10.gsz
Last Saved Date: 2/25/2010
Analysis Type: Spencer
Analysis View: 2D

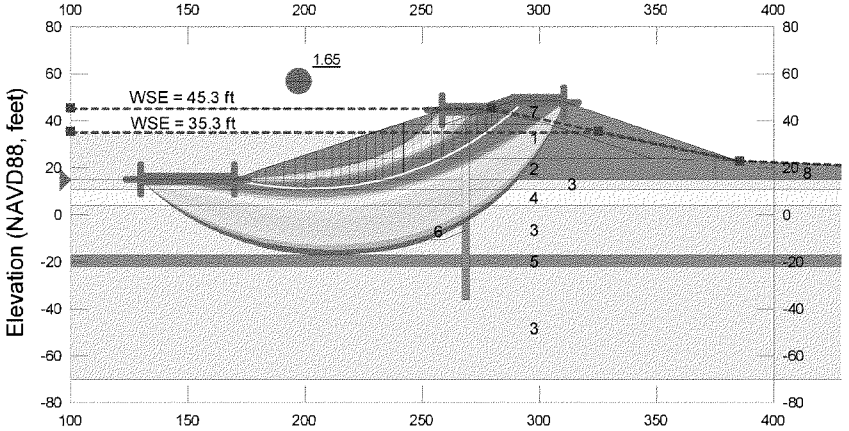
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 15°
Material #4: Sand; Unit Weight: 125 pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #5: Clay; Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #6: Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Clay (Field); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Raised Levee Elevation: 48.3 ft
Landside Levee Toe Elevation: 23 ft
Cutoff Wall Tip Elevation: -36 ft

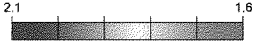
Sudden Drawdown WSE from 45.3 ft to 35.3 ft

Results
Factor of Safety: 1.56



Notes:
1) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 21+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

INDEX CROSS SECTION #8 - NCC
EXISTING RAISED LEVEE WIDTH: 20 FT
WSE: 45.3 FT to 35.3 FT
SUDDEN DRAWDOWN
EXISTING LEVEE CONFIGURATION



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PROJECT NO.	VVR DSGN
DATE:	4.1.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

NCC STATION 21+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
20

File Name: NCC_21+00_200YR_RD_CW_2-17-10_VVR.gsz
Last Saved Date: 4/1/2010
Analysis Type: Spencer
Analysis View: 2D

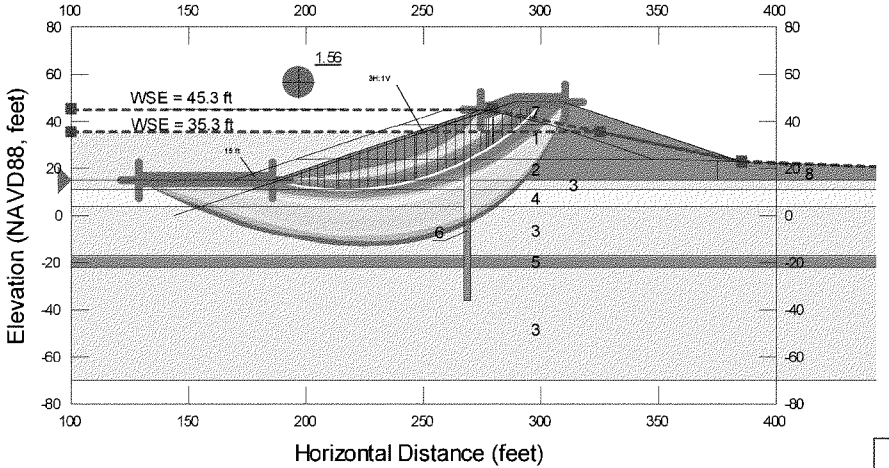
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 15°
Material #4: Sand; Unit Weight: 125 pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #5: Clay; Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #6: Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Clay (Field); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Raised Levee Elevation: 48.3 ft
Landside Levee Toe Elevation: 23 ft
Cutoff Wall Tip Elevation: -36 ft

Sudden Drawdown WSE from 45.3 ft to 35.3 ft

Results
Factor of Safety: 1.56



Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 3H:1V slope starting 15 feet (horizontally) from the waterside toe to the crest of the levee.
2) A levee width of 20 feet or more was retained.
3) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 21+00 presented in Kleinfelder's "Draft Final Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.



Factor of Safety Spectrum

INDEX CROSS SECTION #8 - NCC
EXISTING RAISED LEVEE WIDTH: 20 FT
WSE: 45.3 FT to 35.3 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	4.1.10
DRAWN BY:	L. Roesler
CHECKED BY:	R. Costa
FILE NAME:	

NCC STATION 21+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
21

File Name: SREL_Sta 27+00_SDD_AJ3to1_200yearCOW_VVR_NHC.gsz
Last Saved Date: 3/11/2010
Analysis Type: Spencer
Analysis View: 2D

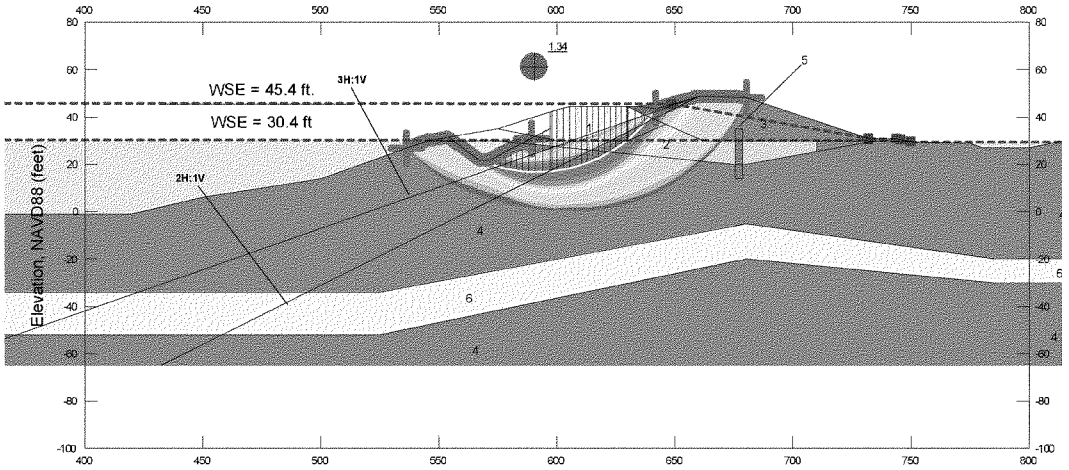
Material Number, Description, Unit Weight, Drained Cohesion, Drained Friction Angle, Undrained Cohesion, Undrained Friction Angle

Material # 1: Poorly Graded Sand - Unit Weight: 115 pcf, Drained C: 0 psf, Drained Phi: 28 °, Undrained C: 0 psf, Undrained Phi: 28 °
Material # 2: Silty Sand (2) - Unit Weight: 115 pcf, Drained C: 0 psf, Drained Phi: 31 °, Undrained C: 0 psf, Undrained Phi: 31 °
Material # 3: Adjacent Levee Clay (CL) - Unit Weight: 123 pcf, Drained C: 200 psf, Drained Phi: 24 °, Undrained C: 200 psf, Undrained Phi: 15 °
Material # 4: Clay - Unit Weight: 110 pcf, Drained C: 100 psf, Drained Phi: 25 °, Undrained C: 200 psf, Undrained Phi: 15 °
Material # 5: Cutoff Wall - Unit Weight: 120 pcf, Drained C: 20 psf, Drained Phi: 0 °, Undrained C: 20 psf, Undrained Phi: 0 °
Material # 6: Poorly Graded Sand (SP) - Unit Weight: 115 pcf, Drained C: 0 psf, Drained Phi: 31 °, Undrained C: 0 psf, Undrained Phi: 31 °

Top of Adjacent Levee Elevation: 48.4 ft
Landside Elevation at Adjacent Levee Toe: 29.5 ft.
Cutoff Wall Tip Elev. 14 ft

Sudden Drawdown WSE from 45.4 ft to 30.4 ft

Results
Factor of Safety: 1.34



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 3b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the stability model for the 200-year WSE, at Station 27+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 1 (Reaches 1 Through 4A), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

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1.8 1.3
Factor of Safety Spectrum

MAXIMUM SCOUR DEPTH: 11.8
WSE: 45.4 FT to 30.4 FT
SUDDEN DRAWDOWN
SCOUR REMENANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Schindler
FILE NAME:	

SREL STATION 27+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
22

File Name: SREL_Sta 287+00_SDD_AJ31_COW-68_R3-VVR_NHC.gsz
Last Saved Date: 3/11/2010
Analysis Type: Spencer
Analysis View: 2D

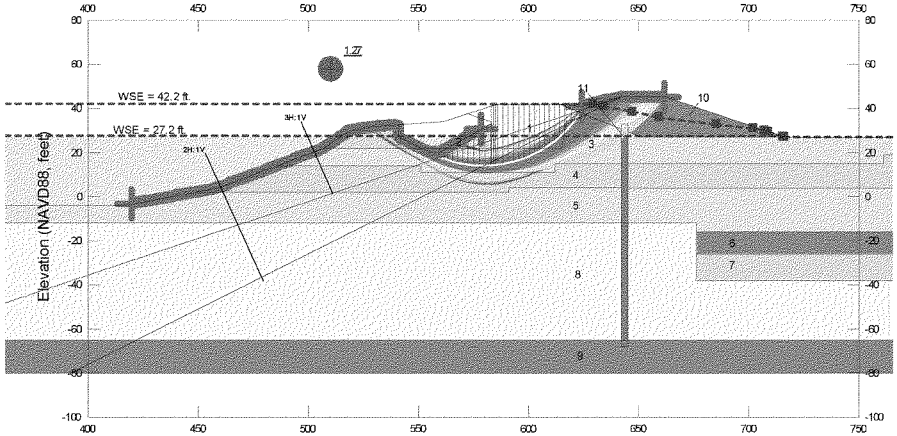
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Levee Fill - PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #2: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #3: Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #4: Interbedded Silty Sand, Silt and Clay; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #5: Deep Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #6: Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #7: Deep Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #8: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #9: Deep Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #10: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #11: Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Adjacent Levee Elevation: 45.7 ft.
Adjacent Levee Toe Elevation: 27 ft.
Cutoff Wall Tip Elevation: -68 ft.

Sudden Drawdown: WSE from 42.2 ft. to 27.2 ft.

Results
Factor of Safety: 1.27



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 4b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 287+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 15, 2010.

1.7 — 1.2
Factor of Safety Spectrum

MAXIMUM SCOUR DEPTH: 11.6
WSE: 42.2 FT to 27.2 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Schindler
FILE NAME:	

SREL STATION 287+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
23

File Name: SREL_640+00_SDD_AJ31_COW0_5SB100 rev sta f w tree.gsz
Last Saved Date: 3/12/2010
Analysis Type: Spencer
Analysis View: 2D

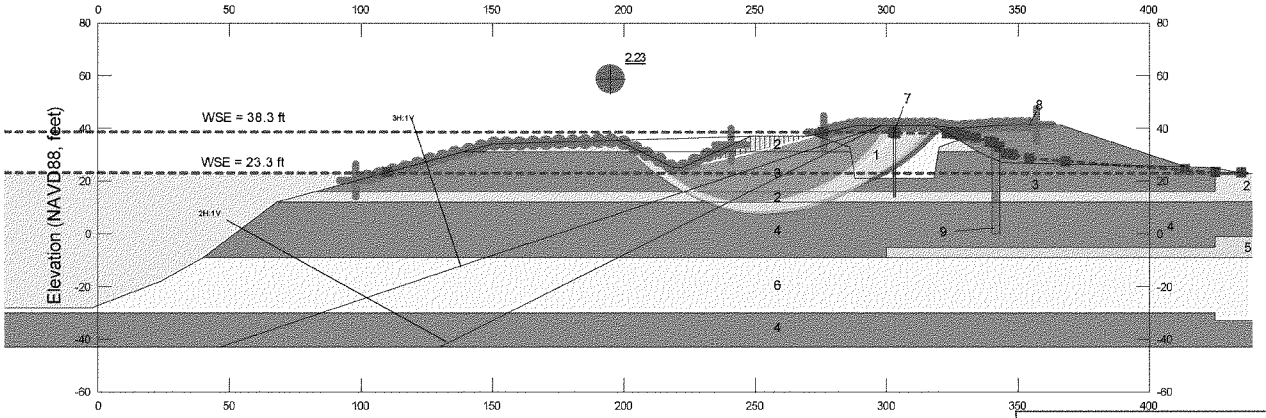
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Silt; Unit Weight: 110 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 100 psf; Total Phi: 20°
Material #3: Clay Blanket; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #4: Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #5: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #6: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #7: Existing Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #8: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #9: SB Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Adjacent Levee Elevation: 41.3 ft
Adjacent Levee Toe Elevation: 25.5 ft
Existing Cutoff Wall Tip Elevation: 14 ft
Cutoff Wall Tip Elevation: 0 ft.

Sudden Drawdown: WSE from 38.3 ft to 23.3 ft

Results
Factor of Safety: 2.23



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 5b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 12, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevations are based off of the sudden drawdown model for the 200-year WSE, at Station 640+00 presented in Kleinfelder's "Draft Basis of Design Report, Sacramento River East Levee, SREL 3 (Reaches 10 Through 15), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated September 23, 2009.

MAXIMUM SCOUR DEPTH: 11.7 FT
WSE: 38.3 FT to 23.3 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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2.7 — 2.2
Factor of Safety Spectrum

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Schindler
FILE NAME:	

SREL STATION 640+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
24

File Name: SREL_789+00_200YR_15AJ31_SDD- tree hole 3 12 10.gsz
Last Saved Date: 3/12/2010
Revision Number: 229
Analysis Type: Spencer
Analysis View: 2D

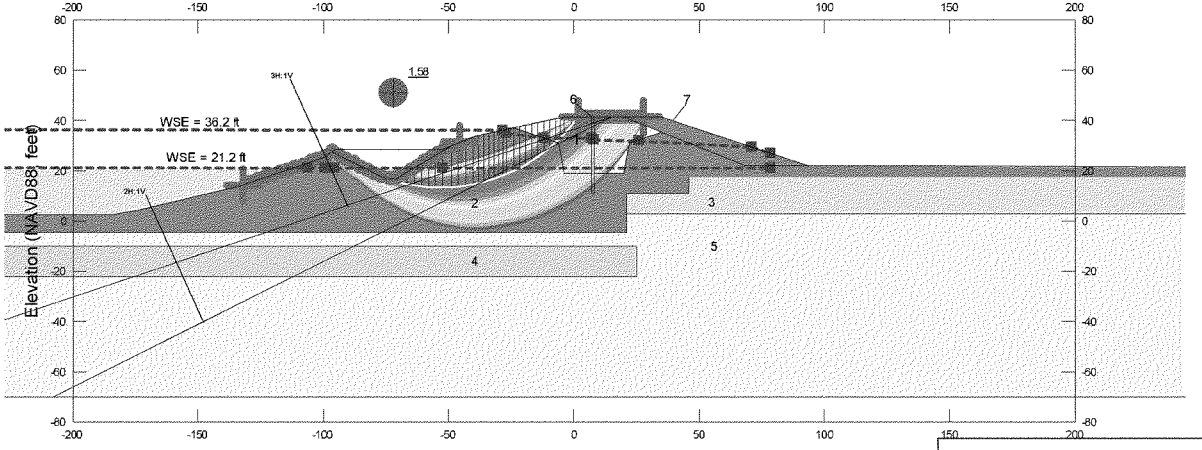
Top of Levee Elevation: 41.5 ft
Widened Adjacent Levee: 15 ft
Adjacent Levee Toe: 22 ft

Sudden Drawdown: WSE from 36.2 ft to 21.2 ft

Results
Factor of Safety: 1.58

Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Clay; Unit Weight: 112 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 110 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #4: Clayey Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #5: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #6: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #7: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°



Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 7b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 789+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 6, 2009.

MAXIMUM SCOUR DEPTH: 11.7 ft
WSE: 36.2 FT to 21.2 FT

SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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2.0 — 1.5
Factor of Safety Spectrum

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Schindler
FILE NAME:	

SREL STATION 789+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
25

File Name: ARNL_96+65_200YR_SB_CW-8_VVR_NHC.gsz
Last Saved Date: 4/1/2010
Analysis Type: Spencer
Analysis View: 2D

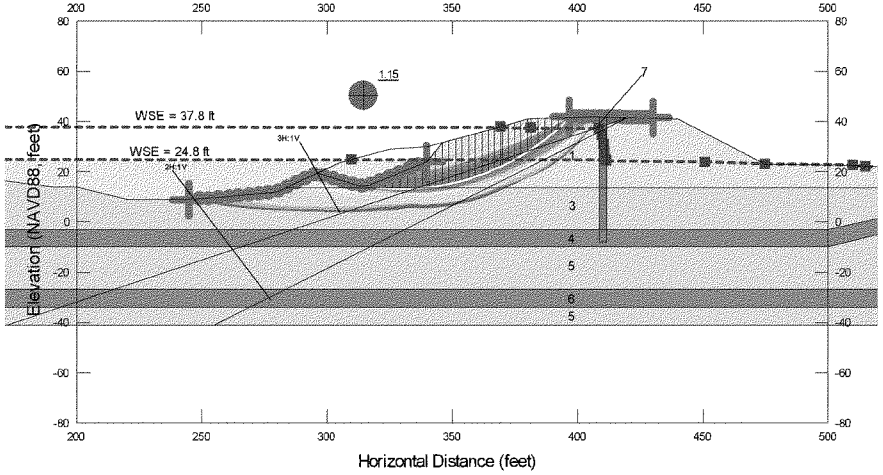
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Silt (Levee Fill, ML); Unit Weight: 115 pcf; Eff Cohesion: 50 psf; Eff Phi: 30°; Total Cohesion: 100 psf; Total Phi: 20°
Material #2: Clay (CL); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silty Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #4: Clay (CL) (2); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28°; Total Cohesion: 200 psf; Total Phi: 15°
Material #5: Silty Sand (SM) (2); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Clay (CL) (3); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28°; Total Cohesion: 200 psf; Total Phi: 15°
Material #7: Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Existing Levee Elevation: 42.0 ft
Landside Toe Elevation: 23 ft
Cutoff Wall Tip Elevation: -8 ft

Sudden Drawdown WSE from 37.8 ft to 24.8 ft

Results:
Factor of Safety: 1.15



MAXIMUM SCOUR DEPTH: 11.7 FT
WSE: 37.8 FT to 24.8 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 10b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 96+65 presented in Kleinfelder's "Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

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1.6 — 1.1
Factor of Safety Spectrum

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Schindler
FILE NAME:	

ARNL STATION 96+65
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
26

File Name: NEMDC_Sta 58+00_RD_CW-9_200YR_Rev3_3-31-10__VVR_NHC.gsz
Last Saved Date: 4/2/2010
Analysis Type: Spencer
Analysis View: 2D

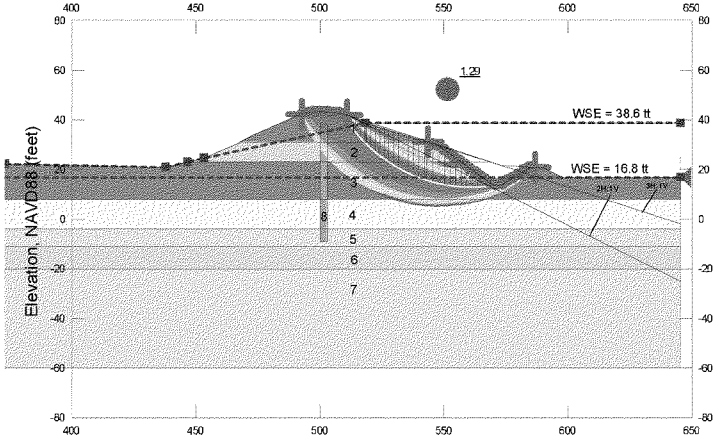
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (CL); Unit Weight: 120 pcf; Eff Cohesion: 150 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #2: Silty Clayey Sand (SC-SM); Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #3: Clay (CL) (2); Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 24°
Material #4: Sand (SP-SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #5: Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Silt (ML) (2) Unit Weight: 110 pcf, Eff Cohesion: 50 psf, Eff Phi: 32 °, Total Cohesion: 200 psf, Total Phi: 24 °
Material #8: Slurry Wall Unit Weight: 100 pcf, Eff Cohesion:50 psf, Eff Phi:0 °, Total Cohesion: 50 psf, Total Phi: 0 °

Top of Levee Elevation: 43.4 ft
Landside Toe Elevation: 21 ft
Cutoff Wall Tip Elevation: -9 ft

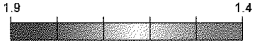
Sudden Drawdown WSE from 38.6 ft to 16.8 ft

Results
Factor of Safety: 1.29



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 11b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 12, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.



MAXIMUM SCOUR DEPTH: 8 FT
WSE: 38.6 to 26.8 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	4.1.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Schindler
FILE NAME:	

NEMDC STATION 58+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
27

File Name: NEMDC_Sta 58+00_RD_CW-9_200YR_Rev3_3-31-10__VVR_NHC2.gsz
Last Saved Date: 4/7/2010
Analysis Type: Spencer
Analysis View: 2D

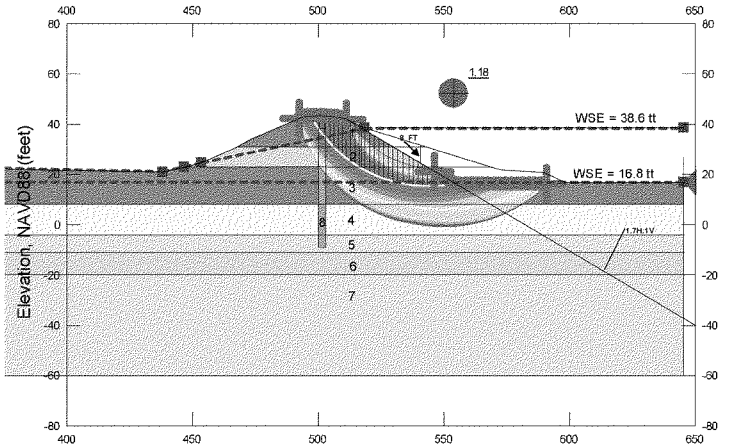
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (CL); Unit Weight: 120 pcf; Eff Cohesion: 150 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #2: Silty Clayey Sand (SC-SM); Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #3: Clay (CL) (2); Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 24°
Material #4: Sand (SP-SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #5: Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Silt (ML) (2) Unit Weight: 110 pcf, Eff Cohesion: 50 psf, Eff Phi: 32 °, Total Cohesion: 200 psf, Total Phi: 24 °
Material #8: Slurry Wall Unit Weight: 100 pcf, Eff Cohesion:50 psf, Eff Phi:0 °, Total Cohesion: 50 psf, Total Phi: 0 °

Top of Levee Elevation: 43.4 ft
Landside Toe Elevation: 21 ft
Cutoff Wall Tip Elevation: -9 ft

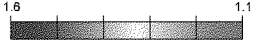
Sudden Drawdown WSE from 38.6 ft to 16.8 ft

Results
Factor of Safety: 1.18



Notes:

1) A section from the waterside slope was removed for this investigation. The based on scour data provided in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based oft of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.



MAXIMUM SCOUR DEPTH: 8 FT (IN LOWER 1/2 of LEVEE)
WSE: 38.6 to 26.8 FT
SUDDEN DRAWDOWN
SCOUR ENVELOPE-
REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	4.3.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Schindler
FILE NAME:	

NEMDC STATION 58+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
28

File Name: NCC_21+00_200YR_RD_CW_2-17-10_VVR_NHC.gsz
Last Saved Date: 3/12/2010
Analysis Type: Spencer
Analysis View: 2D

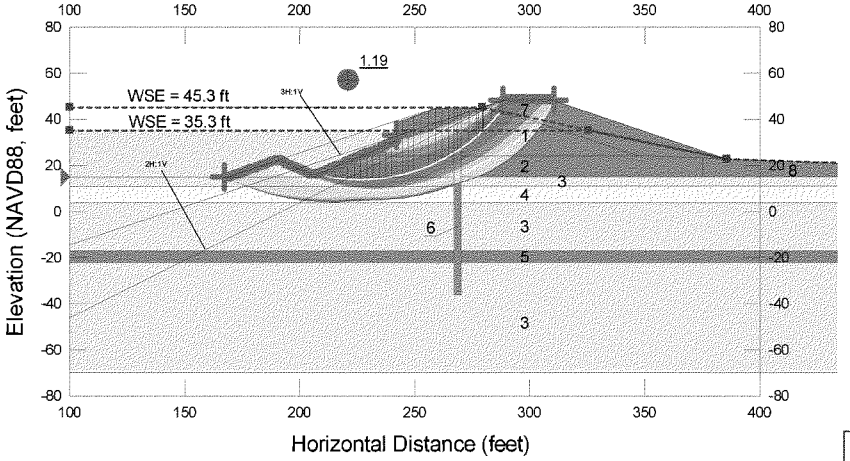
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 15°
Material #4: Sand; Unit Weight: 125 pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #5: Clay; Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #6: Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Clay (Field); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Raised Levee Elevation: 48.3 ft
Landside Levee Toe Elevation: 23 ft
Cutoff Wall Tip Elevation: -36 ft

Sudden Drawdown WSE from 45.3 ft to 35.3 ft

Results
Factor of Safety: 1.19



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 12b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated March 30, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 21+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

MAXIMUM SCOUR DEPTH: 12.2 FT
WSE: 45.3 FT to 35.3 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	3.12.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Schindler
FILE NAME:	

NCC STATION 21+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
29

File Name: SREL_838+00_200YR_31AJ15_RD_3-30-10_VVR3.gsz
Last Saved Date: 3/30/2010
Analysis Type: Spencer
Analysis View: 2D

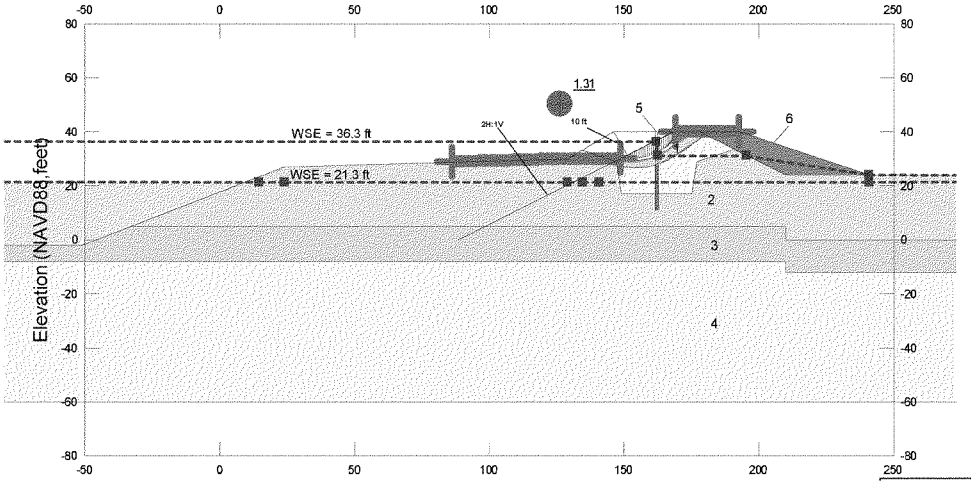
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Silt; Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #4: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #5: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #6: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Levee Elevation: 40 ft
Widened Adjacent Levee: 15 ft
Landside Toe Elevation: 24 ft
Existing Cutoff Wall Tip Elevation: 11 ft

Sudden Drawdown WSE from 36.3 ft to 21.3 ft

Results
Factor of Safety: 1.31



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed followed a 2H:1V slope 10 feet perpendicular to the slope of the levee.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 838+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 6, 2009

INDEX CROSS SECTION #2 - SREL
ADJACENT LEVEE WIDTH: 20 FT
EXISTING LEVEE WIDTH: 12 FT
WSE: 36.3 FT TO 21.3 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION
VEGETATION IN UPPER 1/3 of LEVEE

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1.7 — 1.3
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PROJECT NO.	VVR DSGN
DATE:	4.2.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Stanley
FILE NAME:	

SREL STATION 838+00
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
30

File Name: ARNL_47+98_200YR_SS&RDD_CW0_3-30-10_VVR3variance.gsz
Last Saved Date: 3/30/2010
Analysis Type: Spencer
Analysis View: 2D

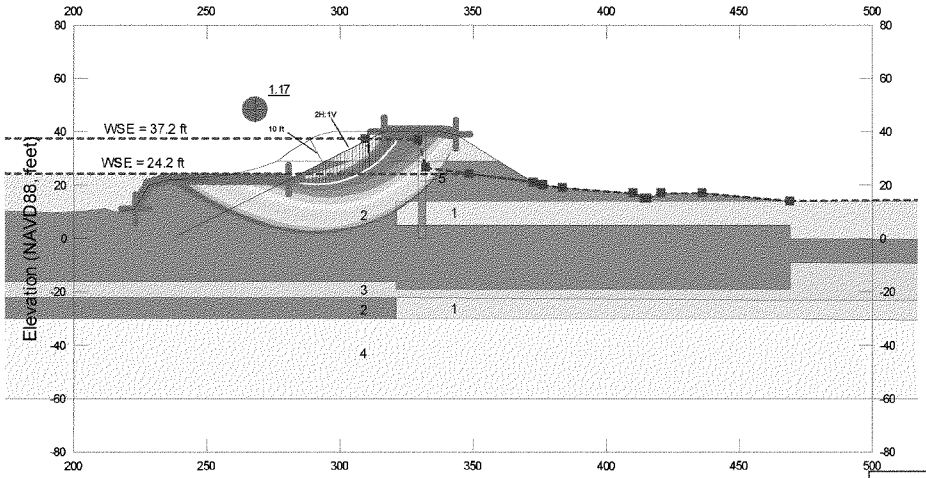
Material Number, Description, Unit Weight, Cohesion, Friction Angle

Material #1: Silt (ML); Unit Weight: 115 pcf; Eff Cohesion: 50 psf; Eff Phi: 30 degrees; Total Cohesion: 100 psf; Total Phi: 20 degrees
Material #2: Clay (CL); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28 degrees; Total Cohesion: 200 psf; Total Phi: 15 degrees
Material #3: Silty Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #4: Poorly Graded Sand (SP); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32 degrees; Total Cohesion: 0 psf; Total Phi: 32 degrees
Material #5: New Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0 degrees; Total Cohesion: 20 psf; Total Phi: 0 degrees

Top of Existing Levee Elevation: 40.0 ft
Landside Toe Elevation: 20.0 ft

Sudden Drawdown: WSE from 37.2 ft to 24.2 ft

Results
Factor of Safety: 1.17



INDEX CROSS SECTION #4 - ARNL
EXISTING LEVEE WIDTH: 27 FT
WSE: 37.2 FT to 24.2 FT
SUDDEN DRAWDOWN
REMNANT LEVEE CONFIGURATION
VEGETATION IN UPPER 1/3 of LEVEE

Notes:
1) A section from the waterside slope was removed for this investigation. The section removed followed a 2H:1V slope 10 feet perpendicular to the slope of the levee..
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 47+ 98 presented in Kleinfelder's "Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California." dated November 2, 2009.

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DATE:	4.2.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Stanley
FILE NAME:	

ARNL STATION 47+98
STABILITY ANALYSIS

VEGETATION VARIANCE GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
31

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April 23, 2010
File: 94582

Mr. Tim Washburn, Esq.
Sacramento Area Flood Control Agency
1007 7th Street, 7th Floor
Sacramento, California 95814

Subject: Vegetation Variance Supplemental Geotechnical Evaluation
Natomas Levee Improvement Program (NLIP)
Sacramento and Sutter Counties, California

Dear Mr. Washburn:

At the request of SAFCA, Kleinfelder performed supplemental analyses of potential waterside stability impacts based on the most recent analyses performed by Northwest Hydraulic Consultants (nhc). The information provided in this letter is intended to supplement the analyses in Kleinfelder's report "Vegetation Variance Geotechnical Evaluation," dated April 8, 2010.

BACKGROUND

In the scour analyses presented in nhc's "Report for: NLIP Vegetation Variance Request Tree Fall Levee Erosion Studies," dated March 30, 2010, a 15-foot by 3-foot root plate was used to model erosion/scour for tree falls at ten sites. The resulting scour holes were calculated by nhc and used to establish the geometry of the scour remnant levee configuration. SAFCA requested that nhc further its study to include analyses with a 20 foot by 4 foot root plate. Due to the increased size of the root plate, the scour analyses resulted in deeper and wider scour holes at the ten nhc study sites, changing the geometry of the scour remnant levee configuration at each location. The results of the nhc scour analyses are summarized in Table 1.

SAFCA requested that Kleinfelder perform supplemental sudden draw down analyses including the revised nhc scour remnant sections presented in nhc's "Report for: NLIP Vegetation Variance Request Tree Fall Levee Erosion Studies," dated April 22, 2010.

Please refer to the section titled "nhc Scour Remnants Sections" in Kleinfelder's aforementioned report for details regarding site selection, location, and results of the previous analyses.

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ANALYSES

Kleinfelder analyzed the potential effects of deeper scour holes on sudden draw down stability caused by tree falls with a 20-foot by 4-foot root plate on the waterside slope/toe. The geometry of the larger scour holes was submitted in the nhc drawings provided to Kleinfelder on April 16, 2010, and are included in the April 22, 2010, nhc report. All analyses were conducted using the 200-year water surface elevation (WSE). Based on the model results for the other sections, the small amount of scour in nhc locations Sac 4, Sac 6, and ARNL 1 is judged to have little impact on the global stability of the levee and was not modeled.

Table 1 – Summary of nhc Scour Analysis Results for 20-foot by 4-foot Root Plate

Site (LM)	200-year WSE (NAVD88 ft)	Elevation of Tree (NAVD88 ft)	Maximum Scour Depth for Scour Configuration (ft)
Sac 1 (0.3)	43.1	31	17.9
Sac 2 (5.3)	41.3	35	16.5
Sac 3 (12.0)	36.4	27	16.5
Sac 4 (13.3)	35.7	33.7	2.8
Sac 5 (14.9)	34.4	27	16.6
Sac 6 (17.4)	34.9	31	0.14
NEMDC (1.3)	36.1	30	9.8
NCC1 (3.7)	42.3	31	13.3
ARNL 1 (0.7)	35.4	34.4	6.7
ARNL 2 (1.7)	35.8	25	17.4

RESULTS

The results of our supplemental analyses are presented in Table 2 and are shown graphically on Plates 1 through 7. All scour remnant sections were found to have a sudden drawdown FOS greater that 1.1, the USACE minimum criteria.

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Table 2 –Scour Analysis Stability Results Summary for 20-foot by 4-foot Root Plate

nhc Cross Section ID	Analysis Type	Levee Section	Kleinfelder Representative Station (Model)	Sudden Drawdown FOS With Scour Configuration
Sac 1	Scour Hole	SREL 2	27+00	1.11
Sac 2	Scour Hole	SREL 2	287+00	1.11
Sac 3	Scour Hole	SREL 3	640+00	1.35
Sac 5	Scour Hole	SREL 4	789+00	1.33
ARNL 2	Scour Hole	ARNL	96+65	1.50
NEMDC	Scour Hole	NEMDC	58+00	1.17
NCC1	Scour Hole	NCC	21+00	1.11

We appreciate the opportunity to provide our services for this project. If you have questions regarding this report or if we may be of further assistance, please contact the undersigned.

Respectfully,

KLEINFELDER WEST, INC.

Elizabeth Roesler, EIT
Geotechnical Professional

Lynn M. O'Leary, PE, PMP
Project Manager

Attachments:

Plates 1-7

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File Name: SREL_Sta 27+00_SDD_AJ3to1_200yearCOW_VVR_NHC3.gsz
Last Saved Date: 4/21/2010
Analysis Type: Spencer
Analysis View: 2D

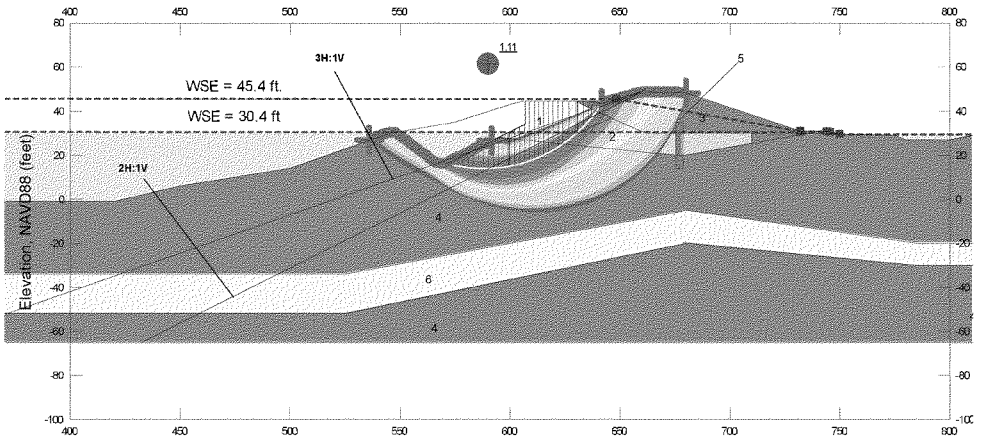
Material Number, Description, Unit Weight, Drained Cohesion, Drained Friction Angle, Undrained Cohesion, Undrained Friction Angle

Material # 1: Poorly Graded Sand - Unit Weight: 115 pcf, Drained C: 0 psf, Drained Phi: 28 °, Undrained C: 0 psf, Undrained Phi: 28 °
Material # 2: Silty Sand (2) - Unit Weight: 115 pcf, Drained C: 0 psf, Drained Phi: 31 °, Undrained C: 0 psf, Undrained Phi: 31 °
Material # 3: Adjacent Levee Clay (CL) - Unit Weight: 123 pcf, Drained C: 200 psf, Drained Phi: 24 °, Undrained C: 200 psf, Undrained Phi: 15 °
Material # 4: Clay - Unit Weight: 110 pcf, Drained C: 100 psf, Drained Phi: 25 °, Undrained C: 200 psf, Undrained Phi: 15 °
Material # 5: Cutoff Wall - Unit Weight: 120 pcf, Drained C: 20 psf, Drained Phi: 0 °, Undrained C: 20 psf, Undrained Phi: 0 °
Material # 6: Poorly Graded Sand (SP) - Unit Weight: 115 pcf, Drained C: 0 psf, Drained Phi: 31 °, Undrained C: 0 psf, Undrained Phi: 31 °

Top of Adjacent Levee Elevation: 48.4 ft
Landside Elevation at Adjacent Levee Toe: 29.5 ft.
Cutoff Wall Tip Elev. 14 ft

Sudden Drawdown WSE from 45.4 ft to 30.4 ft

Results
Factor of Safety: 1.11



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 3b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the stability model for the 200-year WSE, at Station 27+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 1 (Reaches 1 Through 4A), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

MAXIMUM SCOUR DEPTH: 17.9 FT
WSE: 45.4 FT to 30.4 FT
SUDDEN DRAWDOWN
SCOUR REMENANT LEVEE CONFIGURATION

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PROJECT NO.	VVR DSGN
DATE:	4.22.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Stanley
FILE NAME:	

SREL STATION 27+00
STABILITY ANALYSIS

VEGETATION VARIANCE SUPPLEMENTAL GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
1

File Name: SREL_Sta 287+00_SDD_AJ31_COW-68_R3-VVR_NHC3.gsz
Last Saved Date: 4/21/2010
Analysis Type: Spencer
Analysis View: 2D

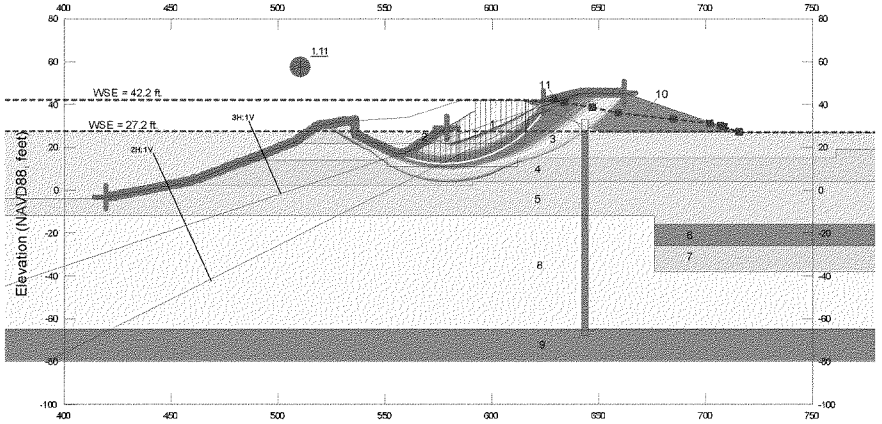
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Levee Fill - PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #2: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #3: Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #4: Interbedded Silty Sand, Silt and Clay; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #5: Deep Silt; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #6: Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #7: Deep Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #8: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 33°; Total Cohesion: 0 psf; Total Phi: 33°
Material #9: Deep Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #10: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #11: Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Adjacent Levee Elevation: 45.7 ft.
Adjacent Levee Toe Elevation: 27 ft.
Cutoff Wall Tip Elevation: -68 ft.

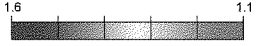
Sudden Drawdown: WSE from 42.2 ft. to 27.2 ft.

Results
Factor of Safety: 1.11



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 4b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 287+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Sacramento River East Levee, SREL 2 (Reaches 5 Through 9), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 15, 2010.



MAXIMUM SCOUR DEPTH: 16.5 FT
WSE: 42.2 FT to 27.2 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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PROJECT NO.	VVR.DSGN
DATE:	4.22.10
DRAWN BY:	L. Roesler
CHECKED BY:	M. Stanley
FILE NAME:	

SREL STATION 287+00
STABILITY ANALYSIS

VEGETATION VARIANCE SUPPLEMENTAL GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
2

File Name: SREL_640+00_SDD_AJ31_COW0_5SB100 rev_NHC3.gsz
Last Saved Date: 4/21/2010
Analysis Type: Spencer
Analysis View: 2D

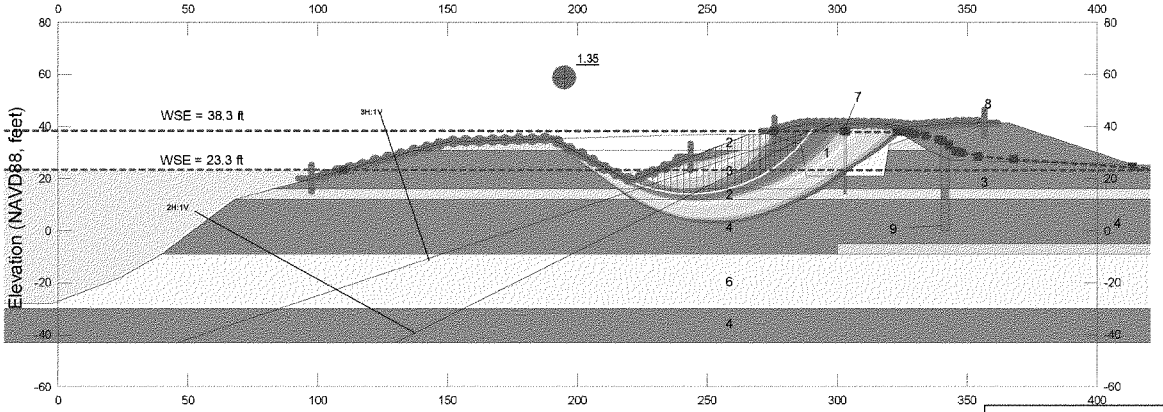
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Waight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Silt; Unit Weight: 110 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 100 psf; Total Phi: 20°
Material #3: Clay Blanket; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #4: Clay; Unit Weight: 112 pcf; Eff Cohesion: 50 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #5: Silty Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #6: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #7: Existing Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #8: Adjacent Levee; Unit Waight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #9: SB Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Adjacent Levee Elevation: 41.3 ft
Adjacent Levee Toe Elevation: 25.5 ft
Existing Cutoff Wall Tip Elevation: 14 ft
Cutoff Wall Tip Elevation: 0 ft.

Sudden Drawdown: WSE from 38.3 ft to 23.3 ft

Results
Factor of Safety: 1.35



Notes:
1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 5b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevations are based off of the sudden drawdown model for the 200-year WSE, at Station 640+00 presented in Kleinfelder's "Draft Basis of Design Report, Sacramento River East Levee, SREL 3 (Reaches 10 Through 15), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated September 23, 2009.

MAXIMUM SCOUR DEPTH: 16.5 FT
WSE: 38.3 FT to 23.3 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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SREL STATION 640+00
STABILITY ANALYSIS

VEGETATION VARIANCE SUPPLEMENTAL GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
3

File Name: SREL_789+00_200YR_15AJ31_SDD_NHC3.gsz
Last Saved Date: 4/21/2010
Revision Number: 245
Analysis Type: Spencer
Analysis View: 2D

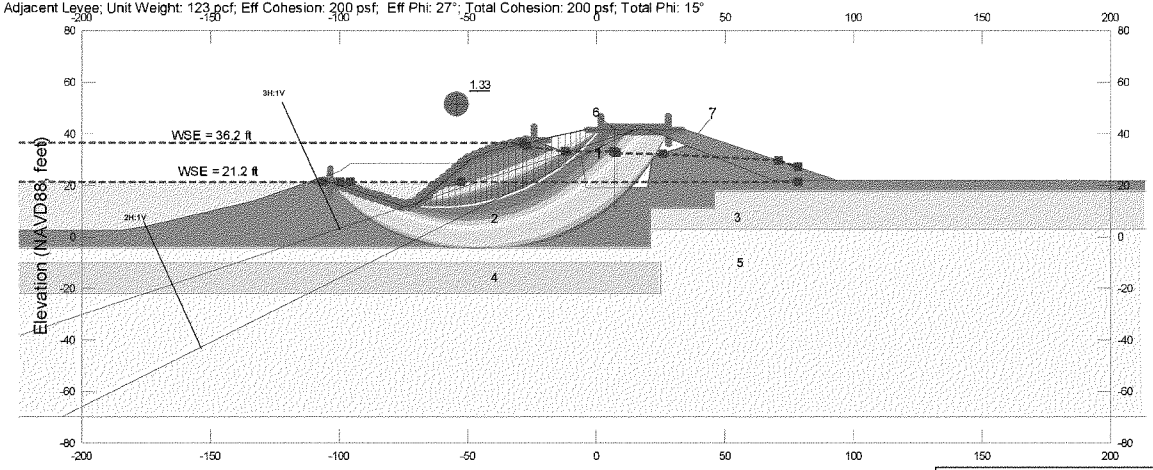
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: PG Sand (Levee Fill); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 28°; Total Cohesion: 0 psf; Total Phi: 28°
Material #2: Clay; Unit Weight: 112 pcf; Eff Cohesion: 150 psf; Eff Phi: 25°; Total Cohesion: 400 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 110 pcf; Eff Cohesion: 0 psf; Eff Phi: 26°; Total Cohesion: 100 psf; Total Phi: 20°
Material #4: Clayey Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 27°; Total Cohesion: 0 psf; Total Phi: 27°
Material #5: PG Sand; Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 29°; Total Cohesion: 0 psf; Total Phi: 29°
Material #6: Existing Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°
Material #7: Adjacent Levee; Unit Weight: 123 pcf; Eff Cohesion: 200 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Levee Elevation: 41.5 ft
Widened Adjacent Levee: 15 ft
Adjacent Levee Toe: 22 ft

Sudden Drawdown: WSE from 36.2 ft to 21.2 ft

Results
Factor of Safety: 1.33



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 7b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, soil stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 789+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Sacramento River East Levee, SREL 4 (Reaches 16 Through 20), Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 6, 2009.

MAXIMUM SCOUR DEPTH: 16.6 FT
WSE: 36.2 FT to 21.2 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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SREL STATION 789+00
STABILITY ANALYSIS

VEGETATION VARIANCE SUPPLEMENTAL GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
4

File Name: ARNL_96+65_200YR_SB_CW-8_VVR_NHC3.gsz
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Analysis Type: Spencer
Analysis View: 2D

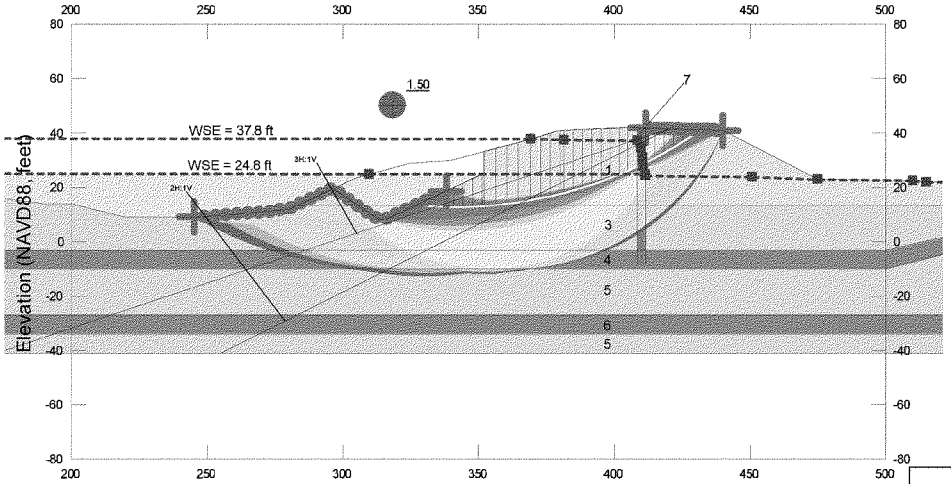
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Silt (Levee Fill, ML); Unit Weight: 115 pcf; Eff Cohesion: 50 psf; Eff Phi: 30°; Total Cohesion: 100 psf; Total Phi: 20°
Material #2: Clay (CL); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silty Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #4: Clay (CL) (2); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28°; Total Cohesion: 200 psf; Total Phi: 15°
Material #5: Silty Sand (SM) (2); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Clay (CL) (3); Unit Weight: 115 pcf; Eff Cohesion: 100 psf; Eff Phi: 28°; Total Cohesion: 200 psf; Total Phi: 15°
Material #7: Cutoff Wall; Unit Weight: 110 pcf; Eff Cohesion: 20 psf; Eff Phi: 0°; Total Cohesion: 20 psf; Total Phi: 0°

Top of Existing Levee Elevation: 42.0 ft
Landside Toe Elevation: 23 ft
Cutoff Wall Tip Elevation: -8 ft

Sudden Drawdown WSE from 37.8 ft to 24.8 ft

Results:
Factor of Safety: 1.50



MAXIMUM SCOUR DEPTH: 17.4 FT
WSE: 37.8 FT to 24.8 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 10b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 96+65 presented in Kleinfelder's "Draft Alternatives Analysis Report, American River North Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California." dated November 2, 2009.

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ARNL STATION 96+65
STABILITY ANALYSIS

VEGETATION VARIANCE SUPPLEMENTAL GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
5

File Name: NEMDC_Sta 58+00_RD_CW-9_200YR_Rev3_4-20-10__VVR_NHC4.gsz
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Analysis View: 2D

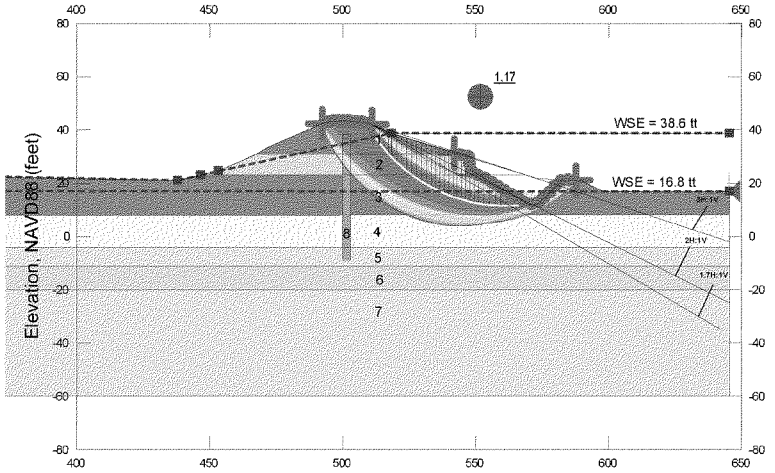
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (CL); Unit Weight: 120 pcf; Eff Cohesion: 150 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #2: Silty Clayey Sand (SC-SM); Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 32°; Total Cohesion: 200 psf; Total Phi: 24°
Material #3: Clay (CL) (2); Unit Weight: 110 pcf; Eff Cohesion: 150 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 24°
Material #4: Sand (SP-SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #5: Sand (SM); Unit Weight: 115 pcf; Eff Cohesion: 0 psf; Eff Phi: 32°; Total Cohesion: 0 psf; Total Phi: 32°
Material #6: Slurry Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Silt (ML) (2) Unit Weight: 110 pcf, Eff Cohesion: 50 psf, Eff Phi: 32 °, Total Cohesion: 200 psf, Total Phi: 24 °
Material #8: Slurry Wall Unit Weight: 100 pcf, Eff Cohesion:50 psf, Eff Phi:0 °, Total Cohesion: 50 psf, Total Phi: 0 °

Top of Levee Elevation: 43.4 ft
Landside Toe Elevation: 21 ft
Cutoff Wall Tip Elevation: -9 ft

Sudden Drawdown WSE from 38.6 ft to 16.8 ft

Results
Factor of Safety: 1.17



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 11b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 58+00 presented in Kleinfelder's "Draft Alternatives Analysis Report, Natomas East Main Drainage Canal—South, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated November 2, 2009.

1.6 — 1.1
Factor of Safety Spectrum

MAXIMUM SCOUR DEPTH: 9.8 FT
WSE: 38.6 to 26.8 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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NEMDC STATION 58+00
STABILITY ANALYSIS

VEGETATION VARIANCE SUPPLEMENTAL GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
6

File Name: NCC_21+00_200YR_RD_CW_4-22-10_VVR_NHC3.gsz
Last Saved Date: 4/22/2010
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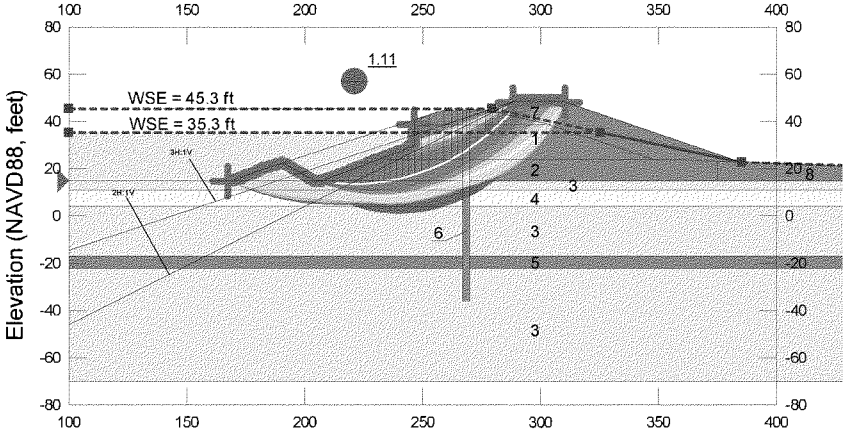
Material Number, Description, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material #1: Clay (Existing Levee); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #2: Clay (Blanket); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #3: Silt; Unit Weight: 120 pcf; Eff Cohesion: 50 psf; Eff Phi: 29°; Total Cohesion: 200 psf; Total Phi: 15°
Material #4: Sand; Unit Weight: 125 pcf; Eff Cohesion: 0 psf; Eff Phi: 31°; Total Cohesion: 0 psf; Total Phi: 31°
Material #5: Clay; Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°
Material #6: Cutoff Wall; Unit Weight: 100 pcf; Eff Cohesion: 50 psf; Eff Phi: 0°; Total Cohesion: 50 psf; Total Phi: 0°
Material #7: Clay (Levee Raise); Unit Weight: 125 pcf; Eff Cohesion: 150 psf; Eff Phi: 24°; Total Cohesion: 200 psf; Total Phi: 15°
Material #8: Clay (Field); Unit Weight: 115 pcf; Eff Cohesion: 150 psf; Eff Phi: 27°; Total Cohesion: 200 psf; Total Phi: 15°

Top of Raised Levee Elevation: 48.3 ft
Landside Levee Toe Elevation: 23 ft
Cutoff Wall Tip Elevation: -36 ft

Sudden Drawdown WSE from 45.3 ft to 35.3 ft

Results
Factor of Safety: 1.11



Notes:

1) A section from the waterside slope was removed for this investigation. The section removed was based on Figure 12b in the nhc report titled, "NLIP Vegetation Variance Request, Tree Fall Levee Erosion Studies," dated April 22, 2010.
2) WSE, stratigraphy, strength parameters, and cutoff wall elevation are based off of the sudden drawdown model for the 200-year WSE, at Station 21+00 presented in Kleinfelder's "Geotechnical Basis of Design Report, Natomas Cross Canal South Levee, Natomas Levee Improvement Program, Sacramento and Sutter Counties, California," dated January 30, 2009.

MAXIMUM SCOUR DEPTH: 13.3 FT
WSE: 45.3 FT to 35.3 FT
SUDDEN DRAWDOWN
SCOUR REMNANT LEVEE CONFIGURATION

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NCC STATION 21+00
STABILITY ANALYSIS

VEGETATION VARIANCE SUPPLEMENTAL GEOTECHNICAL EVALUATION
NATOMAS LEVEE IMPROVEMENT PROGRAM
SACRAMENTO AND SUTTER COUNTIES, CALIFORNIA

PLATE
7

APPENDIX F

NHC Report: NLIP Vegetation Variance Request
Tree-Fall Levee Erosion Studies

Report For:

NLIP Vegetation Variance Request
Tree Fall Levee Erosion Studies

Submitted to:

Sacramento Area Flood Control Agency
1007 7th Street, 7th Floor
Sacramento, CA 95814

Attention: Tim Washburn

Prepared by:

northwest hydraulic consultants inc.
3950 Industrial Blvd, Suite 100C
West Sacramento, CA 95691

Contact: Ken Rood
Phone: (916) 371-7400
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Project No: 50439

Submitted on:

April 22, 2010

Report Prepared by:

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Ken Rood, Project Manager

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Brian Wardman, P.E., Project Engineer

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Robert Odell, P.E., Internal Quality Review

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1. INTRODUCTION

1.1 Background and Objectives

The Sacramento Area Flood Control Agency (SAFCA) and the Central Valley Flood Protection Board (CVFPB) will be applying to the U. S. Army Corps of Engineers (USACE) for a variance from the standard vegetation guidelines set forth in Engineering Technical Letter 1110-2-571 (referred to as the "Levee Vegetation ETL" or "ETL") as part of improvements proposed for the Natomas perimeter levees. The variance request assumes that the over-widened or otherwise improved sections proposed for some segments of the perimeter levees will be adequate to maintain levee stability from erosion if trees fall.

This report describes the potential loss of the bank and levee that might result from tree fall on the waterside slopes of the perimeter levees, erosion around the root plate and the potential for instability of the levee from this erosion where the variance request will apply. The variance request includes a vegetation maintenance plan that will identify, monitor and treat unstable or fallen trees. Consequently, the main concern is for tree fall that occurs just before or during a major flood, when maintenance and repairs cannot be easily undertaken.

1.2 Levee Segments for Vegetation Variance Request

The variance requested by SAFCA would allow existing vegetation to remain on the following portions of the waterside slopes and berms of the perimeter levee system protecting the Natomas Basin:

- The entire waterside slope of the Sacramento River east levee (SREL) between the Natomas Cross Canal (NCC) and the American River.
- The lower 2/3 of the waterside slope of the American River north levee (or "ARNL") between the Sacramento River and the Natomas East Main Drainage Canal (or "NEMDC") at Northgate Boulevard.
- The entire waterside slope of the NEMDC west levee between Northgate Boulevard and the Arden-Garden Connector Bridge and the lower 1/3 of the waterside slope and berm of the NEMDC west levee from Arden-Garden to the NEMDC pumping facility.
- The lower half of the waterside slope of the NCC south levee between LM 3.5 and 4.38 and on the waterside berm of the NCC south levee below the projection of the landside toe between LM 0.0 and 3.5.

The general nature and character of the vegetation on these levee segments and the proposed structural and other measures for the ARCF Natomas project levee improvements are described in SAFCA's "*Vegetation Variance Request: Natomas Levee Improvement Program*".

1.3 Approach to Tree Fall Erosion

Literature review, discussions with wind throw and other vegetation experts, and local knowledge all led to the conclusions that 1) there is no well-accepted or satisfactory procedure for predicting the erosion that will result from tree fall on the banks of large rivers like the Sacramento or American River and 2) there are only a few documented observations of tree fall along the NLIP perimeter levees and no measurements of the erosion that occurred around these fallen trees.

Given the above, and the urgency of addressing this issue, we recommended applying scour analysis to the geometry resulting from a tree fall in order to predict the likely erosion under the hydraulic conditions associated with the 200-year flood. We are unaware of an application of scour analysis to fallen trees and consequently, we will adapt and apply the analyses developed for piers, abutments or other structures in the flow. This will be considered further in Chapter 4.

The basic approach is to predict the maximum likely scour or erosion that could occur for a "worst case" or "weakest link" site along each levee segment included in the variance request during the 200-year flood. Such a site is the one where the potential impact of erosion on levee stability is likely to be greatest after the NLIP improvements, not necessarily where the extent of erosion would be greatest, although the two may coincide. Generally, the equations for scour predict conservative results suitable for design (see discussion in Chapter 4). We also adopted relatively conservative assumptions for the parameters included in the scour analysis and completed a Monte Carlo simulation of the expected maximum scour depth based on input values selected from a range around the adopted values (Section 4.6).

The scour analysis was supplemented with observations and measurements near existing fallen trees along the Sacramento River (Appendix A). These observations do not necessarily indicate the maximum erosion that might occur because these fallen trees have not experienced the 200-year flood. However, the observations are useful in understanding how the erosion develops with time and whether or not the scour analyses adopted for this report provide a reasonable model of the erosion processes that typically occur.

1.4 Tasks and Report Organization

The steps necessary to complete the scour analysis and other modeling and analysis tasks are summarized below:

1. Identify and select suitable "worst case" sites along the four levee segments included in the study area
2. Define the geometry of the levee and waterside levee slope at the site, including the position and diameter of waterside trees that might fall and the nature or grain size distribution of local soils from field visits or existing studies. Define the levee geometry proposed for the NLIP improvements
3. Based on literature review and discussion with experts, define the dimensions and positions of fallen trees on the waterside berm or bank

4. Complete an air photo inventory of fallen trees along the Sacramento River and collect measurements of the tree and bank geometry
5. Define the local 200-year hydraulic conditions in the vicinity of the fallen trees from existing hydraulic models developed by MBK Engineers, Ayres Associates or the USACE. Chapter 4 describes the approach to selecting local velocities.
6. Adopt suitable equations and calculate the maximum expected depth of scour during the 200-year flood based on local hydraulic conditions, fallen tree geometry, soils and other relevant factors
7. Based on the maximum scour depth and typical scour hole geometry, construct the maximum eroded or scoured sections in the vicinity of the fallen trees and plot them on the section geometry
8. Provide the eroded or scoured sections to Kleinfelder, Inc for stability analysis (see Appendix E to the Vegetation Variance Request) and report their results.

The results of the levee geometry tasks and site selection tasks are described in Chapter 2 (Levee Geometry and Site Selection); the tree fall geometry is described in Chapter 3. The results of tasks 5 to 8 are described in Chapter 4 (Estimating Erosion after Tree Fall). The results of the air photo and field measurements of fallen trees are provided in Appendix A.

1.5 Information Provided by Others

The analyses in this report rely on water levels, topography, and other data provided by SAFCA, USACE Sacramento District, and their consultants, as follows:

- 200-year water surface elevations (WSE) for the study sites in the project area were provided by the USACE Sacramento District.
- Topography for existing conditions at the study sites was provided by PSOMAS from their 2008 base maps for the Natomas Levee Improvement Project, as prepared for SAFCA. For the SREL and NCC south levee, the location of trees on the waterside levee slope was based on PSOMAS ground surveys of tree locations.
- Proposed or constructed NLIP levee geometry at the study sites was provided by HDR Engineers or Wood Rodgers Inc and added to the existing topography.
- Velocities in the vicinity of the study sites were interpreted from model results provided by MBK Engineers, Ayres Associates or the USACE Sacramento District.
- General information on the soils in the vicinity of the study sites was provided by Kleinfelder, Inc.

These data were inspected for consistency but formal check surveys were not completed as part of the project work.

1.6 Project Datum and Coordinate Systems

Elevations are reported in feet and refer to the North American Vertical Datum of 1988 (NAVD 88). Elevations provided in the National Geodetic Vertical Datum of 1929 (NGVD 29) were converted to NAVD 88 by adding 2.28 feet. This conversion was prepared by PSOMAS for the Natomas Levee Improvement Program of SAFCA.

Levee stationing was based on the revised baseline for the NLIP that was prepared in 2009 by PSOMAS. Northing and easting coordinates on figures are based on the California Coordinate System Zone II and the 1983 North American Datum (NAD 83). When River Miles are quoted, they are based on the stationing shown on the 1991 Aerial Atlas of the Sacramento River (USACE 1991) or on USGS topographic maps.

2. Levee Geometry and Site Selection

2.1 Waterside Slope Description

The main features of the waterside levee slopes on the Natomas perimeter levees were named as *levee crown (or crest)*, *levee slope*, *berm*, *lower bank*, *low-water shelf (or berm)*, and *toe of bank* in this report (Figure 1). The *berm* is the reasonably flat floodplain or terrace that lies between the top of bank and the toe of the levee along the SREL at about the elevation of the 2-year water surface, but is mostly absent from the ARNL, NEMDC and NCC. Along these levee segments, the levee slope continues to a lower elevation berm, inspection road or low-water shelf that lie above the banks of the low water channel.

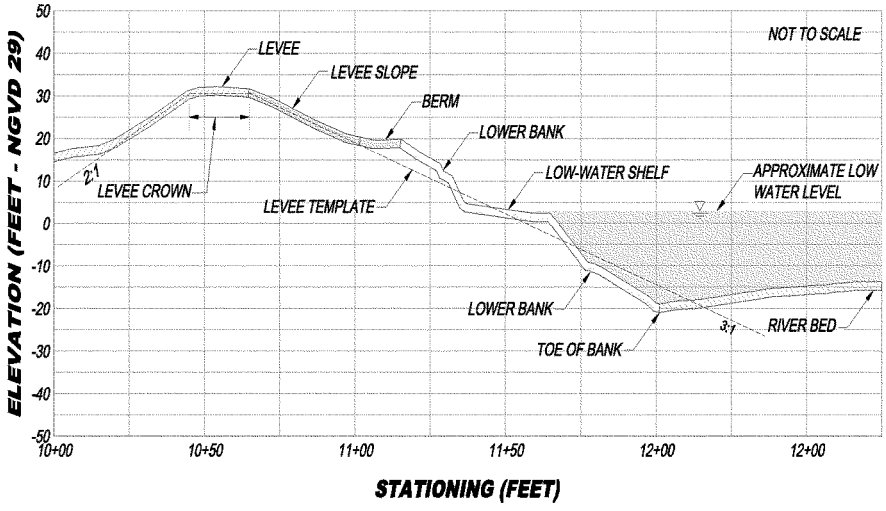


Figure 1: Definition sketch for Waterside Levee Slope Nomenclature

In general, large trees are found on the levee slope, berm and lower bank above low water levels along the Sacramento River east levee, but are least common on the levee slope. Along the American River north, NCC south and NEMDC west levees, large trees are found on the berm at the toe of the levee slope and on the levee slope. Large trees are least common on the upper part of the levee slopes.

2.2 Levee Geometry

In selecting the "worst case" study sites, particularly when considering the potential for erosion following tree fall to penetrate the levee, we compared existing waterside slopes to two waterside template slopes. The first template was based on the minimum standards in Title 23 of the California Code of Regulations (see Figure 2), revised to meet local USACE Standard Operating

Procedures. The section geometry include a crown or crest width of 20 feet, a 3:1 (horizontal to vertical) waterside slope extended into the bank, and a landside slope of 2:1 for existing condition levees in good condition or 3:1 for proposed or built NLIP levees. The levee template is positioned by setting the landside edge of the template crown at the existing landside levee crown and starting the waterside slope at 20 feet from the landside hinge point. As such, when the levee is widened to the landside, as is proposed for some of the Natomas perimeter levee segments, the minimum levee template will shift landward also. The second waterside template slope is defined by the above procedures but has a slope of 2:1, consistent with the slopes shown on the cross section drawings for the index points that are included in the main body of the Vegetation Variance Request.

The section drawings for each tree fall erosion site show both waterside template slopes for existing levee geometry (Figures 3a to 12a) and after the NLIP improvements (Figures 3b to 12b) and indicate how close large trees are to the levee section.

2.3 NLIP Levee Improvements

The proposed (or constructed) NLIP improvements for the levee segments where a vegetation variance is requested were obtained from HDR Engineers or Wood Rodgers. The SREL improvements include either a raised or an adjacent levee to the landward of the existing levee. There are essentially two different geometries proposed. In the upper 14 miles, a raised adjacent levee is proposed; an adjacent levee with varying widths is proposed for the lower 5 miles. The raised adjacent levee is typically larger than the existing levee. The width of the adjacent levee varies, depending on development at the landside toe. The narrowest section is expected to lie along the lower few miles, upstream of the American River. The NCC levee segment was widened in place and its waterside and landward slopes lowered. No widening is planned for the ARNL or NEMDC levees, which meet current standards for crest height and geometry.

The proposed or built NLIP improvements are shown on Figures 3b through 12b, along with the revised minimum levee template and the remnant levee configuration prepared by Kleinfelder (2010).

2.4 Site Selection

The general philosophy for site selection was to identify at least one site in each levee segment, and one in each of the different proposed improvements along the SREL, where the greatest potential for erosion to penetrate the minimum levee template configuration occurred. To the extent practical, we selected sites where large trees grew on the levee slope or close to the levee toe on the berm. However, the sites selected for analysis depended on the presence of large trees as well as whether or not the waterside levee slope was close to the minimum template.

On the SREL we were interested in considering potential erosion for large trees that grew on the levee slope, on the berm and on the lower bank above the low water elevation. Along the ARNL, NEMDC and NCC levee segments we were interested in potential erosion for large trees that grew on the levee slope and on the berm at the toe of the slope. We also tried to select sites where local velocities along the bank or levee slope were likely to be highest.

A total of 10 sites were selected for erosion analysis in the four levee reaches, distributed as described in Table 1:

Table 1: Description of Sites Selected for Erosion Analysis

No.	Levee Mile	River Mile	NLIP Improvement	Tree Position	Comment
Sacramento River East Levee					
1	0.32	78.5	Raised adjacent levee	Lower bank	Roots may grow into template
2	5.3	73.6	Raised adjacent levee	Slope/Berm	At levee toe
3	12.0	66.8	Raised adjacent levee	Berm	High velocities
4	13.5	65.5	Adjacent levee	Levee slope	Waterside residences
5	14.9	63.9	Adjacent levee with no development	Berm	None
6	17.4	61.3	Adjacent levee with development	Levee slope	Downstream of Sacramento Weir
American River North Levee					
1	0.7	0.7	None proposed	Levee slope	Discovery Park
2	1.75	1.8	None proposed	Berm	None
Natomas East Main Drainage Canal West Levee					
1	1.3	--	None proposed	Slope/Berm	Opposite Arcade Creek
Natomas Cross Canal South Levee					
1	3.7	--	As Constructed	Berm	None

Six sites were selected along the SREL to accommodate the three different NLIP improvement geometries and to include large trees on the levee slope, berm and lower bank, with an emphasis on the levee slope. The large tree on the levee slope at LM 13.3 (Site Sacramento 4) occurs where residents live on the waterside berm of the East Levee.

Along the NCC large trees grew mostly on the berm and we selected one site where a large tree grew near the levee toe. The levee geometry did not change much along this segment. On the NEMDC, we selected a narrow levee section (opposite Arcade Creek) where large trees grew on the berm near the levee toe. We did not identify any sites where large trees grew on the upper levee slope along the NEMDC where the levee geometry is near the minimum dimensions.

We selected two sites on the American River North Levee. The first, ARNL 1, was in Discovery Park, close to the mouth of the American River, where large trees grew on the levee slope. The second, ARNL 2, was near the upstream end of the ARNL where velocities were highest and large trees grew on the berm at the levee toe.

Figure 2 shows the locations of the study sites along the Sacramento River and the other levee segments. A site photograph, topography and cross section for existing conditions are included on Figures 3a through 12a. The cross sections were cut from the topography developed by PSOMAS in 2008 for the NLIP.

The sites selected for erosion analysis sites do not necessarily match the index or representative sites that are described in the main body of the Vegetation Variance Request (refer to Plate 3 for locations). However, several of the erosion analysis sites are quite close to the index sites. The scour analyses described in this report were generalized to the index sites as described in Chapter 5 of the main report.

3. TREE FALL GEOMETRY

3.1 Required Information

The geometric elements of the fallen tree that are required for scour analysis include the dimensions of the root pit or scar, the dimensions of the root plate (diameter and thickness) of the tree, the orientation and position of the tree and root plate after falling and the grain sizes and other characteristics of the underlying soils. These parameters were defined from literature review, discussions with local experts, air photo and field observations, or from other studies, as discussed in the following sections.

3.2 Description of Existing Trees

The position, species and breast height diameter of trees at the study sites on the SREL and NCC were initially taken from maps prepared by PSOMAS. Field work confirmed the locations, species and diameters quoted by PSOMAS map and calculated tree heights. The positions, species, diameters and heights of trees at the other study sites were measured during field visits. The trees selected for scour analysis are shown on Figures 3a through 12a.

3.3 Tree Roots and Root Plate Geometry

The general nature of the roots and potential root plate geometry for Valley Oak (*quercus lobata*) and Fremont Cottonwood (*populus fremontii*) were identified from literature review and discussions with local experts.

The Valley Oak is a dominant species in low elevation riparian habitats in California. It is a deciduous tree, growing as tall as 100 feet, with a broad and rounded crown (NRCS 2009). The Valley Oak grows in deep, fertile soils subject to drought. A young Valley Oak exhibits a tap root which can grow up to 60 ft deep in search of water (Pavlik et al. 1993). As the tree matures, the tap root is replaced by a lateral root system that can spread as much as twice the tree crown diameter and extend as much as 5 feet below the ground surface (Berry, pers. comm.). Berry (2007) examined the root architecture of a mature Valley Oak tree along the south bank levee of the American River at RM 11.0. A 4 foot wide trench was dug parallel to the levee to determine the extent of root penetration. Roots in excess of 2" in diameter were found at depths of up to 4 to 5 feet and extended laterally beyond the crown diameter of 56 feet.

The Fremont Cottonwood is a dominant tree in riparian areas and is always found near water. They grow rapidly, as much as 12 to 18 ft in 3 years when in contact with a reliable water source, and can reach large tree size within 30 years (Grenfell 1988). Cottonwoods are typically dominant on the stream banks whereas Valley Oaks grow further up the stream bank or on the berm. Maximum rooting depths in mature stands of Fremont Cottonwoods are between 9.8 ft and 16.4 feet (Braatne *et al* 1996; Zimmermann 1969). Cottonwoods can exhibit strongly horizontal root systems with vertical sinker roots extending to depths of 4 to 5 feet (Berry 2007).

We also discussed root systems for these two species with Dr. Chris Peterson and Dr. Alison Berry. Dr. Peterson is leading wind throw investigations for SAFCA. Dr. Berry is a professor in the Department of Environmental Horticulture at the University of California, Davis, and is leading the root architecture investigations for SAFCA. They both indicated that the majority of the root system in mature trees of these species lie within 3 to 4 feet of the ground surface. Roots grow opportunistically. Soil type, degree of compaction, and the water table affect the extent of lateral root spreading and depth of root penetration. In cases with sandy and excessively well drained soils, roots are more likely to grow downward, following the moisture gradient, rather than spread laterally. In cases where soils have high bulk density such as clayey or excessively stony soils, or where the ground water table is near the surface, the tendency is for more lateral root spreading to occur (Crow 2005).

In general, when the trees are blown over, the exposed or lifted root plate is not as large as the root mass because roots are broken or snapped off by the imposed wind forces. These forces and the weight of the bare tree above the ground limit the maximum size of the root plate that can be lifted by the falling tree. Peterson (2010; Appendix H) describes a study of root pit depths measured during experiment studies of tree fall on levee slopes. He noted average root pit depths of about 1.6 feet and maximum depths of about 3.5 feet. Root plate areas averaged 10.6 square feet. The advice of Drs. Peterson and Berry was that the root plate of large trees on the waterside slope will typically be a maximum of three feet thick and extend about 15 feet laterally. The very largest root plates might be about 4 feet thick and extend about 20 feet laterally. Shallower roots and a thinner root plate are expected on the lower bank where there is an aquitard or where trees grow close to the water table. Under these conditions, the root plate might be much shallower (1 foot or so) and correspondingly wider. Small trees are expected to have a root plate with a thickness of about 1 foot and a diameter of about 8 feet. Such geometry is consistent with the few fallen trees that we observed in the study area (see Appendix A).

3.4 Fallen Tree Orientation and Position

Dr. Chris Peterson pointed out that trees on the bank will generally fall downslope, into the river, and then be rotated downstream by the current. Appendix A summarizes our investigations of fallen trees within the NLIP study area. The fallen trees were identified from Google Earth (air photo dated between 2007 and 2009) and video from a helicopter reconnaissance taken in August 2007. For each fallen tree the angle of the trunk relative to the bank line was measured. The average angle from a perpendicular to the bank was estimated to be 24° and this was adopted as the skew of the root plate relative to flow in the scour analyses in Chapter 4.

Appendix A also provides some observations on the size of root plates observed in the study area and observations of the typical erosion into the stream bank that has occurred.

3.5 Soils and Underlying Materials

The grain size distribution and nature of exposed soils in the root pit will determine whether or not erosion occurs and the rate at which the scour hole develops on the berm or bank. Soil layers underlying the surface will also affect the rate of development of scour, particularly if cohesive or erosion-resistant ones are exposed during scour. Discussion with Kleinfelder (O'Leary, pers.

comm.) indicated that no borings or other soil analyses had been completed on the waterside of the levee and that the borings through the levee crest could not be easily extrapolated to the waterside berm and bank because of disturbance along the levee during construction.

The materials in the upper two or three feet of soil at the tree erosion sites were characterized from soil pits or auguring on the NEMDC, NCC and ARNL. Assumptions regarding soils at the SREL sites and the nature of materials at depth are summarized in Chapter 4.

3.6 Adopted Fallen Tree Geometry

Based on the review, discussions and other studies described above, we have adopted the following geometry for the fallen trees:

- The primary large tree species on the waterside levee slope are Valley Oak and Fremont Cottonwood.
- Generally, the majority of the root system in mature trees of these species lies within 3 to 4 feet of the ground surface, although this will vary depending on soil characteristics, the distance to the water table and other factors. When trees are blown over, the root plates for large trees are expected to be as much as 3 feet thick and 15 feet in extent. The very largest plates might reach 4 feet thick and 20 feet in diameter.
- In order to have as large a root plate as practical we selected large, mature trees at the study sites. For these trees we have assumed a three-foot thick and 15-foot diameter root plate after tree fall based on advice from local experts and general observations around the NLIP. The exposed root pit will have the same dimensions as the root plate.
- It has been observed that trees almost always fall down the slope. We have assumed that this will also occur along the Natomas perimeter levees.
- Air photo analysis indicates that existing fallen trees along the Sacramento River point downriver, at an average angle of about 24° off a perpendicular to the bank (Appendix A). We assume that the trees point downriver because of drag on the stem and branches and we have adopted the average angle above as the typical skew of the root plate for scour calculations.

Figures 3b through 12b show the bank geometry immediately after tree fall at the study sites, based on the adopted geometry above and the measured tree dimensions.

4. ESTIMATING EROSION AFTER TREE FALL

4.1 General Considerations for Applying Scour Analysis

As discussed in Section 1.3 (Approach to Tree Fall Erosion) we recommended estimating the maximum potential erosion around a fallen tree by applying scour analysis. As was noted in that section, we are unaware of another well-accepted procedure for predicting erosion after tree fall and are unaware of any empirical measurements that could be used in place of a satisfactory equation.

There are a few studies of scour and deposition near log jams (e.g. Lester and Wright 2009; Floyd et al. 2009). However, consideration of the FHWA Hydraulic Engineering Circular 9 (Bradley et al., 2005), the relatively few large woody debris pieces transported by the rivers surrounding the Natomas project, and the O&M requirements to remove fallen trees suggested that log jams are very unlikely to develop along the NLIP levees. Based on these considerations, we limited our study to the scour expected to occur around a single fallen tree.

TAC (2004) separates scour into four broad categories: 1) contraction scour which results from a constriction of the floodway, 2) local scour which results from the vortex system generated when flows diverge around a structure, 3) natural scour which results from temporal variations in flow and channel processes, and 4) channel profile degradation which results from geologic processes. Previous studies for SAFCA considered natural scour and profile degradation in the Sacramento River (NHC 2007) and the NEMDC (NHC 2009). Further profile degradation was considered very unlikely based on these studies. Natural scour does occur at the toe of the banks along the Sacramento and American Rivers (and to a much lesser extent in the NEMDC or NCC) during large floods. This scour occurs at elevations well below those where large trees grow and the extent of this scour is not expected to be affected by tree fall. However, natural scour may steepen banks and undermine trees, or cause bank slumps, that may add to the erosion that is calculated around a single fallen tree.

The main considerations for tree fall are then contraction and local scour. Contraction scour is not thought to be significant, but it is briefly discussed in a later section of this Chapter. Local scour results from the increase in bed shear caused by the vortex system formed around the structure. The depth and geometry of the scour hole depends upon upstream local hydraulic conditions, the geometry and size of the structure, the location of the structure in the flow column, and the local soil or bed materials. Although studies have quantified the local scour around submerged vanes (e.g. Biron et al 2005), the local scour around complex geometries such as fallen trees is not well understood. Due to the urgency of addressing this issue, we have calculated local scour by utilizing standard equations for determining maximum local scour depths around bridge piers.

The root plates of the fallen trees under consideration in this report will generally lie either on a levee slope or berm, such as occurs along the Sacramento River, or on the bank above the typical low water elevation. These sites are raised well above the stream bed and well above elevations

where active bed material transport occurs during floods. Previous analyses have also demonstrated that the existing grass and ground cover on the banks and berm are likely to be stable or nearly stable under the imposed velocities and shear stresses exerted during the 200-year flood.

Given the above considerations, the scour that occurs around the fallen tree will be of the "clear water" type, where erosion and bed material transport does not occur generally upstream and downstream of the fallen tree but only in its vicinity where erodible soils are exposed in the root pit. Under this condition, scour will develop over time to reach an equilibrium or maximum depth. The analogous case for scour analysis at bridges would be calculation of local scour around a pier on a wide floodplain. We have adopted similar procedures for our tree fall scour calculations below.

4.2 Hydraulic Values for Scour Analysis

During extreme flood events in the Sacramento Basin, the rivers and canals adjacent to the study levee segments will have complex flows across the relatively shallow and vegetated berms and waterside levee slopes. The shallow depths and dense vegetation increase the hydraulic roughness near the levee and reduce the flow velocity relative to the main channel. Two-dimensional depth-averaged hydraulic models are generally required to adequately represent the lateral distribution of velocity across a cross-section, and provide a good estimate of the velocities where tree fall is expected to occur. The hydraulic characteristics for the scour analysis, which are the depths and velocities upstream of the fallen trees, were defined from hydraulic models developed by MBK Engineers, Ayres Associates, and the USACE.

Sacramento and American Rivers

Along the Sacramento and American Rivers, both depths and velocities increase with discharge, so the most extreme case for scour is at the most extreme discharge; for this analysis, the 200-year flood was adopted.

Local velocities at five of the six study sites on the Sacramento River were taken from an RMA-2 model of the 200-year flow in the Sacramento River prepared by MBK Engineers. This model utilized in-channel Manning's n values of 0.027 and overbank values of 0.05. The local velocity that was adopted was the greatest value for the grid cells that are in the vicinity of the tree fall study site (Table 2). The grid cells are much larger than the individual trees and the adopted velocities are averages over an area that extends from the edge of the floodplain towards the main channel. These averaged velocities will be often greater than the local velocity at the tree, particularly when the tree lies close to the levee or is on the levee slope where the depths are shallowest and the roughness greatest. Velocity contour plots are provided in Appendix B.

Table 2 compares local velocities at the study sites from existing 2-D models to section-averaged velocities extracted from the USACE Sacramento River Basin unsteady HEC-RAS model. The average cross-sectional velocities predicted by the 1-D model are much greater than the local velocities near the tree fall sites, as described above.

As of this writing, the two-dimensional hydraulic modeling has not been extended to the vicinity of the Sac 6 site. As this site lies between the Sacramento weir and the confluence with the American River, very complex flow behavior occurs during extreme floods. The Sacramento River Basin HEC-RAS model predicts a section average velocity of 0.3 ft/s with a friction slope of 0. It was conservatively assumed that this velocity was representative of near bank velocities at the study site as well.

Table 2: 200-Year Velocities at the Study Sites

Site	RMA-2/ FESWMS Near Bank Velocity (ft/s)	RMA-2/ FESWMS Centerline Velocity (ft/s)	HEC-RAS Average Cross-Section Velocity (ft/s)
Sac_1	3.5	6.5	5.0
Sac_2	2.5	7.0	4.8
Sac_3	2.5	7.0	5.6
Sac_4	2.5	7.0	4.6
Sac_5	2.5	7.0	4.8
Sac_6	NA	NA	0.3
NCC	NA	NA	2.7
NEMDC	2.0	3.5	5.3
ARNL 1	2.0	9.0	4.3
ARNL 2	3.0	7.5	7.1

Hydraulic conditions at the American River study site were adopted from a RMA-2 hydraulic model of the 200-year flood (160,000 cfs) that was developed by Ayres Associates (2003). Ayres Associates (2001) provides details on the model calibration and operation. Velocity contour plots are provided in Appendix B.

Natomas Cross Canal and NEMDC

The NEMDC and the NCC are backwatered during the 200-year flood; depths are greatest then, but velocities are near zero. In these two canals, the worst case for scour may occur at intermediate conditions, particularly those with lower tailwater levels in the Sacramento and American Rivers. For the initial analysis (Table 2), the adopted velocity at the NCC study site was the maximum calculated for a theoretical 200-year flood in the NCC with the Sacramento River at a 50-year water level. In the NEMDC, velocities were calculated from a MBK Engineers FESWMS model for the 100-year flood with a downstream boundary condition of 35.3 feet NAVD 88 (American River base flood elevation). The FESWMS model had an in-channel Manning's n of 0.041 and an overbank Manning's n of 0.07.

Both these adopted velocities were thought to be conservative and we also assumed depths that are equivalent to those during the 200-year flood. Given that flow depth dominates the calculated scour, this was thought to provide conservative assumptions for calculating worst case maximum scour. The following paragraphs describe a sensitivity analysis undertaken to confirm this assumption.

As is discussed in Section 4.5 (following), maximum scour depths depend on both the velocity and depth of flow. Maxima do not always occur at flows with the highest velocities or greatest depths. On the Sacramento and American Rivers, the overbank velocity and depth are usually maximized during the 200-year flow; thereby making this the most extreme hydraulic conditions for scour. However, those sites that are backwatered during the 200-year flow (NEMDC, NCC, and Sac_6), the greatest scour may occur for some combination of high flow and low tailwater conditions which produce combinations of water levels (and depths) and velocities that maximize scour. We attempted to account for this by selecting conservative velocities to combine with the 200-year water levels, as discussed above, but also examined hydraulic conditions to confirm that this is so.

The USACE provided HEC-RAS model results for over 40 different combinations of discharges (ranging from the 2-year to the 200-year) and downstream water levels (from 2-year to 200-year). From these results, we analyzed which combinations of depths and velocities would provide the greatest scour. Since HEC-RAS provides cross-section average velocities which are not representative of overbank velocities (as discussed above), we used a form of the Manning's equation shown below to approximate the velocity at the tree-fall location.

$$V = \frac{1.49}{n} y^{2/3} S_f^{1/2}$$

In this equation, the velocity, V, is a function of the flow depth, y, and the friction slope, S_f. The flow depth is computed as the difference in the water surface elevation provided in the HEC-RAS output and the elevation of the base of the root plate. The friction slope and Manning's n values were taken directly from the HEC-RAS model results. This form of the Manning's equation neglects the effects of the boundary roughness at the edges of the river resulting in a slight over-estimation of the velocity.

Using this method to determine a depth and velocity near each tree-fall location for different flow and tailwater combinations, we computed maximum scour depths and compared them to those shown in Tables 5 and 6. The flow depths and velocities associated with various flow combinations, as well as the computed scour depths, are shown in Appendix C. The analysis shows that the velocities and depths adopted to calculate maximum scour in Tables 5 and 6 are relatively conservative provide reasonable results.

4.3 Soil Characteristics for Scour Analysis

Maximum scour depths and rates of scour depend upon the size and gradation of the sediment exposed to scour. For this analysis, the surface soils initially exposed at the SREL study sites were assumed to be silty sand with the characteristics shown in Table 3. Soils exposed at the NCC, NEMDC and ARNL were determined by auguring and their characteristics are also provided in Table 3.

We assumed that the observed or assumed soils also extended to the maximum depth of scour. Where silty sand is assumed, this will result in conservative estimates of the maximum depth; the presence of cohesive or erosion-resistant layers under the surface will reduce the maximum

depth. Where cohesive soils are assumed, the maximum depth of scour may be underestimated if these soils are shallow and underlain by erodible sand.

Table 3: Assumed Grain Sizes at Each Study Site

Study Site	Soil Type	D_{50} (mm)	D_{95} (mm)
Sac_1	Silty Sand	0.25	3
Sac_2	Silty Sand	0.25	3
Sac_3	Silty Sand	0.25	3
Sac_4	Silty Sand	0.25	3
Sac_5	Silty Sand	0.25	3
Sac_6	Silty Sand	0.25	3
NCC	Silty Clay	Unknown	Unknown
NEMDC	Silty Clay	Unknown	Unknown
ARNL 1	Silty Sand	0.25	3
ARNL 2	Silty Sand	0.25	3

4.4 Contraction Scour

An initial appraisal of the potential for contraction scour was based on comparing tree area to flow area. HEC-RAS modeling results showed conveyance areas during extreme flows of over 20,000 square feet on the Sacramento River, 30,000 square feet on the American River, and 10,000 square feet in the NEMDC and NCC. Assuming trees with 4 feet diameter trunk that are 100 feet tall, and a safety factor of two, a tree fall would reduce the conveyance area of these cross-sections by less than 4%, 2%, and 8%, respectively. Such small reductions in flow area are not expected to cause contraction scour.

To check the above assumption, the conveyance area was adjusted to account for the increase due to local scour and the decrease or loss from the fallen tree. Table 4 shows the net change in conveyance area due to a fallen tree. As the percentage of the conveyance area lost to tree fall is less than 5% at each of the cross-sections, we do not expect significant changes in bulk velocities or significant additional scour or section readjustments from tree fall.

Table 4: Net Change in Conveyance Area Due to Tree Fall.

Site	Sac_1	Sac_2	Sac_3	Sac_4	Sac_5	Sac_6	NEMDC	ARNL 1	ARNL 2	NCC
Initial Conveyance Area (ft^2)	24000	25000	21000	25000	24000	22000	5000	30000	30000	13000
% Change in Conveyance Area	1.4	-0.1	-3.2	-2.0	-0.2	-2.3	-4.8	0.0	0.0	4.9

4.5 Local Scour Calculations

Maximum Scour Depth Equations

Most of the procedures for calculating scour at piers under either the clear water or live bed condition are based on laboratory studies with non-cohesive sediments. Generally, maximum or equilibrium scour depths are determined by extending the studies until scour stops; scour equations are then based on enveloping results from different studies and geometries. Thus, the depths calculated by pier scour equations should be considered "upper bounds".

The maximum scour predicted by these equations often over-estimates the local scour observed under field conditions (May et al 2002; TAC 2004). Many factors may prevent the development of the maximum predicted scour in natural rivers. Flood duration is an important factor; roots that reinforce soils, underlying less erodible layers in the soils or varying local hydraulic conditions also may reduce actual scour compared to maximum predicted scour. In this study, the movement of the tree downstream due to buoyant and drag forces and erosion of soil from the root plate may also reduce the likelihood that the maximum scour will be achieved.

Our analysis focused on the scour around the root plate or root wad while neglecting potential erosion around the tree trunk and branches. The reasons for this are twofold. First, because the trees typically fall towards the river, the root wad is expected to be nearest the levee and will provide the most extreme case to analyze. Second, results from by Biron *et al* (2005) and Melville and Coleman (2000) for wide structures show that scour is most extreme near the edges of the structure. Dey *et al* (2008) also shows the depth of scour is strongly dependent upon the height of the structure. Therefore, the scour around a fallen tree is expected to be maximized at the root plate, where its height will work to maximize the erosion depths.

Two of the most commonly adopted procedures for pier scour are from the FHWA Hydraulic Engineering Circular No. 18 (Richardson and Davies 2001) and the New Zealand pier scour equations published by Melville and Coleman (2000; also Melville 1997). Both equations calculate the maximum (equilibrium) scour as functions of the flow depth, pier width, flow velocity, flow orientation, the shape of the pier, and the local sediment characteristics, as described in the next two sections. The two equations were used to 1) predict the maximum scour depth that might occur and 2) predict the maximum scour depth that might occur during the 200-year flood, accounting for flood duration and other considerations.

FWHA Scour Equations

The HEC-18 equation is:

$$d_s = 2.0 y_1 K_1 K_2 K_3 K_4 K_w \left(\frac{a_1}{y_1}\right)^{0.65} F_1^{0.43} \qquad \text{Equation (1)}$$

Where d_s is the depth of scour below the ambient (in this case, existing bank) bed, y_1 is the depth of the approach flow, K_1 is the correction factor for the pier nose shape (1.0 for rounded piers, 1.1 for square nose piers), K_2 is the correction for angle of attack, θ, described below, K_3 is the correction factor for the pier scour depths under either clear water or live bed scour conditions (1.1 for clear water scour), K_4 is the correction factor for the size of the bed material (1.0 when

median grain size is less than 2mm), K_w is the correction factor for very wide piers shown below, a_1 is the width of the pier or thickness of the root plate, and F_1 is the Froude number of the approach flow. This is a dimensionally homogenous relationship and is valid for either SI or English units.

$K_2 = \left(Cos\theta + \left(L/a_1 \right) Sin\theta \right)^{0.65}$ where L is the length of the pier

$K_w = 2.58 \left(y_1/a_1 \right)^{0.34} F^{0.65}$ for $y_1/a_1 < 0.8$ under clear water conditions

New Zealand Scour Equations

The Melville and Coleman (2000) Equation is:

$$d_s = K_1 K_2 K_{ya} K_i K_D \qquad \text{Equation (2)}$$

where the K_1 and K_2 are the same as in the HEC-18 equation, K_{ya} is the flow depth-pier size expression defined below, K_i is the flow intensity factor, and K_D is the sediment size factor defined below. It is important to note that the Melville and Colman relationships are not dimensionally homogenous and are only valid for SI units. Units were converted to SI and back to English units by using a factor of 1 meter=3.281 feet.

The depth-pier size is defined as follows

$K_{ya} = 2.4 a_1$ for $a_1/y_1 < 0.7$

$K_{ya} = 2\sqrt{y_1 a_1}$ for $0.7 < a_1/y_1 < 5$

$K_{ya} = 4.5 y_1$ for $a_1/y_1 > 5$

The sediment size factor relates the size of the bed material to the width of the structure, and is defined as follows

$K_D = 1.0$ for $a_1/D_{50} > 25$

$K_D = 0.57 \log\left(2.24 a_1 / D_{50} \right)$ for $a_1/D_{50} < 25$

The flow intensity factor relates the velocity of the approach flow to the critical velocity of the local sediment; thereby accounting for clear water or live bed scour. The flow intensity factor is defined using the following relationships:

$K_i = \dfrac{V_1 - (V_a - V_c)}{V_c}$ if $\dfrac{V_1 - (V_a - V_c)}{V_c} < 1$ for non-uniform, non-cohesive sediments or

$$K_i = \frac{V_1}{V_c} \qquad \text{if} \quad \frac{V_1}{V_c} < 1 \qquad \text{for cohesive sediments}$$

Otherwise K_i=1.

V_1 is the velocity of the approach flow, V_a is the critical velocity of the expected armor layer (based on D_{95} of soil) and V_c is the critical velocity of the bed sediment. The critical velocities for non-cohesive sediments were determined as:

$$V_a = 0.8V_{ca}$$

$$V_{ca} = V_{*ca}\,5.75\log\left(5.53\frac{y_1}{D_{50a}}\right)$$

$$V_c = V_{*c}\,5.75\log\left(5.53\frac{y_1}{D_{50}}\right)$$

Where D_{50} is in meters in the above relationships, and in millimeters in the relationships below:

$$V_{*c} = 0.0115 + 0.125D_{50}^{1.4}$$

$$V_{*ca} = 0.0115 + 0.125D_{50a}^{1.4}$$

And D_{50a}=D_{95}/1.8.

For cohesive sediment, the critical velocity was determined based on empirical findings published in May *et al* (2002). The silty clay floodplain deposits found at the NCC and NEMDC study sites were assumed to behave similarly to light loamy clay of medium to high density and have a critical velocity of approximately 2.6 ft/s.

Effects of Duration

The Melville and Coleman (2000) equation also includes a factor for flood duration that limits maximum scour development. This relationship, shown below, determines both the number of days that a constant flow is required for the scour hole to reach its maximum depth, as well as a weighting factor, K_T, which estimates the percentage of the maximum scour depth reached over a given duration.

$$K_T = \exp\left\{-0.03\left|\frac{V_c}{V}\ln\left(\frac{t}{t_e}\right)\right|^{1.6}\right\}$$

Where t is the duration of the storm, and t_e is duration required for equilibrium to occur, defined as

$$t_e = 48.26\frac{a_1}{V}\left(\frac{V}{V_c} - 0.4\right) \quad \text{for} \quad \frac{y_1}{a_1} > 6 \quad \text{and} \quad \frac{V}{V_c} > 0.4$$

$$t_e = 30.89\frac{a_1}{V}\left(\frac{V}{V_c} - 0.4\right)\left(\frac{y_1}{a_1}\right)^{0.25} \quad \text{for} \quad \frac{y_1}{a_1} < 6 \text{ and } \frac{V}{V_c} > 0.4$$

Investigation of the 200-year hydrographs (Appendix B) along the Sacramento River near Natomas showed the water surface elevations within one foot of the peak water levels exist for about 4 days. The product of the weighting factor, K_T, and maximum scour depth then provide an estimate of what the expected scour depth would be after the 200-year flood event at a given location.

Accounting for Submergence

Dey *et al* (2008) identified a strong dependence of local scour on relative submergence. For cases where the depth of the water exceeded the height of the root plate, L, the computed scour depths were also multiplied by a submergence coefficient, K_s, defined by Dey *et al* (2008) as:

$$K_s = 1 - 0.73S + 3.63S^2 - 12.8S^3 + 17.23S^4 - 8.33S^5$$

$$S = \frac{y_1 - L}{y_1}$$

4.6 Study Site Maximum Scour Depths

Introduction

The potential maximum or equilibrium scour that could be reached at each study site was calculated with the above procedures for two different root plate conditions, as follows:

- Trial 1: A typical root plate thickness of 3 feet and a width and length of 15 feet.
- Trial 2: A typical root plate thickness of 4 feet and a width and length of 20 feet.

During the Trial 1 calculations, the Melville and Coleman equation consistently computed larger scour depths than the HEC-18 equation as well as proving more sensitive to variability in input values (Table 5). The reasons why the Melville and Coleman equations compute greater values than the FWHA equations are discussed in TAC (2004). As the Melville and Coleman equations predicted more conservative scour depths than the HEC-18 equations, they were adopted for calculation of the Trial 2 maximum scour depths. The effects of flood duration, as described above, were applied to the maximum scour depths from the Melville and Coleman equation to adjust to the maximum scour depth expected during the 200-year flood.

Trial 1 Calculations

A Monte Carlo approach was used to account for uncertainty in root plate geometry, orientation to flow, flow velocity and flow depth. In this approach, the input variables are assigned a range of values centered on the expected value for a given variable. A repetitive numerical process randomly selected the input variables from these ranges and computed a scour depth for each random set of input variables. The final outcome of this approach was a distribution of scour

depths centered on the expected scour depth with a variance representative of the uncertainty in the various inputs to the scour depth equations (Table 5).

The Monte Carlo approach predicted the expected maximums value and the standard deviations around those maxima at each study site from 25,000 calculations using random combinations of input variables. The input values for each individual calculation were randomly selected from a uniform distribution. The ranges of input variables used in the scour equations are generally representative of variation in input variables which maximized scour in Appendix C. The ranges of input variables were:

- Water levels: +/- 1 foot from UNET model values
- Bench elevations: +/- 3 feet from PSOMAS surveys
- Height of Root Plate: 12-15 feet
- Width of Root Plate: 2-3.5 feet
- Length of Root Plate: 12-15 feet
- Velocity: +/- 20% from values chosen from hydraulic models
- Angle of tree to flow: 0 to 45 degrees
- Pier shape correction factor (K_1): 1.0-1.1

Table 5: Trial 1 Maximum (Equilibrium) and 200-year Scour Depths

Site	Sac_1	Sac_2	Sac_3	Sac_4	Sac_5	Sac_6	NCC	NEMDC	ARNL 1	ARNL 2
Water Surface Elev. (NAVD88 ft)	43.1	41.3	36.4	35.7	34.4	34.9	42.3	36.1	35.4	35.8
Elevation of Tree (NAVD88 ft)	31	35	27	33.7	27	31	31	30	34.4	25
Velocity (ft/s)	3.5	2.5	2.5	2.5	2.5	0.3	2.7	2.0	2.0	3.0
Mean HEC-18 Scour Depth (ft)	9.2	7.3	7.8	3.7	7.5	2.8	8.2	6.6	4.5	8.5
Standard Deviation HEC-18 Scour Depth (ft)	2.2	1.8	1.9	0.9	1.8	0.7	2.0	1.6	1.2	2.0
Mean Melville and Coleman Scour Depth (ft)	12.5	12.5	12.7	5.9	12.6	5.6	10.4	7.7	4.2	12.6
Standard Deviation Melville and Coleman Scour Depth (ft)	3.1	3.1	3.1	1.7	3.1	1.4	2.9	2.1	1.4	3.1
Time to Equilibrium (Days)	29.0	22.0	22.9	50.0	22.3	50.0	18.7	10.5	16.1	26.3
Percent of Maximum Depth for Duration of 4 Days (K_T)	94%	92%	92%	40%	92%	2%	92%	94%	95%	93%
Maximum Trial 1 Scour Depth for 200-year Event (ft)	11.8	11.6	11.7	2.4	11.7	0.1	9.6	7.3	3.9	11.7

The scour depths in Table 5 are often about the same as the typical lateral radii for the root plates. It seems likely that the tree roots remaining in the soil will be eroded during the scour process and the tree will float away before the maximum scour hole is developed.

Trial 2 Calculations

The Trial 2 maximum scour depths were calculated for a 4-foot thick root plate with a length and width of 20 feet. The analysis followed the procedures described above, but with the root plate dimensions held constant in the Monte Carlo simulation. The ranges of input variables used in the Trial 2 calculations were:

- Water levels: +/- 1 foot from UNET model values
- Bench elevations: +/- 3 feet from PSOMAS surveys
- Velocity: +/- 20% from values chosen from hydraulic models
- Angle of tree to flow: 0 to 45 degrees
- Pier shape correction factor (K_I): 1.0-1.1

The results of these calculations are summarized in Table 6 below.

Table 6: Trial 2 Maximum (Equilibrium) and 200-year Scour Depths

Site	Sac_1	Sac_2	Sac_3	Sac_4	Sac_5	Sac_6	NCC	NEMDC	ARNL 1	ARNL 2
Water Surface Elevation (NAVD88 ft)	43.1	41.3	36.4	35.7	34.4	34.9	42.3	36.1	35.4	35.8
Elevation of Tree (NAVD88 ft)	31	35	27	33.7	27	31	31	30	34.4	25
Velocity (ft/s)	3.5	2.5	2.5	2.5	2.5	0.3	2.7	2.0	2.0	3.0
Mean HEC-18 Scour Depth (ft)	11.5	9.2	9.6	2.0	9.3	3.2	10.2	8.2	5.4	10.6
Standard Deviation HEC-18 Scour Depth (ft)	2.6	2.1	2.2	0.8	2.1	1.0	2.3	1.9	1.4	2.4
Mean Melville and Coleman Scour Depth (ft)	18.0	18.0	18.0	6.9	18.0	6.8	14.8	10.7	7.2	18.0
Standard Deviation of Scour Depth (ft)	4.0	4.0	4.0	1.9	4.0	1.6	3.7	2.7	2.7	4.0
Time to Equilibrium (Days)	38.5	29.3	30.3	50.0	29.8	50.0	24.7	14.0	21.9	35.0
Percent of Maximum Depth for Duration of 4 Days (K_T)	99%	92%	92%	40%	92%	2%	90%	91%	93%	96%
Maximum Trial 2 Scour Depth for 200-year Event (ft)	17.9	16.5	16.5	2.8	16.6	0.14	13.3	9.8	7.4	17.4

The four-foot thick root plate may not actually occur. The wind forces required to blow down a tree and topple or lift such a weight may seldom be reached (Petersen 2010). Consequently, we view the Trial 2 calculations as providing very conservative scour depths.

4.7 The Estimated Eroded Section

The eroded section around the root plate at each study site was calculated by extending slopes from the 200-year maximum scour depths (Tables 5 and 6) at the base of the scour holes, at 2H:1V. This side slope is recommended for calculating scour geometry in Garcia (2008). It is possible that roots in the soil or more erosion-resistant layers in the bank will result in steeper slopes in practice.

The side slopes of the scour hole are extended until they reach about the elevation of the original ground and then are drawn steeply to intersect the levee slope, berm or bank. The assumption is that the steep eroded slope above the original ground elevation will be modified by Kleinfelder when re-calculating levee stability. Results are provided on Figures 3b through 12b.

4.8 Interpreting Levee Stability after Erosion

The geometries for the eroded or scoured section for the two trials discussed above (see Figures 3b through 12b) were provided to Kleinfelder for further analysis. As is reported in Appendix E (Kleinfelder 2010), they analyzed the levee stability under waterside sudden drawdown for 7 of the eroded sections calculated under Trial 1 conditions. Scour depths at Sites Sac 4, Sac 6 and ARNL 1 were less than 4 feet, did not penetrate the levee section, and were judged to have little impact on levee stability based on the results at the other sections. Their analyses (See their Table 6) showed factors of safety that exceeded the minimum USACE criterion of 1.1 and all the study sites for Trial 1 scour were judged to be stable under tree fall erosion.

Kleinfelder subsequently re-analyzed levee stability for the Trial 2 sections and determined that factors of safety exceeded the minimum USACE criterion of 1.1 and that all the study sites were judged to be stable under the Trial 2 tree fall erosion.

4.9 Mitigating Instability from Tree Fall Erosion

Given that the levees at all the "worst case" study sites remain stable under the predicted maximum tree fall erosion, no mitigation is required.

5. RESULTS AND CONCLUSIONS

The objective of this report was to calculate the potential loss of the bank and levee that might result from tree fall on the waterside slopes of the ARCF Natomas Project prior to a flood, the subsequent erosion around the root plate during the 200-year flood, and the potential for instability of the levee from this erosion, assuming that the NLIP improvements have been constructed.

The general approach to the analysis was to adopt a "worst case" or "weakest link" approach by choosing study sites on the levee segments where the vegetation variance will be requested that have the greatest potential for erosion to affect levee stability. Sites were selected to correspond to the different proposed NLIP levee geometries along the Sacramento River and to evaluate the erosion from tree fall on the levee slope, berm and lower bank.

We recommended adopting scour analysis to calculate the potential erosion around an individual fallen tree. The impact of the fallen tree on contraction scour, natural scour and profile degradation appeared to be inconsequential. As a result, the potential erosion from tree fall was calculated by applying pier scour equations to the root plate of the fallen tree, ignoring the contribution of the trunk or stem for the reasons described in the text.

The depth and extent of the erosion around the root plate depended upon local hydraulic conditions, the geometry and size of the root plate, the location of the structure in the flow column, and the local soil exposed on the surface and at depth. There was considerable uncertainty in all these parameters but particularly in the local hydraulic conditions and the soils exposed by the tree fall and those encountered at depth in the scour hole as it develops. We adopted conservative parameters to maximize the calculated scour depth.

Both the FWHA (Richardson and Davies 1995) and the New Zealand (Melville and Coleman 2000) equations were applied to calculate local scour depths. These equations were used to predict the maximum or equilibrium scour depth that might develop at each site. Given the uncertainties in the parameters at the study sites and uncertainties about how these parameters might apply to calculating local scour around a root plate, the expected maximum scour depths and the standard deviations of the maximum depths were calculated from a Monte Carlo simulation. The FWHA equations predicted maximum scour depths ranged from 2.8 to 9.2 feet. The New Zealand scour equations predicted maximum scour depths that were about 15 to 100% greater than those from the FWHA equations, ranging from 5.6 to 12.7 feet.

Adopting a conservative approach, we chose the New Zealand scour equation maximum scour depths for further calculations. Maximum scour depths were then predicted for two root plate characteristics, referred to as "trials" in the report. The trials consisted of:

- Trial 1: Typical root plate thickness of 3 feet and height and length of 15 feet. Maximum scour depth were predicted from a Monte Carlo simulation based on ranges of all the input variables, with the ranges intended to reflect the uncertainties in that parameter.
- Trial 2: Typical root plate thickness of 4 feet and height and length of 20 feet. Maximum scour depths were predicted from a Monte Carlo simulation based on ranges of all the input variables, excluding root plate dimensions.

The maximum scour depths were adjusted to reflect the scour that would develop during the duration of the 200-year flood at the study sites, which was assumed to be four days. These adjusted maximum scour depths were then plotted on the cross sections and the extent of erosion calculated by assuming that the scour hole would develop with a 2:1 side slope to about the original elevation of the root plate and then extend to meet the levee slope or bank at a steeper slope, ultimately to be defined by Kleinfelder as part of their further geotechnical studies.

It is our view that all the maximum scour depths calculated in this report are conservative and overestimate the actual scour that is likely to occur. The elements of conservatism that are incorporated into the calculations in addition to root plate characteristics include:

- We assumed that the root plate was similar to a pier when calculating scour even though the root plate may not extend to maximum scour depth at a constant diameter. We believe that drag and buoyancy may move the tree from the site before scour reaches the maximum calculated depth.
- Scour on the Sacramento and American Rivers was calculated from depth-averaged velocities taken from 2-D model grid cells that are much larger than the individual trees. These velocities do not fully account for the effect of structures or other large trees on local velocities and they are an average over a large area so they do not predict the velocities near the levee face well. Scour on the NEMDC and NCC were based on a conservative combination of depths and velocities, selected to maximize scour.
- We assumed erodible silty sands to depth along the Sacramento River and did not account for erosion resistance from roots, other vegetation, erosion-resistant layers, etc. All of these would reduce the maximum scour depth reached during the 200-year flood.
- We calculated maximum scour depths from two common sets of equations. Both equations predict maximum scour depth from envelope curves based on laboratory studies and are known to overestimate the observed scour under field conditions by up to 100% (May *et al* 2002). We adopted the greater of the two sets of estimates for calculating the eroded section.
- The eroded section that develops from the maximum scour hole assumed 2:1 side slopes based on the ASCE Manual No 110 on Sedimentation Engineering (Garcia 2006). Other advice suggested that these side slopes are conservative and that steeper slopes may develop, resulting in less erosion than predicted.

The geometries for the eroded or scoured waterside cross sections for the three trials were provided to Kleinfelder who analyzed them for stability under waterside sudden drawdown (Appendix E; Kleinfelder 2010). These analyses showed that all the levee sections were stable for the maximum tree fall erosion calculated in the two trials.

6. REFERENCES

Ayres Associates Inc. 2001. Two-dimensional Modeling and Analysis of Spawning Bed Mobilization, Lower American River. US Army Corps of Engineers, Sacramento District. October.

Ayres Associates Inc. 2003. Lower American River FEMA Certification: Draft Appendix Technical Report, Including Draft Hydraulic Model Plots. US Army Corps of Engineers, Sacramento District. July 21.

Berry, Alison. 2007. Trees and levees: How and where do tree roots grow? Vegetation Challenge Symposium, Sacramento, CA.
web: http://www.safca.org/protection/leveevegetation.html

Biron, P.M., Robson, C., Lapointe, M., Gaskin, S. 2005. Three-dimensional flow dynamics around deflectors. River Research and Applications 31: 961-975.

Braatne, Jeffrey H., Rood, Stewart B., Heilman, Paul E. 1996. Life history, ecology, and conservation of riparian cottonwoods in North America. In: Steller, R. F., ed. Biology of Populus and its implications for management and conservation. Ottawa, ON: National Research Council of Canada, NRC Research Press: 57-85. [29693]

Bradley, J.B., Richards, J.L., Bahner, C.D. 2005. Debris Control Structures – Evaluation and Countermeasures, third edition. U.S. Federal Highway Administration, Hydraulic Engineering Circular No. 9.

Breusers, H., Raudkivi, A. 1991. Scouring. International Association for Hydraulic Research Hydraulic Structures Design Manual: Hydraulic Design Considerations. A.A. Balkema, Rotterdam.

Crow, Peter. November 2005. The influence of soils and species on tree root depth, Information Note, Great Britain Forestry Commission, Edinburgh, United Kingdom, 8 p.

Dey S., Raikar, R.V., Roy, A. 2008. Scour at Submerged Cylindrical Obstacles under Steady Flow. J. Hydraulic Engineering. 134: 105-109.

Floyd, T.A., MacInnis, C., Taylor, B.R. 2009. Effects of Artificial Woody Structures on Atlantic Salmon Populations in a Nova Scotia Stream. River Research and Applications 25: 272-282.

Garcia, M.H. (ed). 2008. Sedimentation Engineering: Processes, Measurements, Modeling and Practice. ASCE Manuals and Reports on Engineering Practice 110. Reston VA. 1,132 p.

Grenfell, W.E., Jr. 1988. Valley foothill riparian. In: Mayer, Kenneth.A. and Laudenslayer, W.F., Jr.. A guide to wildlife habitats of California, U.S. Department of Agriculture, Pacific Southwest Forest and Range Experiment Station, California, pp 86-87.

Kleinfelder, Inc. 2010. Letter to Mr. T. Washburn of SAFCA, titled "Draft Vegetation Variance Geotechnical Evaluation: Natomas Levee Improvement Program, Sacramento and Sutter Counties, California" and dated April 1st. 13 p. and figures.

Lester, R.E., Wright, W. 2009. Reintroducing Wood to Streams in Agricultural Landscapes: Changes in Velocity Profile, Stage, and Erosion Rate. River Research and Applications 25: 396-392.

May, R., Ackers J., Kirby, A. 2002. Manual on scour at bridges and other hydraulic structures. Construction Industry Research and Information Association (CIRIA). London. 225 pp.

Melville, B.W. 1997. Pier and abutment scour: integrated approach. Journal of Hydraulic Engineering 123(2): 125-136.

Melville, B.W., Coleman, S. 2000. Bridge scour. Water Resources Publications, Colorado.

Northwest Hydraulic Consultants (NHC). 2007. NLIP Design, Environmental Compliance and Regulatory Permitting of Bank Protection Improvements. Basis of Design (30% Submission). Submitted to SAFCA. June 4.

Northwest Hydraulic Consultants (NHC). 2009. Technical Memorandum titled "NLIP Natomas East Main Drainage Canal Erosion Assessment" to SAFCA dated April 15.

NRCS (National Resource Conservation Service). 2009. Plant Guide, California White Oak, *Quercus lobata* Nee, U.S. Department of Agriculture, National Plant Data Center. *web: http://plants.usda.gov/plantguide/pdf/pg_qulo.pdf*

Pavlik, Bruce, Muick, Pamela, Johnson, Sharon. 1993. Oaks of California, Cachuma Press, 184 p.

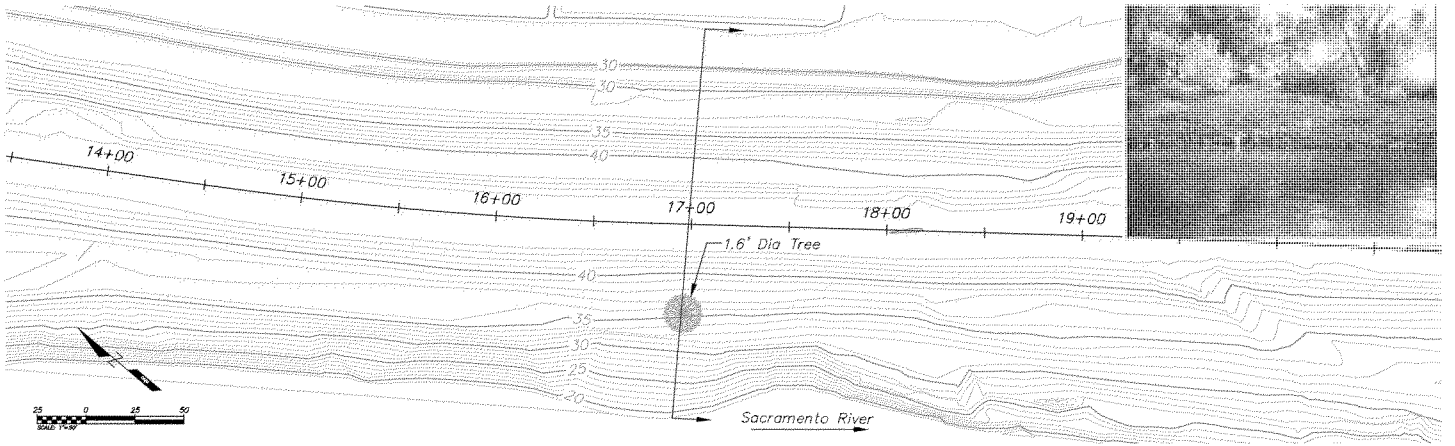
Peterson, C. 2010. Preliminary Data and Analysis of Tree Fall in the California Central Valley. Appendix H to the NLIP Vegetation Variance Request. 6 pp.

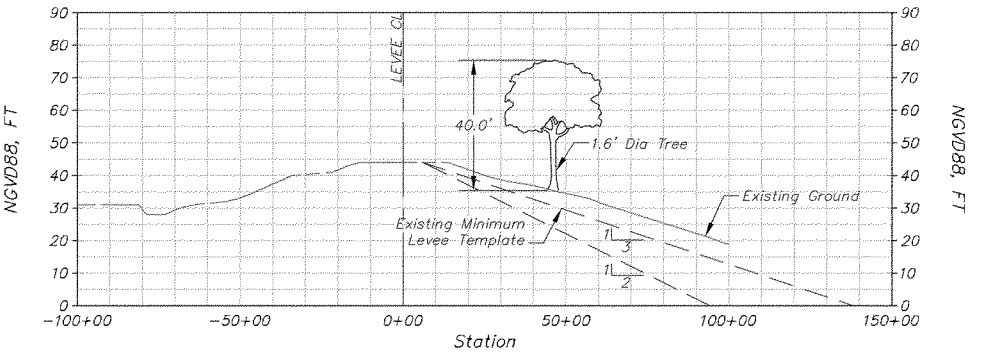
Richardson, E.V. and S.R. Davis 2001. Evaluating scour at bridges, fourth edition. U.S. Federal Highway Administration, Hydraulic Engineering Circular No.18.

Transport Association of Canada (TAC). 2004. Guide to Bridge Hydraulics: Second Edition. Thomas Telford, London. 181 p.

U.S. Army Corps of Engineers. 1991. Sacramento River, Sloughs and Tributaries, California. 1991 Aerial Atlas: Collinsville to Shasta Dam. Sacramento District, 46 plates.

Zimmermann, Robert C. 1969. Plant ecology of an arid basin: Tres Alamos-Redington Area, southeastern Arizona. Geological Survey Professional Paper 485-D. Washington, DC: U.S. Department of the Interior, Geological Survey. 51 p. [4287]

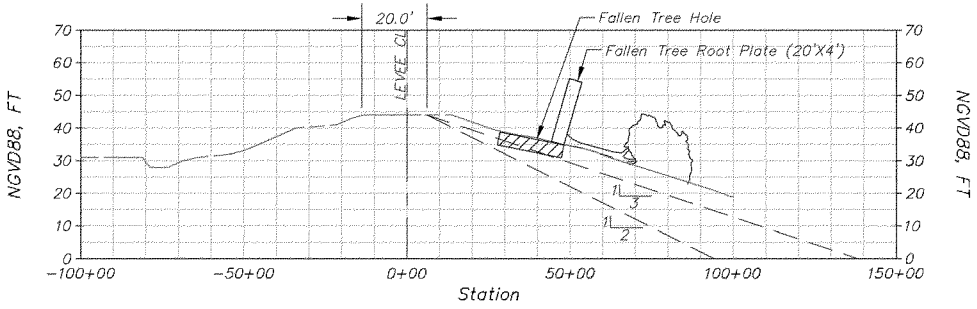




SREL Levee Mile 0.32- Sac 1 Treefall Erosion Site

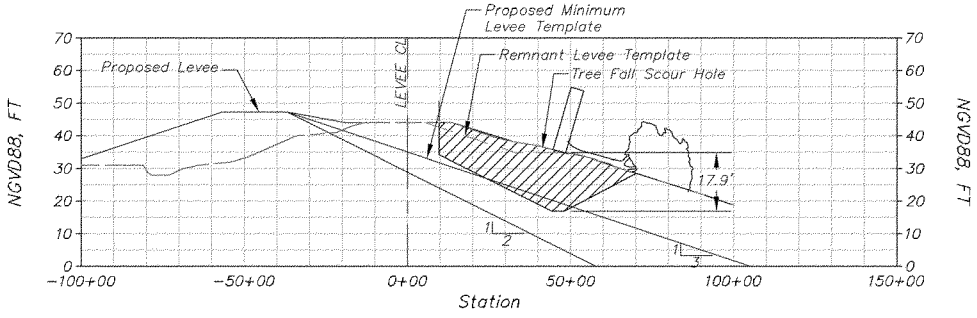
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Figure 3a. Sac River Tree Fall Erosion Site 1



Sac River Site 1 Section with Treefall

H:1"=30' V:1"=30'

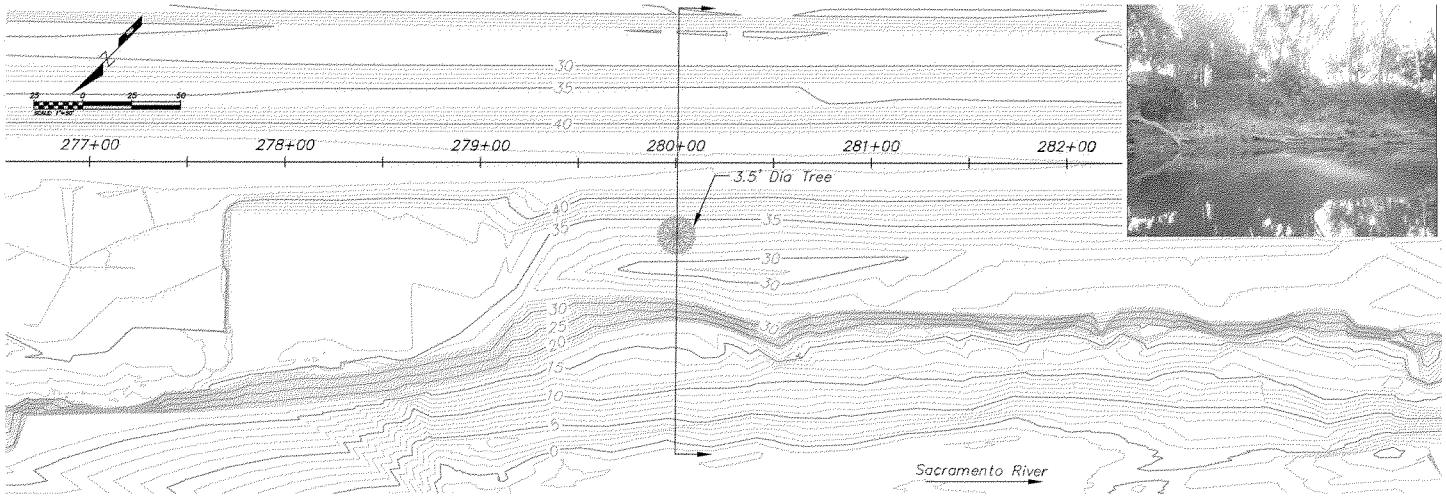


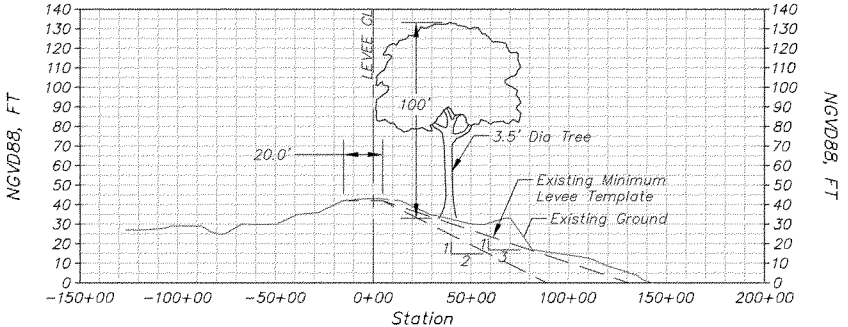
Sac River Site 1 Section with Treefall Scour Hole

H:1"=30' V:1"=30'

1628

Figure 3b. Sac River Tree Fall Erosion Site 1

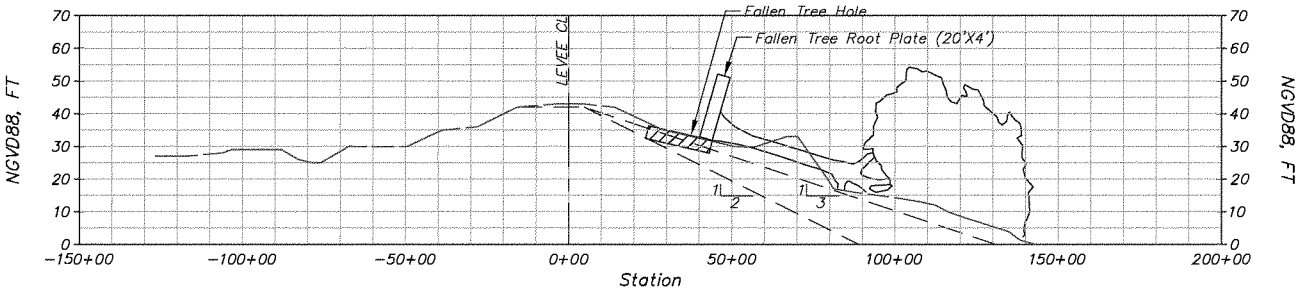




SREL Levee Mile 5.3-Sac2 Treefall Erosion Site

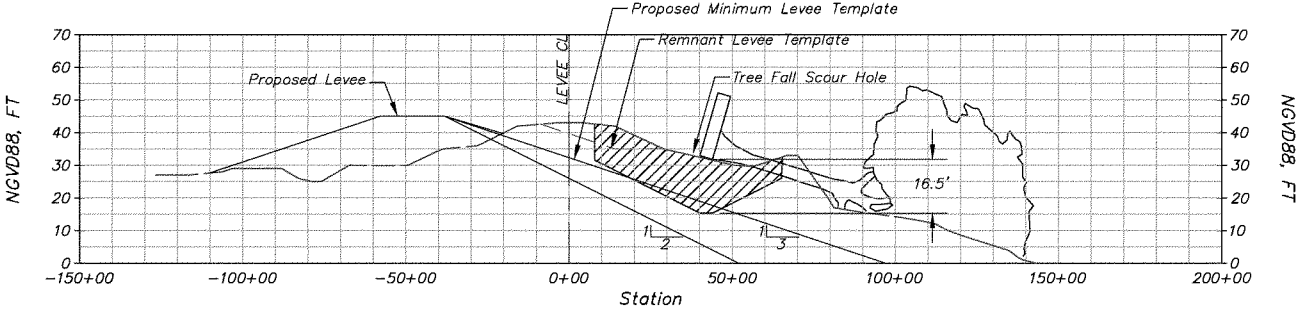
H:1"=50' V:1"=50'

Figure 4a. Sac River Tree Fall Erosion Site 2



Sac River Site 2 Section with Treefall

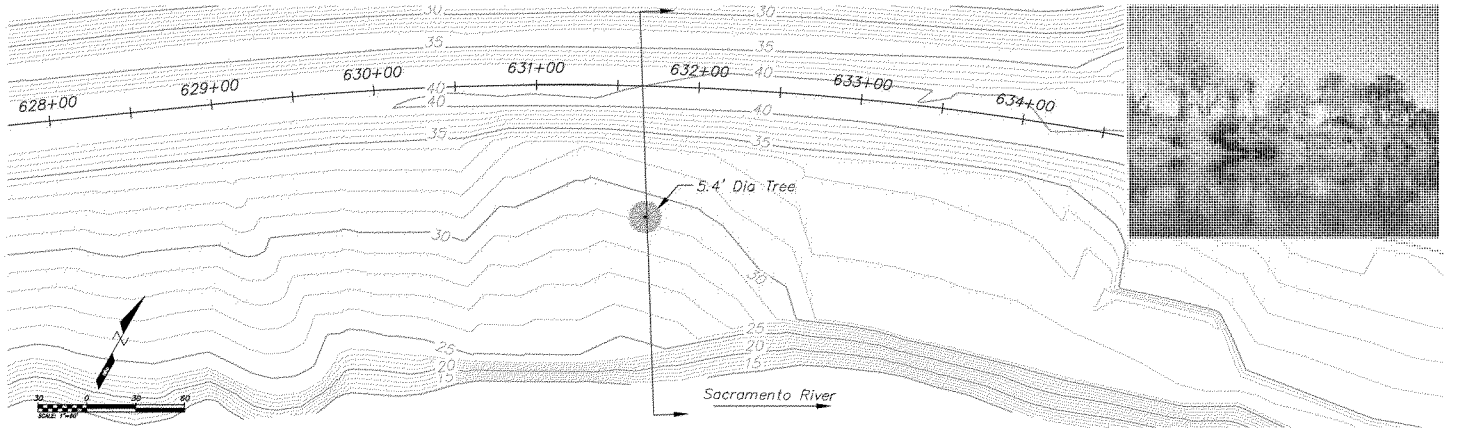
H:1"=30' V:1"=30'

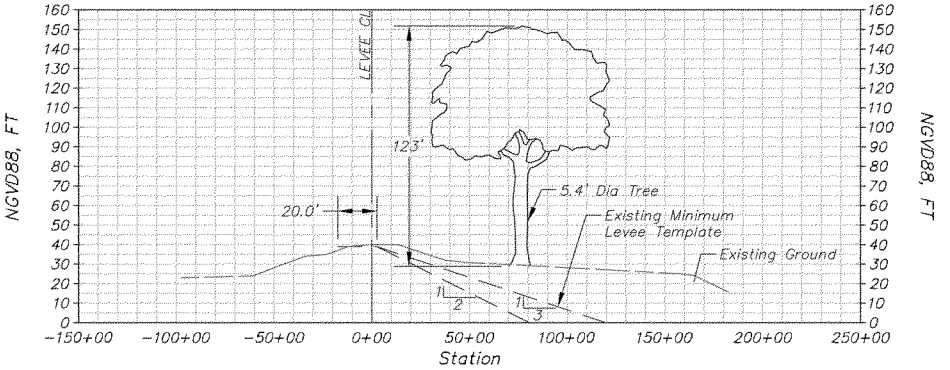


Sac River Site 2 Section with Treefall Scour Hole

H:1"=30' V:1"=30'

Figure 4b. Sac River Tree Fall Erosion Site 2

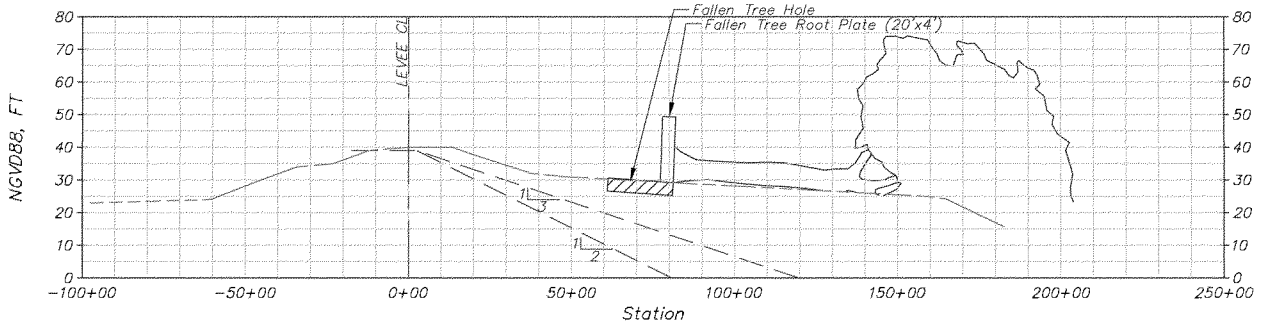




SREL Levee Mile 12.0-Sac 3 Treefall Erosion Site

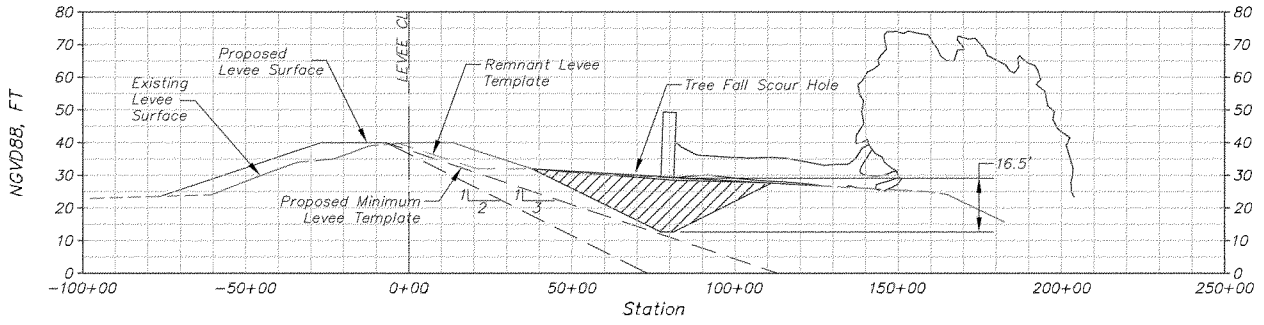
H:1"=50' V:1"=50'

Figure 5a. Sac River Tree Fall Erosion Site 3



Sac River Site 3 Section with Treefall

H:1"=30' V:1"=30'



Sac River Site 3 Section with Treefall Scour Hole

H:1"=30' V:1"=30'

Figure 5b. Sac River Tree Fall Erosion Site 3

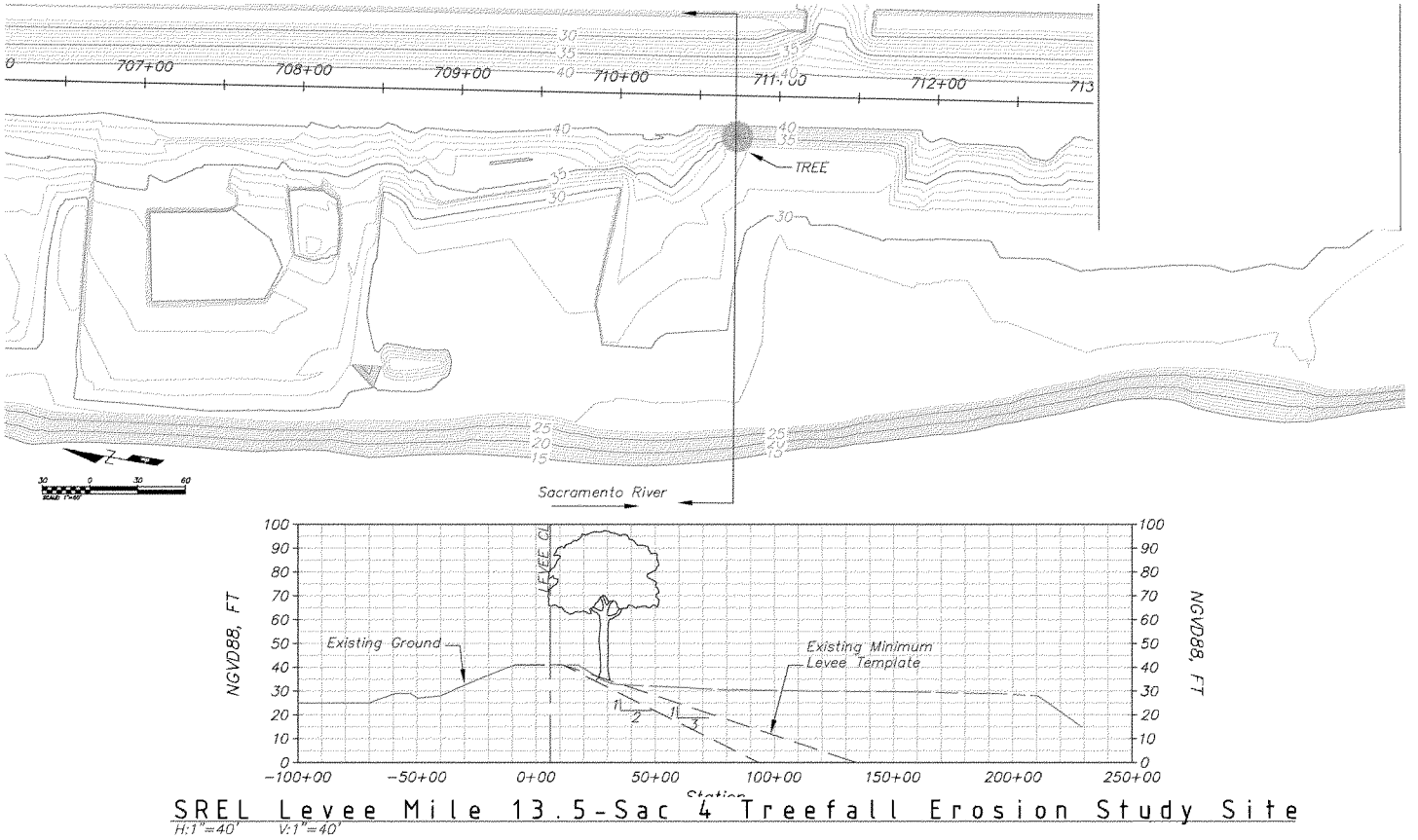
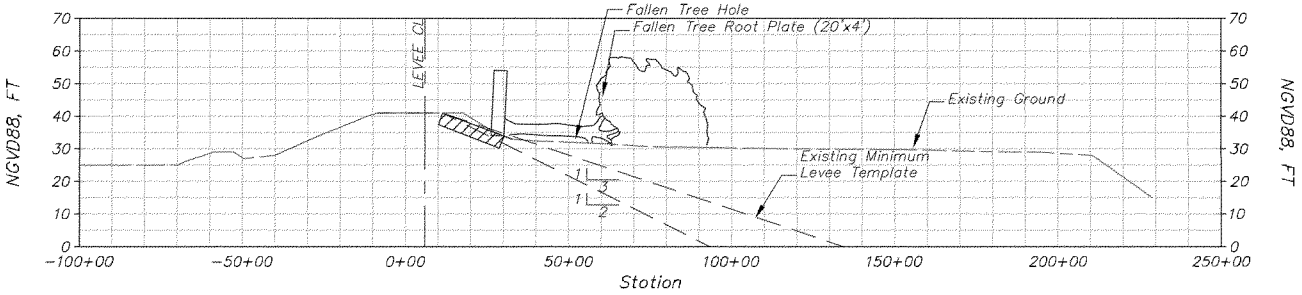
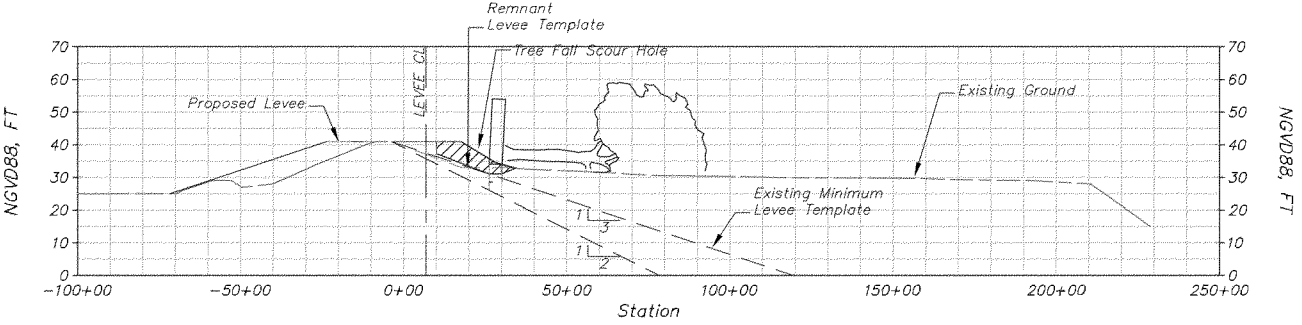


Figure 6a. Sac River Tree Fall Erosion Site 4



Site River 4 Section with Treefall

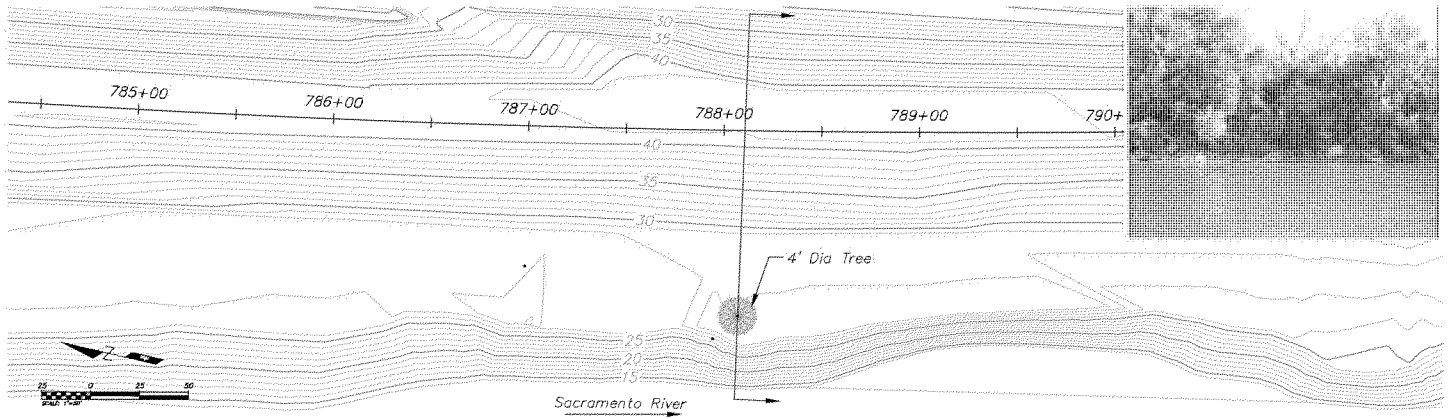
H:1"=30' V:1"=30'

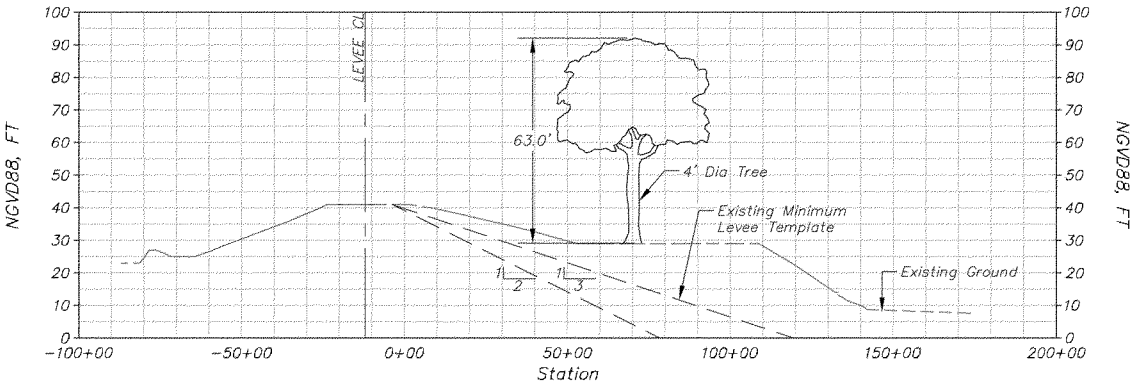


Sac River Site 4 Section with Treefall Scour Hole

H:1"=30' V:1"=30'

Figure 6b. Sac River Tree Fall Erosion Site 4

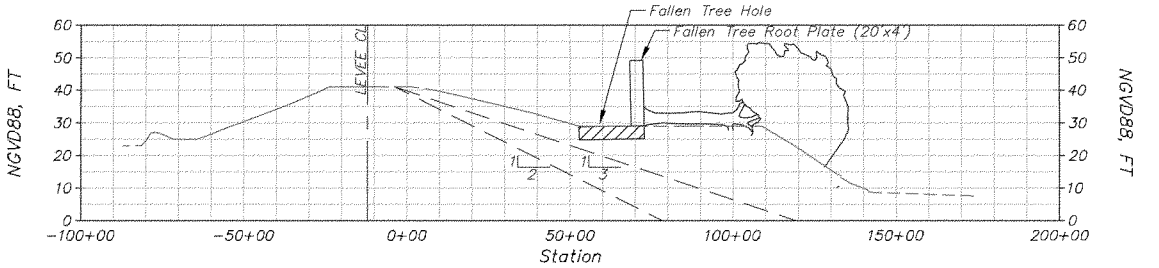




SREL Levee Mile 14.9 -Sac 5 Treefall Erosion Site

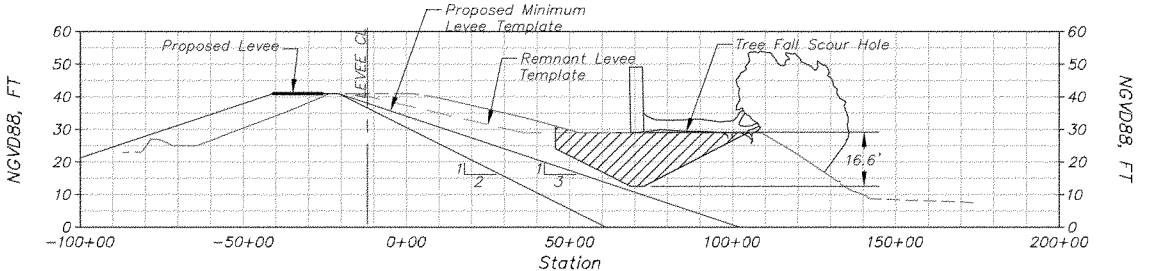
H:1"=30' V:1"=30'

Figure 7a. Sac River Tree Fall Erosion Site 5



Sac River Site 5 Section with Treefall

H:1"=30' V:1"=30'

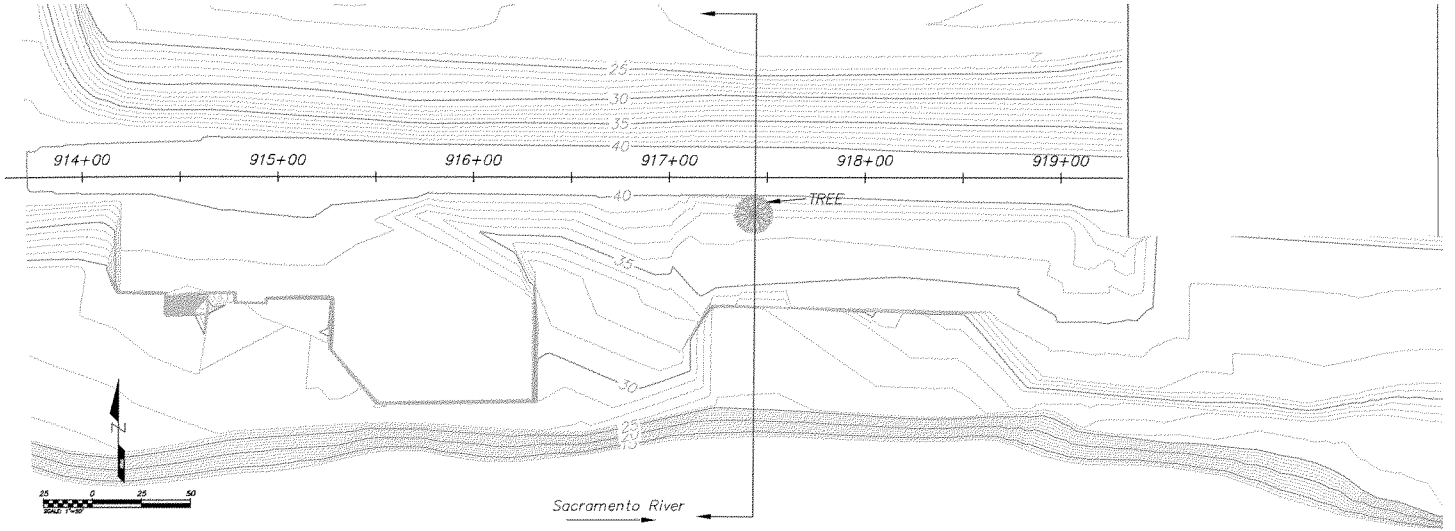


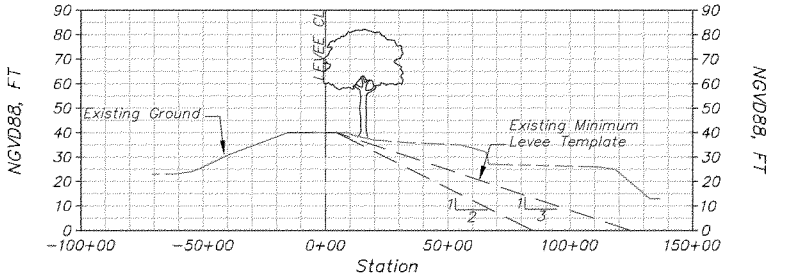
Sac River Site 5 Section with Treefall Scour Hole

H:1"=30' V:1"=30'

1636

Figure 7b. Sac River Tree Fall Erosion Site 5

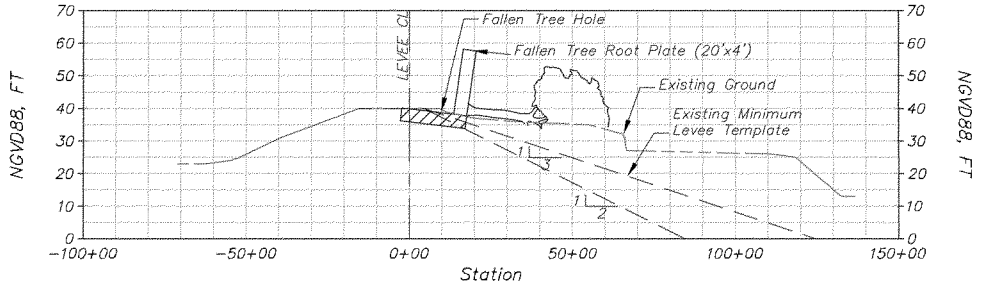




SREL Levee Mile 17.4 - Sac 6 Treefall Erosion Study Site

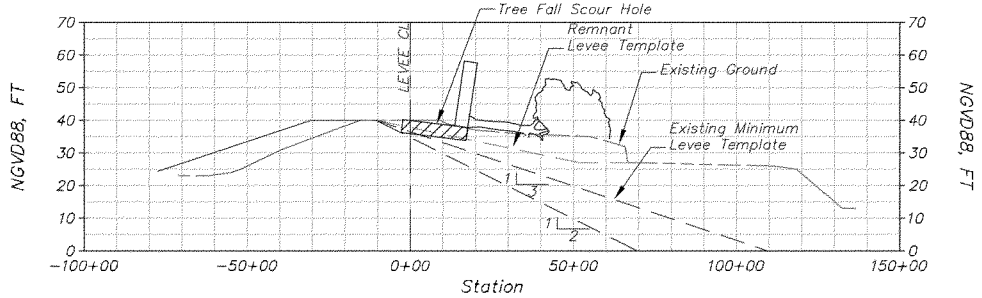
H:1"=40' V:1"=40'

Figure 8a. Sac River Tree Fall Erosion Site 6



Site River 6 Section with Treefall

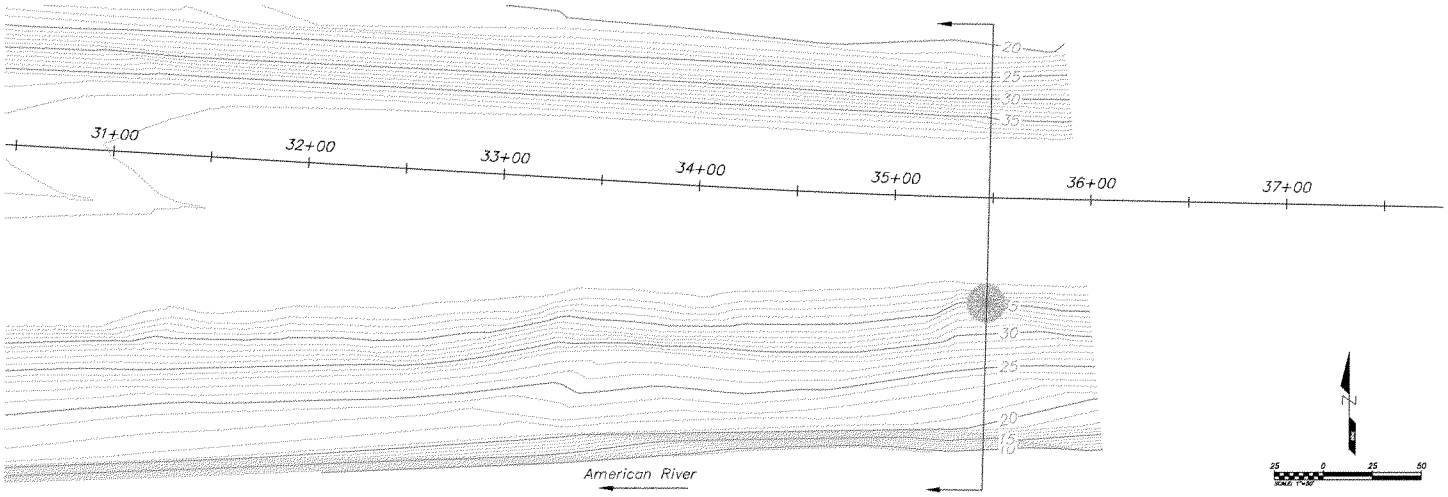
H:1"=30' V:1"=30'

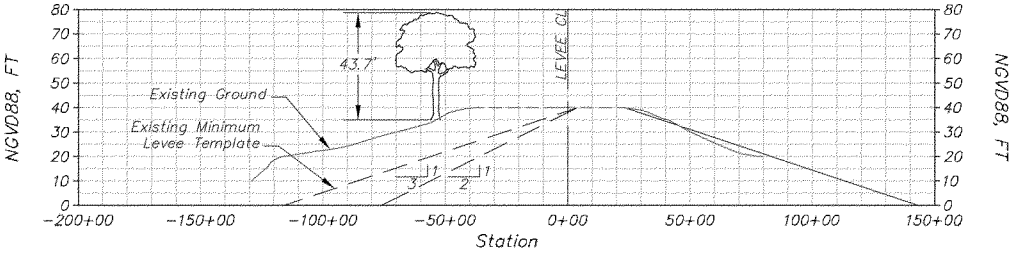


Sac River Site 6 Section with Treefall Scour Hole

H:1"=30' V:1"=30'

Figure 8b. Sac River Tree Fall Erosion Site 6

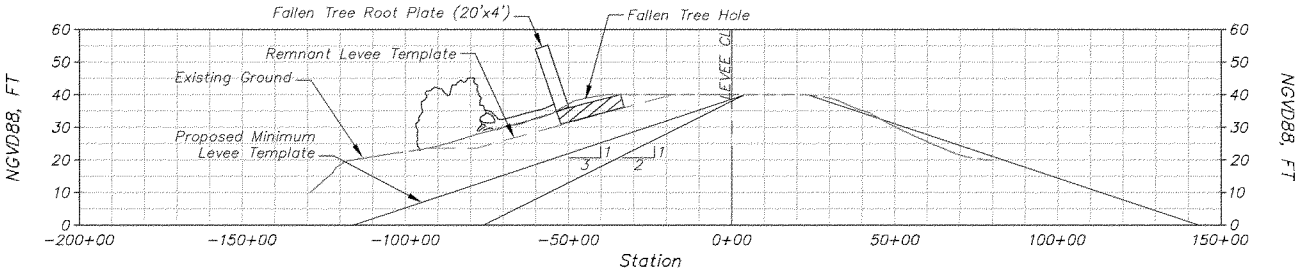




ARNL Levee Mile 0.70 American River Treefall Erosion Study Site 1

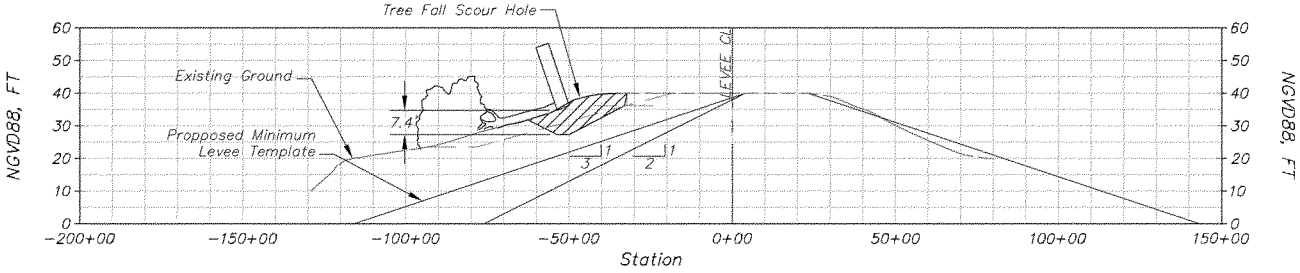
H:1"=40' V:1"=40'

Figure 9a. American River Tree Fall Erosion Site 1



American River Site 1 Section with Treefall

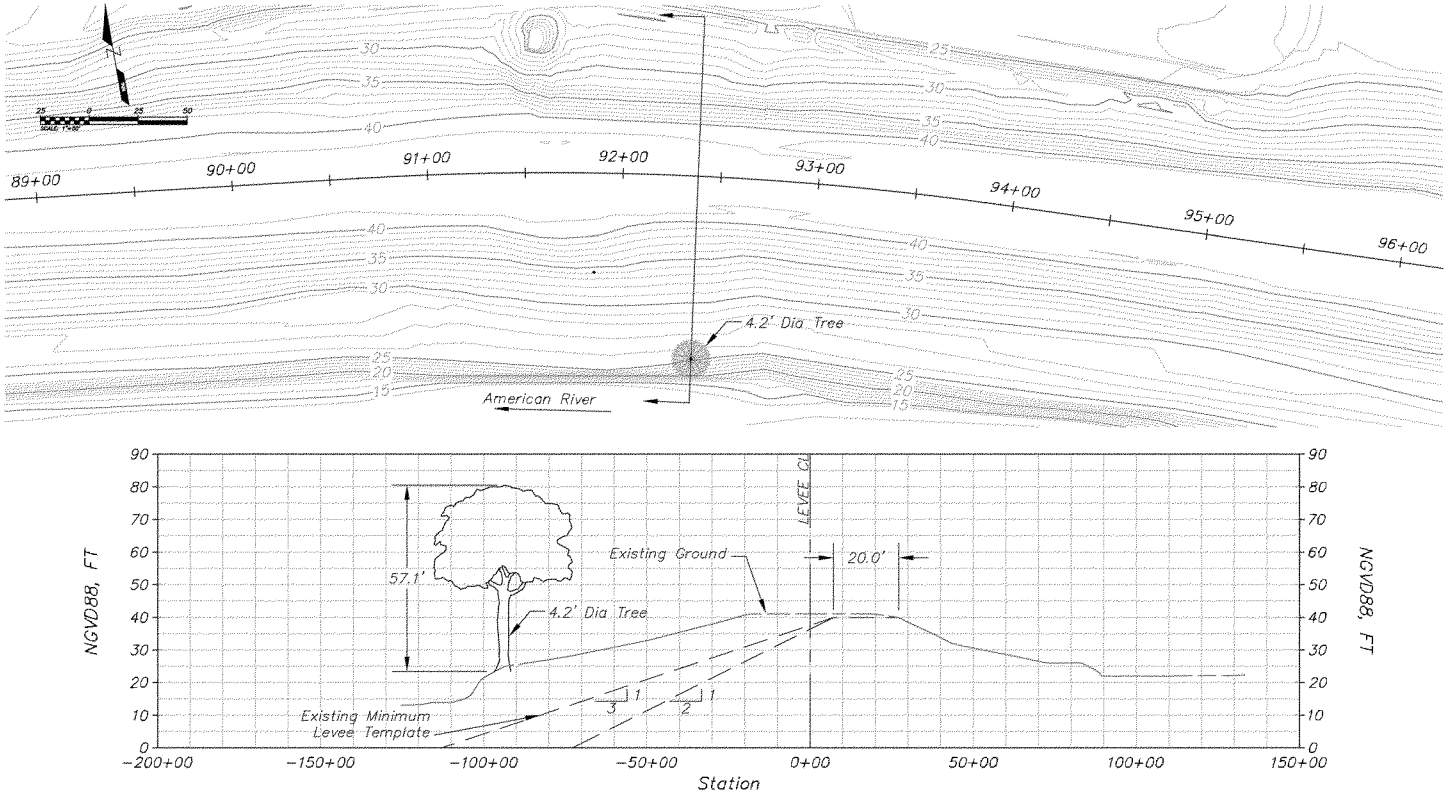
H:1"=30' V:1"=30'



American River Site 1 Section with Treefall Scour Hole

H:1"=30' V:1"=30'

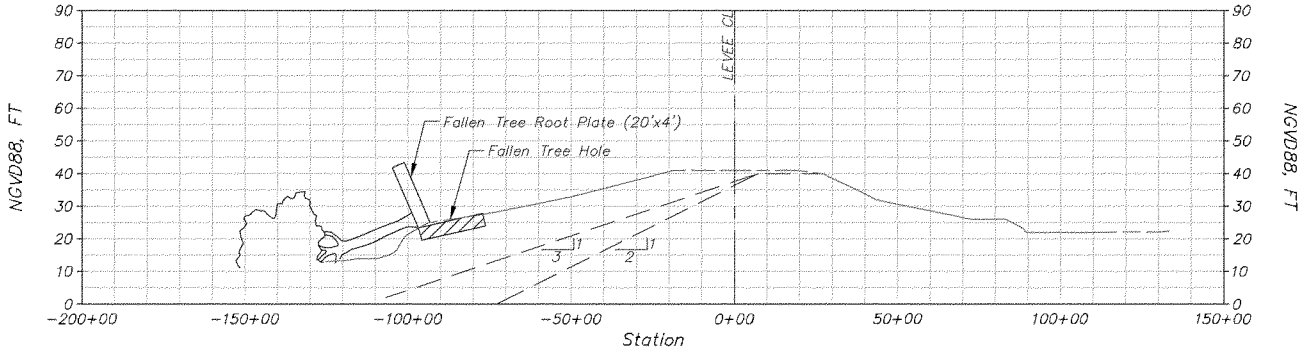
Figure 9b. American River Tree Fall Erosion Site 1



ARNL Levee Mile 1.75-American River Treefall Erosion Site 2

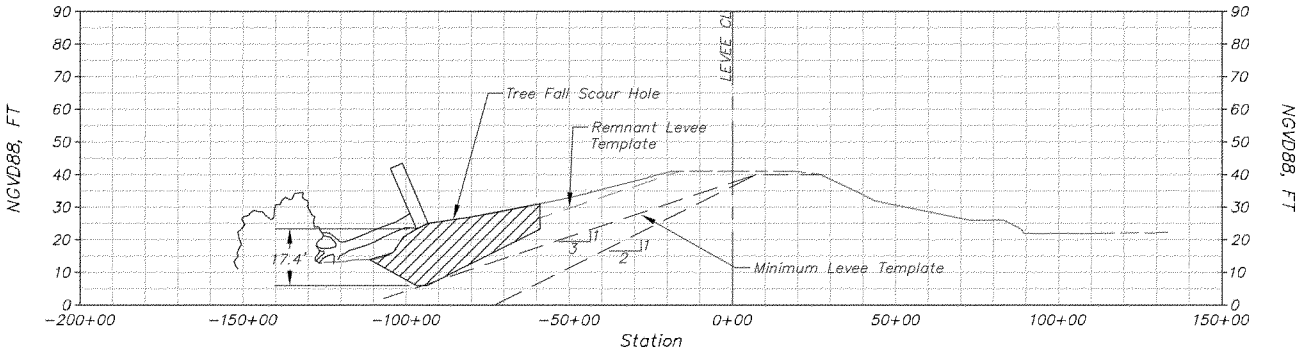
H:1"=30' V:1"=30'

Figure 10a. American River Tree Fall Erosion Site 2



American River Site 2 Section with Treefall

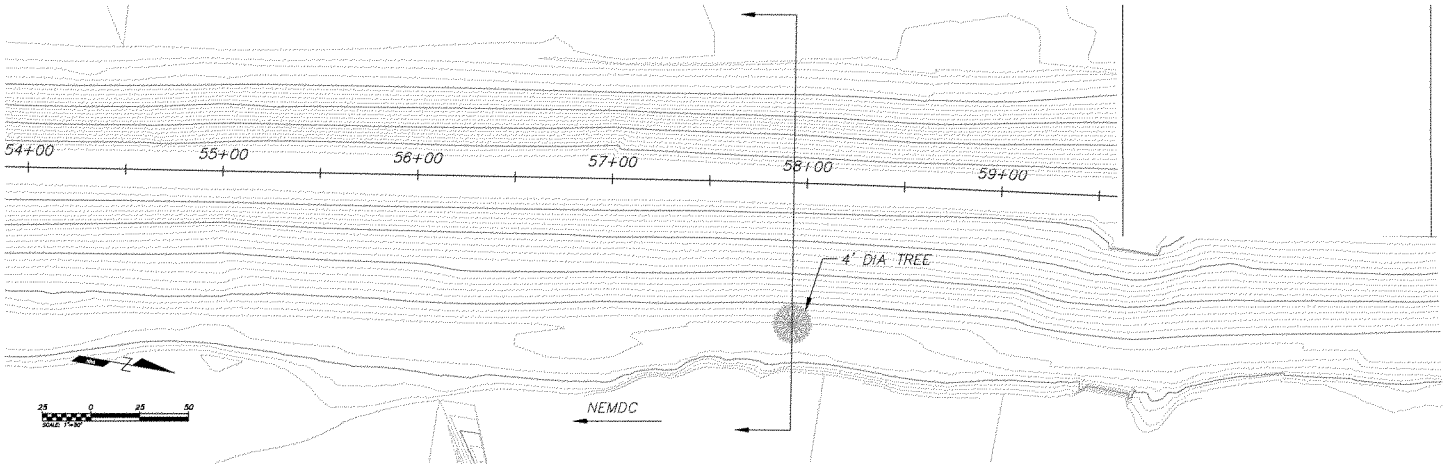
H:1"=30' V:1"=30'

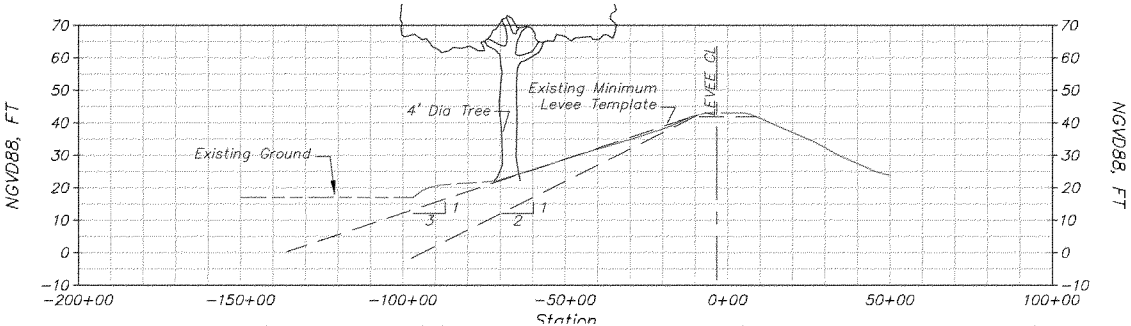


American River Site 2 Section with Treefall Scour Hole

H:1"=30' V:1"=30'

Figure 10b. American River Tree Fall Erosion Site 2

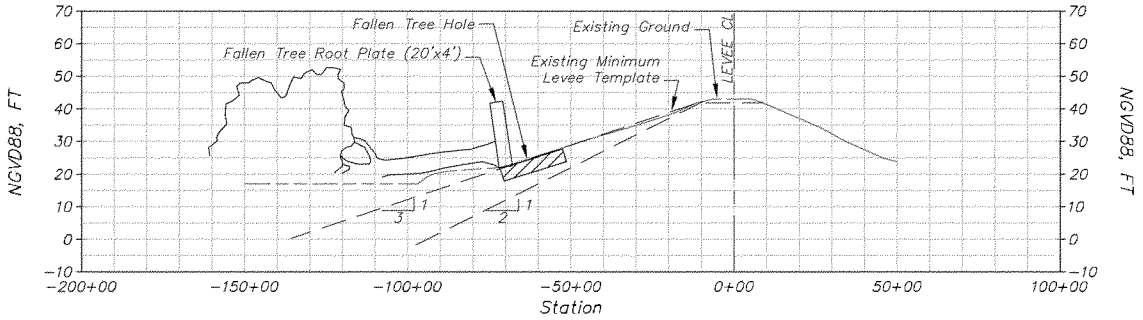




NEMDC Levee Mile 1.3 NEMDC Treefall Erosion Study Site

H:1"=30' V:1"=30'

Figure 11a. NEMDC Tree Fall Erosion Site



NEMDC Site Section with Treefall

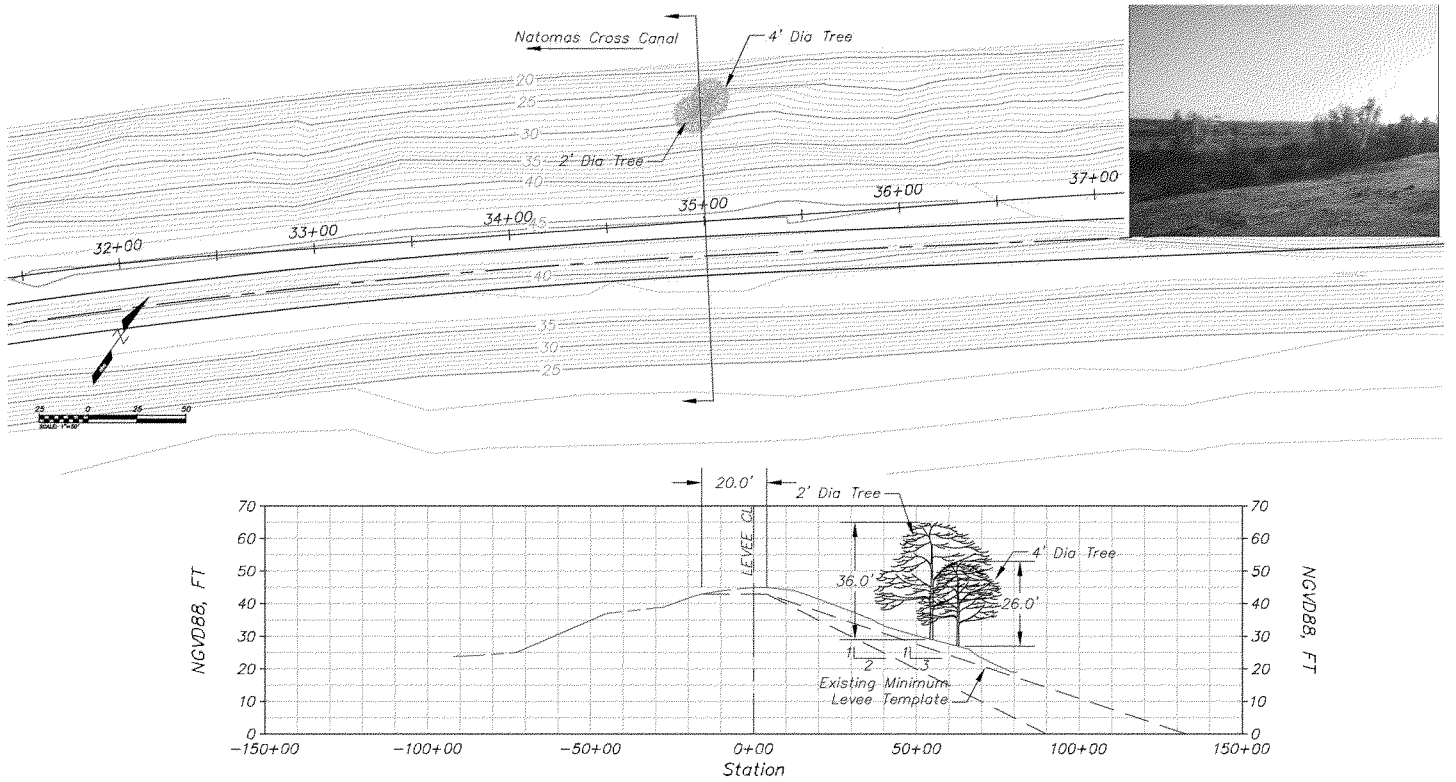
H:1"=30' V:1"=30'



NEMDC Site Section with Treefall Scour Hole

H:1"=30' V:1"=30'

Figure 11b. NEMDC Tree Fall Erosion Site



NCC Levee Mile 3.7-Natomas Cross Canal Treefall Erosion Site

H:1"=30' V:1"=30'

Figure 12a. Natomas Cross Canal Tree Fall Erosion Site

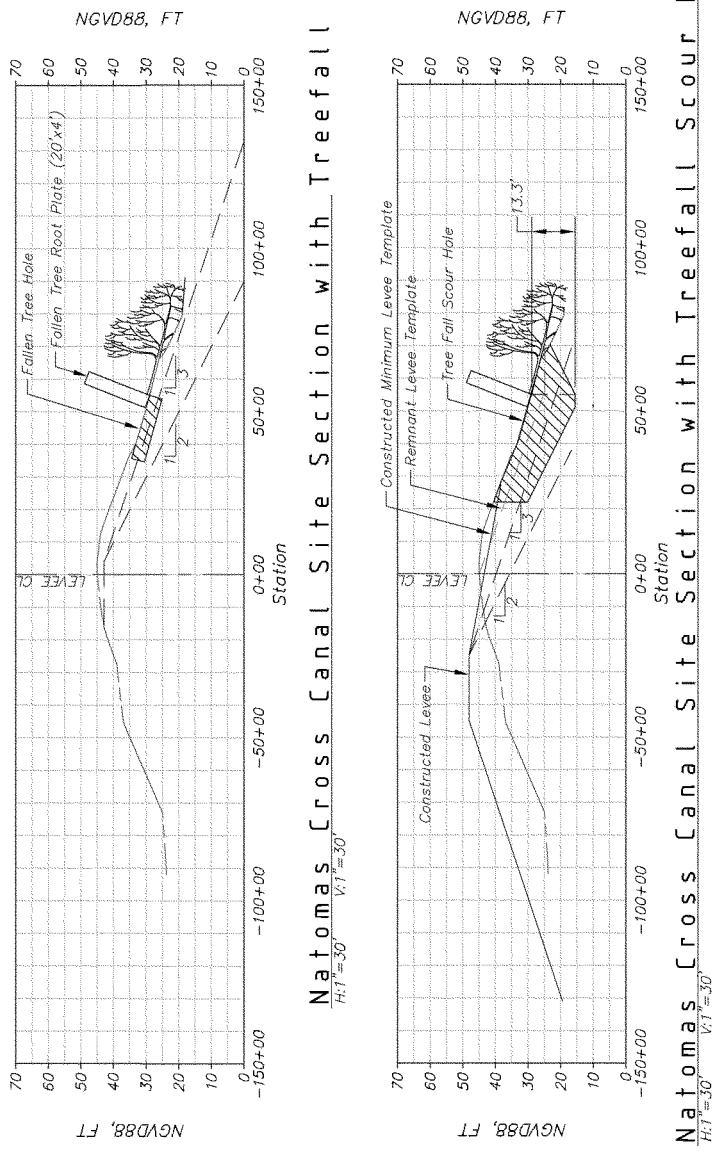


Figure 12b. Natomas Cross Canal Tree Fall Erosion Site

Natomas Levee Improvement Project
Tree-Fall Erosion

nhc
April 2010

Appendix A

Air Photo and Field Reconnaissance Studies

A. TREE FALL OBSERVATIONS

This appendix provides an inventory of fallen trees around the NLIP project area and particularly along the Sacramento River. The terms 'tree fall' and 'fallen tree' are used synonymously in this Appendix and refer to a tree that has fallen onto the bank or into the river and remains there or that has been transported some distance downstream before coming to rest along the bankline.

The tree fall inventory was conducted to:

- Find and document examples of bank scour caused by river flows around fallen trees on the waterside of the levee.
- Characterize the orientation of fallen trees to help develop a typical geometry for fallen trees for bank scour calculations.

The Appendix is divided into two parts: results of an aerial photo and video inventory of tree fall sites and observations made during a limited field inspection.

A.1 Aerial Photo and Video Inventory

NHC documented the location and characteristics of fallen trees on the water side of the levee from:

- the Sacramento River from the Feather River (RM 80) to Freeport (RM 44)
- the Sacramento River at RM 121.15L where there is a known tree fall with local bank scour around the root plate
- the downstream part of the American River from RM 0 to RM 2.5
- the Natomas Cross Canal (NCC)
- the Natomas East Main Drainage Canal (NEMDC)

Fallen trees were identified on Google Earth (air photo dates varied between 2007 and 2009) and video from a helicopter reconnaissance done in August, 2007. The helicopter reconnaissance covered the Sacramento and American River segments listed above but did not cover the NEMDC or the NCC. Table 1 lists the fallen trees; Figure A.1 provides a map of the tree fall locations, except SAC-121.15L which is 40 river miles northeast of the Feather River confluence.

Table 1 Tree Fall Location Descriptions

Site ID[1]	Description	Angle[1]
SAC-46.92L	tree fall on lower bank; tree is laying on the bank and the canopy points upstream	180
SAC-47.71R	a medium sized tree log is on the lower bank and in the water	45
SAC-48.54R	tree laying in water near lower bank	0
SAC-48.95R	tree on lower bank and partially in water	65
SAC-49.26R	tree laying on bank pointing downslope, not in water	80
SAC-49.43R	tree laying on bank, canopy points downslope and upstream	110
SAC-49.92L	tree still partially anchored on low bank but laying in water and pointing toward channel center	90

SAC-49.92R	tree anchored on low bank and partially laying in water pointing toward channel center	90
SAC-50.17R	tree laying on bank, canopy points upstream	180
SAC-50.24R	jumble of trees in river pointing partly downstream	45
SAC-50.35L	large tree trunk and root plate in water at base of slope, root plate points upstream	10
SAC-50.79R	tree anchored on low bank and partially laying in water; canopy pointing downstream	20
SAC-51.85R	a tree trunk is laying on the bank and partially in the water	30
SAC-55.86R	a tree trunk is laying on the bank, partially in the water and the canopy points upstream	150
SAC-58.65R	tree laying on low bank, partially in the water and pointing downstream	10
SAC-63.73L	tree laying on low bank and partially in water; tree23 image from aerial video	90
SAC-63.92L	Assemblage of fallen tree and debris on low bank and partially in water; tree22 image from aerial video	90
SAC-68.61L	tree laying on low bank and partially in water; tree18 image from aerial video	120
SAC-69.03L	tree laying on low bank and partially in water; tree17 image from aerial video	30
SAC-69.12L	tree laying on low bank and partially in water; tree15 image from aerial video	90
SAC-69.21L	tree laying on low bank and partially in water; tree14 image from aerial video	90
SAC-70.02L	tree laying on low bank and partially in water; tree11 image from aerial video	90
SAC-70.23L	tree laying on lower bank and in water; tree9 image from aerial video	90
SAC-71.55L	tree laying in water on lower bank; tree7 image from aerial video	80
SAC-74.63L	tree fall on lower bank and partially in the water; tree6 image from aerial video	80
SAC-79.49L	tree fall on lower bank and partially in the water; tree2 image from aerial video	80
SAC-121.15L	tree fall on lower bank and partially in the water; scour along the lower bank visible in Google Earth	45
AR-0.24R	tree laying on low bank and partially in water; AR_tree3 image from aerial video	80
AR-0.36R	tree laying on low bank and partially in water; first tree in AR_tree4 image from aerial video	45
AR-0.37R	tree laying on low bank and partially in water; second tree in AR_tree4 image from aerial video	45
AR-1.07R	3 trees laying on low bank and partially in water; AR_tree6 image from aerial video	90
AR-1.19R	tree laying on low bank and partially in water; AR_tree7 image from aerial video	90
AR-2.46R	tree laying on low bank and partially in water; AR_tree9 image from aerial video	90
NCC-192+00L	tree fall on Natomas Cross Canal with large exposed root plate	90

1 – these terms are defined below

The 'Site ID' column in Table 1 describes the location of the fallen tree: 'SAC' refers to sites on the Sacramento River, 'AR' to the American River, and 'NCC' to the Natomas Cross Canal. The Site ID also includes river miles for fallen trees, referenced to 1:24,000 scale U.S. Geological Survey topographic maps, except for the Natomas Cross Canal which is referenced to the NLIP baseline stationing. The letters 'L' or 'R' refer to the left or right bank when looking downstream. The 'Angle' column in Table 1 is in degrees and refers to the angle of the fallen tree trunk relative to the bankline. Zero degrees means the tree trunk is aligned along the bank with the crown pointing downstream and 180 degrees means the crown points upstream. An angle of 90 degrees means the crown points toward the middle of the channel.

NHC observed 34 fallen trees over approximately 35 river miles, or 70 miles of bankline. 30 tree falls were partially submerged whereas 4 were higher on the bank. The average angle of tree falls in the water was 66 degrees; essentially, their crowns pointed toward the channel center and somewhat downstream. Of the fallen trees in the water, only two had their crowns pointing upstream. The average angle of the 4 dry tree falls higher on bank was 115 degrees, pointing generally downslope toward the channel but also upstream. It is thought that prevailing southerly winds during winter storms may have caused wind throw towards the north (generally upstream) whereas trees that fall into the river are partially rotated downstream by the current.

A.2 Field Inspection

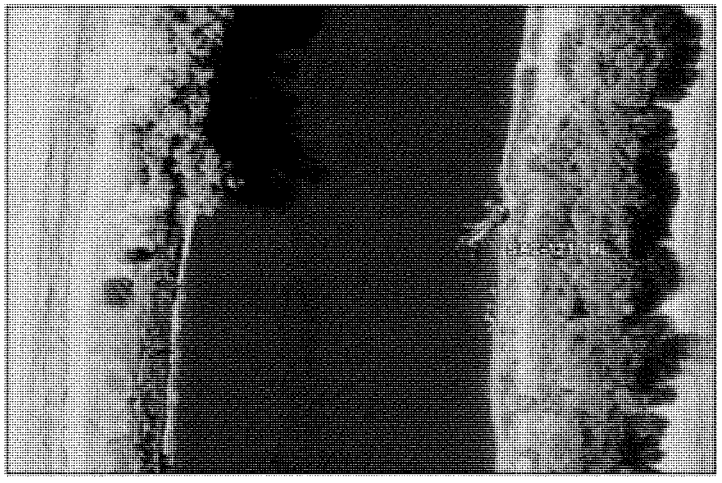
NHC inspected fallen trees at the following sites:

- SAC-121.15L – This was the only site in the inventory that showed obvious local bank scour around the root plate of a fallen tree.
- SAC-50.35L – This was a partially submerged, large tree fall with an exposed root plate on the lower bank. We measured velocities around the root plate and trunk of this fallen tree.
- NCC-3.64L – This site had the largest exposed root plate and root pit in the inventory.

A description and photographs of each site visited during the field inspection are provided below.

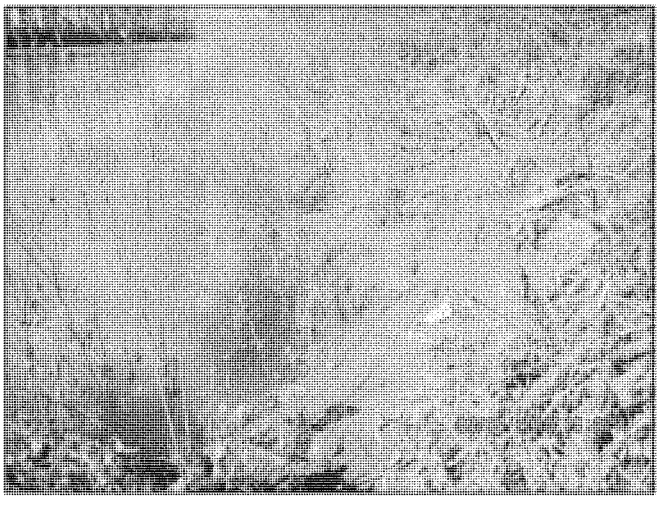
Site SAC-121.15L

The Google Earth aerial photo for this site was dated June 2007. It showed a large fallen tree with an exposed root plate on the lower bank. A scallop or indentation in the bankline indicated local erosion around the root plate. The scoured area was 45 feet long and 5 to 10 feet wide in the 2007 aerial photo, shown below.

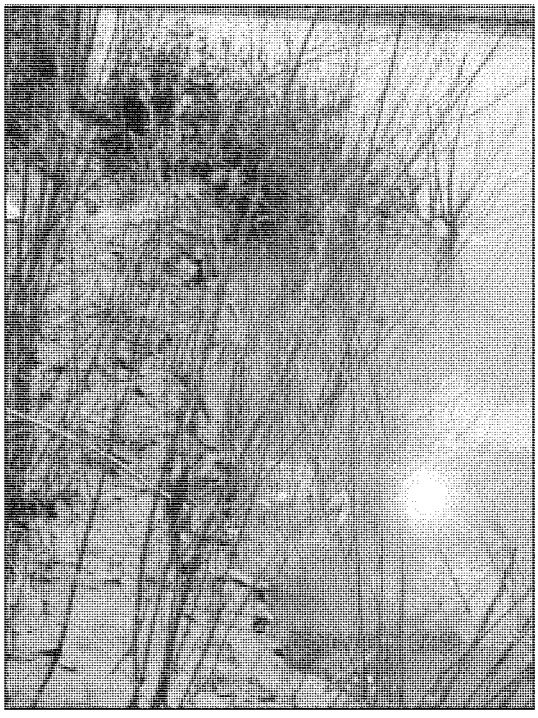


2007 aerial photo of tree fall site SAC-121.19L

The site was visited on 4 March, 2010. The fallen tree was submerged except for part of the crown. The eroded area along the bank measured about 25 feet long by 4 feet wide. Bank materials consisted of unconsolidated fine to medium sand. Photographs of the site are provided below.



2010 field inspection photo at tree fall site SAC-121.19L
Looking upstream at local bank erosion next to fallen tree



2010 field inspection photo at tree fall site SAC-121.19L
Looking downstream at local bank erosion next to fallen tree

Site SAC-50.35L
NHC collected stream velocity measurements at this tree fall site. The tree was partially submerged and parallel to the bankline with the root plate pointing upstream.



2010 field inspection photo at tree fall site SAC-50.35L
Looking upstream at fallen tree with exposed root plate



2010 field inspection photo at tree fall site SAC-50.35L
Looking at exposed root plate

Site NCC-192+00L

NHC was made aware of this tree fall site on the Natomas Cross Canal by John Downs of AECOM on February 19, 2010. He sent the following photo showing a large tree fall and

exposed root plate. This is the largest root plate exposure NHC identified during the tree fall inventory.



February 2010 ground photo of exposed root plate at tree fall site NCC-192+00L

NHC visited this site on March 4th, 2010 but was unable to measure the size of the root plate due to higher water levels. We estimated the size of the root plate to be approximately 6 feet high and 15 feet wide at the time of the site visit.



March 4, 2010 ground photo at tree fall site NCC-192+00L
High water levels prevented closer access

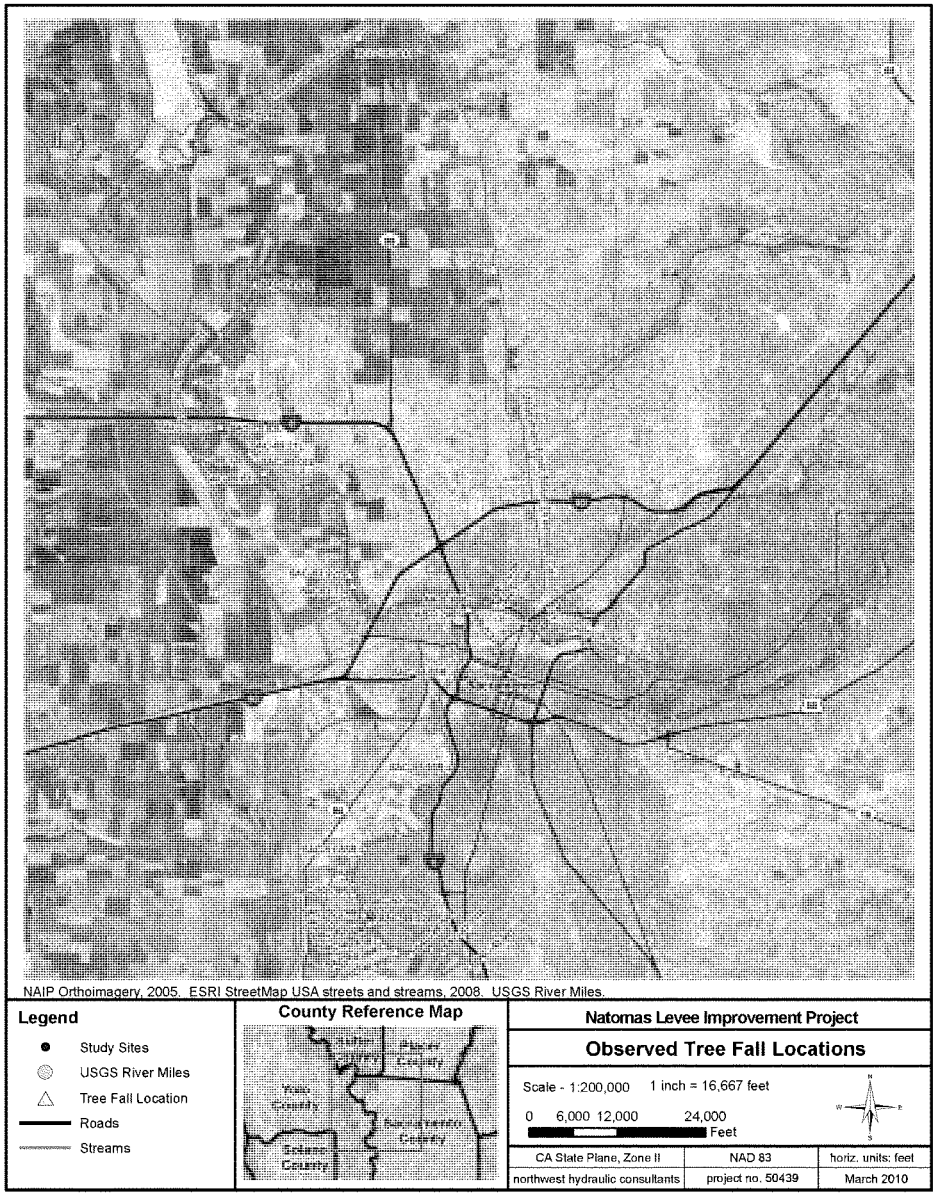
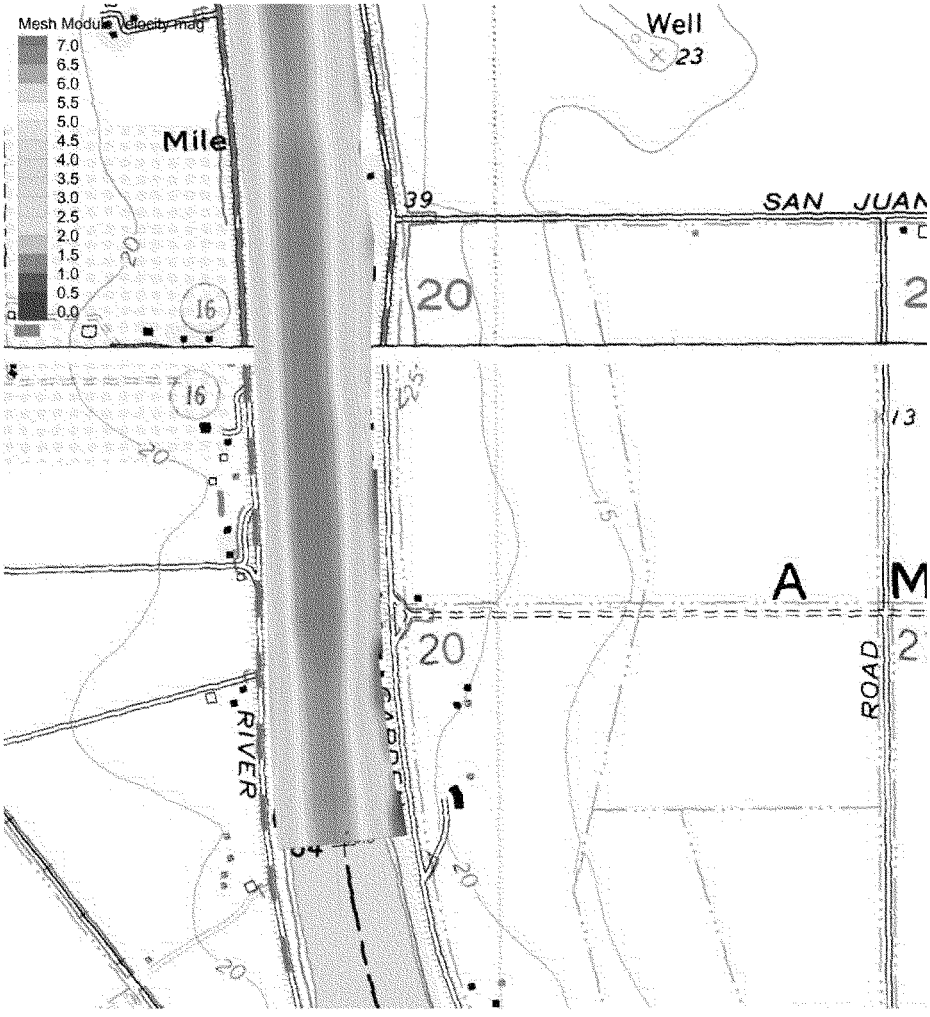


Figure A.1 - Observed Tree Fall Locations

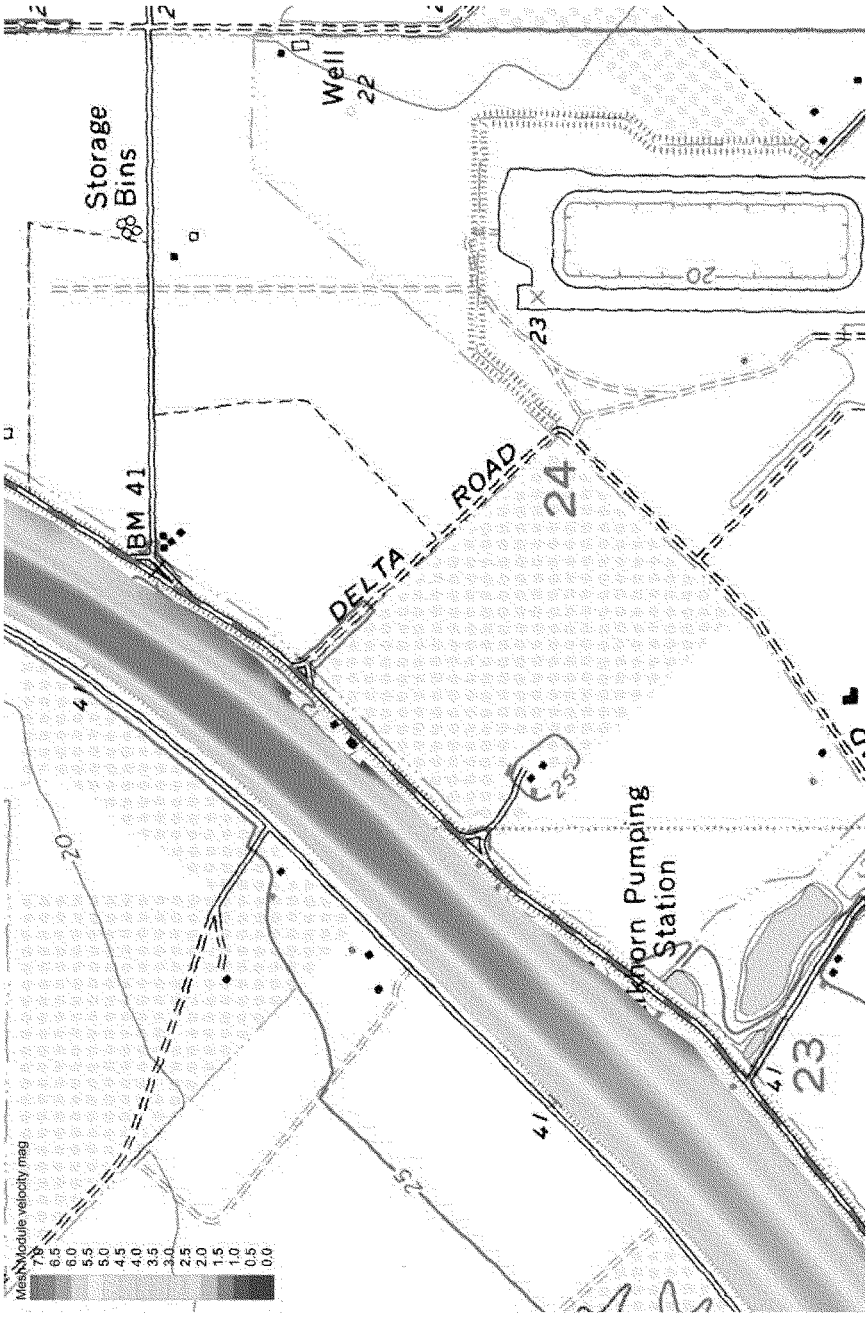
Appendix B

Velocities in the Vicinity of the Study Sites

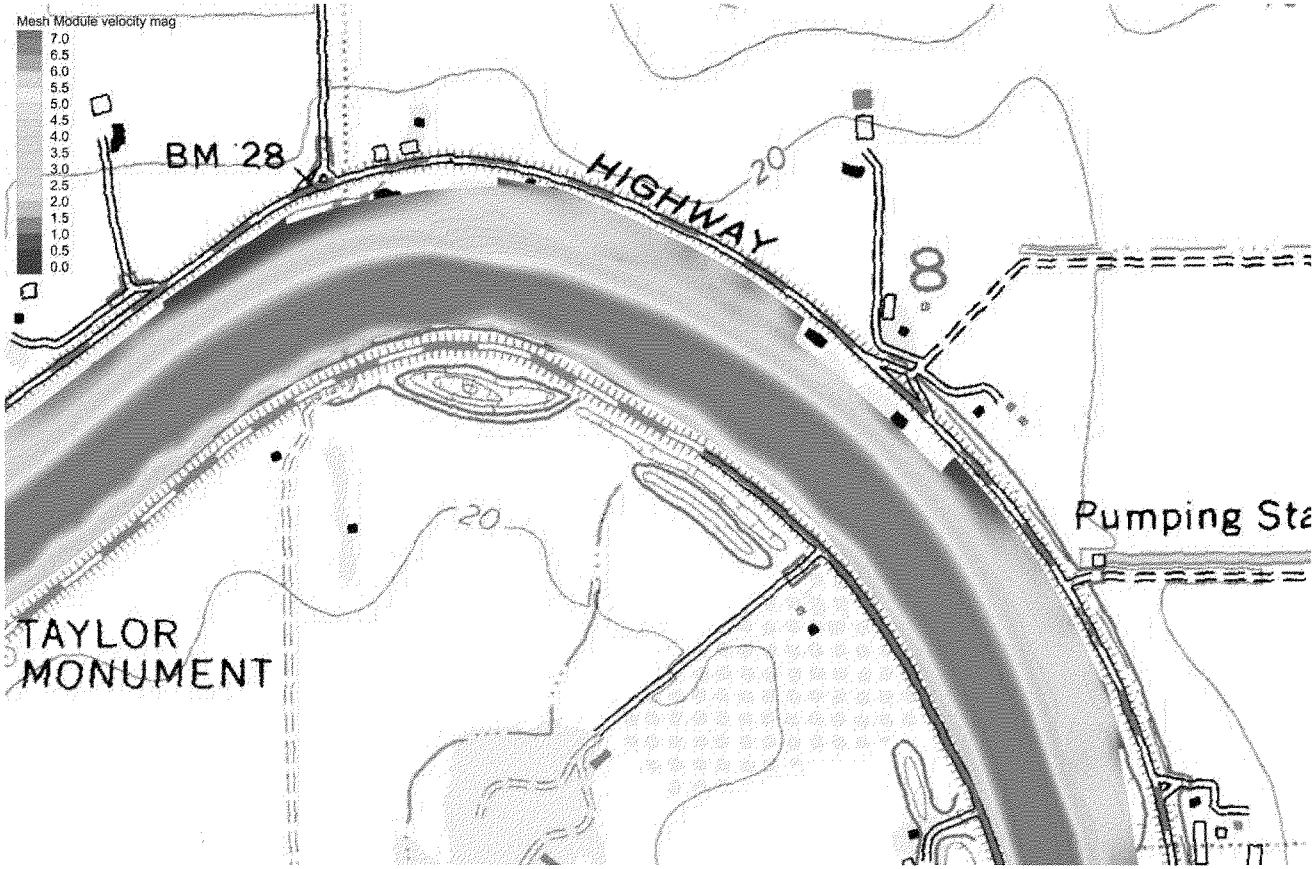
200-Year Velocity Profile at study Site Sac_1. Model results provided by MBK Engineers



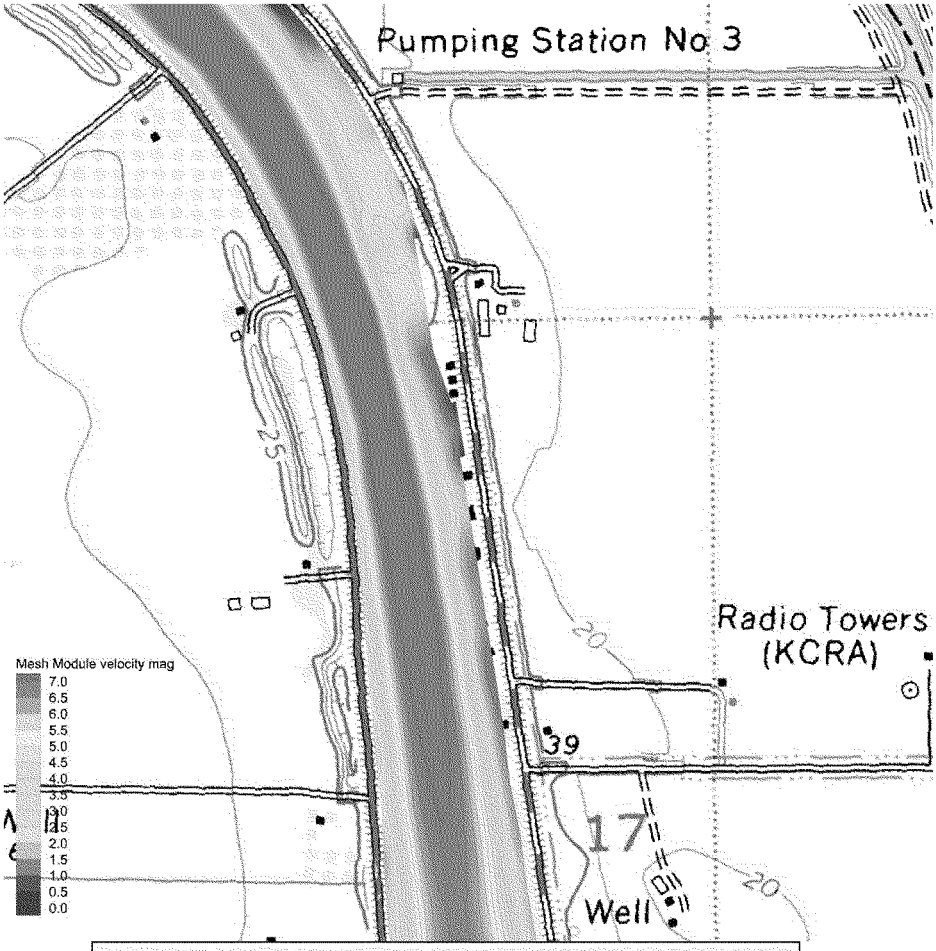
200-Year Velocity Profile at study site Sac_2. Model results provided by MBK Engineers



200-Year Velocity Profile at study Site Sac_3. Model results provided by MBK Engineers



200-Year Velocity Profile at study Site Sac_4. Model results provided by MBK Engineers



200-Year Velocity Profile at study site Sac_5. Model results provided by MBK Engineers



100-Year Velocity Profile at *NEMDC*. Model results provided by MBK Engineers

Lower American River - Velocity Contours
115,000 cfs
RM 1
RM 2
AYRES
ASSOCIATES
PLATE 2

Appendix C
Scour Calculations for Variable Hydraulic Conditions

This appendix provides spreadsheet calculations for scour depths based on HEC-RAS model output provided by the USACE. Although the cross-sections are not necessarily at the same site as our erosion analysis, the expected elevation of the trees were adjusted to maintain a consistent depth at the 200-year water elevation as was expected at the individual study site (Table 5 and 6 of main text). The purpose of this exercise is to ensure that our depth and velocity values provide reasonable estimates of the maximum cases.

With the exception of the NEMDC channel, all of our computed scour depths provided in the main text are greater than those computed in the following tables. Our combinations of velocities and depths generally exceed those found as a result of this modeling exercise as well. Although the NEMDC scour computed here is slightly higher than the values reported in Tables 5 and 6, the velocity and depth values are well within the ranges of input variables used in our Monte Carlo simulation. Our NEMDC study site is also expected to be about 0.5 miles upstream of this cross-section location, lending some uncertainty to the values reported in the cross-section.

Below is a key to each of the column headers in the following spreadsheets; the coefficients pertain to those described in the Section 4 of the main text. The scour calculations used in this exercise assumed a root plate which was 4 feet wide, 20 feet long, and 20 feet wide oriented at 24 degrees to the flow. The column headers are defined as follows:

River	Name of river or canal the model results are from
Reach	Name of the reach modeled in HEC-RAS
River Sta	River Mile of the Cross-Section in HEC-RAS
Profile	Name of the profile outputted from HEC-RAS
Plan	Name of the plan modeled in HEC-RAS. The name provides the frequency of both the tailwater condition and the discharge in the tributary, (*i.e.* "002SACWPRJ-200T", Sac River was at a 2-yr water surface elevation while the tributary had a concurrent 200-yr discharge).
Q Total	Total flow through the cross-section when output was printed from HEC-RAS
Min Ch El	Minimum Channel Elevation in HEC-RAS
W.S. Elev	Water surface elevation outputted from HEC-RAS
Vel Chnl	The average channel velocity from HEC-RAS
Frctn Slope	The friction slope outputted from HEC-RAS
Vel-Tree	The velocity at the depth where the base of the rootplate is expected to be.
Depth-Tree	The depth of rootplate beneath the water surface
K1	Pier shape correction factor for scour computation
K2	Angle of flow correction factor for scour computation

Kya	The depth-pier size coefficient for scour computation
KI	Flow intensity coefficient for scour computation
ds	Scour depth without accounting for time coefficient
te	Computed duration in days required for scour hole required to reach equilibrium
Kt	Duration coefficient which adjusts the scour depth for duration
*ds*Kt*	Duration adjusted scour depth.

HEC-RAS OUTPUT										Scour Computations										
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Frctn Slope (ft/ft)	Vel-Tree m/s	Vel fps	Depth-Tree m	Depth Tree ft	K1	K2	Kya	Kl	ds (ft)	te	Kt	ds*Kt (ft)
Cross Canal	Main	0.27	Max WS	002SACWPRJ-2T	1330.14	12.28	33.51	0.17	3.60E-05	0.18	0.59	1.07	3.51	1.1	2.01	2.27	0.22	3.68	0.00	0.08	0.29
Cross Canal	Main	0.27	Max WS	002SACWPRJ-10T	3506.64	12.28	33.61	0.44	3.70E-05	0.19	0.61	1.10	3.61	1.1	2.01	2.30	0.23	3.86	0.00	0.08	0.31
Cross Canal	Main	0.27	Max WS	002SACWPRJ-25T	5706.59	12.28	33.68	0.71	3.90E-05	0.19	0.63	1.12	3.68	1.1	2.01	2.32	0.24	4.05	0.00	0.08	0.32
Cross Canal	Main	0.27	Max WS	002SACWPRJ-50T	7419.58	12.28	33.73	0.92	4.10E-05	0.20	0.65	1.14	3.73	1.1	2.01	2.34	0.25	4.22	0.00	0.08	0.34
Cross Canal	Main	0.27	Max WS	002SACWPRJ-100T	9457.77	12.28	33.77	1.17	4.40E-05	0.21	0.68	1.15	3.77	1.1	2.01	2.35	0.26	4.43	0.00	0.08	0.35
Cross Canal	Main	0.27	Max WS	002SACWPRJ-200T	11677.46	12.28	33.82	1.44	4.60E-05	0.21	0.70	1.16	3.82	1.1	2.01	2.36	0.27	4.60	0.00	0.08	0.37
Cross Canal	Main	0.27	Max WS	010SACWPRJ-2T	706.25	12.28	36.15	0.08	4.30E-05	0.28	0.93	1.87	6.15	1.1	2.01	2.88	0.36	7.44	0.00	0.08	0.60
Cross Canal	Main	0.27	Max WS	010SACWPRJ-10T	1813.16	12.28	36.16	0.2	4.50E-05	0.29	0.96	1.88	6.16	1.1	2.01	2.88	0.36	7.62	0.00	0.08	0.61
Cross Canal	Main	0.27	Max WS	010SACWPRJ-25T	2858.95	12.28	36.19	0.31	4.60E-05	0.30	0.97	1.89	6.19	1.1	2.01	2.88	0.37	7.73	0.00	0.08	0.62
Cross Canal	Main	0.27	Max WS	010SACWPRJ-50T	3570.69	12.28	36.21	0.39	4.70E-05	0.30	0.98	1.89	6.21	1.1	2.01	2.88	0.37	7.83	0.00	0.08	0.63
Cross Canal	Main	0.27	Max WS	010SACWPRJ-100T	4433.84	12.28	36.23	0.48	4.80E-05	0.30	1.00	1.90	6.23	1.1	2.01	2.88	0.38	7.93	0.00	0.08	0.63
Cross Canal	Main	0.27	Max WS	010SACWPRJ-200T	4433.84	12.28	36.23	0.48	4.80E-05	0.30	1.00	1.90	6.23	1.1	2.01	2.88	0.38	7.93	0.00	0.08	0.63
Cross Canal	Main	0.27	Max WS	025SACWPRJ-2T	456.87	12.28	38.07	0.05	4.10E-05	0.33	1.09	2.46	8.07	1.1	2.01	2.88	0.42	8.71	0.00	0.08	0.70
Cross Canal	Main	0.27	Max WS	025SACWPRJ-10T	1022.79	12.28	38.09	0.1	4.10E-05	0.33	1.10	2.47	8.09	1.1	2.01	2.88	0.42	8.72	0.00	0.08	0.70
Cross Canal	Main	0.27	Max WS	025SACWPRJ-25T	1444.36	12.28	38.11	0.14	4.20E-05	0.34	1.11	2.47	8.11	1.1	2.01	2.88	0.42	8.84	0.00	0.08	0.71
Cross Canal	Main	0.27	Max WS	025SACWPRJ-50T	1687.02	12.28	38.12	0.17	4.20E-05	0.34	1.11	2.47	8.12	1.1	2.01	2.88	0.42	8.85	0.00	0.08	0.71
Cross Canal	Main	0.27	Max WS	025SACWPRJ-100T	1936.93	12.28	38.12	0.19	4.20E-05	0.34	1.11	2.47	8.12	1.1	2.01	2.88	0.42	8.85	0.00	0.08	0.71
Cross Canal	Main	0.27	Max WS	025SACWPRJ-200T	2175	12.28	38.13	0.22	4.20E-05	0.34	1.11	2.48	8.13	1.1	2.01	2.88	0.42	8.85	0.00	0.08	0.71
Cross Canal	Main	0.27	Max WS	050SACWPRJ-2T	3599.24	12.28	38.9	0.35	4.40E-05	0.37	1.21	2.71	8.90	1.1	2.01	2.88	0.46	9.63	0.00	0.08	0.77
Cross Canal	Main	0.27	Max WS	050SACWPRJ-10T	1951.85	12.28	38.86	0.19	4.20E-05	0.36	1.18	2.70	8.86	1.1	2.01	2.88	0.45	9.38	0.00	0.08	0.75
Cross Canal	Main	0.27	Max WS	050SACWPRJ-25T	2949.69	12.28	38.89	0.29	4.30E-05	0.36	1.19	2.71	8.89	1.1	2.01	2.88	0.46	9.51	0.00	0.08	0.76
Cross Canal	Main	0.27	Max WS	050SACWPRJ-50T	3599.24	12.28	38.9	0.35	4.40E-05	0.37	1.21	2.71	8.90	1.1	2.01	2.88	0.46	9.63	0.00	0.08	0.77
Cross Canal	Main	0.27	Max WS	050SACWPRJ-100T	4330.61	12.28	38.92	0.42	4.40E-05	0.37	1.21	2.72	8.92	1.1	2.01	2.88	0.46	9.64	0.00	0.08	0.77
Cross Canal	Main	0.27	Max WS	050SACWPRJ-200T	5233.98	12.28	38.94	0.51	4.50E-05	0.37	1.23	2.72	8.94	1.1	2.01	2.88	0.47	9.76	0.00	0.08	0.78
Cross Canal	Main	0.27	Max WS	100SACWPRJ-2T	735.4	12.28	39.82	0.07	4.20E-05	0.38	1.26	2.99	9.82	1.1	2.01	2.88	0.48	10.04	0.00	0.08	0.80
Cross Canal	Main	0.27	Max WS	100SACWPRJ-10T	1843.66	12.28	39.86	0.17	4.30E-05	0.39	1.28	3.01	9.86	1.1	2.01	2.88	0.49	10.19	0.00	0.08	0.82
Cross Canal	Main	0.27	Max WS	100SACWPRJ-25T	2788.66	12.28	39.88	0.26	4.30E-05	0.39	1.28	3.01	9.88	1.1	2.01	2.88	0.49	10.20	0.00	0.08	0.82
Cross Canal	Main	0.27	Max WS	100SACWPRJ-50T	2801.66	12.28	39.88	0.26	4.30E-05	0.39	1.28	3.01	9.88	1.1	2.01	2.88	0.49	10.20	0.00	0.08	0.82
Cross Canal	Main	0.27	Max WS	100SACWPRJ-100T	4011.27	12.28	39.91	0.37	4.40E-05	0.40	1.30	3.02	9.91	1.1	2.01	2.88	0.50	10.34	0.00	0.08	0.83
Cross Canal	Main	0.27	Max WS	100SACWPRJ-200T	4670.38	12.28	39.93	0.43	4.50E-05	0.40	1.32	3.03	9.93	1.1	2.01	2.88	0.50	10.47	11.80	0.90	9.45
Cross Canal	Main	0.27	Max WS	200SACWPRJ-2T	578.19	12.28	41.16	0.05	4.10E-05	0.41	1.36	3.40	11.16	1.1	2.01	2.88	0.52	10.81	13.63	0.89	9.59
Cross Canal	Main	0.27	Max WS	200SACWPRJ-10T	1888.32	12.28	41.19	0.17	4.20E-05	0.42	1.38	3.41	11.19	1.1	2.01	2.88	0.52	10.96	14.27	0.88	9.68
Cross Canal	Main	0.27	Max WS	200SACWPRJ-25T	2943.89	12.28	41.21	0.26	4.30E-05	0.43	1.39	3.42	11.21	1.1	2.01	2.88	0.53	11.10	14.87	0.88	9.77
Cross Canal	Main	0.27	Max WS	200SACWPRJ-50T	3597.79	12.28	41.22	0.32	4.30E-05	0.43	1.40	3.42	11.22	1.1	2.01	2.88	0.53	11.11	14.90	0.88	9.77
Cross Canal	Main	0.27	Max WS	200SACWPRJ-100T	3597.79	12.28	41.22	0.32	4.30E-05	0.43	1.40	3.42	11.22	1.1	2.01	2.88	0.53	11.11	14.90	0.88	9.77
Cross Canal	Main	0.27	Max WS	200SACWPRJ-200T	5064.84	12.28	41.25	0.45	4.40E-05	0.43	1.41	3.43	11.25	1.1	2.01	2.88	0.54	11.25	15.51	0.88	9.87

HEC-RAS OUTPUT										Scour Computations											
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Frctn Slope (ft/ft)	Vel-Tree m/s	Vel fps	Depth-Tree m	Depth Tree ft	K1	K2	Kya	Ki	ds (ft)	te	Kt	ds*Kt (ft)
Cross Canal	Main	1.07	Max WS	002SACWPRJ-2T	1328.89	10.8	33.52	0.15	0.00E+00	0.00	0.00	1.07	3.52	1.1	2.01	2.27	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	002SACWPRJ-10T	3590.44	10.8	33.61	0.41	1.00E-06	0.03	0.10	1.10	3.61	1.1	2.01	2.30	0.04	0.63	0.00	0.08	0.05
Cross Canal	Main	1.07	Max WS	002SACWPRJ-25T	6331.98	10.8	33.7	0.71	4.00E-06	0.06	0.20	1.13	3.70	1.1	2.01	2.33	0.08	1.31	0.00	0.08	0.10
Cross Canal	Main	1.07	Max WS	002SACWPRJ-50T	8654.19	10.8	33.76	0.97	8.00E-06	0.09	0.29	1.15	3.76	1.1	2.01	2.35	0.11	1.88	0.00	0.08	0.15
Cross Canal	Main	1.07	Max WS	002SACWPRJ-100T	11274.73	10.8	33.82	1.26	1.40E-05	0.12	0.39	1.16	3.82	1.1	2.01	2.36	0.15	2.54	0.00	0.08	0.20
Cross Canal	Main	1.07	Max WS	002SACWPRJ-200T	13553.6	10.8	33.9	1.51	2.00E-05	0.14	0.47	1.19	3.90	1.1	2.01	2.39	0.18	3.11	0.00	0.08	0.25
Cross Canal	Main	1.07	Max WS	010SACWPRJ-2T	706.3	10.8	36.15	0.07	0.00E+00	0.00	0.00	1.87	6.15	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	010SACWPRJ-10T	1820.83	10.8	36.16	0.18	0.00E+00	0.00	0.00	1.88	6.16	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	010SACWPRJ-25T	2902.72	10.8	36.19	0.29	1.00E-06	0.04	0.14	1.89	6.19	1.1	2.01	2.88	0.05	1.14	0.00	0.08	0.09
Cross Canal	Main	1.07	Max WS	010SACWPRJ-50T	3674.93	10.8	36.21	0.37	1.00E-06	0.04	0.14	1.89	6.21	1.1	2.01	2.88	0.05	1.14	0.00	0.08	0.09
Cross Canal	Main	1.07	Max WS	010SACWPRJ-100T	6066.21	10.8	36.23	0.61	2.00E-06	0.06	0.20	1.90	6.23	1.1	2.01	2.88	0.08	1.62	0.00	0.08	0.13
Cross Canal	Main	1.07	Max WS	010SACWPRJ-200T	6066.21	10.8	36.23	0.61	2.00E-06	0.06	0.20	1.90	6.23	1.1	2.01	2.88	0.08	1.62	0.00	0.08	0.13
Cross Canal	Main	1.07	Max WS	025SACWPRJ-2T	454.51	10.8	38.07	0.04	0.00E+00	0.00	0.00	2.46	8.07	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	025SACWPRJ-10T	1020.23	10.8	38.09	0.09	0.00E+00	0.00	0.00	2.47	8.09	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	025SACWPRJ-25T	1443.65	10.8	38.11	0.13	0.00E+00	0.00	0.00	2.47	8.11	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	025SACWPRJ-50T	1685.74	10.8	38.12	0.16	0.00E+00	0.00	0.00	2.47	8.12	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	025SACWPRJ-100T	1937.59	10.8	38.12	0.18	0.00E+00	0.00	0.00	2.47	8.12	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	025SACWPRJ-200T	2175.01	10.8	38.13	0.2	0.00E+00	0.00	0.00	2.48	8.13	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	050SACWPRJ-2T	3633.16	10.8	38.91	0.32	1.00E-06	0.06	0.18	2.72	8.91	1.1	2.01	2.88	0.07	1.45	0.00	0.08	0.12
Cross Canal	Main	1.07	Max WS	050SACWPRJ-10T	1955.34	10.8	38.86	0.17	0.00E+00	0.00	0.00	2.70	8.86	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	050SACWPRJ-25T	2964.31	10.8	38.89	0.26	0.00E+00	0.00	0.00	2.71	8.89	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	050SACWPRJ-50T	3633.16	10.8	38.91	0.32	1.00E-06	0.06	0.18	2.72	8.91	1.1	2.01	2.88	0.07	1.45	0.00	0.08	0.12
Cross Canal	Main	1.07	Max WS	050SACWPRJ-100T	4391.22	10.8	38.92	0.39	1.00E-06	0.06	0.18	2.72	8.92	1.1	2.01	2.88	0.07	1.45	0.00	0.08	0.12
Cross Canal	Main	1.07	Max WS	050SACWPRJ-200T	5432.67	10.8	38.94	0.48	2.00E-06	0.08	0.26	2.72	8.94	1.1	2.01	2.88	0.10	2.06	0.00	0.08	0.16
Cross Canal	Main	1.07	Max WS	100SACWPRJ-2T	735.36	10.8	39.82	0.06	0.00E+00	0.00	0.00	2.99	9.82	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	100SACWPRJ-10T	1849.1	10.8	39.86	0.16	0.00E+00	0.00	0.00	3.01	9.86	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	100SACWPRJ-25T	2801.01	10.8	39.88	0.24	0.00E+00	0.00	0.00	3.01	9.88	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	100SACWPRJ-50T	2810.91	10.8	39.88	0.24	0.00E+00	0.00	0.00	3.01	9.88	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	100SACWPRJ-100T	4051.86	10.8	39.91	0.35	1.00E-06	0.06	0.20	3.02	9.91	1.1	2.01	2.88	0.07	1.56	0.00	0.08	0.12
Cross Canal	Main	1.07	Max WS	100SACWPRJ-200T	4739.93	10.8	39.93	0.41	1.00E-06	0.06	0.20	3.03	9.93	1.1	2.01	2.88	0.07	1.56	0.00	0.08	0.12
Cross Canal	Main	1.07	Max WS	200SACWPRJ-2T	572.59	10.8	41.16	0.05	0.00E+00	0.00	0.00	3.40	11.16	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	200SACWPRJ-10T	1888.43	10.8	41.19	0.15	0.00E+00	0.00	0.00	3.41	11.19	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	200SACWPRJ-25T	2943.43	10.8	41.21	0.24	0.00E+00	0.00	0.00	3.42	11.21	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.07	Max WS	200SACWPRJ-50T	3601.03	10.8	41.23	0.29	1.00E-06	0.06	0.21	3.42	11.23	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	1.07	Max WS	200SACWPRJ-100T	3601.03	10.8	41.23	0.29	1.00E-06	0.06	0.21	3.42	11.23	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	1.07	Max WS	200SACWPRJ-200T	5076.11	10.8	41.26	0.41	1.00E-06	0.07	0.21	3.43	11.26	1.1	2.01	2.88	0.08	1.70	0.00	0.08	0.14

HEC-RAS OUTPUT										Scour Computations												
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Frctn Slope (ft/ft)	Vel-Tree m/s	Vel fps	Depth-Tree m	Depth Tree ft	K1	K2	Kya	Ki	ds (ft)	te	Kt	ds*Kt (ft)
Cross Canal	Main	1.99	Max WS	002SACWPRJ-2T	1328.9	10.8	33.52	0.14	0.00E+00	0.00	0.00	1.07	3.52	1.1	2.01	2.27	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	002SACWPRJ-10T	3749.7	10.8	33.62	0.4	2.00E-06	0.04	0.14	1.10	3.62	1.1	2.01	2.30	0.05	0.90	0.00	0.08	0.07
Cross Canal	Main	1.99	Max WS	002SACWPRJ-25T	7770.62	10.8	33.74	0.83	7.00E-06	0.08	0.27	1.14	3.74	1.1	2.01	2.34	0.10	1.75	0.00	0.08	0.14
Cross Canal	Main	1.99	Max WS	002SACWPRJ-50T	10332.87	10.8	33.83	1.1	1.20E-05	0.11	0.36	1.17	3.83	1.1	2.01	2.37	0.14	2.36	0.00	0.08	0.19
Cross Canal	Main	1.99	Max WS	002SACWPRJ-100T	25860.09	10.8	34.11	2.71	7.20E-05	0.28	0.92	1.25	4.11	1.1	2.01	2.45	0.35	6.26	0.00	0.08	0.50
Cross Canal	Main	1.99	Max WS	002SACWPRJ-200T	29381.64	10.8	34.42	3.04	9.00E-05	0.33	1.08	1.35	4.42	1.1	2.01	2.54	0.41	7.62	0.00	0.08	0.61
Cross Canal	Main	1.99	Max WS	010SACWPRJ-2T	707.34	10.8	36.15	0.07	0.00E+00	0.00	0.00	1.87	6.15	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	010SACWPRJ-10T	1833.96	10.8	36.16	0.18	0.00E+00	0.00	0.00	1.88	6.16	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	010SACWPRJ-25T	2994.54	10.8	36.2	0.29	1.00E-06	0.04	0.14	1.89	6.20	1.1	2.01	2.88	0.05	1.14	0.00	0.08	0.09
Cross Canal	Main	1.99	Max WS	010SACWPRJ-50T	3857.97	10.8	36.22	0.37	1.00E-06	0.04	0.14	1.90	6.22	1.1	2.01	2.88	0.05	1.14	0.00	0.08	0.09
Cross Canal	Main	1.99	Max WS	010SACWPRJ-100T	8519.12	10.8	36.26	0.81	5.00E-06	0.10	0.32	1.91	6.26	1.1	2.01	2.88	0.12	2.57	0.00	0.08	0.21
Cross Canal	Main	1.99	Max WS	010SACWPRJ-200T	8519.12	10.8	36.26	0.81	5.00E-06	0.10	0.32	1.91	6.26	1.1	2.01	2.88	0.12	2.57	0.00	0.08	0.21
Cross Canal	Main	1.99	Max WS	025SACWPRJ-2T	455.68	10.8	38.07	0.04	0.00E+00	0.00	0.00	2.46	8.07	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	025SACWPRJ-10T	1020.33	10.8	38.09	0.09	0.00E+00	0.00	0.00	2.47	8.09	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	025SACWPRJ-25T	1442.31	10.8	38.11	0.13	0.00E+00	0.00	0.00	2.47	8.11	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	025SACWPRJ-50T	1684.58	10.8	38.12	0.15	0.00E+00	0.00	0.00	2.47	8.12	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	025SACWPRJ-100T	1937.1	10.8	38.13	0.17	0.00E+00	0.00	0.00	2.48	8.13	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	025SACWPRJ-200T	2174.7	10.8	38.13	0.19	0.00E+00	0.00	0.00	2.48	8.13	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	050SACWPRJ-2T	3667.51	10.8	38.91	0.31	1.00E-06	0.06	0.18	2.72	8.91	1.1	2.01	2.88	0.07	1.45	0.00	0.08	0.12
Cross Canal	Main	1.99	Max WS	050SACWPRJ-10T	1962.25	10.8	38.86	0.17	0.00E+00	0.00	0.00	2.70	8.86	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	050SACWPRJ-25T	2987.67	10.8	38.89	0.25	0.00E+00	0.00	0.00	2.71	8.89	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	050SACWPRJ-50T	3667.51	10.8	38.91	0.31	1.00E-06	0.06	0.18	2.72	8.91	1.1	2.01	2.88	0.07	1.45	0.00	0.08	0.12
Cross Canal	Main	1.99	Max WS	050SACWPRJ-100T	4464.97	10.8	38.93	0.38	1.00E-06	0.06	0.18	2.72	8.93	1.1	2.01	2.88	0.07	1.45	0.00	0.08	0.12
Cross Canal	Main	1.99	Max WS	050SACWPRJ-200T	6822.21	10.8	38.95	0.58	2.00E-06	0.08	0.26	2.73	8.95	1.1	2.01	2.88	0.10	2.06	0.00	0.08	0.16
Cross Canal	Main	1.99	Max WS	100SACWPRJ-2T	735.46	10.8	39.82	0.06	0.00E+00	0.00	0.00	2.99	9.82	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	100SACWPRJ-10T	1852.98	10.8	39.86	0.15	0.00E+00	0.00	0.00	3.01	9.86	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	100SACWPRJ-25T	2819.96	10.8	39.89	0.23	0.00E+00	0.00	0.00	3.01	9.89	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	100SACWPRJ-50T	2832.88	10.8	39.89	0.23	0.00E+00	0.00	0.00	3.01	9.89	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	100SACWPRJ-100T	4097.7	10.8	39.92	0.34	1.00E-06	0.06	0.20	3.02	9.92	1.1	2.01	2.88	0.07	1.56	0.00	0.08	0.12
Cross Canal	Main	1.99	Max WS	100SACWPRJ-200T	4806.19	10.8	39.94	0.39	1.00E-06	0.06	0.20	3.03	9.94	1.1	2.01	2.88	0.07	1.56	0.00	0.08	0.12
Cross Canal	Main	1.99	Max WS	200SACWPRJ-2T	1119.69	10.8	41.16	0.09	0.00E+00	0.00	0.00	3.40	11.16	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	200SACWPRJ-10T	2476.78	10.8	41.19	0.19	0.00E+00	0.00	0.00	3.41	11.19	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	1.99	Max WS	200SACWPRJ-25T	3555.36	10.8	41.21	0.28	1.00E-06	0.06	0.21	3.42	11.21	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	1.99	Max WS	200SACWPRJ-50T	4227.28	10.8	41.23	0.33	1.00E-06	0.06	0.21	3.42	11.23	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	1.99	Max WS	200SACWPRJ-100T	4227.28	10.8	41.23	0.33	1.00E-06	0.06	0.21	3.42	11.23	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	1.99	Max WS	200SACWPRJ-200T	5754.71	10.8	41.26	0.45	1.00E-06	0.07	0.21	3.43	11.26	1.1	2.01	2.88	0.08	1.70	0.00	0.08	0.14

HEC-RAS OUTPUT										Scour Computations											
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Frctn Slope (ft/ft)	Vel-Tree m/s	Vel fps	Depth-Tree m	Depth Tree ft	K1	K2	Kya	Kl	ds (ft)	te	Kt	ds*Kt (ft)
Cross Canal	Main	3.14	Max WS	002SACWPRJ-2T	1330.44	10.8	33.52	0.21	1.00E-06	0.03	0.10	1.07	3.52	1.1	2.01	2.27	0.04	0.62	0.00	0.08	0.05
Cross Canal	Main	3.14	Max WS	002SACWPRJ-10T	4036.35	10.8	33.64	0.62	5.00E-06	0.07	0.22	1.11	3.64	1.1	2.01	2.31	0.09	1.43	0.00	0.08	0.11
Cross Canal	Main	3.14	Max WS	002SACWPRJ-25T	19758.2	10.8	33.93	2.97	1.16E-04	0.35	1.14	1.20	3.93	1.1	2.01	2.40	0.43	7.55	0.00	0.08	0.60
Cross Canal	Main	3.14	Max WS	002SACWPRJ-50T	23243.26	10.8	34.35	3.4	1.47E-04	0.42	1.37	1.33	4.35	1.1	2.01	2.52	0.52	9.56	11.14	0.92	8.76
Cross Canal	Main	3.14	Max WS	002SACWPRJ-100T	26541.86	10.8	34.79	3.78	1.76E-04	0.49	1.60	1.46	4.79	1.1	2.01	2.65	0.61	11.71	16.74	0.89	10.41
Cross Canal	Main	3.14	Max WS	002SACWPRJ-200T	29854.61	10.8	35.23	4.13	2.05E-04	0.56	1.83	1.59	5.23	1.1	2.01	2.77	0.70	14.00	21.23	0.89	12.40
Cross Canal	Main	3.14	Max WS	010SACWPRJ-2T	707.46	10.8	36.15	0.09	0.00E+00	0.00	0.00	1.87	6.15	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	3.14	Max WS	010SACWPRJ-10T	1839.41	10.8	36.17	0.24	1.00E-06	0.04	0.14	1.88	6.17	1.1	2.01	2.88	0.05	1.14	0.00	0.08	0.09
Cross Canal	Main	3.14	Max WS	010SACWPRJ-25T	3098.54	10.8	36.2	0.4	2.00E-06	0.06	0.20	1.89	6.20	1.1	2.01	2.88	0.08	1.61	0.00	0.08	0.13
Cross Canal	Main	3.14	Max WS	010SACWPRJ-50T	7929.98	10.8	36.24	1.03	1.00E-05	0.14	0.46	1.90	6.24	1.1	2.01	2.88	0.17	3.62	0.00	0.08	0.29
Cross Canal	Main	3.14	Max WS	010SACWPRJ-100T	10838.91	10.8	36.32	1.41	2.10E-05	0.20	0.67	1.93	6.32	1.1	2.01	2.88	0.25	5.29	0.00	0.08	0.42
Cross Canal	Main	3.14	Max WS	010SACWPRJ-200T	10838.91	10.8	36.32	1.41	2.10E-05	0.20	0.67	1.93	6.32	1.1	2.01	2.88	0.25	5.29	0.00	0.08	0.42
Cross Canal	Main	3.14	Max WS	025SACWPRJ-2T	454.53	10.8	38.07	0.05	0.00E+00	0.00	0.00	2.46	8.07	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	3.14	Max WS	025SACWPRJ-10T	1018.04	10.8	38.09	0.12	0.00E+00	0.00	0.00	2.47	8.09	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	3.14	Max WS	025SACWPRJ-25T	1439.71	10.8	38.11	0.17	0.00E+00	0.00	0.00	2.47	8.11	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	3.14	Max WS	025SACWPRJ-50T	1685.27	10.8	38.12	0.2	0.00E+00	0.00	0.00	2.47	8.12	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	3.14	Max WS	025SACWPRJ-100T	1935.76	10.8	38.13	0.23	1.00E-06	0.05	0.17	2.48	8.13	1.1	2.01	2.88	0.07	1.37	0.00	0.08	0.11
Cross Canal	Main	3.14	Max WS	025SACWPRJ-200T	2175.11	10.8	38.14	0.26	1.00E-06	0.05	0.17	2.48	8.14	1.1	2.01	2.88	0.07	1.37	0.00	0.08	0.11
Cross Canal	Main	3.14	Max WS	050SACWPRJ-2T	3710.31	10.8	38.91	0.42	2.00E-06	0.08	0.26	2.72	8.91	1.1	2.01	2.88	0.10	2.05	0.00	0.08	0.16
Cross Canal	Main	3.14	Max WS	050SACWPRJ-10T	1969.3	10.8	38.86	0.22	0.00E+00	0.00	0.00	2.70	8.86	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	3.14	Max WS	050SACWPRJ-25T	3011.15	10.8	38.89	0.34	1.00E-06	0.06	0.18	2.71	8.89	1.1	2.01	2.88	0.07	1.45	0.00	0.08	0.12
Cross Canal	Main	3.14	Max WS	050SACWPRJ-50T	3710.31	10.8	38.91	0.42	2.00E-06	0.08	0.26	2.72	8.91	1.1	2.01	2.88	0.10	2.05	0.00	0.08	0.16
Cross Canal	Main	3.14	Max WS	050SACWPRJ-100T	4578.37	10.8	38.94	0.52	2.00E-06	0.08	0.26	2.72	8.94	1.1	2.01	2.88	0.10	2.06	0.00	0.08	0.16
Cross Canal	Main	3.14	Max WS	050SACWPRJ-200T	10153.12	10.8	38.98	1.14	1.10E-05	0.19	0.61	2.74	8.98	1.1	2.01	2.88	0.23	4.84	0.00	0.08	0.39
Cross Canal	Main	3.14	Max WS	100SACWPRJ-2T	735.51	10.8	39.82	0.08	0.00E+00	0.00	0.00	2.99	9.82	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	3.14	Max WS	100SACWPRJ-10T	1858.74	10.8	39.86	0.2	0.00E+00	0.00	0.00	3.01	9.86	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	3.14	Max WS	100SACWPRJ-25T	2847.73	10.8	39.89	0.31	1.00E-06	0.06	0.20	3.01	9.89	1.1	2.01	2.88	0.07	1.56	0.00	0.08	0.12
Cross Canal	Main	3.14	Max WS	100SACWPRJ-50T	2857.44	10.8	39.89	0.31	1.00E-06	0.06	0.20	3.01	9.89	1.1	2.01	2.88	0.07	1.56	0.00	0.08	0.12
Cross Canal	Main	3.14	Max WS	100SACWPRJ-100T	4160.47	10.8	39.92	0.45	2.00E-06	0.08	0.28	3.02	9.92	1.1	2.01	2.88	0.11	2.21	0.00	0.08	0.18
Cross Canal	Main	3.14	Max WS	100SACWPRJ-200T	4911.74	10.8	39.95	0.53	2.00E-06	0.08	0.28	3.03	9.95	1.1	2.01	2.88	0.11	2.21	0.00	0.08	0.18
Cross Canal	Main	3.14	Max WS	200SACWPRJ-2T	1102.76	10.8	41.16	0.11	0.00E+00	0.00	0.00	3.40	11.16	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	3.14	Max WS	200SACWPRJ-10T	2475.59	10.8	41.19	0.25	1.00E-06	0.06	0.21	3.41	11.19	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	3.14	Max WS	200SACWPRJ-25T	3554.41	10.8	41.22	0.36	1.00E-06	0.06	0.21	3.42	11.22	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	3.14	Max WS	200SACWPRJ-50T	4225.73	10.8	41.23	0.43	1.00E-06	0.06	0.21	3.42	11.23	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	3.14	Max WS	200SACWPRJ-100T	4225.73	10.8	41.23	0.43	1.00E-06	0.06	0.21	3.42	11.23	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	3.14	Max WS	200SACWPRJ-200T	5779	10.8	41.27	0.58	3.00E-06	0.11	0.37	3.43	11.27	1.1	2.01	2.88	0.14	2.94	0.00	0.08	0.24

HEC-RAS OUTPUT										Scour Computations											
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Frctn Slope (ft/ft)	Vel-Tree m/s	Vel fps	Depth-Tree m	Depth Tree ft	K1	K2	Kya	Ki	ds (ft)	te	kt	ds*Kt (ft)
Cross Canal	Main	4	Max WS	002SACWPRJ-2T	1332.1	11.5	33.52	0.22	1.00E-06	0.03	0.10	1.07	3.52	1.1	2.01	2.27	0.04	0.62	0.00	0.08	0.05
Cross Canal	Main	4	Max WS	002SACWPRJ-10T	5326.47	11.5	33.66	0.86	8.00E-06	0.09	0.29	1.12	3.66	1.1	2.01	2.31	0.11	1.82	0.00	0.08	0.15
Cross Canal	Main	4	Max WS	002SACWPRJ-25T	20002.68	11.5	34.36	3.07	1.03E-04	0.35	1.15	1.33	4.36	1.1	2.01	2.53	0.44	8.03	0.00	0.08	0.64
Cross Canal	Main	4	Max WS	002SACWPRJ-50T	23407.53	11.5	34.69	3.46	1.27E-04	0.42	1.38	1.49	4.89	1.1	2.01	2.67	0.53	10.19	11.66	0.91	9.28
Cross Canal	Main	4	Max WS	002SACWPRJ-100T	26694.66	11.5	35.43	3.8	1.48E-04	0.49	1.60	1.65	5.43	1.1	2.01	2.82	0.61	12.43	17.17	0.89	11.01
Cross Canal	Main	4	Max WS	002SACWPRJ-200T	29970.95	11.5	35.97	4.12	1.69E-04	0.55	1.82	1.82	5.97	1.1	2.01	2.88	0.69	14.46	21.70	0.88	12.75
Cross Canal	Main	4	Max WS	010SACWPRJ-2T	708.7	11.5	36.15	0.1	0.00E+00	0.00	0.00	1.87	6.15	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	010SACWPRJ-10T	1866.96	11.5	36.17	0.25	1.00E-06	0.04	0.14	1.88	6.17	1.1	2.01	2.88	0.05	1.14	0.00	0.08	0.09
Cross Canal	Main	4	Max WS	010SACWPRJ-25T	3214.06	11.5	36.21	0.44	2.00E-06	0.06	0.20	1.89	6.21	1.1	2.01	2.88	0.08	1.61	0.00	0.08	0.13
Cross Canal	Main	4	Max WS	010SACWPRJ-50T	9270.02	11.5	36.29	1.25	1.50E-05	0.17	0.56	1.92	6.29	1.1	2.01	2.88	0.21	4.46	0.00	0.08	0.36
Cross Canal	Main	4	Max WS	010SACWPRJ-100T	26435.12	11.5	36.71	3.47	1.14E-04	0.49	1.61	2.05	6.71	1.1	2.01	2.88	0.61	12.84	18.47	0.88	11.28
Cross Canal	Main	4	Max WS	010SACWPRJ-200T	26435.12	11.5	36.71	3.47	1.14E-04	0.49	1.61	2.05	6.71	1.1	2.01	2.88	0.61	12.84	18.47	0.88	11.28
Cross Canal	Main	4	Max WS	025SACWPRJ-2T	452.42	11.5	38.07	0.05	0.00E+00	0.00	0.00	2.46	8.07	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	025SACWPRJ-10T	1016.61	11.5	38.1	0.12	0.00E+00	0.00	0.00	2.47	8.10	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	025SACWPRJ-25T	1439.78	11.5	38.11	0.17	0.00E+00	0.00	0.00	2.47	8.11	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	025SACWPRJ-50T	1684.19	11.5	38.12	0.2	0.00E+00	0.00	0.00	2.47	8.12	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	025SACWPRJ-100T	1935.89	11.5	38.13	0.23	0.00E+00	0.00	0.00	2.48	8.13	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	025SACWPRJ-200T	2174.92	11.5	38.14	0.26	1.00E-06	0.05	0.17	2.48	8.14	1.1	2.01	2.88	0.07	1.37	0.00	0.08	0.11
Cross Canal	Main	4	Max WS	050SACWPRJ-2T	3750.23	11.5	38.92	0.43	2.00E-06	0.08	0.26	2.72	8.92	1.1	2.01	2.88	0.10	2.06	0.00	0.08	0.16
Cross Canal	Main	4	Max WS	050SACWPRJ-10T	1976.35	11.5	38.86	0.23	0.00E+00	0.00	0.00	2.70	8.86	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	050SACWPRJ-25T	3031.71	11.5	38.9	0.35	1.00E-06	0.06	0.18	2.71	8.90	1.1	2.01	2.88	0.07	1.45	0.00	0.08	0.12
Cross Canal	Main	4	Max WS	050SACWPRJ-50T	3750.23	11.5	38.92	0.43	2.00E-06	0.08	0.26	2.72	8.92	1.1	2.01	2.88	0.10	2.06	0.00	0.08	0.16
Cross Canal	Main	4	Max WS	050SACWPRJ-100T	8929.49	11.5	38.95	1.03	7.00E-06	0.15	0.48	2.73	8.95	1.1	2.01	2.88	0.18	3.85	0.00	0.08	0.31
Cross Canal	Main	4	Max WS	050SACWPRJ-200T	11454.63	11.5	39.03	1.32	1.40E-05	0.21	0.69	2.75	9.03	1.1	2.01	2.88	0.26	5.48	0.00	0.08	0.44
Cross Canal	Main	4	Max WS	100SACWPRJ-2T	735.53	11.5	39.82	0.08	0.00E+00	0.00	0.00	2.99	9.82	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	100SACWPRJ-10T	1866.49	11.5	39.86	0.21	0.00E+00	0.00	0.00	3.01	9.86	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	100SACWPRJ-25T	2872.17	11.5	39.89	0.32	1.00E-06	0.06	0.20	3.01	9.89	1.1	2.01	2.88	0.07	1.56	0.00	0.08	0.12
Cross Canal	Main	4	Max WS	100SACWPRJ-50T	2875.75	11.5	39.89	0.32	1.00E-06	0.06	0.20	3.01	9.89	1.1	2.01	2.88	0.07	1.56	0.00	0.08	0.12
Cross Canal	Main	4	Max WS	100SACWPRJ-100T	4210	11.5	39.93	0.46	2.00E-06	0.08	0.28	3.03	9.93	1.1	2.01	2.88	0.11	2.21	0.00	0.08	0.18
Cross Canal	Main	4	Max WS	100SACWPRJ-200T	5004.89	11.5	39.95	0.55	2.00E-06	0.08	0.28	3.03	9.95	1.1	2.01	2.88	0.11	2.21	0.00	0.08	0.18
Cross Canal	Main	4	Max WS	200SACWPRJ-2T	1096.91	11.5	41.16	0.11	0.00E+00	0.00	0.00	3.40	11.16	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	200SACWPRJ-10T	2476.88	11.5	41.19	0.25	0.00E+00	0.00	0.00	3.41	11.19	1.1	2.01	2.88	0.00	0.00	0.00	0.08	0.00
Cross Canal	Main	4	Max WS	200SACWPRJ-25T	3553.97	11.5	41.22	0.37	1.00E-06	0.06	0.21	3.42	11.22	1.1	2.01	2.88	0.08	1.69	0.00	0.08	0.14
Cross Canal	Main	4	Max WS	200SACWPRJ-50T	4225.84	11.5	41.24	0.43	1.00E-06	0.06	0.21	3.43	11.24	1.1	2.01	2.88	0.08	1.70	0.00	0.08	0.14
Cross Canal	Main	4	Max WS	200SACWPRJ-100T	4225.84	11.5	41.24	0.43	1.00E-06	0.06	0.21	3.43	11.24	1.1	2.01	2.88	0.08	1.70	0.00	0.08	0.14
Cross Canal	Main	4	Max WS	200SACWPRJ-200T	5823.48	11.5	41.28	0.6	3.00E-06	0.11	0.37	3.44	11.28	1.1	2.01	2.88	0.14	2.94	0.00	0.08	0.24

HEC-RAS OUTPUT										Scour Computations											
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Frctn Slope (ft/ft)	Vel-Tree m/s	Vel-Tree fps	Depth-Tree m	Depth Tree ft	K1	K2	Kya	Kl	ds (ft)	te	Kt	ds*Kt (ft)
NEMDC	Reach 1	2.955	Max WS	002SACWPRJ-2T	1900.21	12.8	27.05	0.78	4.70E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	2.955	Max WS	002SACWPRJ-10T	8816.63	12.8	29.04	2.85	5.42E-04	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	2.955	Max WS	002SACWPRJ-25T	11540.67	12.8	30.27	3.29	6.14E-04	0.16	0.53	0.16	0.52	1.1	1	0.71	0.20	0.52	0.00	0.08	0.04
NEMDC	Reach 1	2.955	Max WS	002SACWPRJ-50T	13697.29	12.8	31.07	3.61	6.60E-04	0.31	1.02	0.40	1.32	1.1	2.01	1.39	0.39	3.92	0.00	0.08	0.31
NEMDC	Reach 1	2.955	Max WS	002SACWPRJ-100T	17080.23	12.8	32.2	4.07	7.24E-04	0.49	1.61	0.75	2.45	1.1	2.01	1.89	0.62	8.45	14.40	0.91	7.67
NEMDC	Reach 1	2.955	Max WS	002SACWPRJ-200T	20023.94	12.8	33.12	4.42	7.65E-04	0.63	2.05	1.03	3.37	1.1	2.01	2.22	0.78	12.60	21.77	0.90	11.36
NEMDC	Reach 1	2.955	Max WS	010SACWPRJ-2T	1954.46	12.8	28.84	0.65	2.70E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	2.955	Max WS	010SACWPRJ-10T	8921.43	12.8	29.37	2.79	2.76E-04	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	2.955	Max WS	010SACWPRJ-25T	11590.82	12.8	30.44	3.24	5.79E-04	0.19	0.62	0.21	0.69	1.1	1	0.95	0.24	0.81	0.00	0.08	0.06
NEMDC	Reach 1	2.955	Max WS	010SACWPRJ-50T	13734.26	12.8	31.17	3.59	6.40E-04	0.32	1.06	0.43	1.42	1.1	2.01	1.44	0.40	4.20	0.00	0.08	0.34
NEMDC	Reach 1	2.955	Max WS	010SACWPRJ-100T	17105.21	12.8	32.26	4.06	7.13E-04	0.50	1.63	0.77	2.51	1.1	2.01	1.92	0.62	8.62	14.71	0.91	7.82
NEMDC	Reach 1	2.955	Max WS	010SACWPRJ-200T	17105.21	12.8	32.26	4.06	7.13E-04	0.50	1.63	0.77	2.51	1.1	2.01	1.92	0.62	8.62	14.71	0.91	7.82
NEMDC	Reach 1	2.955	Max WS	025SACWPRJ-2T	921.31	12.8	31.89	0.23	2.00E-06	0.02	0.08	0.65	2.14	1.1	2.01	1.77	0.03	0.38	0.00	0.08	0.03
NEMDC	Reach 1	2.955	Max WS	025SACWPRJ-10T	1549.11	12.8	31.98	0.38	6.00E-06	0.04	0.14	0.68	2.23	1.1	2.01	1.81	0.05	0.69	0.00	0.08	0.06
NEMDC	Reach 1	2.955	Max WS	025SACWPRJ-25T	5329.83	12.8	32.06	1.29	3.00E-05	0.10	0.32	0.70	2.31	1.1	2.01	1.84	0.12	1.61	0.00	0.08	0.13
NEMDC	Reach 1	2.955	Max WS	025SACWPRJ-50T	6836.93	12.8	32.22	1.63	1.03E-04	0.19	0.61	0.75	2.47	1.1	2.01	1.90	0.23	3.22	0.00	0.08	0.26
NEMDC	Reach 1	2.955	Max WS	025SACWPRJ-100T	17060.08	12.8	32.56	3.95	3.54E-04	0.38	1.24	0.86	2.81	1.1	2.01	2.03	0.47	6.93	0.00	0.08	0.55
NEMDC	Reach 1	2.955	Max WS	025SACWPRJ-200T	20044.79	12.8	33.42	4.32	6.98E-04	0.63	2.08	1.12	3.67	1.1	2.01	2.32	0.79	13.29	22.50	0.90	11.97
NEMDC	Reach 1	2.955	Max WS	050SACWPRJ-2T	11090.7	12.8	32.93	2.49	2.24E-04	0.33	1.07	0.97	3.18	1.1	2.01	2.16	0.41	6.37	0.00	0.08	0.51
NEMDC	Reach 1	2.955	Max WS	050SACWPRJ-10T	1682.81	12.8	32.44	0.39	6.00E-06	0.05	0.16	0.82	2.69	1.1	2.01	1.98	0.06	0.86	0.00	0.08	0.07
NEMDC	Reach 1	2.955	Max WS	050SACWPRJ-25T	5360.06	12.8	32.6	1.24	5.60E-05	0.15	0.50	0.87	2.85	1.1	2.01	2.04	0.19	2.80	0.00	0.08	0.22
NEMDC	Reach 1	2.955	Max WS	050SACWPRJ-50T	11090.7	12.8	32.93	2.49	2.24E-04	0.33	1.07	0.97	3.18	1.1	2.01	2.16	0.41	6.37	0.00	0.08	0.51
NEMDC	Reach 1	2.955	Max WS	050SACWPRJ-100T	14701.1	12.8	33.43	3.17	3.39E-04	0.44	1.45	1.12	3.68	1.1	2.01	2.32	0.55	9.29	12.55	0.91	8.44
NEMDC	Reach 1	2.955	Max WS	050SACWPRJ-200T	19234.1	12.8	34.15	3.92	4.96E-04	0.60	1.97	1.34	4.40	1.1	2.01	2.54	0.75	13.85	22.31	0.89	12.37
NEMDC	Reach 1	2.955	Max WS	100SACWPRJ-2T	920.65	12.8	32.95	0.21	2.00E-06	0.03	0.10	0.98	3.20	1.1	2.01	2.16	0.04	0.61	0.00	0.08	0.05
NEMDC	Reach 1	2.955	Max WS	100SACWPRJ-10T	1671.6	12.8	33.02	0.37	5.00E-06	0.05	0.16	1.00	3.27	1.1	2.01	2.19	0.06	0.98	0.00	0.08	0.08
NEMDC	Reach 1	2.955	Max WS	100SACWPRJ-25T	11534.03	12.8	33.14	2.54	7.80E-05	0.20	0.66	1.03	3.39	1.1	2.01	2.23	0.25	4.05	0.00	0.08	0.32
NEMDC	Reach 1	2.955	Max WS	100SACWPRJ-50T	13588.91	12.8	33.56	2.9	2.93E-04	0.42	1.38	1.16	3.81	1.1	2.01	2.36	0.53	9.00	10.96	0.92	8.26
NEMDC	Reach 1	2.955	Max WS	100SACWPRJ-100T	17064.34	12.8	34.28	3.44	3.86E-04	0.54	1.78	1.38	4.53	1.1	2.01	2.57	0.68	12.64	19.62	0.89	11.23
NEMDC	Reach 1	2.955	Max WS	100SACWPRJ-200T	20010.95	12.8	34.89	3.86	4.61E-04	0.64	2.11	1.57	5.14	1.1	2.01	2.74	0.80	16.00	24.90	0.89	14.31
NEMDC	Reach 1	2.955	Max WS	200SACWPRJ-2T	953.69	12.8	35.46	0.18	1.00E-06	0.03	0.11	1.74	5.71	1.1	2.01	2.88	0.04	0.84	0.00	0.08	0.07
NEMDC	Reach 1	2.955	Max WS	200SACWPRJ-10T	2109.5	12.8	35.55	0.39	4.00E-06	0.06	0.21	1.77	5.80	1.1	2.01	2.88	0.08	1.70	0.00	0.08	0.14
NEMDC	Reach 1	2.955	Max WS	200SACWPRJ-25T	4125.53	12.8	35.59	0.76	1.30E-05	0.12	0.39	1.78	5.84	1.1	2.01	2.88	0.15	3.07	0.00	0.08	0.25
NEMDC	Reach 1	2.955	Max WS	200SACWPRJ-50T	5333.91	12.8	35.64	0.98	2.60E-05	0.17	0.55	1.80	5.89	1.1	2.01	2.88	0.21	4.37	0.00	0.08	0.35
NEMDC	Reach 1	2.955	Max WS	200SACWPRJ-100T	5333.91	12.8	35.64	0.98	2.60E-05	0.17	0.55	1.80	5.89	1.1	2.01	2.88	0.21	4.37	0.00	0.08	0.35
NEMDC	Reach 1	2.955	Max WS	200SACWPRJ-200T	18573.07	12.8	35.85	3.35	1.18E-04	0.36	1.20	1.86	6.10	1.1	2.01	2.88	0.46	9.53	0.00	0.08	0.76

HEC-RAS OUTPUT														Scour Computations								
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Frctn Slope (ft/ft)	Vel-Tree m/s	Vel fps	Depth-Tree m	Depth Tree ft	K1	K2	Kya	Ki	ds (ft)	te	Kt	ds*Kt (ft)
NEMDC	Reach 1	4.016	Max WS	002SACWPRJ-2T	1641.94	16.1	27.1	0.66	1.20E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	4.016	Max WS	002SACWPRJ-10T	6037.62	16.1	29.58	1.8	7.40E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	4.016	Max WS	002SACWPRJ-25T	7998.56	16.1	30.94	2.06	8.70E-05	0.07	0.23	0.20	0.64	1.1	1	0.88	0.09	0.28	0.00	0.08	0.02
NEMDC	Reach 1	4.016	Max WS	002SACWPRJ-50T	9676.47	16.1	31.84	2.28	9.90E-05	0.13	0.44	0.47	1.54	1.1	2.01	1.50	0.17	1.82	0.00	0.08	0.15
NEMDC	Reach 1	4.016	Max WS	002SACWPRJ-100T	12718.1	16.1	33.13	2.67	1.24E-04	0.22	0.74	0.86	2.83	1.1	2.01	2.03	0.28	4.14	0.00	0.08	0.33
NEMDC	Reach 1	4.016	Max WS	002SACWPRJ-200T	15122.84	16.1	34.17	2.91	1.37E-04	0.29	0.95	1.18	3.87	1.1	2.01	2.38	0.36	6.27	0.00	0.08	0.50
NEMDC	Reach 1	4.016	Max WS	010SACWPRJ-2T	1668.15	16.1	28.87	0.54	7.00E-06	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	4.016	Max WS	010SACWPRJ-10T	6034.56	16.1	29.88	1.74	6.80E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	4.016	Max WS	010SACWPRJ-25T	8021.49	16.1	31.09	2.03	8.40E-05	0.08	0.26	0.24	0.79	1.1	2.01	1.08	0.10	0.77	0.00	0.08	0.06
NEMDC	Reach 1	4.016	Max WS	010SACWPRJ-50T	9676.88	16.1	31.92	2.26	9.70E-05	0.14	0.45	0.49	1.62	1.1	2.01	1.54	0.17	1.91	0.00	0.08	0.15
NEMDC	Reach 1	4.016	Max WS	010SACWPRJ-100T	12714.7	16.1	33.17	2.66	1.22E-04	0.22	0.74	0.87	2.87	1.1	2.01	2.05	0.28	4.17	0.00	0.08	0.33
NEMDC	Reach 1	4.016	Max WS	010SACWPRJ-200T	12714.7	16.1	33.17	2.66	1.22E-04	0.22	0.74	0.87	2.87	1.1	2.01	2.05	0.28	4.17	0.00	0.08	0.33
NEMDC	Reach 1	4.016	Max WS	025SACWPRJ-2T	370.67	16.1	31.89	0.09	0.00E+00	0.00	0.00	0.48	1.59	1.1	2.01	1.53	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	4.016	Max WS	025SACWPRJ-10T	1287	16.1	31.99	0.3	2.00E-06	0.02	0.07	0.52	1.69	1.1	2.01	1.57	0.03	0.29	0.00	0.08	0.02
NEMDC	Reach 1	4.016	Max WS	025SACWPRJ-25T	4675.62	16.1	32.17	1.07	2.10E-05	0.07	0.23	0.57	1.87	1.1	2.01	1.65	0.09	1.05	0.00	0.08	0.08
NEMDC	Reach 1	4.016	Max WS	025SACWPRJ-50T	5850.59	16.1	32.39	1.31	3.10E-05	0.09	0.30	0.64	2.09	1.1	2.01	1.75	0.11	1.45	0.00	0.08	0.12
NEMDC	Reach 1	4.016	Max WS	025SACWPRJ-100T	12722.48	16.1	33.42	2.6	1.15E-04	0.23	0.76	0.95	3.12	1.1	2.01	2.14	0.29	4.46	0.00	0.08	0.36
NEMDC	Reach 1	4.016	Max WS	025SACWPRJ-200T	15131.08	16.1	34.41	2.86	1.30E-04	0.29	0.97	1.25	4.11	1.1	2.01	2.45	0.37	6.55	0.00	0.08	0.52
NEMDC	Reach 1	4.016	Max WS	050SACWPRJ-2T	8543.7	16.1	33.29	1.77	5.30E-05	0.15	0.50	0.91	2.99	1.1	2.01	2.09	0.19	2.88	0.00	0.08	0.23
NEMDC	Reach 1	4.016	Max WS	050SACWPRJ-10T	3189.28	16.1	32.46	0.71	9.00E-06	0.05	0.17	0.66	2.16	1.1	2.01	1.78	0.06	0.81	0.00	0.08	0.07
NEMDC	Reach 1	4.016	Max WS	050SACWPRJ-25T	6706.19	16.1	32.77	1.45	3.70E-05	0.11	0.37	0.75	2.47	1.1	2.01	1.90	0.14	1.93	0.00	0.08	0.15
NEMDC	Reach 1	4.016	Max WS	050SACWPRJ-50T	8543.7	16.1	33.29	1.77	5.30E-05	0.15	0.50	0.91	2.99	1.1	2.01	2.09	0.19	2.88	0.00	0.08	0.23
NEMDC	Reach 1	4.016	Max WS	050SACWPRJ-100T	12567.9	16.1	34.07	2.44	9.60E-05	0.24	0.78	1.15	3.77	1.1	2.01	2.35	0.30	5.09	0.00	0.08	0.41
NEMDC	Reach 1	4.016	Max WS	050SACWPRJ-200T	14830.89	16.1	34.95	2.68	1.10E-04	0.29	0.96	1.42	4.65	1.1	2.01	2.61	0.37	6.96	0.00	0.08	0.56
NEMDC	Reach 1	4.016	Max WS	100SACWPRJ-2T	815.16	16.1	32.95	0.17	1.00E-06	0.02	0.06	0.81	2.65	1.1	2.01	1.97	0.02	0.34	0.00	0.08	0.03
NEMDC	Reach 1	4.016	Max WS	100SACWPRJ-10T	1409.92	16.1	33.03	0.3	2.00E-06	0.03	0.09	0.83	2.73	1.1	2.01	2.00	0.03	0.50	0.00	0.08	0.04
NEMDC	Reach 1	4.016	Max WS	100SACWPRJ-25T	8002	16.1	33.49	1.63	4.40E-05	0.14	0.47	0.97	3.19	1.1	2.01	2.16	0.18	2.83	0.00	0.08	0.23
NEMDC	Reach 1	4.016	Max WS	100SACWPRJ-50T	9677.89	16.1	34.01	1.89	5.70E-05	0.18	0.60	1.13	3.71	1.1	2.01	2.33	0.23	3.85	0.00	0.08	0.31
NEMDC	Reach 1	4.016	Max WS	100SACWPRJ-100T	12714.75	16.1	34.9	2.31	8.20E-05	0.25	0.83	1.40	4.60	1.1	2.01	2.59	0.32	5.93	0.00	0.08	0.47
NEMDC	Reach 1	4.016	Max WS	100SACWPRJ-200T	15123.84	16.1	35.64	2.6	9.90E-05	0.31	1.00	1.63	5.34	1.1	2.01	2.80	0.38	7.75	0.00	0.08	0.62
NEMDC	Reach 1	4.016	Max WS	200SACWPRJ-2T	680.88	16.1	35.46	0.12	0.00E+00	0.00	0.00	1.57	5.16	1.1	2.01	2.75	0.00	0.00	0.00	0.08	0.00
NEMDC	Reach 1	4.016	Max WS	200SACWPRJ-10T	1819.94	16.1	35.56	0.31	1.00E-06	0.03	0.10	1.60	5.26	1.1	2.01	2.77	0.04	0.77	0.00	0.08	0.06
NEMDC	Reach 1	4.016	Max WS	200SACWPRJ-25T	3909.91	16.1	35.63	0.67	6.00E-06	0.08	0.25	1.62	5.33	1.1	2.01	2.79	0.09	1.90	0.00	0.08	0.15
NEMDC	Reach 1	4.016	Max WS	200SACWPRJ-50T	4440.84	16.1	35.69	0.76	8.00E-06	0.09	0.29	1.64	5.39	1.1	2.01	2.81	0.11	2.23	0.00	0.08	0.18
NEMDC	Reach 1	4.016	Max WS	200SACWPRJ-100T	4440.84	16.1	35.69	0.76	8.00E-06	0.09	0.29	1.64	5.39	1.1	2.01	2.81	0.11	2.23	0.00	0.08	0.18
NEMDC	Reach 1	4.016	Max WS	200SACWPRJ-200T	14735.26	16.1	36.43	2.4	7.90E-05	0.30	0.98	1.87	6.13	1.1	2.01	2.88	0.37	7.82	0.00	0.08	0.63

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HEC-RAS OUTPUT										Scour Computations											
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Frctn Slope (ft/ft)	Vel-Tree m/s	Vel fps	Depth-Tree m	Depth Tree ft	K1	K2	Kya	Kl	ds (ft)	te	Kt	ds*Kt (ft)
acramento Rive	CC to NEMS	62.4965	Max WS	002SACWPRJ-2T	64061.34	-15.14	27.37	3.29	7.60E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	002SACWPRJ-10T	62884.19	-15.14	27.62	3.21	7.20E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	002SACWPRJ-25T	62059.16	-15.14	27.77	3.15	6.80E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	002SACWPRJ-50T	59539.11	-15.14	27.92	3	6.20E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	002SACWPRJ-100T	58123.11	-15.14	28.08	2.92	5.80E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	002SACWPRJ-200T	56849.56	-15.14	28.24	2.84	5.40E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	010SACWPRJ-2T	57998.65	-15.14	28.48	2.87	5.50E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	010SACWPRJ-10T	58322.54	-15.14	28.48	2.89	5.60E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	010SACWPRJ-25T	58534.48	-15.14	28.49	2.9	5.60E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	010SACWPRJ-50T	58642.92	-15.14	28.49	2.9	5.60E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	010SACWPRJ-100T	58473.21	-15.14	28.49	2.89	5.60E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	010SACWPRJ-200T	58473.21	-15.14	28.49	2.89	5.60E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	025SACWPRJ-2T	-5021.66	-15.14	30.4	-0.23	0.00E+00	0.00	0.00	0.15	0.50	1.1	1	0.69	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	025SACWPRJ-10T	-5741.46	-15.14	30.45	-0.27	0.00E+00	0.00	0.00	0.17	0.55	1.1	1	0.75	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	025SACWPRJ-25T	-5928.59	-15.14	30.48	-0.27	0.00E+00	0.00	0.00	0.18	0.58	1.1	1	0.80	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	025SACWPRJ-50T	-5980.28	-15.14	30.49	-0.28	0.00E+00	0.00	0.00	0.18	0.59	1.1	1	0.81	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	025SACWPRJ-100T	-5889.01	-15.14	30.49	-0.27	0.00E+00	0.00	0.00	0.18	0.59	1.1	1	0.81	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	025SACWPRJ-200T	-5937.48	-15.14	30.5	-0.27	0.00E+00	0.00	0.00	0.18	0.60	1.1	1	0.82	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	050SACWPRJ-2T	-3689.06	-15.14	31.07	-0.17	0.00E+00	0.00	0.00	0.36	1.17	1.1	2.01	1.31	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	050SACWPRJ-10T	-3468.55	-15.14	31.03	-0.16	0.00E+00	0.00	0.00	0.34	1.13	1.1	2.01	1.29	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	050SACWPRJ-25T	-3626.05	-15.14	31.05	-0.16	0.00E+00	0.00	0.00	0.35	1.15	1.1	2.01	1.30	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	050SACWPRJ-50T	-3689.06	-15.14	31.07	-0.17	0.00E+00	0.00	0.00	0.36	1.17	1.1	2.01	1.31	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	050SACWPRJ-100T	-3603.42	-15.14	31.08	-0.16	0.00E+00	0.00	0.00	0.36	1.18	1.1	2.01	1.31	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	050SACWPRJ-200T	-3660.69	-15.14	31.09	-0.17	0.00E+00	0.00	0.00	0.36	1.19	1.1	2.01	1.32	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	100SACWPRJ-2T	1481.24	-15.14	31.7	0.07	0.00E+00	0.00	0.00	0.55	1.80	1.1	2.01	1.62	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	100SACWPRJ-10T	946.38	-15.14	31.75	0.04	0.00E+00	0.00	0.00	0.56	1.85	1.1	2.01	1.65	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	100SACWPRJ-25T	807.79	-15.14	31.77	0.04	0.00E+00	0.00	0.00	0.57	1.87	1.1	2.01	1.65	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	100SACWPRJ-50T	732.27	-15.14	31.77	0.03	0.00E+00	0.00	0.00	0.57	1.87	1.1	2.01	1.65	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	100SACWPRJ-100T	829.85	-15.14	31.79	0.04	0.00E+00	0.00	0.00	0.58	1.89	1.1	2.01	1.66	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	100SACWPRJ-200T	782.37	-15.14	31.8	0.03	0.00E+00	0.00	0.00	0.58	1.90	1.1	2.01	1.67	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMS	62.4965	Max WS	200SACWPRJ-2T	-28074.2	-15.14	33.61	-1.18	8.00E-06	0.09	0.29	1.13	3.71	1.1	2.01	2.33	0.11	1.85	0.00	0.08	0.15
acramento Rive	CC to NEMS	62.4965	Max WS	200SACWPRJ-10T	-29115.5	-15.14	33.67	-1.22	8.00E-06	0.09	0.29	1.15	3.77	1.1	2.01	2.35	0.11	1.89	0.00	0.08	0.15
acramento Rive	CC to NEMS	62.4965	Max WS	200SACWPRJ-25T	-29220.9	-15.14	33.68	-1.22	8.00E-06	0.09	0.29	1.15	3.78	1.1	2.01	2.35	0.11	1.89	0.00	0.08	0.15
acramento Rive	CC to NEMS	62.4965	Max WS	200SACWPRJ-50T	-29385.8	-15.14	33.7	-1.23	8.00E-06	0.09	0.29	1.16	3.80	1.1	2.01	2.36	0.11	1.91	0.00	0.08	0.15
acramento Rive	CC to NEMS	62.4965	Max WS	200SACWPRJ-100T	-29385.8	-15.14	33.7	-1.23	8.00E-06	0.09	0.29	1.16	3.80	1.1	2.01	2.36	0.11	1.91	0.00	0.08	0.15
acramento Rive	CC to NEMS	62.4965	Max WS	200SACWPRJ-200T	-29260.9	-15.14	33.71	-1.22	8.00E-06	0.09	0.29	1.16	3.81	1.1	2.01	2.36	0.11	1.91	0.00	0.08	0.15

HEC-RAS OUTPUT										Scour Computations											
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Vel Chnl (ft/s)	Frctn Slope (ft/ft)	Vel-Tree m/s	Vel fps	Depth-Tree m	Depth Tree ft	K1	K2	Kya	KI	ds (ft)	te	Kt	ds*Kt (ft)
acramento Rive	CC to NEMI	61.4986	Max WS	002SACWPRJ-2T	64039.86	-19.59	26.94	3.57	7.10E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	002SACWPRJ-10T	62837.93	-19.59	27.22	3.48	6.70E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	002SACWPRJ-25T	61997.11	-19.59	27.38	3.41	6.40E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	002SACWPRJ-50T	59448.36	-19.59	27.57	3.26	5.80E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	002SACWPRJ-100T	58081.29	-19.59	27.76	3.16	5.40E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	002SACWPRJ-200T	56802.3	-19.59	27.93	3.08	5.10E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	010SACWPRJ-2T	57804.75	-19.59	28.17	3.11	5.20E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	010SACWPRJ-10T	58163.82	-19.59	28.17	3.13	5.20E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	010SACWPRJ-25T	58373.63	-19.59	28.18	3.14	5.30E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	010SACWPRJ-50T	58479.85	-19.59	28.18	3.15	5.30E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	010SACWPRJ-100T	58313.04	-19.59	28.18	3.14	5.30E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	010SACWPRJ-200T	58313.04	-19.59	28.18	3.14	5.30E-05	0.00	0.00	0.00	0.00	1.1	NAN	NAN	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	025SACWPRJ-2T	-5048.29	-19.59	30.4	-0.26	0.00E+00	0.00	0.00	0.15	0.50	1.1	1	0.69	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	025SACWPRJ-10T	-5755.7	-19.59	30.45	-0.29	0.00E+00	0.00	0.00	0.17	0.55	1.1	1	0.75	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	025SACWPRJ-25T	-5936.42	-19.59	30.48	-0.3	0.00E+00	0.00	0.00	0.18	0.58	1.1	1	0.80	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	025SACWPRJ-50T	-5994.33	-19.59	30.49	-0.3	0.00E+00	0.00	0.00	0.18	0.59	1.1	1	0.81	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	025SACWPRJ-100T	-5912.83	-19.59	30.49	-0.3	0.00E+00	0.00	0.00	0.18	0.59	1.1	1	0.81	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	025SACWPRJ-200T	-5945.96	-19.59	30.5	-0.3	0.00E+00	0.00	0.00	0.18	0.60	1.1	1	0.82	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	050SACWPRJ-2T	-3689.27	-19.59	31.07	-0.18	0.00E+00	0.00	0.00	0.36	1.17	1.1	2.01	1.31	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	050SACWPRJ-10T	-3467.73	-19.59	31.03	-0.17	0.00E+00	0.00	0.00	0.34	1.13	1.1	2.01	1.29	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	050SACWPRJ-25T	-3628.1	-19.59	31.05	-0.18	0.00E+00	0.00	0.00	0.35	1.15	1.1	2.01	1.30	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	050SACWPRJ-50T	-3689.27	-19.59	31.07	-0.18	0.00E+00	0.00	0.00	0.36	1.17	1.1	2.01	1.31	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	050SACWPRJ-100T	-3603.8	-19.59	31.08	-0.18	0.00E+00	0.00	0.00	0.36	1.18	1.1	2.01	1.31	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	050SACWPRJ-200T	-3662.79	-19.59	31.1	-0.18	0.00E+00	0.00	0.00	0.37	1.20	1.1	2.01	1.32	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	100SACWPRJ-2T	1481.36	-19.59	31.7	0.07	0.00E+00	0.00	0.00	0.55	1.80	1.1	2.01	1.62	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	100SACWPRJ-10T	946.24	-19.59	31.74	0.05	0.00E+00	0.00	0.00	0.56	1.84	1.1	2.01	1.64	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	100SACWPRJ-25T	807.78	-19.59	31.77	0.04	0.00E+00	0.00	0.00	0.57	1.87	1.1	2.01	1.65	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	100SACWPRJ-50T	733.34	-19.59	31.77	0.04	0.00E+00	0.00	0.00	0.57	1.87	1.1	2.01	1.65	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	100SACWPRJ-100T	829.55	-19.59	31.79	0.04	0.00E+00	0.00	0.00	0.58	1.89	1.1	2.01	1.66	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	100SACWPRJ-200T	782.87	-19.59	31.8	0.04	0.00E+00	0.00	0.00	0.58	1.90	1.1	2.01	1.67	0.00	0.00	0.00	0.08	0.00
acramento Rive	CC to NEMI	61.4986	Max WS	200SACWPRJ-2T	-28090.6	-19.59	33.65	-1.31	8.00E-06	0.09	0.29	1.14	3.75	1.1	2.01	2.34	0.11	1.88	0.00	0.08	0.15
acramento Rive	CC to NEMI	61.4986	Max WS	200SACWPRJ-10T	-29137.4	-19.59	33.71	-1.35	8.00E-06	0.09	0.29	1.16	3.81	1.1	2.01	2.36	0.11	1.91	0.00	0.08	0.15
acramento Rive	CC to NEMI	61.4986	Max WS	200SACWPRJ-25T	-29266.6	-19.59	33.72	-1.36	8.00E-06	0.09	0.29	1.16	3.82	1.1	2.01	2.36	0.11	1.92	0.00	0.08	0.15
acramento Rive	CC to NEMI	61.4986	Max WS	200SACWPRJ-50T	-29417	-19.59	33.73	-1.36	8.00E-06	0.09	0.29	1.17	3.83	1.1	2.01	2.37	0.11	1.92	0.00	0.08	0.15
acramento Rive	CC to NEMI	61.4986	Max WS	200SACWPRJ-100T	-29417	-19.59	33.73	-1.36	8.00E-06	0.09	0.29	1.17	3.83	1.1	2.01	2.37	0.11	1.92	0.00	0.08	0.15
acramento Rive	CC to NEMI	61.4986	Max WS	200SACWPRJ-200T	-29281.6	-19.59	33.75	-1.36	8.00E-06	0.09	0.29	1.17	3.85	1.1	2.01	2.37	0.11	1.93	0.00	0.08	0.15

1675

APPENDIX G

California Department of Water Resources
2009 Levee Inspection Reports for Natomas Basin

STATE OF CALIFORNIA – THE RESOURCES AGENCY ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

January 26, 2010

TO: State-Federal Flood Control Project Maintaining Agencies
2009 Inspection Results

The Department of Water Resources (DWR) has completed the fall 2009 annual levee inspections for all State-Federal flood control project levees, as well as the annual project channel, structures, and pumping plant inspections. The results of your district's applicable inspections are enclosed in the following documents:

- Fall 2009 Levee Maintenance Deficiency Summary Report by Local Maintaining Agency (LMA) and by unit
- Levee Inspection Report by Mile for each unit with unit cover sheets and LMA cover sheet
- 2009 Channel Summary Report
- 2009 Structure Summary Report
- 2009 Pumping Plant Summary Report

Inspection Criteria and Ratings

A detailed explanation of all the inspection criteria can be found in the 2009 Inspection Report at http://cdec.water.ca.gov/fsir.html.

LMA Self-Inspections

You are again required to inspect your levee system during the December through February period. **You are only required to report any deficiencies that are different than those identified in your Fall 2009 Levee Inspection Report by Mile.** To complete your inspection report:

- Check the appropriate box on each unit cover sheet.
- Include information (location and description) as needed to identify new deficiencies.
- Sign, date, and make a copy of each sheet.
- Return the unit cover sheets and any new sheets to us by March 31, 2010.
- Please mail the reports back to DWR Summer/Winter Inspection Reports, 3310 El Camino Avenue, Room LL-30, Sacramento, California 95821-9000.

We are sending this letter and its attachments by regular mail to identified LMA officials and consultants. We are also sending this information electronically to those who have provided us with an email address. If you wish to receive such information via email instead of, or in addition to, regular mail, please inform your inspector and give him or her your email address.

If you have any questions, please contact your inspector, or contact me at (916) 574-1729 or by email at ilenewb@water.ca.gov.

Sincerely,

Ilene Wellman-Barbree

Ilene Wellman-Barbree, Chief
Flood Project Inspection Section

Attachments

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch

Flood Control Project Maintenance
Levee Inspections

Fall 2009 Levee Maintenance Deficiency Summary Report

Overall LMA & Unit Ratings, including USACE Erosion Survey

Sacramento River Basin

RD1000	Overall LMA Rating	Total LMA Miles				
Reclamation District No. 1000	A	42.48				
					Encroachments	
Rated Item	M Miles	U Miles	M + 4U Miles	Threshold %	PO Miles	CO Miles
Encroachments					11.04	1.31
USACE Erosion Survey	0.13		0.13	0.31%		
LMA Totals:	0.13	0.00	0.13	0.31%	11.04	1.31

Unit No. 01 Sacramento River	Overall Unit Rating	Total Unit Miles				
	A	18.60				
					Encroachments	
Rated Item	M Miles	U Miles	M + 4U Miles	Threshold %	PO Miles	CO Miles
Encroachments					7.88	1.31
USACE Erosion Survey	0.13		0.13	0.70%		
Unit Totals:	0.13	0.00	0.13	0.70%	7.88	1.31

Unit No. 02 American River	Overall Unit Rating	Total Unit Miles				
	A	2.33				
					Encroachments	
Rated Item	M Miles	U Miles	M + 4U Miles	Threshold %	PO Miles	CO Miles
Encroachments					2.43	
Unit Totals:	0.00	0.00	0.00	0.00%	2.43	0.00

Unit No. 03 Natomas East Canal	Overall Unit Rating	Total Unit Miles				
	A	17.17				
					Encroachments	
Rated Item	M Miles	U Miles	M + 4U Miles	Threshold %	PO Miles	CO Miles
Encroachments					0.73	
Unit Totals:	0.00	0.00	0.00	0.00%	0.73	0.00

Unit No. 04 Natomas Cross Canal	Overall Unit Rating	Total Unit Miles				
	A	4.38				
					Encroachments	
Rated Item	M Miles	U Miles	M + 4U Miles	Threshold %	PO Miles	CO Miles
No Items						
Unit Totals:	0.00	0.00	0.00	0.00%	0.00	0.00

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

LMA District Cover Sheet

Fall 2009 Levee Inspection Results

Reclamation District No. 1000

	Spring (March - May)	Summer ** (June - August)	Fall (September - November)	Winter ** (December - February)
* Overall LMA Rating (Fall Only)			A	

** Non-receipt of Summer or Winter Inspection Reports may effect overall annual rating.

*

SPRING INSPECTIONS: Overall maintenance ratings are not determined for the spring inspection results. Individual maintenance deficiencies are rated using the same criteria in the spring and in the fall.

FALL INSPECTIONS: The overall maintenance rating shown above is based on operation and maintenance deficiencies identified within the attached unit inspection reports.

Comments

Monday, January 25, 2010 10:59

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Unit Cover Sheet

Fall 2009 Levee Inspection Results

Reclamation District No. 1000

Waterway	Bank	Unit Miles
Unit No. 01 Sacramento River	Left	18.60

	Spring (March - May)	Summer (June - August)	(September - November) Fall	Winter (December - February)
Unit Maintenance Rating (Fall Only)			A	
Date of Inspection	3/17/2009		9/24/2009	
DWR Inspector	Clay Thomas		Clay Thomas	
Accompanied By				

Check one:

[ ] During the current winter (or summer) inspection period, my staff or I have inspected the levee and associated flood project components identified in the attached Levee Inspection Report by Mile. We have found no changes in flood project conditions other than the results of our normal maintenance and the corrections we have made to maintenance deficiencies identified in the enclosed report.

[ ] During the current winter (or summer) inspection period, my staff or I have inspected the levee and associated flood project components identified in the attached Levee Inspection Report by Mile. In addition to the results of our normal maintenance and the corrections we have made to maintenance deficiencies identified in the report, we have found the following changes in flood project conditions.

(In the comment section below or on additional sheet(s), identify change of condition by: Start to End Levee Mile or GPS coordinates, location (Land Side, Water Side, or Crown), Item identification, and description of the current condition).

Comments

One of the boxes above is to be checked by the Local Maintaining Agency (LMA). If the second box is checked, additional information must also be submitted. This Unit Cover Sheet should be signed and dated by the LMA Representative and returned to DWR with any additional sheets by September 30 (Summer Inspection) or March 31 (Winter Inspection). Please retain a copy for your records. Please mail all of this information to : DWR Summer/Winter Inspection Reports
3310 El Camino Avenue, Room LL-30
Sacramento, CA 95821-9000

x _____
Signature of LMA Representative Date

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	11/24/2009 12/01/2009	Clay Thomas

Levee Mile		Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude		Issue No.
Start	End						Start	End	Photo
0.08	0.08	Earthen Levee	Encroachments	WS	PO	Buildings	38.779583 ° -121.602598 °	38.779583 ° -121.602598 °	957
0.18	0.22	Earthen Levee	Encroachments	WS	PO	Landscaping	38.778408 ° -121.601488 °	38.777902 ° -121.601062 °	131
0.48	0.61	Supplemental	USACE Erosion Survey	WS	M	Inspector Comments: tree hazards, seepage	38.774507 ° -121.598865 °	38.772921 ° -121.597788 °	953
1.69	1.71	Earthen Levee	Encroachments	WS	PO	Landscaping	38.758697 ° -121.591178 °	38.758447 ° -121.591253 °	136
1.74	1.77	Earthen Levee	Encroachments	WS	PO	Landscaping	38.757962 ° -121.591342 °	38.757480 ° -121.591147 °	135
1.77	1.79	Earthen Levee	Encroachments	WS	PO	Landscaping	38.757478 ° -121.591140 °	38.757238 ° -121.591272 °	134
1.88	1.91	Earthen Levee	Encroachments	WS	PO	Landscaping	38.755975 ° -121.591433 °	38.755585 ° -121.591530 °	133
1.96	1.98	Earthen Levee	Encroachments	WS	PO	Landscaping	38.754948 ° -121.591742 °	38.754562 ° -121.591795 °	132
2.02	2.03	Earthen Levee	Encroachments	WS	PO	Landscaping	38.753983 ° -121.591737 °	38.753848 ° -121.591797 °	129
2.04	2.04	Earthen Levee	Encroachments	WS	PO	Landscaping	38.753691 ° -121.592149 °	38.753691 ° -121.592149 °	123
2.11	2.18	Earthen Levee	Encroachments	WS	PO	Landscaping	38.752513 ° -121.592017 °	38.751822 ° -121.592857 °	122
2.55	2.70	Earthen Levee	Encroachments	WS	PO	Landscaping	38.747087 ° -121.595582 °	38.745127 ° -121.598793 °	121
5.23	5.29	Earthen Levee	Encroachments	WS	PO	Landscaping	38.711248 ° -121.610500 °	38.710700 ° -121.611233 °	120
5.31	5.34	Earthen Levee	Encroachments	WS	PO	Landscaping	38.710508 ° -121.611450 °	38.710132 ° -121.611882 °	119
5.55	5.55	Earthen Levee	Rip Rap Revetments	WS	C	Inspector Comments: erosion repair site	38.708156 ° -121.614518 °	38.708156 ° -121.614518 °	958
5.68	5.72	Earthen Levee	Encroachments	WS	CO	Landscaping	38.706593 ° -121.616155 °	38.706082 ° -121.616385 °	118
5.72	5.75	Earthen Levee	Encroachments	WS	PO	Landscaping	38.706085 ° -121.616385 °	38.705662 ° -121.616837 °	117
6.04	6.07	Earthen Levee	Encroachments	WS	PO	Landscaping	38.702742 ° -121.620567 °	38.702467 ° -121.620947 °	116

* Location
LS : Land Side
WS : Water Side
CR : Crown

** Rating
A : Acceptable
M : Minimally Acceptable
U : Unacceptable
PO : Partially Obstructing
CO : Completely Obstructing
N : Not Inspected
C : Corrected

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	11/24/2009 12/01/2009	Clay Thomas

Unit No.	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. Photo
19	6.20	6.22	Earthen Levee	Encroachments	WS	PO	Landscaping	38.701422 ° -121.622755 °	38.701120 ° -121.623063 °	113
20	6.22	6.24	Earthen Levee	Encroachments	LS	PO	Landscaping	38.701177 ° -121.623057 °	38.700950 ° -121.623375 °	115
21	6.22	6.24	Earthen Levee	Encroachments	LS	PO	Fences	38.701178 ° -121.623060 °	38.700947 ° -121.623370 °	114
22	6.22	6.25	Earthen Levee	Encroachments	WS	CO	Landscaping	38.701120 ° -121.623085 °	38.700822 ° -121.623468 °	112
23	6.36	6.39	Earthen Levee	Encroachments	WS	CO	Landscaping	38.699877 ° -121.624948 °	38.699575 ° -121.625475 °	111
24	6.41	6.47	Earthen Levee	Encroachments	WS	PO	Landscaping	38.758757 ° -121.596252 °	38.757943 ° -121.596515 °	124
25	6.43	6.47	Earthen Levee	Encroachments	WS	PO	Landscaping	38.699237 ° -121.626088 °	38.698907 ° -121.626617 °	110
26	6.49	6.49	Earthen Levee	Encroachments	WS	PO	Landscaping	38.758607 ° -121.601933 °	38.758607 ° -121.601933 °	125
27	6.58	6.61	Earthen Levee	Encroachments	WS	PO	Landscaping	38.697958 ° -121.628273 °	38.697773 ° -121.628682 °	109
28	6.61	6.70	Earthen Levee	Encroachments	WS	PO	Landscaping	38.697775 ° -121.628685 °	38.696618 ° -121.629425 °	108
29	6.76	6.78	Earthen Levee	Encroachments	WS	PO	Landscaping	38.695892 ° -121.630053 °	38.695642 ° -121.630353 °	107
30	6.88	6.89	Earthen Levee	Encroachments	WS	PO	Landscaping	38.694348 ° -121.631007 °	38.694187 ° -121.631200 °	106
31	6.89	6.92	Earthen Levee	Encroachments	WS	PO	Landscaping	38.694192 ° -121.631203 °	38.693932 ° -121.631470 °	105
32	6.92	6.95	Earthen Levee	Encroachments	WS	PO	Landscaping	38.693935 ° -121.631478 °	38.693412 ° -121.631765 °	104
33	6.99	7.03	Earthen Levee	Encroachments	WS	PO	Landscaping	38.693043 ° -121.632048 °	38.692553 ° -121.632373 °	103
34	7.03	7.07	Earthen Levee	Encroachments	WS	PO	Landscaping	38.692535 ° -121.632423 °	38.691872 ° -121.632490 °	102
35	7.10	7.16	Earthen Levee	Encroachments	WS	PO	Landscaping	38.691422 ° -121.632585 °	38.690707 ° -121.632842 °	101
36	7.16	7.18	Earthen Levee	Encroachments	WS	PO	Landscaping	38.690678 ° -121.632840 °	38.690367 ° -121.632797 °	100

*** Location**
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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	11/24/2009 12/01/2009	Clay Thomas

Levee Mile Start	Levee Mile End	Category	Item	Location *	Rating **	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. Photo
7.22	7.27	Earthen Levee	Encroachments	WS	PO	Landscaping	38.689753 ° -121.632788 °	38.689077 ° -121.633003 °	99
7.36	7.36	Earthen Levee	Encroachments	WS	PO	Landscaping	38.687808 ° -121.632495 °	38.687808 ° -121.632495 °	97
7.36	7.36	Earthen Levee	Encroachments	WS	PO	Landscaping	38.687808 ° -121.632495 °	38.687808 ° -121.632495 °	98
7.39	7.43	Earthen Levee	Encroachments	WS	PO	Landscaping	38.687347 ° -121.632433 °	38.686760 ° -121.632138 °	85
7.66	7.72	Earthen Levee	Encroachments	WS	PO	Landscaping	38.683620 ° -121.631180 °	38.682742 ° -121.631190 °	95
7.72	7.75	Earthen Levee	Encroachments	WS	PO	Landscaping	38.682742 ° -121.631168 °	38.682310 ° -121.631085 °	94
7.81	7.86	Earthen Levee	Encroachments	WS	PO	Landscaping	38.681592 ° -121.630768 °	38.680837 ° -121.630530 °	93
8.08	8.11	Earthen Levee	Encroachments	WS	PO	Landscaping	38.678023 ° -121.628670 °	38.677672 ° -121.628432 °	92
8.18	8.19	Earthen Levee	Encroachments	WS	PO	Landscaping	38.676893 ° -121.627980 °	38.676747 ° -121.627725 °	91
8.22	8.25	Earthen Levee	Encroachments	WS	CO	Landscaping	38.676425 ° -121.627462 °	38.676038 ° -121.627063 °	90
8.25	8.28	Earthen Levee	Encroachments	WS	PO	Landscaping	38.676040 ° -121.627063 °	38.675772 ° -121.626785 °	89
8.36	8.38	Earthen Levee	Encroachments	WS	PO	Landscaping	38.674830 ° -121.625830 °	38.674610 ° -121.625552 °	88
8.38	8.42	Earthen Levee	Encroachments	WS	PO	Landscaping	38.674607 ° -121.625655 °	38.674117 ° -121.625143 °	87
8.56	8.59	Earthen Levee	Encroachments	WS	PO	Landscaping	38.672878 ° -121.623203 °	38.672603 ° -121.622892 °	86
8.60	8.66	Earthen Levee	Encroachments	WS	PO	Landscaping	38.672487 ° -121.622783 °	38.671790 ° -121.622118 °	85
8.77	8.86	Earthen Levee	Encroachments	WS	PO	Landscaping	38.670647 ° -121.620832 °	38.669790 ° -121.619482 °	84
8.96	8.98	Earthen Levee	Encroachments	WS	PO	Landscaping	38.668898 ° -121.618195 °	38.668672 ° -121.617775 °	83
8.98	9.02	Earthen Levee	Encroachments	WS	CO	Landscaping	38.668673 ° -121.617772 °	38.668405 ° -121.617278 °	82

* Location
LS : Land Side
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PO : Partially Obstructing
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N : Not Inspected
C : Corrected

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	11/24/2009 12/01/2009	Clay Thomas

Unit No.	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. Photo
55	9.03	9.08	Earthen Levee	Encroachments	WS	PO	Landscaping	38.668312 ° -121.617138 °	38.667783 ° -121.616382 °	81
56	9.09	9.11	Earthen Levee	Encroachments	WS	PO	Landscaping	38.667672 ° -121.616215 °	38.667552 ° -121.616018 °	80
57	9.11	9.14	Earthen Levee	Encroachments	WS	PO	Landscaping	38.667505 ° -121.615912 °	38.667255 ° -121.615525 °	79
58	9.15	9.17	Earthen Levee	Encroachments	WS	PO	Landscaping	38.667256 ° -121.615522 °	38.667028 ° -121.615115 °	78
59	9.57	9.57	Earthen Levee	Encroachments	WS	CO	Buildings	38.663307 ° -121.609949 °	38.663307 ° -121.609949 °	950
60	10.28	10.28	Earthen Levee	Animal Control	WS	C	Exterminate rodents and backfill and compact or grout burrows.	38.655161 ° -121.601900 °	38.655161 ° -121.601900 °	954
61	10.34	10.36	Earthen Levee	Encroachments	LS	PO	Landscaping	38.654508 ° -121.601280 °	38.654332 ° -121.601097 °	76
62	10.88	10.92	Earthen Levee	Encroachments	WS	CO	Landscaping	38.648127 ° -121.595872 °	38.647663 ° -121.595483 °	74
63	10.95	10.99	Earthen Levee	Encroachments	WS	CO	Landscaping	38.647373 ° -121.595248 °	38.646825 ° -121.594800 °	73
64	11.23	11.30	Earthen Levee	Encroachments	WS	PO	Landscaping	38.644548 ° -121.591768 °	38.644302 ° -121.590572 °	72
65	11.42	11.51	Earthen Levee	Encroachments	WS	CO	Landscaping	38.644393 ° -121.588498 °	38.644702 ° -121.586992 °	70
66	11.62	11.62	Earthen Levee	Animal Control	WS	C	Exterminate rodents and backfill and compact or grout burrows.	38.645479 ° -121.585212 °	38.645479 ° -121.585212 °	955
67	11.84	11.88	Earthen Levee	Encroachments	WS	PO	Landscaping	38.647408 ° -121.582090 °	38.647773 ° -121.581423 °	69
68	12.21	12.24	Earthen Levee	Encroachments	LS	PO	Landscaping	38.650302 ° -121.576493 °	38.650216 ° -121.575890 °	83
69	12.25	12.29	Earthen Levee	Encroachments	LS	CO	Buildings	38.650315 ° -121.575622 °	38.650367 ° -121.575005 °	68
70	12.33	12.35	Earthen Levee	Encroachments	WS	PO	Landscaping	38.653208 ° -121.573895 °	38.650245 ° -121.572188 °	66
71	12.35	12.43	Earthen Levee	Encroachments	WS	PO	Landscaping	38.650867 ° -121.573877 °	38.648223 ° -121.569630 °	67
72	12.44	12.55	Earthen Levee	Encroachments	WS	PO	Landscaping	38.651785 ° -121.571670 °	38.649560 ° -121.570438 °	65

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WS : Water Side	M : Minimally Acceptable	CO : Completely Obstructing	
CR : Crown	U : Unacceptable	N : Not Inspected	

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	11/24/2009 12/01/2009	Clay Thomas

LMR No.	Levee Mile Start	Levee Mile End	Category	Item	Location *	Rating **	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. Photo
73	12.55	12.59	Earthen Levee	Encroachments	WS	PO	Landscaping	38.649533 ° -121.570387 °	38.649253 ° -121.569810 °	64
74	12.59	12.64	Earthen Levee	Encroachments	WS	CO	Landscaping	38.649253 ° -121.569815 °	38.648895 ° -121.569043 °	62
75	12.64	12.67	Earthen Levee	Encroachments	WS	PO	Landscaping	38.648897 ° -121.569030 °	38.648588 ° -121.568467 °	61
76	12.72	12.77	Earthen Levee	Encroachments	WS	CO	Landscaping	38.648172 ° -121.567643 °	38.647738 ° -121.567167 °	60
77	12.77	12.85	Earthen Levee	Encroachments	WS	PO	Landscaping	38.647065 ° -121.567045 °	38.646812 ° -121.566135 °	59
78	12.89	12.98	Earthen Levee	Encroachments	WS	CO	Landscaping	38.646400 ° -121.565695 °	38.645302 ° -121.564733 °	58
79	13.08	13.08	Earthen Levee	Encroachments	WS	PO	Landscaping	38.644028 ° -121.563623 °	38.644028 ° -121.563823 °	56
80	13.12	13.13	Earthen Levee	Encroachments	WS	PO	Landscaping	38.643527 ° -121.563519 °	38.643378 ° -121.563402 °	55
81	13.13	13.14	Earthen Levee	Encroachments	WS	PO	Fences	38.643380 ° -121.563400 °	38.643275 ° -121.563307 °	54
82	13.26	13.30	Earthen Levee	Encroachments	WS	PO	Landscaping	38.641620 ° -121.562753 °	38.641113 ° -121.562557 °	52
83	13.27	14.57	Earthen Levee	Vegetation	LS	C	Remove the wild growth other than native grasses from the levee slopes.	38.640471 ° -121.562497 °	38.623167 ° -121.560322 °	137
84	13.34	17.63	Earthen Levee	Encroachments	LS	PO	Agricultural Ditch	38.640469 ° -121.562502 °	38.605560 ° -121.528064 °	956
85	13.36	13.41	Earthen Levee	Encroachments	WS	PO	Landscaping	38.640205 ° -121.562370 °	38.639540 ° -121.562238 °	51
86	13.47	13.51	Earthen Levee	Encroachments	WS	PO	Landscaping	38.638668 ° -121.562085 °	38.638065 ° -121.562015 °	50
87	13.51	13.55	Earthen Levee	Encroachments	WS	PO	Landscaping	38.638067 ° -121.562013 °	38.637600 ° -121.561932 °	49
88	13.55	13.58	Earthen Levee	Encroachments	WS	PO	Landscaping	38.637602 ° -121.561930 °	38.637060 ° -121.561833 °	48
89	13.58	13.62	Earthen Levee	Encroachments	WS	PO	Landscaping	38.637052 ° -121.561833 °	38.636527 ° -121.561743 °	47
90	13.60	13.60	Earthen Levee	Encroachments	LS	PO	Landscaping	38.636842 ° -121.561804 °	38.636842 ° -121.561804 °	136

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	11/24/2009 12/01/2009	Clay Thomas

LMR No	Levee Mile Start	Levee Mile End	Category	Item	Location *	Rating **	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. Photo
91	13.62	13.64	Earthen Levee	Encroachments	WS	PO	Landscaping	38.636522 ° -121.561743 °	38.636250 ° -121.561667 °	46
92	13.68	13.70	Earthen Levee	Encroachments	WS	PO	Landscaping	38.635638 ° -121.561570 °	38.635387 ° -121.561497 °	45
93	13.70	13.72	Earthen Levee	Encroachments	WS	PO	Landscaping	38.635390 ° -121.561490 °	38.635032 ° -121.561482 °	44
94	13.86	13.90	Earthen Levee	Encroachments	WS	CO	Fences	38.633238 ° -121.561097 °	38.632590 ° -121.560915 °	43
95	14.21	14.24	Earthen Levee	Encroachments	WS	CO	Landscaping	38.628300 ° -121.560180 °	38.627873 ° -121.560202 °	42
96	14.31	14.32	Earthen Levee	Encroachments	WS	PO	Landscaping	38.626905 ° -121.560062 °	38.626863 ° -121.561015 °	41
97	14.37	14.39	Earthen Levee	Encroachments	WS	PO	Landscaping	38.625975 ° -121.560127 °	38.625642 ° -121.560185 °	39
98	14.38	14.52	Earthen Levee	Encroachments	WS	PO	Landscaping	38.623976 ° -121.560372 °	38.623812 ° -121.561345 °	40
99	14.79	14.82	Earthen Levee	Encroachments	WS	PO	Landscaping	38.620077 ° -121.560120 °	38.619630 ° -121.560067 °	38
100	14.85	14.90	Earthen Levee	Encroachments	WS	PO	Landscaping	38.619112 ° -121.560113 °	38.618493 ° -121.560070 °	37
101	14.92	14.92	Earthen Levee	Encroachments	WS	PO	Landscaping	38.618163 ° -121.560113 °	38.618163 ° -121.560113 °	36
102	14.98	15.02	Earthen Levee	Encroachments	WS	PO	Landscaping	38.617388 ° -121.559970 °	38.616835 ° -121.559807 °	35
103	15.33	15.38	Earthen Levee	Encroachments	WS	PO	Landscaping	38.612555 ° -121.558258 °	38.611900 ° -121.558303 °	34
104	15.46	15.48	Earthen Levee	Encroachments	WS	PO	Fences	38.610787 ° -121.557817 °	38.610455 ° -121.557638 °	33
105	15.50	15.52	Earthen Levee	Encroachments	WS	PO	Fences	38.610180 ° -121.557453 °	38.609908 ° -121.557328 °	32
106	15.54	15.57	Earthen Levee	Encroachments	WS	CO	Landscaping	38.609743 ° -121.557252 °	38.609315 ° -121.557000 °	31
107	15.70	15.73	Earthen Levee	Encroachments	WS	CO	Landscaping	38.607715 ° -121.555847 °	38.607345 ° -121.555538 °	30
108	15.74	15.82	Earthen Levee	Encroachments	WS	CO	Fences	38.607207 ° -121.555465 °	38.606255 ° -121.554582 °	29

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	11/24/2009 12/01/2009	Clay Thomas

Unit No.	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. / Photo
109	15.85	15.87	Earthen Levee	Encroachments	WS	PO	Landscaping	38.605915 ° -121.554290 °	38.605687 ° -121.554070 °	28
110	15.88	15.91	Earthen Levee	Encroachments	WS	PO	Landscaping	38.605586 ° -121.553983 °	38.605273 ° -121.553663 °	27
111	15.91	15.93	Earthen Levee	Encroachments	WS	PO	Landscaping	38.605265 ° -121.553647 °	38.605032 ° -121.553437 °	26
112	15.93	15.97	Earthen Levee	Encroachments	WS	PO	Landscaping	38.605002 ° -121.553413 °	38.604598 ° -121.553008 °	25
113	16.09	16.10	Earthen Levee	Encroachments	WS	PO	Landscaping	38.603083 ° -121.551690 °	38.602943 ° -121.551593 °	23
114	16.11	16.13	Earthen Levee	Encroachments	WS	PO	Landscaping	38.602870 ° -121.551598 °	38.602617 ° -121.551330 °	22
115	16.14	16.16	Earthen Levee	Encroachments	WS	PO	Landscaping	38.602517 ° -121.551248 °	38.602373 ° -121.550963 °	21
116	16.20	16.23	Earthen Levee	Encroachments	WS	PO	Fences	38.601977 ° -121.550473 °	38.601678 ° -121.550142 °	20
117	16.30	16.33	Earthen Levee	Encroachments	WS	PO	Landscaping	38.600968 ° -121.549198 °	38.600665 ° -121.548795 °	19
118	16.34	16.36	Earthen Levee	Encroachments	WS	PO	Landscaping	38.600525 ° -121.548640 °	38.600397 ° -121.548447 °	18
119	16.86	16.90	Earthen Levee	Encroachments	WS	CO	Fences	38.602328 ° -121.540788 °	38.602688 ° -121.540157 °	16
120	16.90	16.95	Earthen Levee	Encroachments	WS	PO	Fences	38.602693 ° -121.540165 °	38.603092 ° -121.539490 °	15
121	16.97	17.00	Earthen Levee	Encroachments	WS	PO	Fences	38.603242 ° -121.539318 °	38.603597 ° -121.538875 °	14
122	17.06	17.18	Earthen Levee	Encroachments	WS	PO	Fences	38.604188 ° -121.536027 °	38.604890 ° -121.536105 °	13
123	17.64	17.74	Earthen Levee	Encroachments	WS	PO	Fences	38.605645 ° -121.527902 °	38.605542 ° -121.526112 °	11
124	17.77	17.82	Earthen Levee	Encroachments	WS	CO	Buildings	38.605462 ° -121.525492 °	38.605447 ° -121.524678 °	10
125	17.82	17.91	Earthen Levee	Encroachments	WS	CO	Buildings	38.605445 ° -121.524676 °	38.605305 ° -121.522958 °	9
126	17.83	17.86	Earthen Levee	Encroachments	LS	CO	Buildings	38.605420 ° -121.524376 °	38.605462 ° -121.523852 °	9

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	11/24/2009 12/01/2009	Clay Thomas

Unit No.	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. Photo
127	17.91	17.94	Earthen Levee	Encroachments	WS	CO	Buildings	38.605300 ° -121.522957 °	38.605200 ° -121.522422 °	7
128	18.10	18.10	Earthen Levee	Encroachments	WS	CO	Buildings	38.604788 ° -121.519720 °	38.604788 ° -121.519720 °	6
129	18.10	18.18	Earthen Levee	Encroachments	WS	CO	Buildings	38.604758 ° -121.519610 °	38.604532 ° -121.518190 °	5
130	18.21	18.40	Earthen Levee	Encroachments	WS	CO	Buildings	38.604515 ° -121.517635 °	38.603918 ° -121.514370 °	4

* Location	** Rating		
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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Unit Cover Sheet

Fall 2009 Levee Inspection Results

Reclamation District No. 1000

Waterway	Bank	Unit Miles
Unit No. 02 American River	Right	2.33

	Spring (March - May)	Summer (June - August)	(September - November) Fall	Winter (December - February)
Unit Maintenance Rating (Fall Only)			A	
Date of Inspection	3/17/2009		9/24/2009	
DWR Inspector	Clay Thomas		Clay Thomas	
Accompanied By				

Check one:

☐ During the current winter (or summer) inspection period, my staff or I have inspected the levee and associated flood project components identified in the attached Levee Inspection Report by Mile. We have found no changes in flood project conditions other than the results of our normal maintenance and the corrections we have made to maintenance deficiencies identified in the enclosed report.

☐ During the current winter (or summer) inspection period, my staff or I have inspected the levee and associated flood project components identified in the attached Levee Inspection Report by Mile. In addition to the results of our normal maintenance and the corrections we have made to maintenance deficiencies identified in the report, we have found the following changes in flood project conditions.

(In the comment section below or on additional sheet(s), identify change of condition by: Start to End Levee Mile or GPS coordinates, location (Land Side, Water Side, or Crown), Item identification, and description of the current condition).

Comments

One of the boxes above is to be checked by the Local Maintaining Agency (LMA). If the second box is checked, additional information must also be submitted. This Unit Cover Sheet should be signed and dated by the LMA Representative and returned to DWR with any additional sheets by September 30 (Summer Inspection) or March 31 (Winter Inspection). Please retain a copy for your records. Please mail all of this information to : DWR Summer/Winter Inspection Reports
3310 El Camino Avenue, Room LL-30
Sacramento, CA 95821-9000

X _____

Signature of LMA Representative Date

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 02 American River	Right	2.33	12/01/2009 12/01/2009	Clay Thomas

Unit No.	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. Photo
1	0.07	2.30	Earthen Levee	Encroachments	LS	PO	Landscaping	38.604932 ° -121.510243 °	38.605932 ° -121.470770 °	1
2	1.50	1.70	Earthen Levee	Encroachments	WS	PO	Landscaping	38.607880 ° -121.484500 °	38.607110 ° -121.480950 °	2

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Unit Cover Sheet

Fall 2009 Levee Inspection Results

Reclamation District No. 1000

Waterway	Bank	Unit Miles
Unit No. 03 Natomas East Canal	Right	17.17

	Spring (March - May)	Summer (June - August)	(September - November) Fall	Winter (December - February)
Unit Maintenance Rating (Fall Only)			A	
Date of Inspection	3/17/2009		9/24/2009	
DWR Inspector	Clay Thomas		Clay Thomas	
Accompanied By				

Check one:

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DWR Summer/Winter Inspection Reports
3310 El Camino Avenue, Room LL-30
Sacramento, CA 95821-9000

X

Signature of LMA Representative Date

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 03 Natomas East Canal	Right	17.17	11/24/2009 12/01/2009	Clay Thomas

Unit No.	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. / Photo
1	0.07	0.13	Earthen Levee	Encroachments	LS	PO	Fences	38.606882 ° -121.469480 °	38.607523 ° -121.469033 °	7
2	0.30	0.32	Earthen Levee	Encroachments	LS	PO	Fences	38.609865 ° -121.468183 °	38.610162 ° -121.468122 °	5
3	0.53	0.57	Earthen Levee	Encroachments	LS	PO	Fences	38.613077 ° -121.468133 °	38.613700 ° -121.468263 °	4
4	3.05	3.10	Earthen Levee	Encroachments	LS	PO	Fences	38.648677 ° -121.474882 °	38.649412 ° -121.475005 °	3
5	14.54	14.94	Earthen Levee	Encroachments	LS	C	Agricultural Ditch	38.804665 ° -121.516013 °	38.809031 ° -121.518615 °	8
6	15.51	16.07	Earthen Levee	Encroachments	LS	PO	Agricultural Ditch	38.816259 ° -121.522787 °	38.823314 ° -121.526942 °	9

*** Location**
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CR : Crown

**** Rating**
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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Unit Cover Sheet

Fall 2009 Levee Inspection Results

Reclamation District No. 1000

Waterway	Bank	Unit Miles
Unit No. 04 Natomas Cross Canal	Left	4.38

	Spring (March - May)	Summer (June - August)	(September - November) Fall	Winter (December - February)
Unit Maintenance Rating (Fall Only)			A	
Date of Inspection			9/24/2009	
DWR Inspector			Clay Thomas	
Accompanied By				

Check one:

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(In the comment section below or on additional sheet(s), identify change of condition by: Start to End Levee Mile or GPS coordinates, location (Land Side, Water Side, or Crown), Item identification, and description of the current condition).

Comments

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DWR Summer/Winter Inspection Reports
3310 El Camino Avenue, Room LL-30
Sacramento, CA 95821-9000

X _____

Signature of LMA Representative Date

Monday, January 25, 2010 10:59

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Fall 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 04 Natomas Cross Canal	Left	4.38	11/24/2009 11/24/2009	Clay Thomas

Last No.	Levee Mile Start	Levee Mile End	Category	Item	Location *	Rating **	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Issue No. Photo
1							No issues were reported.	° '	° '	

* Location	** Rating		
LS : Land Side	A : Acceptable	PO : Partially Obstructing	C : Corrected
WS : Water Side	M : Minimally Acceptable	CO : Completely Obstructing	
CR : Crown	U : Unacceptable	N : Not Inspected	

Spring 2009 RD 1000

STATE OF CALIFORNIA -- THE RESOURCES AGENCY
ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

TO: Federal Flood Control Project Maintaining Agencies
Spring 2009 Levee Inspection Results

The Department of Water Resources' (DWR) Flood Project Integrity and Inspection Branch has completed the spring 2009 flood project inspections. Enclosed are the Levee Mile Report(s) (LMRs) and cover sheets for your agency. These inspections utilized the same inspection criteria that have been used since the fall 2007 inspections. Although ratings are given for individual maintenance deficiencies, overall unit and district ratings are not calculated for spring inspections.

As you know, the Code of Federal Regulation (33 CFR 208.10) requires that four inspections of the federal flood control system be performed each year. DWR performs the spring and fall inspections in detail and local districts perform the summer and winter inspections. Your agency is required to inspect your system during the June through August period and report on whether you identified any new maintenance or integrity issues.

The unit cover sheets, enclosed, have two checkboxes that can be used to describe the situation in your system as noted by your agency during the June through August period. If the only changes in conditions are the direct result of maintenance that has been performed or corrections that have been made to deficiencies identified in the spring report, the first box on the unit cover sheet should be checked. If there are other changes in conditions that require correction, the second box should be checked and a description of changes, identifying the location of each change by start and end levee mile or GPS coordinates, location (land side, water side, or crown), item identification (vegetation, animal control, erosion, etc.), and a description of the change in condition should be included. This information should be entered in the comments section of the unit cover sheet and continued on additional sheets as necessary.

Once your agency has completed the summer inspection, please check the appropriate box for each unit, include any additional information, sign, date, and return all Unit Cover Sheets to the address below by **September 30, 2009**. Also, please be sure to duplicate and retain a copy of the Sheets for your records.

DWR – Flood Project Inspection Section
3310 El Camino Avenue Room LL-30
P.O. Box 219000
Sacramento, California 95821-9000

The Flood Project Integrity and Inspection Branch has incorporated your agency's fall 2008 Levee Mile Reports into the AB 156 electronic reporting web application. Currently, an inspection reporting application is being developed and integrated into the AB 156 web application for easy reporting in the near future of your efforts and plans regarding the condition of your system. Workshops will be held in Sacramento on June 23-25, 2009, to provide more information about this program. Please see the enclosed flyer for more details.

We encourage you to have a representative from your agency attend one of these workshops to test the additional functionality and new features of the web application and we look forward to receiving feedback for future improvements.

If you have any questions, or need any additional information, please contact your inspector or contact me at (916) 574-1729 or e-mail at ilenewb@water.ca.gov.

Sincerely,

Ilene Wellman-Barbree

Ilene Wellman-Barbree, Acting Chief
Flood Project Inspection Section

Enclosures

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

LMA District Cover Sheet

Spring 2009 Levee Inspection Results

Reclamation District No. 1000

	Spring (March - May)	Summer ** (June - August)	Fall (September - November)	Winter ** (December - February)
* Overall LMA Rating (Fall Only)				

** Non-receipt of Summer or Winter Inspection Reports may effect overall annual rating.

*

SPRING INSPECTIONS: Overall maintenance ratings are not determined for the spring inspection results. Individual maintenance deficiencies are rated using the same criteria in the spring and in the fall.

FALL INSPECTIONS: The overall maintenance rating shown above is based on operation and maintenance deficiencies identified within the attached unit inspection reports.

Comments

Friday, June 05, 2009 09:55

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Unit Cover Sheet

Spring 2009 Levee Inspection Results

Reclamation District No. 1000

Waterway	Bank	Unit Miles
Unit No. 01 Sacramento River	Left	18.60

	Spring (March - May)	Summer (June - August)	(September - November) Fall	Winter (December - February)
Unit Maintenance Rating (Fall Only)				
Date of Inspection	3/18/2009 - 3/18/2009			
DWR Inspector	Clay Thomas			
Accompanied By				

Check one:

☐ During the current winter (or summer) inspection period, my staff or I have inspected the levee and associated flood project components identified in the attached Levee Inspection Report by Mile. We have found no changes in flood project conditions other than the results of our normal maintenance and the corrections we have made to maintenance deficiencies identified in the enclosed report.

☐ During the current winter (or summer) inspection period, my staff or I have inspected the levee and associated flood project components identified in the attached Levee Inspection Report by Mile. In addition to the results of our normal maintenance and the corrections we have made to maintenance deficiencies identified in the report, we have found the following changes in flood project conditions.

(In the comment section below or on additional sheet(s), identify change of condition by: Start to End Levee Mile or GPS coordinates, location (Land Side, Water Side, or Crown), Item identification, and description of the current condition).

Comments

One of the boxes above is to be checked by the Local Maintaining Agency (LMA). If the second box is checked, additional information must also be submitted. This Unit Cover Sheet should be signed and dated by the LMA Representative and returned to DWR with any additional sheets by September 30 (Summer Inspection) or March 31 (Winter Inspection). Please retain a copy for your records. Please mail all of this information to : DWR Summer/Winter Inspection Reports
3310 El Camino Avenue, Room LL-30
Sacramento, CA 95821-9000.

X _____
Signature of LMA Representative Date

Friday, June 05, 2009 09:55

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	03/18/2009 03/18/2009	Clay Thomas

LMR Line	Levee Mile Start	Levee Mile End	Category	Item	Location*	Rating**	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
1	0.18	0.22	Earthen Levee	Encroachments	WS	PO	Landscaping	38.778408 ° -121.601488 °	38.777902 ° -121.601062 °	131	
2	0.48	0.61	Boat Survey	Boat Survey	WS	M		38.774507 ° -121.598865 °	38.772921 ° -121.597788 °	953	
				Erosion			Inspector Comments: tree hazards, seepage				
3	1.69	1.71	Earthen Levee	Encroachments	WS	PO	Landscaping	38.758697 ° -121.591178 °	38.758447 ° -121.591253 °	136	
4	1.74	1.77	Earthen Levee	Encroachments	WS	PO	Landscaping	38.757982 ° -121.591342 °	38.757480 ° -121.591147 °	135	
5	1.77	1.79	Earthen Levee	Encroachments	WS	PO	Landscaping	38.757478 ° -121.591140 °	38.757238 ° -121.591272 °	134	
6	1.88	1.91	Earthen Levee	Encroachments	WS	PO	Landscaping	38.755975 ° -121.591433 °	38.755585 ° -121.591530 °	133	
7	1.96	1.98	Earthen Levee	Encroachments	WS	PO	Landscaping	38.754848 ° -121.591742 °	38.754562 ° -121.591795 °	132	
8	2.02	2.03	Earthen Levee	Encroachments	WS	PO	Landscaping	38.753983 ° -121.591737 °	38.753848 ° -121.591797 °	129	
9	2.04	2.04	Earthen Levee	Encroachments	WS	PO	Landscaping	38.753591 ° -121.592149 °	38.753691 ° -121.592149 °	123	
10	2.11	2.18	Earthen Levee	Encroachments	WS	PO	Landscaping	38.752513 ° -121.592017 °	38.751822 ° -121.592857 °	122	
11	2.55	2.70	Earthen Levee	Encroachments	WS	PO	Landscaping	38.747087 ° -121.595582 °	38.745127 ° -121.596793 °	121	
12	5.23	5.29	Earthen Levee	Encroachments	WS	PO	Landscaping	38.711248 ° -121.610500 °	38.710700 ° -121.611233 °	120	
13	5.31	5.34	Earthen Levee	Encroachments	WS	PO	Landscaping	38.710508 ° -121.611450 °	38.710132 ° -121.611882 °	119	
14	5.68	5.72	Earthen Levee	Encroachments	WS	CO	Landscaping	38.706593 ° -121.616155 °	38.706082 ° -121.616385 °	118	
15	5.72	5.75	Earthen Levee	Encroachments	WS	PO	Landscaping	38.706085 ° -121.616385 °	38.705662 ° -121.616837 °	117	
16	6.04	6.07	Earthen Levee	Encroachments	WS	PO	Landscaping	38.702742 ° -121.620557 °	38.702467 ° -121.620947 °	116	
17	6.20	6.22	Earthen Levee	Encroachments	WS	PO	Landscaping	38.701422 ° -121.622755 °	38.701120 ° -121.623063 °	113	

* Location
LS : Land Side
WS : Water Side
CR : Crown

** Rating
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PO : Partially Obstructing
CO : Completely Obstructing
N : Not Inspected
C : Corrected

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	03/18/2009 03/18/2009	Clay Thomas

LMR Unit	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
18	6.22	6.24	Earthen Levee	Encroachments	LS	PO	Landscaping	38.701177 ° -121.623057 °	38.700950 ° -121.623375 °		115
19	6.22	6.24	Earthen Levee	Encroachments	LS	PO	Fences	38.701178 ° -121.623060 °	38.700947 ° -121.623370 °		114
20	6.22	6.25	Earthen Levee	Encroachments	WS	CO	Landscaping	38.701120 ° -121.623085 °	38.700822 ° -121.623468 °		112
21	6.36	6.39	Earthen Levee	Encroachments	WS	CO	Landscaping	38.699877 ° -121.624948 °	38.699575 ° -121.625475 °		111
22	6.41	6.47	Earthen Levee	Encroachments	WS	PO	Landscaping	38.755757 ° -121.596252 °	38.757943 ° -121.599515 °		124
23	6.43	6.47	Earthen Levee	Encroachments	WS	PO	Landscaping	38.699237 ° -121.626088 °	38.698907 ° -121.626617 °		110
24	6.49	6.49	Earthen Levee	Encroachments	WS	PO	Landscaping	38.758607 ° -121.601933 °	38.758607 ° -121.601933 °		125
25	6.58	6.61	Earthen Levee	Encroachments	WS	PO	Landscaping	38.697958 ° -121.628273 °	38.697773 ° -121.628682 °		109
26	6.61	6.70	Earthen Levee	Encroachments	WS	PO	Landscaping	38.697775 ° -121.628685 °	38.696618 ° -121.629425 °		108
27	6.76	6.78	Earthen Levee	Encroachments	WS	PO	Landscaping	38.695892 ° -121.630053 °	38.695642 ° -121.630353 °		107
28	6.88	6.89	Earthen Levee	Encroachments	WS	PO	Landscaping	38.694348 ° -121.631007 °	38.694187 ° -121.631200 °		106
29	6.89	6.92	Earthen Levee	Encroachments	WS	PO	Landscaping	38.694192 ° -121.631203 °	38.693932 ° -121.631470 °		105
30	6.92	6.95	Earthen Levee	Encroachments	WS	PO	Landscaping	38.693935 ° -121.631478 °	38.693412 ° -121.631765 °		104
31	6.99	7.03	Earthen Levee	Encroachments	WS	PO	Landscaping	38.693043 ° -121.632048 °	38.692553 ° -121.632373 °		103
32	7.03	7.07	Earthen Levee	Encroachments	WS	PO	Landscaping	38.692535 ° -121.632423 °	38.691872 ° -121.632490 °		102
33	7.10	7.16	Earthen Levee	Encroachments	WS	PO	Landscaping	38.691422 ° -121.632585 °	38.690707 ° -121.632842 °		101
34	7.16	7.18	Earthen Levee	Encroachments	WS	PO	Landscaping	38.690678 ° -121.632840 °	38.690367 ° -121.632797 °		100

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	03/18/2009 03/18/2009	Clay Thomas

LMR Line	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
35	7.22	7.27	Earthen Levee	Encroachments	WS	PO	Landscaping	38.689753 ° -121.632788 °	38.689077 ° -121.633003 °		99
36	7.36	7.36	Earthen Levee	Encroachments	WS	PO	Landscaping	38.687808 ° -121.632495 °	38.687808 ° -121.632495 °		97
37	7.36	7.36	Earthen Levee	Encroachments	WS	PO	Landscaping	38.687808 ° -121.632495 °	38.687808 ° -121.632495 °		98
38	7.39	7.43	Earthen Levee	Encroachments	WS	PO	Landscaping	38.687347 ° -121.632433 °	38.686780 ° -121.632138 °		96
39	7.66	7.72	Earthen Levee	Encroachments	WS	PO	Landscaping	38.683620 ° -121.631180 °	38.682742 ° -121.631190 °		95
40	7.72	7.75	Earthen Levee	Encroachments	WS	PO	Landscaping	38.682742 ° -121.631168 °	38.682310 ° -121.631085 °		94
41	7.81	7.86	Earthen Levee	Encroachments	WS	PO	Landscaping	38.681592 ° -121.630768 °	38.680837 ° -121.630530 °		93
42	8.08	8.11	Earthen Levee	Encroachments	WS	PO	Landscaping	38.678023 ° -121.628670 °	38.677572 ° -121.628432 °		92
43	8.18	8.19	Earthen Levee	Encroachments	WS	PO	Landscaping	38.676893 ° -121.627860 °	38.676747 ° -121.627725 °		91
44	8.22	8.25	Earthen Levee	Encroachments	WS	CO	Landscaping	38.676425 ° -121.627462 °	38.676038 ° -121.627063 °		90
45	8.25	8.28	Earthen Levee	Encroachments	WS	PO	Landscaping	38.676040 ° -121.627063 °	38.675772 ° -121.626785 °		89
46	8.36	8.38	Earthen Levee	Encroachments	WS	PO	Landscaping	38.674830 ° -121.625830 °	38.674610 ° -121.625652 °		88
47	8.38	8.42	Earthen Levee	Encroachments	WS	PO	Landscaping	38.674607 ° -121.625655 °	38.674117 ° -121.625143 °		87
48	8.56	8.59	Earthen Levee	Encroachments	WS	PO	Landscaping	38.672878 ° -121.623203 °	38.672603 ° -121.622892 °		86
49	8.60	8.66	Earthen Levee	Encroachments	WS	PO	Landscaping	38.672487 ° -121.622783 °	38.671790 ° -121.622118 °		85
50	8.77	8.86	Earthen Levee	Encroachments	WS	PO	Landscaping	38.670647 ° -121.620632 °	38.669790 ° -121.619492 °		84
51	8.96	8.98	Earthen Levee	Encroachments	WS	PO	Landscaping	38.668898 ° -121.618195 °	38.668672 ° -121.617775 °		83

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	03/18/2009 03/18/2009	Clay Thomas

UNIT Levee	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issues
52	8.98	9.02	Earthen Levee	Encroachments	WS	CO	Landscaping	38.668673 ° -121.617772 °	38.668405 ° -121.617278 °		82
53	9.03	9.08	Earthen Levee	Encroachments	WS	PO	Landscaping	38.668312 ° -121.617138 °	38.667783 ° -121.616382 °		81
54	9.09	9.11	Earthen Levee	Encroachments	WS	PO	Landscaping	38.667672 ° -121.616215 °	38.667552 ° -121.616018 °		80
55	9.11	9.14	Earthen Levee	Encroachments	WS	PO	Landscaping	38.667505 ° -121.615912 °	38.667255 ° -121.615525 °		79
56	9.15	9.17	Earthen Levee	Encroachments	WS	PO	Landscaping	38.667250 ° -121.615522 °	38.667028 ° -121.615115 °		78
57	10.28	10.28	Earthen Levee	Animal Control	WS	M	Exterminate rodents and backfill and compact or grout burrows.	38.655161 ° -121.601900 °	38.655161 ° -121.601900 °		954
58	10.34	10.36	Earthen Levee	Encroachments	LS	PO	Landscaping	38.654508 ° -121.601280 °	38.654332 ° -121.601097 °		75
59	10.88	10.92	Earthen Levee	Encroachments	WS	CO	Landscaping	38.648127 ° -121.595872 °	38.647663 ° -121.595483 °		74
60	10.95	10.99	Earthen Levee	Encroachments	WS	CO	Landscaping	38.647373 ° -121.595248 °	38.646825 ° -121.594800 °		73
61	11.23	11.30	Earthen Levee	Encroachments	WS	PO	Landscaping	38.644548 ° -121.591768 °	38.644302 ° -121.590572 °		72
62	11.42	11.51	Earthen Levee	Encroachments	WS	CO	Landscaping	38.644393 ° -121.588498 °	38.644702 ° -121.586992 °		70
63	11.62	11.62	Earthen Levee	Animal Control	WS	M	Exterminate rodents and backfill and compact or grout burrows.	38.645479 ° -121.585212 °	38.645479 ° -121.585212 °		955
64	11.84	11.88	Earthen Levee	Encroachments	WS	CO	Landscaping	38.647408 ° -121.582090 °	38.647773 ° -121.581423 °		69
65	12.21	12.24	Earthen Levee	Encroachments	LS	PO	Landscaping	38.650302 ° -121.576493 °	38.650216 ° -121.575890 °		63
66	12.25	12.29	Earthen Levee	Encroachments	LS	CO	Buildings	38.650315 ° -121.575622 °	38.650367 ° -121.575005 °		68
67	12.33	12.35	Earthen Levee	Encroachments	WS	PO	Landscaping	38.653208 ° -121.573895 °	38.650245 ° -121.572188 °		66
68	12.35	12.43	Earthen Levee	Encroachments	WS	PO	Landscaping	38.650867 ° -121.573877 °	38.648223 ° -121.569630 °		67

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	03/18/2009 03/18/2009	Clay Thomas

LMR Line	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
69	12.44	12.55	Earthen Levee	Encroachments	WS	PO	Landscaping	38.651785 ° -121.571670 °	38.649560 ° -121.570438 °		65
70	12.55	12.59	Earthen Levee	Encroachments	WS	PO	Landscaping	38.649533 ° -121.570387 °	38.649253 ° -121.569810 °		64
71	12.59	12.64	Earthen Levee	Encroachments	WS	CO	Landscaping	38.649253 ° -121.569815 °	38.648895 ° -121.569043 °		62
72	12.64	12.67	Earthen Levee	Encroachments	WS	PO	Landscaping	38.648897 ° -121.569030 °	38.648588 ° -121.568467 °		61
73	12.72	12.77	Earthen Levee	Encroachments	WS	CO	Landscaping	38.648172 ° -121.567843 °	38.647738 ° -121.567167 °		60
74	12.77	12.85	Earthen Levee	Encroachments	WS	CO	Landscaping	38.647665 ° -121.567045 °	38.646812 ° -121.566135 °		59
75	12.89	12.98	Earthen Levee	Encroachments	WS	CO	Landscaping	38.646400 ° -121.565695 °	38.645302 ° -121.564733 °		58
76	13.08	13.08	Earthen Levee	Encroachments	WS	PO	Landscaping	38.644028 ° -121.563823 °	38.644028 ° -121.563823 °		56
77	13.12	13.13	Earthen Levee	Encroachments	WS	PO	Landscaping	38.643527 ° -121.563518 °	38.643378 ° -121.563402 °		55
78	13.13	13.14	Earthen Levee	Encroachments	WS	PO	Fences	38.643380 ° -121.563400 °	38.643275 ° -121.563307 °		54
79	13.26	13.30	Earthen Levee	Encroachments	WS	PO	Landscaping	38.641620 ° -121.562753 °	38.641113 ° -121.562557 °		52
80	13.27	14.57	Earthen Levee	Vegetation	LS	M	Remove the wild growth other than native grasses from the levee slopes.	38.640471 ° -121.562497 °	38.623167 ° -121.560322 °		137
81	13.34	17.63	Earthen Levee	Encroachments	LS	PO	Agricultural Ditch	38.640469 ° -121.562502 °	38.605560 ° -121.528054 °		956
82	13.36	13.41	Earthen Levee	Encroachments	WS	PO	Landscaping	38.640205 ° -121.562370 °	38.639540 ° -121.562238 °		51
83	13.47	13.51	Earthen Levee	Encroachments	WS	PO	Landscaping	38.638668 ° -121.562085 °	38.638065 ° -121.562015 °		50
84	13.51	13.55	Earthen Levee	Encroachments	WS	PO	Landscaping	38.638067 ° -121.562013 °	38.637600 ° -121.561932 °		49
85	13.55	13.58	Earthen Levee	Encroachments	WS	CO	Landscaping	38.637602 ° -121.561930 °	38.637060 ° -121.561833 °		48

* Location
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CR : Crown

** Rating
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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	03/18/2009 03/18/2009	Clay Thomas

LMR Line	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
86	13.58	13.62	Earthen Levee	Encroachments	WS	CO	Landscaping	38.637052 ° -121.561833 °	38.636527 ° -121.561743 °		47
87	13.60	13.60	Earthen Levee	Encroachments	LS	PO	Landscaping	38.636842 ° -121.561804 °	38.636842 ° -121.561804 °		138
88	13.62	13.64	Earthen Levee	Encroachments	WS	PO	Landscaping	38.636522 ° -121.561743 °	38.636250 ° -121.561667 °		46
89	13.68	13.70	Earthen Levee	Encroachments	WS	PO	Landscaping	38.635638 ° -121.561570 °	38.635367 ° -121.561497 °		45
90	13.70	13.72	Earthen Levee	Encroachments	WS	CO	Landscaping	38.635390 ° -121.561490 °	38.635032 ° -121.561462 °		44
91	13.86	13.90	Earthen Levee	Encroachments	WS	CO	Fences	38.633238 ° -121.561097 °	38.632590 ° -121.560915 °		43
92	14.21	14.24	Earthen Levee	Encroachments	WS	CO	Landscaping	38.628300 ° -121.560180 °	38.627873 ° -121.560202 °		42
93	14.31	14.32	Earthen Levee	Encroachments	WS	PO	Landscaping	38.626905 ° -121.560062 °	38.626863 ° -121.561015 °		41
94	14.37	14.39	Earthen Levee	Encroachments	WS	PO	Landscaping	38.625975 ° -121.560127 °	38.625642 ° -121.560185 °		39
95	14.38	14.52	Earthen Levee	Encroachments	WS	PO	Landscaping	38.623976 ° -121.560372 °	38.623812 ° -121.561345 °		40
96	14.79	14.82	Earthen Levee	Encroachments	WS	PO	Landscaping	38.620077 ° -121.560120 °	38.619630 ° -121.560067 °		38
97	14.85	14.90	Earthen Levee	Encroachments	WS	PO	Landscaping	38.619112 ° -121.560113 °	38.618493 ° -121.560070 °		37
98	14.92	14.92	Earthen Levee	Encroachments	WS	PO	Landscaping	38.618163 ° -121.560113 °	38.618163 ° -121.560113 °		36
99	14.98	15.02	Earthen Levee	Encroachments	WS	PO	Landscaping	38.617388 ° -121.559970 °	38.616835 ° -121.559807 °		35
100	15.33	15.38	Earthen Levee	Encroachments	WS	CO	Landscaping	38.612555 ° -121.558258 °	38.611900 ° -121.558303 °		34
101	15.46	15.48	Earthen Levee	Encroachments	WS	PO	Fences	38.610767 ° -121.557817 °	38.610455 ° -121.557638 °		33
102	15.50	15.52	Earthen Levee	Encroachments	WS	PO	Fences	38.610180 ° -121.557453 °	38.609908 ° -121.557328 °		32

*** Location**
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CR : Crown

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	03/18/2009 03/18/2009	Clay Thomas

LMR Unit	Levee Mile Start	Levee Mile End	Category	Item	Location *	Rating **	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
103	15.54	15.57	Earthen Levee	Encroachments	WS	CO	Landscaping	38.609743 ° -121.557252 °	38.609315 ° -121.557000 °		31
104	15.70	15.73	Earthen Levee	Encroachments	WS	CO	Landscaping	38.607715 ° -121.555847 °	38.607345 ° -121.555538 °		30
105	15.74	15.82	Earthen Levee	Encroachments	WS	CO	Fences	38.607207 ° -121.555465 °	38.606255 ° -121.554562 °		29
106	15.85	15.87	Earthen Levee	Encroachments	WS	PO	Landscaping	38.605915 ° -121.554290 °	38.605687 ° -121.554070 °		28
107	15.88	15.91	Earthen Levee	Encroachments	WS	PO	Landscaping	38.605585 ° -121.553983 °	38.605273 ° -121.553663 °		27
108	15.91	15.93	Earthen Levee	Encroachments	WS	PO	Landscaping	38.605265 ° -121.553647 °	38.605092 ° -121.553437 °		26
109	15.93	15.97	Earthen Levee	Encroachments	WS	PO	Landscaping	38.605002 ° -121.553413 °	38.604598 ° -121.553008 °		25
110	16.09	16.10	Earthen Levee	Encroachments	WS	PO	Landscaping	38.603083 ° -121.551690 °	38.602943 ° -121.551593 °		23
111	16.11	16.13	Earthen Levee	Encroachments	WS	PO	Landscaping	38.602870 ° -121.551598 °	38.602617 ° -121.551330 °		22
112	16.14	16.16	Earthen Levee	Encroachments	WS	PO	Landscaping	38.602517 ° -121.551248 °	38.602373 ° -121.550963 °		21
113	16.20	16.23	Earthen Levee	Encroachments	WS	PO	Fences	38.601977 ° -121.550473 °	38.601678 ° -121.550142 °		20
114	16.30	16.33	Earthen Levee	Encroachments	WS	PO	Landscaping	38.600988 ° -121.549198 °	38.600665 ° -121.548795 °		19
115	16.34	16.36	Earthen Levee	Encroachments	WS	PO	Landscaping	38.600525 ° -121.548640 °	38.600397 ° -121.548447 °		18
116	16.86	16.90	Earthen Levee	Encroachments	WS	CO	Fences	38.602328 ° -121.540798 °	38.602688 ° -121.540157 °		16
117	16.90	16.95	Earthen Levee	Encroachments	WS	PO	Fences	38.602693 ° -121.540165 °	38.603092 ° -121.539490 °		15
118	16.97	17.00	Earthen Levee	Encroachments	WS	PO	Fences	38.603242 ° -121.539318 °	38.603597 ° -121.538875 °		14
119	17.06	17.18	Earthen Levee	Encroachments	WS	PO	Fences	38.604188 ° -121.538027 °	38.604890 ° -121.536105 °		13

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 01 Sacramento River	Left	18.60	03/18/2009 03/18/2009	Clay Thomas

LMR Line	Levee Mile Start	Levee Mile End	Category	Item	* Location	** Rating	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
120	17.64	17.74	Earthen Levee	Encroachments	WS	PO	Fences	38.605645 ° -121.527902 °	38.605542 ° -121.526112 °		11
121	17.77	17.82	Earthen Levee	Encroachments	WS	CO	Buildings	38.605482 ° -121.525492 °	38.605447 ° -121.524678 °		10
122	17.82	17.91	Earthen Levee	Encroachments	WS	CO	Buildings	38.605445 ° -121.524675 °	38.605305 ° -121.522958 °		8
123	17.83	17.86	Earthen Levee	Encroachments	LS	CO	Buildings	38.605420 ° -121.524375 °	38.605462 ° -121.523852 °		9
124	17.91	17.94	Earthen Levee	Encroachments	WS	CO	Buildings	38.605300 ° -121.522957 °	38.605200 ° -121.522422 °		7
125	18.10	18.10	Earthen Levee	Encroachments	WS	CO	Buildings	38.604788 ° -121.519720 °	° °		6
126	18.10	18.18	Earthen Levee	Encroachments	WS	CO	Buildings	38.604758 ° -121.519610 °	38.604532 ° -121.518190 °		5
127	18.21	18.40	Earthen Levee	Encroachments	WS	CO	Buildings	38.604515 ° -121.517635 °	38.603918 ° -121.514370 °		4

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Flood Control Project Maintenance
Levee Inspections

Unit Cover Sheet

Spring 2009 Levee Inspection Results

Reclamation District No. 1000

Waterway	Bank	Unit Miles
Unit No. 02 American River	Right	2.30

	Spring (March - May)	Summer (June - August)	(September - November) Fall	Winter (December - February)
Unit Maintenance Rating (Fall Only)				
Date of Inspection	3/18/2009 - 3/18/2009			
DWR Inspector	Clay Thomas			
Accompanied By				

Check one:

☐ During the current winter (or summer) inspection period, my staff or I have inspected the levee and associated flood project components identified in the attached Levee Inspection Report by Mile. We have found no changes in flood project conditions other than the results of our normal maintenance and the corrections we have made to maintenance deficiencies identified in the enclosed report.

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(In the comment section below or on additional sheet(s), identify change of condition by: Start to End Levee Mile or GPS coordinates, location (Land Side, Water Side, or Crown), Item identification, and description of the current condition).

Comments

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DWR Summer/Winter Inspection Reports
3310 El Camino Avenue, Room LL-30
Sacramento, CA 95821-9000.

X

Signature of LMA Representative Date

Friday, June 05, 2009 09:56

State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 02 American River	Right	2.30	03/18/2009 03/18/2009	Clay Thomas

LMR Line	Levee Mile Start	Levee Mile End	Category	Item	Location *	Rating **	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
1	0.07	2.30	Earthen Levee	Encroachments	LS	PO	Landscaping	38.604932 ° -121.510243 °	38.605932 ° -121.470770 °		1
2	1.50	1.70	Earthen Levee	Encroachments	WS	PO	Landscaping	38.607880 ° -121.484500 °	38.607110 ° -121.480950 °		2

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Unit Cover Sheet

Spring 2009 Levee Inspection Results

Reclamation District No. 1000

Waterway	Bank	Unit Miles
Unit No. 03 Natomas East Canal	Right	17.30

	Spring (March - May)	Summer (June - August)	(September - November) Fall	Winter (December - February)
Unit Maintenance Rating (Fall Only)				
Date of Inspection	3/17/2009 - 3/18/2009			
DWR Inspector	Clay Thomas			
Accompanied By				

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Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 03 Natomas East Canal	Right	17.30	03/17/2009 03/18/2009	Clay Thomas

LMR Line	Levee Mile Start	Levee Mile End	Category	Item	Location *	Rating **	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
1	0.07	0.13	Earthen Levee	Encroachments	LS	PO	Fences	38.606882 ° -121.469480 °	38.607523 ° -121.469033 °		7
2	0.30	0.32	Earthen Levee	Encroachments	LS	PO	Fences	38.609865 ° -121.468183 °	38.610162 ° -121.468122 °		5
3	0.53	0.57	Earthen Levee	Encroachments	LS	PO	Fences	38.613077 ° -121.468133 °	38.613700 ° -121.468263 °		4
4	3.05	3.10	Earthen Levee	Encroachments	LS	PO	Fences	38.648677 ° -121.474882 °	38.649412 ° -121.475005 °		3
5	14.54	14.94	Earthen Levee	Encroachments	LS	PO	Agricultural Ditch	38.804665 ° -121.516013 °	38.809031 ° -121.518615 °		8
6	15.51	16.07	Earthen Levee	Encroachments	LS	PO	Agricultural Ditch	38.816259 ° -121.522787 °	38.823314 ° -121.526942 °		9

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State of California - Department of Water Resources - Division of Flood Management - Flood Project Integrity & Inspection Branch RD1000

Flood Control Project Maintenance
Levee Inspections

Unit Cover Sheet

Spring 2009 Levee Inspection Results

Reclamation District No. 1000

Waterway	Bank	Unit Miles
Unit No. 04 Natomas Cross Canal	Left	4.40

	Spring (March - May)	Summer (June - August)	(September - November) Fall	Winter (December - February)
Unit Maintenance Rating (Fall Only)				
Date of Inspection	3/17/2009 - 3/17/2009			
DWR Inspector	Clay Thomas			
Accompanied By				

Check one:

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Signature of LMA Representative Date

Friday, June 05, 2009 09:56

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Flood Control Project Maintenance
Levee Inspections

Levee Inspection Report By Mile - Spring 2009

Reclamation District No. 1000

Waterway	Bank	Unit Miles	Inspection Start/End	Inspector
Unit No. 04 Natomas Cross Canal	Left	4.40	03/17/2009 03/17/2009	Clay Thomas

LMR Line	Levee Mile Start	Levee Mile End	Category	Item	Location *	Rating **	Action/Comment	GPS Latitude/Longitude Start	GPS Latitude/Longitude End	Photo	Issue
1							No issues were reported.	° '	° '		

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APPENDIX H

Preliminary Tree Fall Data

Draft Vegetation Variance Request Natomas Levee Improvement Program Supplemental Appendix H – Preliminary Data and Analysis of Tree Fall in the California Central Valley

By Chris J. Peterson
16 March, 2010

Part I: Review of Kleinfelder Report

The March 9, 1989 addendum by Kleinfelder, Inc. contained some sections that I could not evaluate, given my limited familiarity with technical levee drawings, and also because an important photo (R2-6) was not included in my version of the document. That said, based on what material I had, I find that I am in general agreement with the conclusions of the Kleinfelder document. Nevertheless, this document has a number of shortcomings from a research science point of view. The two major shortcomings 1) its reliance on unreplicated or poorly replicated examples; and 2) lack of solid evidence to support its conclusions. I will speak to each in turn, but I should first remark that their attached figures are poorly labeled and it is impossible for the reader to understand what all the lines are for.

1. Kleinfelder indicates that trees pose little threat to levee integrity because their roots don't penetrate very deeply. Their letter of March 9, 1989 contains the results of their safety factor calculations for potential treefall of trees on levees. The verbal description of their analyses is unclear in several respects. For example, their use of the terms "top and bottom" does not make sense since a tree cannot be at both the top and bottom of a levee slope. Their table presents factors of safety for 6 scenarios -- treefall of trees in the three positions having 2-ft deep roots, and treefall of trees in the three positions having 3-ft deep roots. However, they base their calculations on measurement of a single fallen oak tree, 24" in diameter. Thus while I think their findings are more or less correct, they have built their conclusions on a narrow foundation of data from one tree. That said, my own experience after observing literally thousands of uprooted trees in eastern U.S. forests, is that a majority of root pits are indeed less than 2 feet deep, and probably 95% or more of roots pits are less than 3 ft deep. I don't think I have seen a single root pit more than 4 feet deep. Thus I think their approximation of root pit depths is in the right range. More specific to trees on California levees, initial findings from the California Levee Vegetation Research Program's "windthrow" study, of which I am the lead investigator, support the above conclusions. In this study, over 50 trees, most on levee slopes, were winched down to document their wind-firmness and the size of root pits for the ones that uprooted. Of those that uprooted, none created root pits > 3 ft deep, and most were < 2 ft deep. A related observation was measurements our team took from a naturally-uprooted large (40" trunk diameter at 1.3 meters) cottonwood that fell next to the river in Discovery Park, Sacramento. Despite this tree's large size, the root pit created was only slightly more than 1 ft deep.

2. Kleinfelder cites the expert opinion of Mr. Aksland, whose expertise is that he has owned up to 280 acres of almond trees. This doesn't give Mr. Aksland any particular insight into root depth distribution or the size of root pits if a tree uproots. It is unclear how many of Mr. Aksland's almond trees have ever been uprooted or whether he has ever excavated the root system of any of his almond trees. Thus citing Mr. Aksland as an expert to support this document's findings is not convincing. Similarly, Kleinfelder's deduction that the Corps must

consider that trees to pose little threat because the Corps was requiring revegetation, while probably true, does not add weight to the technical argument .

The follow-up letter dated April 14, 1989 by Mr. Robert Dixon has some of the same weaknesses as the March 9, 1989 letter. Again, though, I find myself in full agreement with Mr. Dixon's conclusions; it is just that the evidence that he presents is not very robust. Like the Kleinfelder March 9 letter, Mr. Dixon relies on sampling with limited replication. For example, Mr. Dixon had root borings done near four trees. The subject trees were described as "four of the largest and most representative"; but it is not clear that "largest" are the most "representative". Because of understandable logistical constraints, Mr. Dixon drilled 1-3 holes with an auger at varying distances from the four focal trees. However, a single 6" diameter hole tells us very little about the root distribution of a tree. Even 2 or 3 holes are such a tiny sample of the volume of soil occupied by a tree's root system, that the findings from the borings are very uncertain. In a number of locations, Mr. Dixon makes observations that reflect his opinion; however his expertise in this area is unclear. His resume reflects a lot of practical experience but little of it seems to be really relevant to this particular topic.

Despite the above weaknesses, I think that both letters reach conclusions that are consistent with current knowledge. In particular, Mr. Dixon writes a very good brief summary of root penetration into soil. Taken together, I think these two letters make statements that are broadly consistent with what we know about root penetration into soil, and about root pit formation when a tree uproots. However, anyone eager to find flaws in their evidence and the approaches presented herein, would not have to look very hard. I think that if anything, this pair of letters argues for just the suite of field investigations that are now underway as part of the Levee Vegetation Science Team's efforts to provide empirical data to guide levee vegetation decisions.

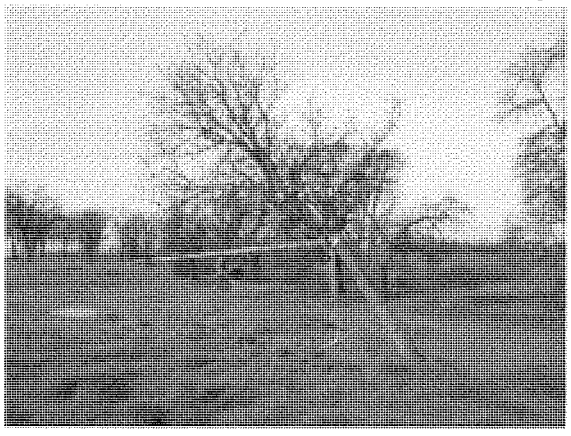
Part II: Relevant observations from experimental treefall studies

In January and February 2010, a tree-windthrow-vulnerability experiment was initiated, led by Dr. Chris Peterson of University of Georgia, and underwritten by California Department of Water Resources and Sacramento Area Flood Control Agency, with support and cooperation from several other state and federal agencies. The goal of this study (it will be continued in January and February 2011) is to determine the relative stability of levee trees to windthrow. The approach taken is called 'static winching' and consists of attaching a winch and steel cable to a tree, pulling until the tree breaks or uproots, and in the process measuring the force generated by the winch. Photos in this section show this research in



progress. The first photo shows winching, cable attachment to the anchor tree, and Peterson seated by the field computer that recorded the cable strain and tree tilt from electronic instruments.

Results of this research confirm the general impressions presented in Part I above. In this study, 54 trees were attempted, and 49 reached the point of breakage or uprooting. The study species were primarily *Quercus lobata* (valley oak) and *Populus fremontii* (Fremont cottonwood). A few *Acer negundo* (boxelder) were also included. Winched trees ranged in size from 4 inches to 20 inches in trunk diameter. The majority of trees were located on levee slopes, but for the purposes of comparison, some trees located on floodplains next to levee slopes were also winched. Photo at left shows a valley oak at the Bear River study site, part-way through the winching process. For all trees considered together, the average size was 11.0 inches diameter; trees on the flooplains were slightly larger (levee slope trees had average sizes of 10.2 inches diameter). Each tree was fitted with two inclinometers ("tilt meters") that measured the tilt simultaneously with the measurement of cable strain by a load cell inline with the steel cable. Both of these instruments fed their output directly into a laptop computer at the study site.



Findings included 26 trees that experienced trunk breakage, and 23 that uprooted. Almost all of the trees on the floodplains uprooted. If the nine uproots from floodplains are removed, the proportions are 26 trunk breakage and 14 uprooted of the trees on the levee slopes proper. The breakage and uprooting data yield several preliminary conclusions: on levee slopes, winched trees were almost twice as likely to break rather than uproot, so for a given probability that a levee tree might be toppled by high winds, it appears that perhaps 2/3 may break off rather than uproot. Oaks on levee slopes were roughly evenly distributed between trunk breakage and uprooting; cottonwoods on levee slopes almost always had trunk breakage; while boxelders almost always uprooted. These patterns suggest that when

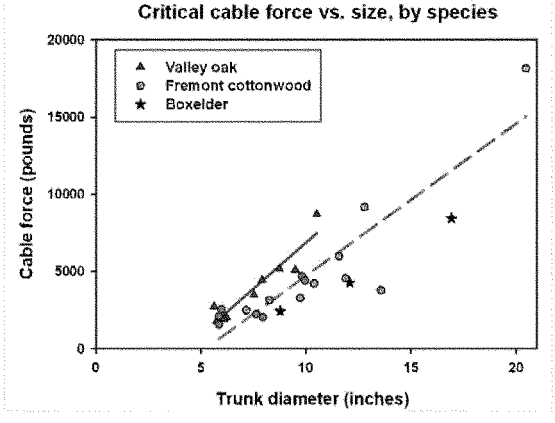


concern is with the potential impacts of tree uprooting on levee integrity, oaks and cottonwoods are of less concern because they are less likely to uproot, compared to boxelders. Future research will examine other species, such as willows. The photo at left shows the result of trunk breakage.

Uprooting occurred in a total of 23 trees, 14 of which were on levee slopes. Of these levee slope trees, the root pit created by uprooting was on average 4.1 feet x 2.9 feet, for an average area of 10.6 square feet. The trees on floodplains created larger root pits (data not shown here), probably because they were slightly larger. Root pit areas were significantly positively correlated with tree size (diameter; $p = 0.035$, $r = 0.56$). Root pits for levee slope trees had mean depths of 1.62 feet; maximum recorded depth was 3.5 feet for levee slope trees that uprooted. Root pit depth was significantly positively correlated with tree diameter.



Finally, the force required to cause trees to break or uproot was measured in this study. The critical force ranged from less than 1 ton of lateral force for small trees, to more than 9 tons for the largest trees studied. Thus while larger trees create larger root pits, the force necessary to break or uproot a large tree (9 tons in this study) would likely require wind speeds that are quite rare in the Central Valley area. The graph below shows the cable force necessary to bring down trees of differing sizes, as a function of trunk diameter.



PLATES



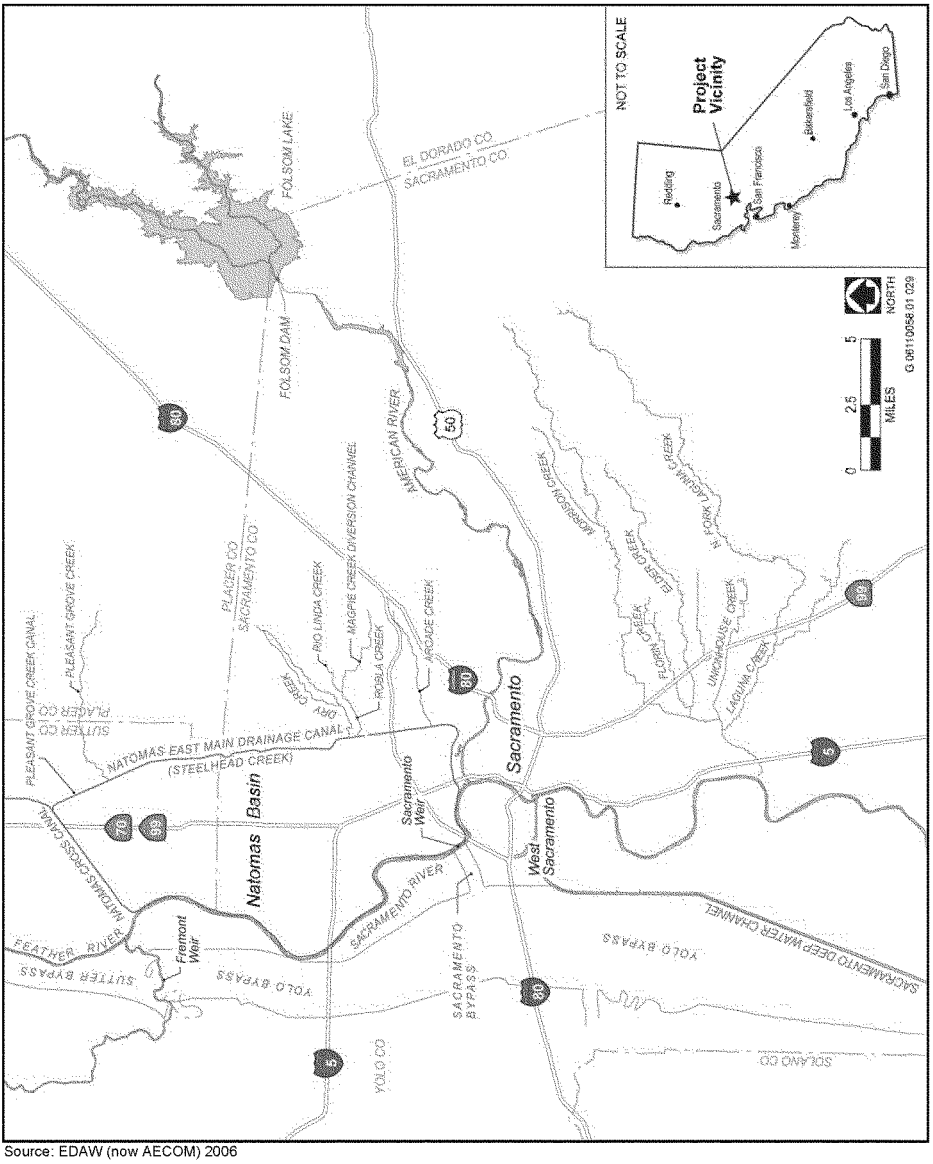
Source: MBK 2010

Natomas Levee System

SAFCA and CVFPB

Plate 1

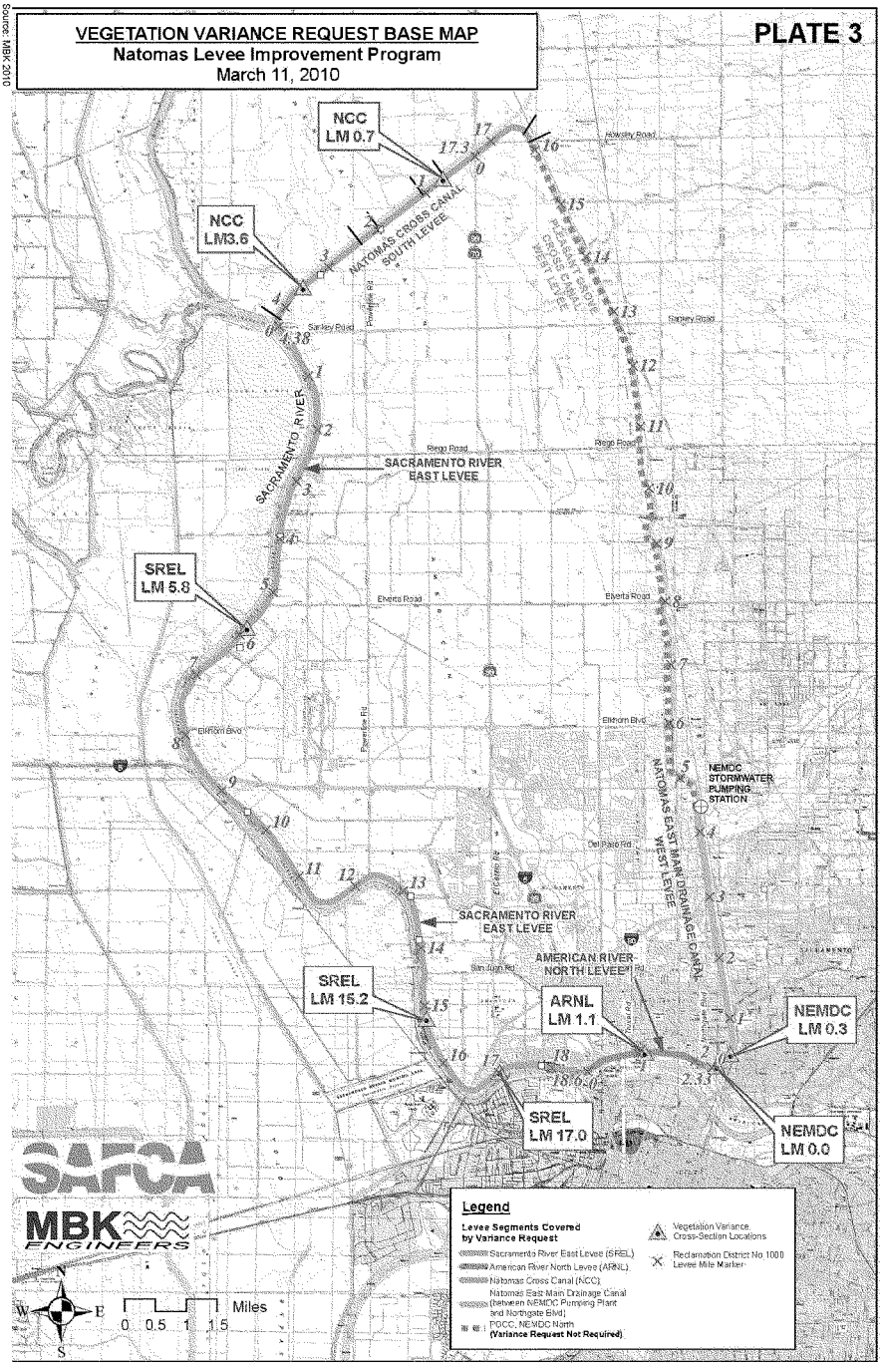
Vegetation Variance Request Plates



Source: EDAW (now AECOM) 2006

Project Area **Plate 2**

SAFCA and CVFPB

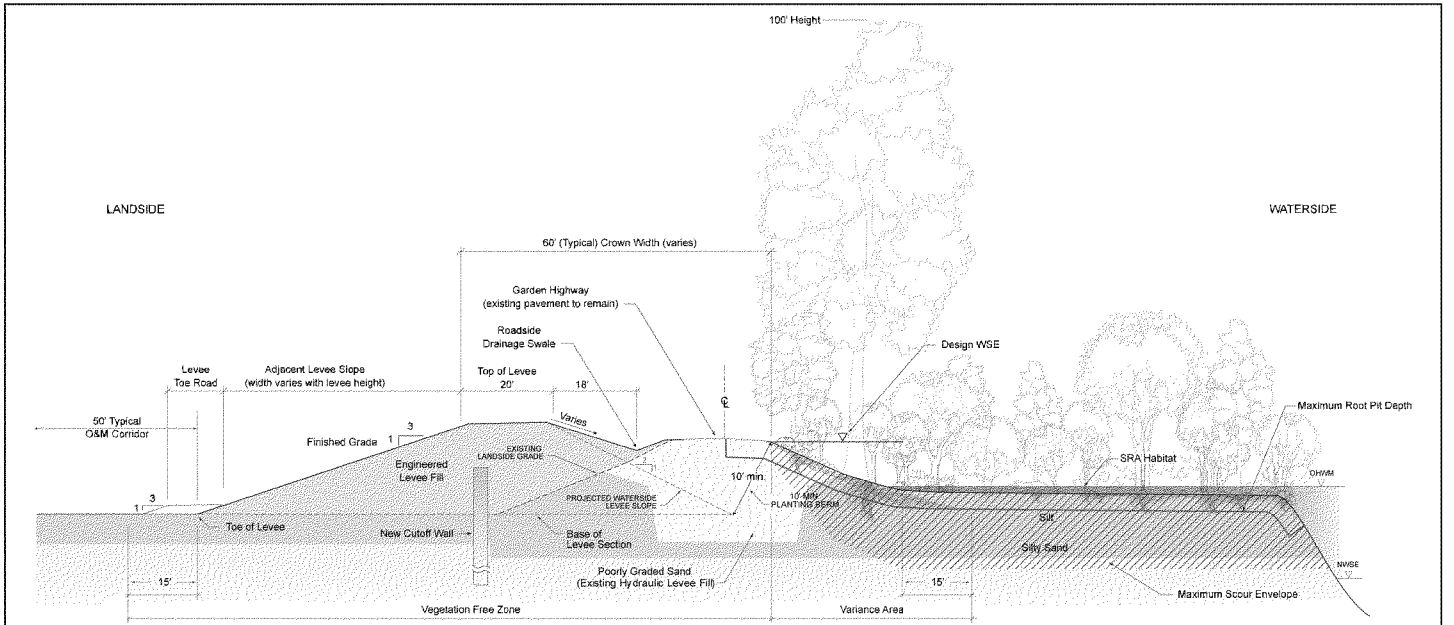

VEGETATION VARIANCE REQUEST BASE MAP
Natomas Levee Improvement Program
March 11, 2010
PLATE 3
NCC LM 0.7
NCC LM3.6
SREL LM 5.8
SREL LM 15.2
SREL LM 17.0
ARNL LM 1.1
NEMDC LM 0.3
NEMDC LM 0.0
NATOMAS CROSS CANAL SOUTH LEVEE
PLEASANT GROVE CREEK CANAL WEST LEVEE
SACRAMENTO RIVER EAST LEVEE
NATOMAS EAST MAIN DRAINAGE CANAL WEST LEVEE
AMERICAN RIVER NORTH LEVEE
NEMDC STORMWATER PUMPING STATION
Howsley Road
Sankey Road
Rego Road
Elverta Road
Elkhorn Blvd
Del Paso Rd
San Juan Rd
Power Inn Rd
SACRAMENTO RIVER
SAFCA
MBK ENGINEERS
N
W
E
S
0 0.5 1 1.5 Miles
Legend
Levee Segments Covered by Variance Request
Sacramento River East Levee (SREL)
American River North Levee (ARNL)
Natomas Cross Canal (NCC)
Natomas East Main Drainage Canal (between NEMDC Pumping Plant and Northgate Blvd)
PDCC, NEMDC North
(Variance Request Not Required)
Vegetation Variance Cross-Section Locations
Reclamation District No.1000 Levee Mile Marker



G:06110058:01:242

Source: AECOM 2010

SREL LM 5.8 Waterside Vegetation (LM 0 to LM 13.2) **Plate 4**



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

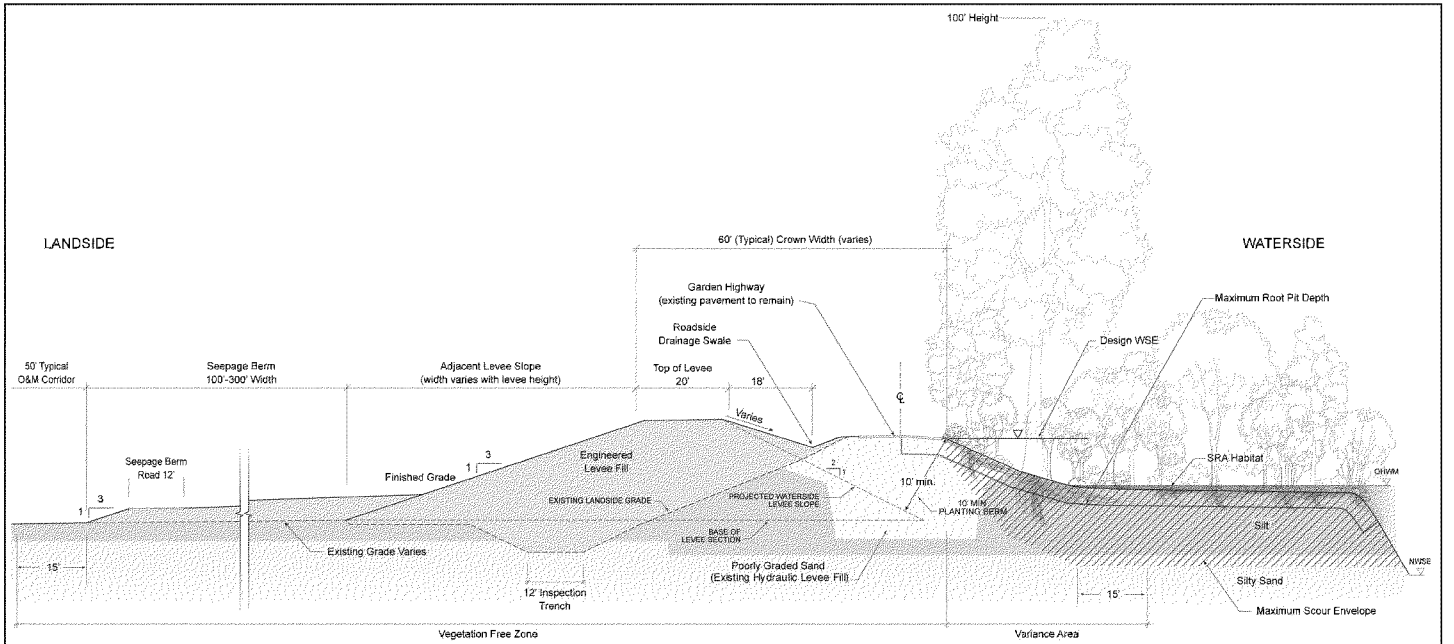
d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.0001 during the 200-year water level. This approximates a velocity of 2.0 ft/s at the levee toe concurrent with the 200-year water level.

e. 100 foot tall trees depicted represent potential maximum Valley Oak tree height and are not representative of actual field conditions.

f. 8' tap root depicted is representative of the worst case scenario and is unlikely to occur in these site conditions.

Source: Data provided by HDR, NHC, and Kleinfelder; adapted by AECOM in 2010

SREL LM 5.8 Levee Section with Cutoff Wall (LM 0 to LM 13.2) **Plate 5 (May 17, 2010)**



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.0001 during the 200-year water level. This approximates a velocity of 2.0 ft/s at the levee toe concurrent with the 200-year water level.

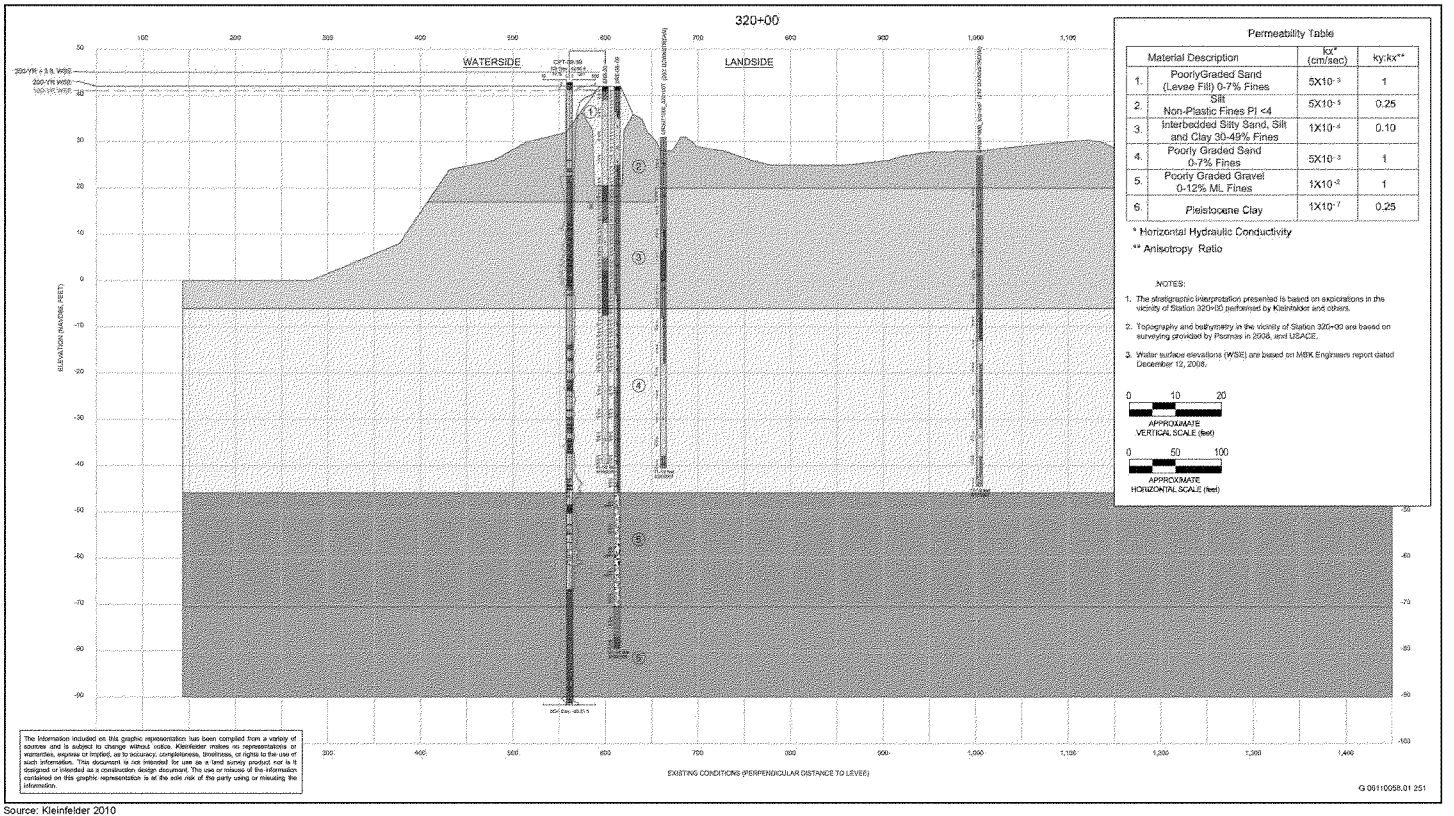
e. 100 foot tall trees depicted represent potential maximum Valley Oak tree height and are not representative of actual field conditions.

f. 8' tap root depicted is representative of the worst case scenario and is unlikely to occur in these site conditions.

Source: Data provided by HDR, NHC, and Kleinfelder; adapted by AECOM in 2010

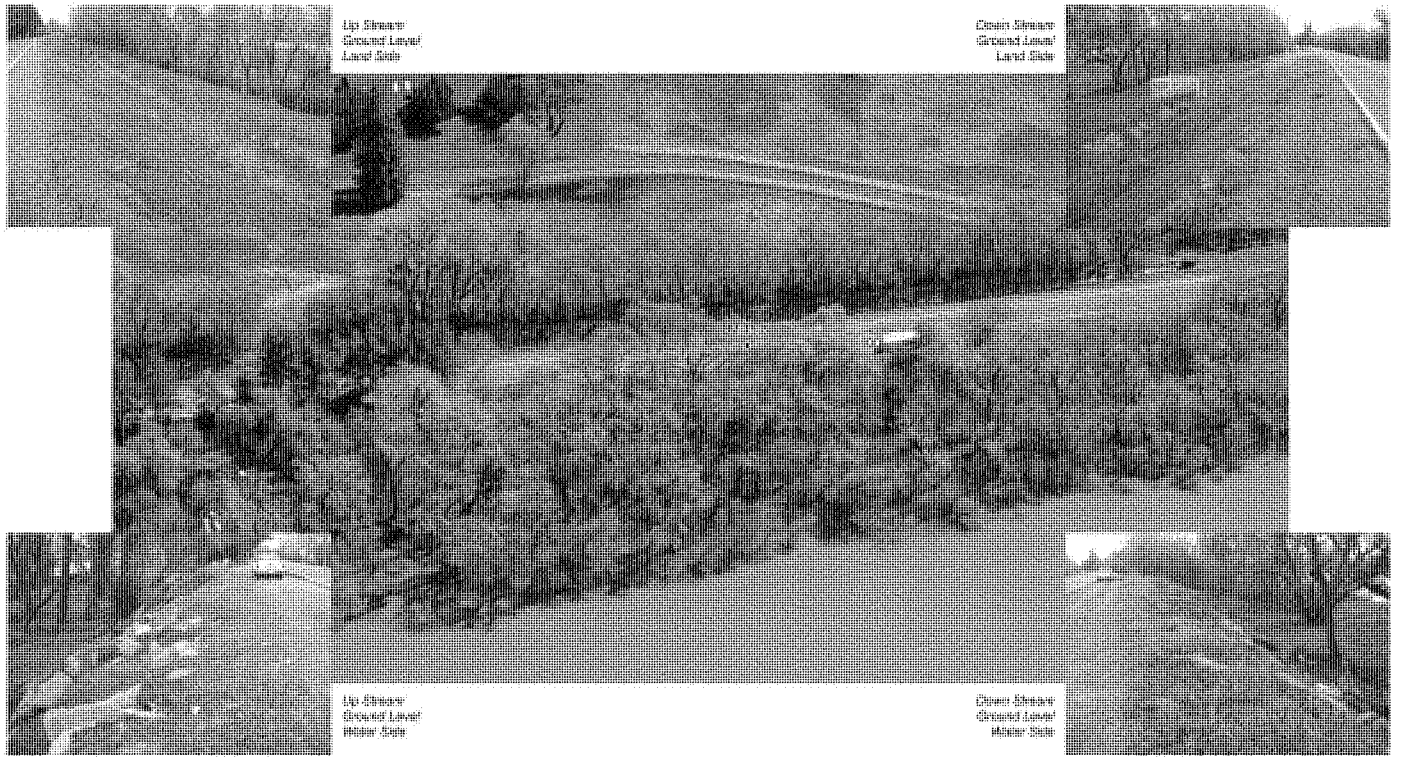
SREL LM 5.8 Levee Section with Seepage Berm (LM 0 to LM 13.2)

Plate 6 (May 17, 2010)



Source: Kleinfelder 2010

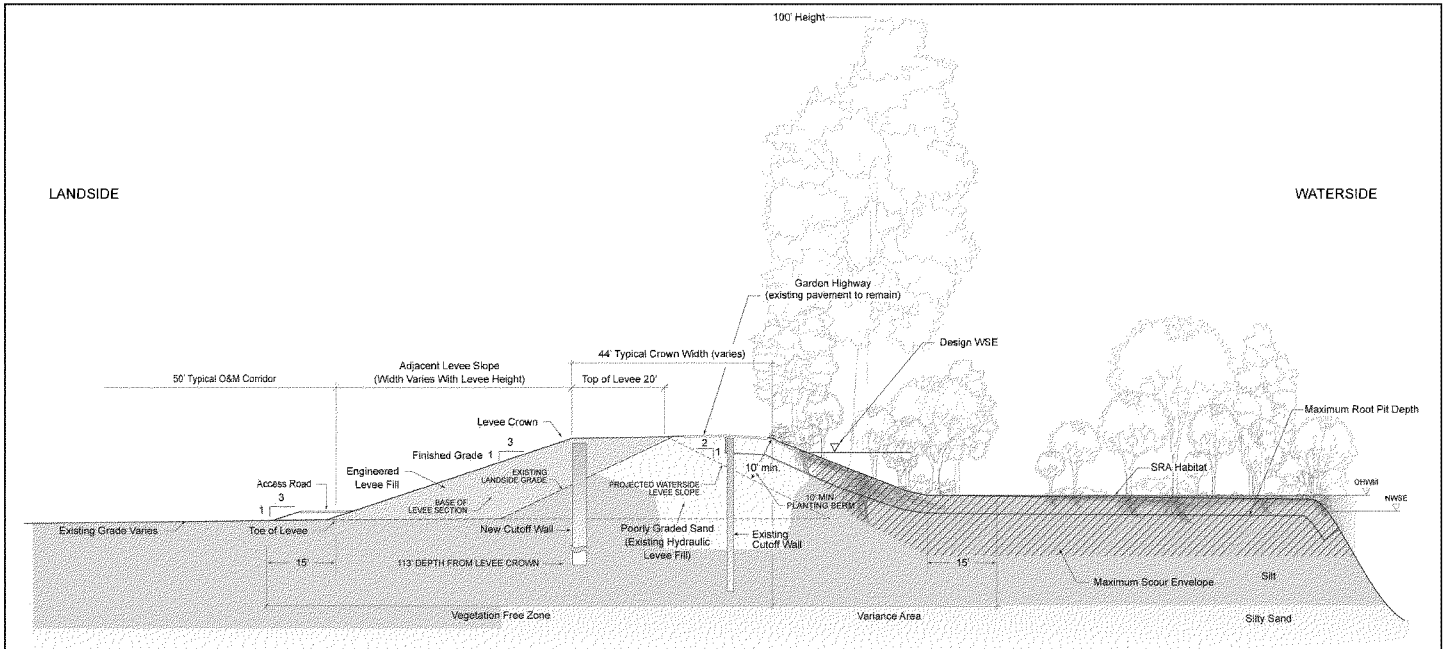
SREL LM 5.8 Stratigraphy (LM 0 to LM 13.2) **Plate 7**



G:\5110056.01\243

Source: Data provided by HDR; adapted by AECOM in 2010

SREL LM 15.2 Waterside Vegetation (LM 13.2 to LM 16.5) **Plate 8**



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.038 and the friction slope was assumed to be 0.0001 during the 200-year water level. This approximates a velocity of 2.3 ft/s at the levee toe concurrent with the 200-year water level.

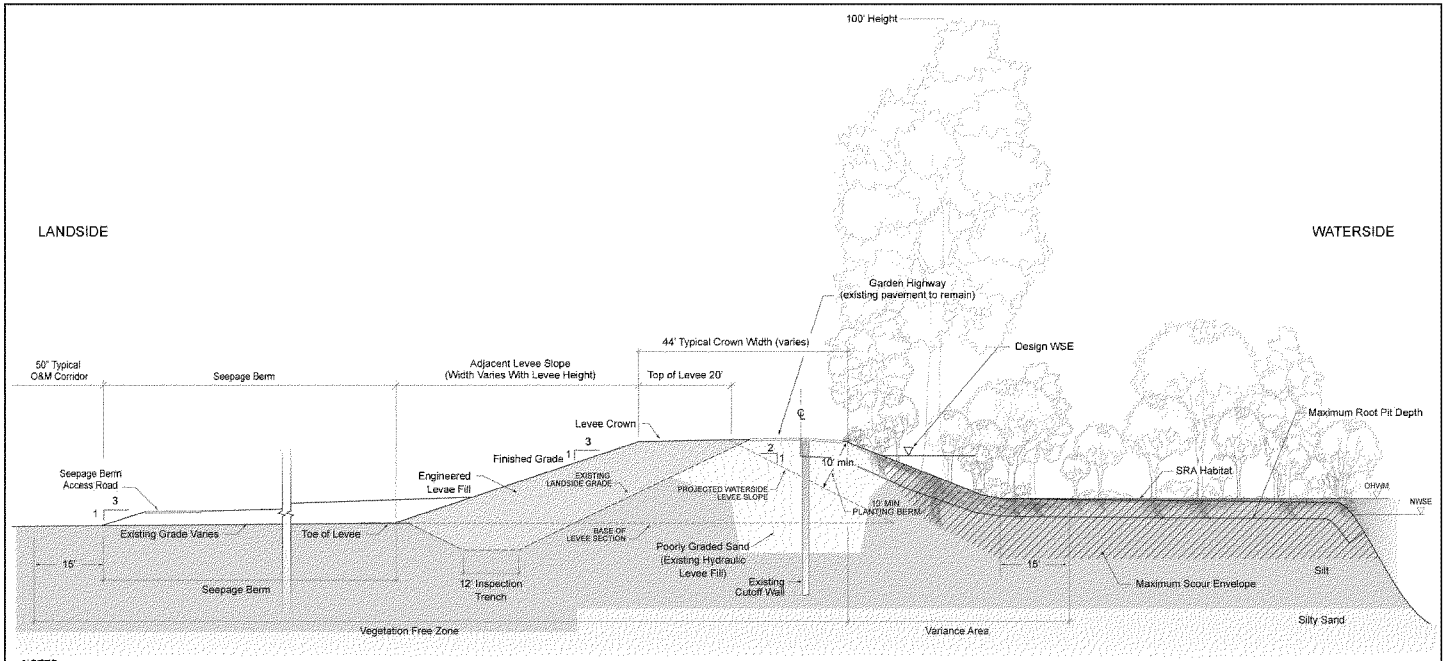
e. 100 foot tall trees depicted represent potential maximum Valley Oak tree height and are not representative of actual field conditions.

f. 8' tap root depicted is representative of the worst case scenario and is unlikely to occur in these site conditions.

Source: Data provided by HDR, NHC, and Kleinfelder; adapted by AECOM in 2010

SREL LM 15.2 Levee Section with Cutoff Wall (LM 13.2 to LM 16.5)

Plate 9 (May 17, 2010)



Source: Data provided by HDR, NHC, and Kleinfelder; adapted by AECOM in 2010

SREL LM 15.2 Levee Section with Seepage Berm (LM 13.2 to LM 16.5)

Plate 10 (May 17, 2010)

Permeability Table

	Material Description	k_x^* (cm/sec)	ky/kx**
1.	PG Sand (Levee Fill)	$5X10^{-3}$	0.25
2.	Silt	$2X10^{-4}$	0.25
3.	Silty Sand	$4X10^{-4}$	0.25
4.	PG Sand	$5X10^{-3}$	0.25
5.	Existing Cutoff Wall	$1X10^{-6}$	1

* Horizontal Hydraulic Conductivity

** Anisotropy Ratio

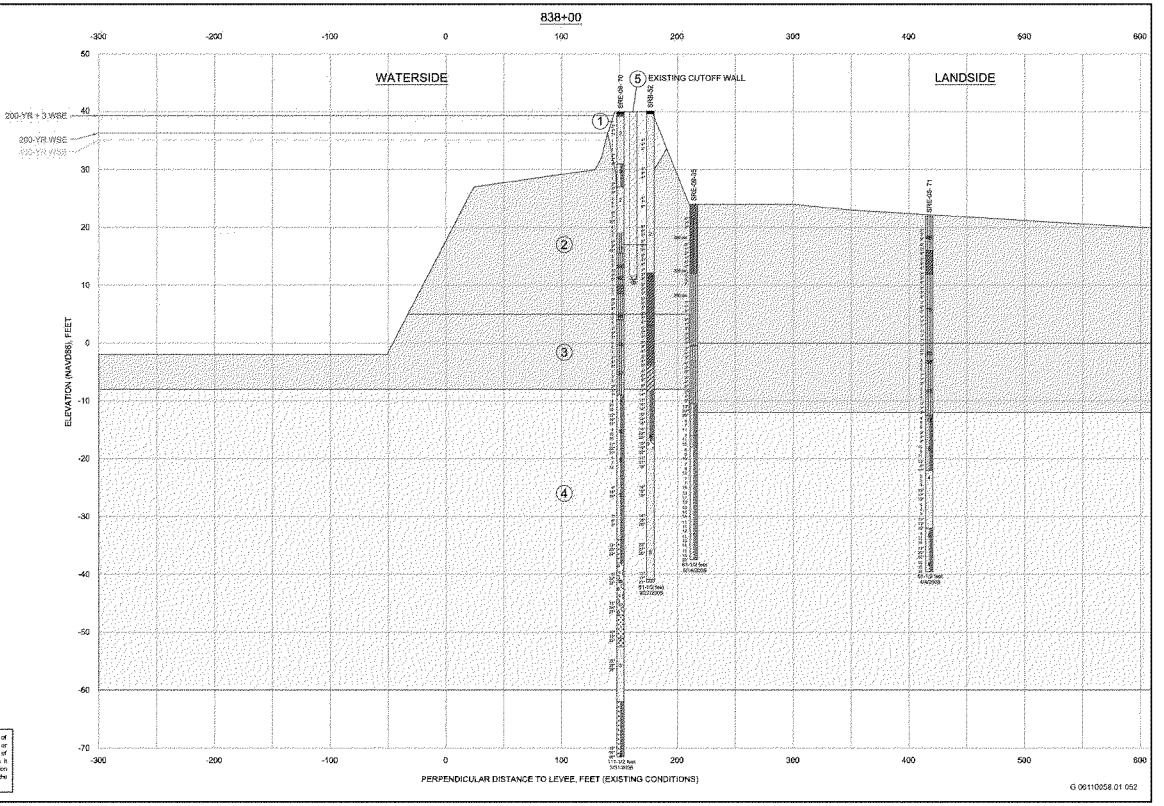
NOTES:

1. Our Stratigraphic interpretation presented is generalized for modeling purposes and based on explorations in the vicinity of station 838+00 performed by Kleinfelder and others.
2. Topography and bathymetry are based on surveying provided by Psomas and USACE, respectively. Both are generalized for the area near 838+00.
3. Water surface elevations (WSE) are provided by MBK Engineers in their report dated December 12, 2008.

0 8 16
APPROXIMATE VERTICAL SCALE (feet)

0 40 80
APPROXIMATE HORIZONTAL SCALE (feet)

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Source: Kleinfelder 2010

SREL LM 15.2 Stratigraphy (LM 13.2 to LM 16.5) **Plate 11**

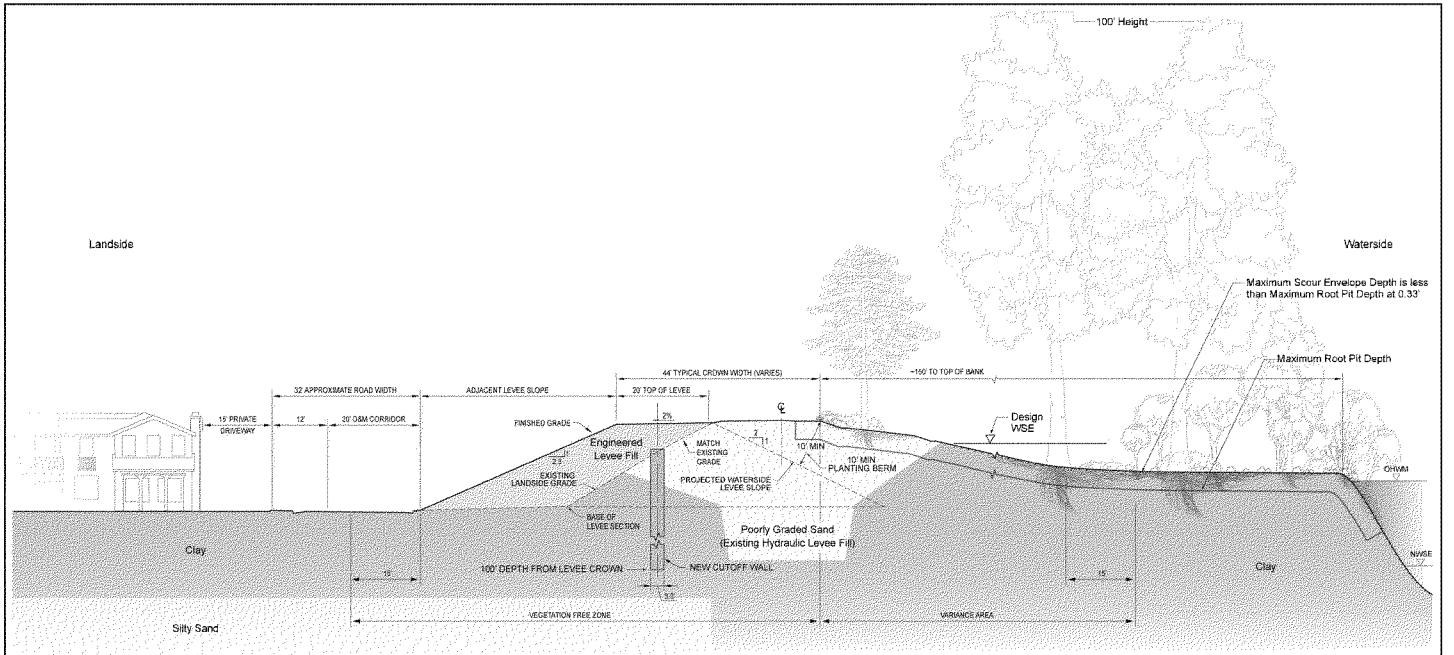


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Source: AECOM 2010

SREL LM 17.0 Waterside Vegetation (LM 16.5 to LM 18.6)

Plate 12



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.000001 during the 200-year water level. This approximates a velocity of 0.3 ft/s at the levee toe concurrent with the 200-year water level.

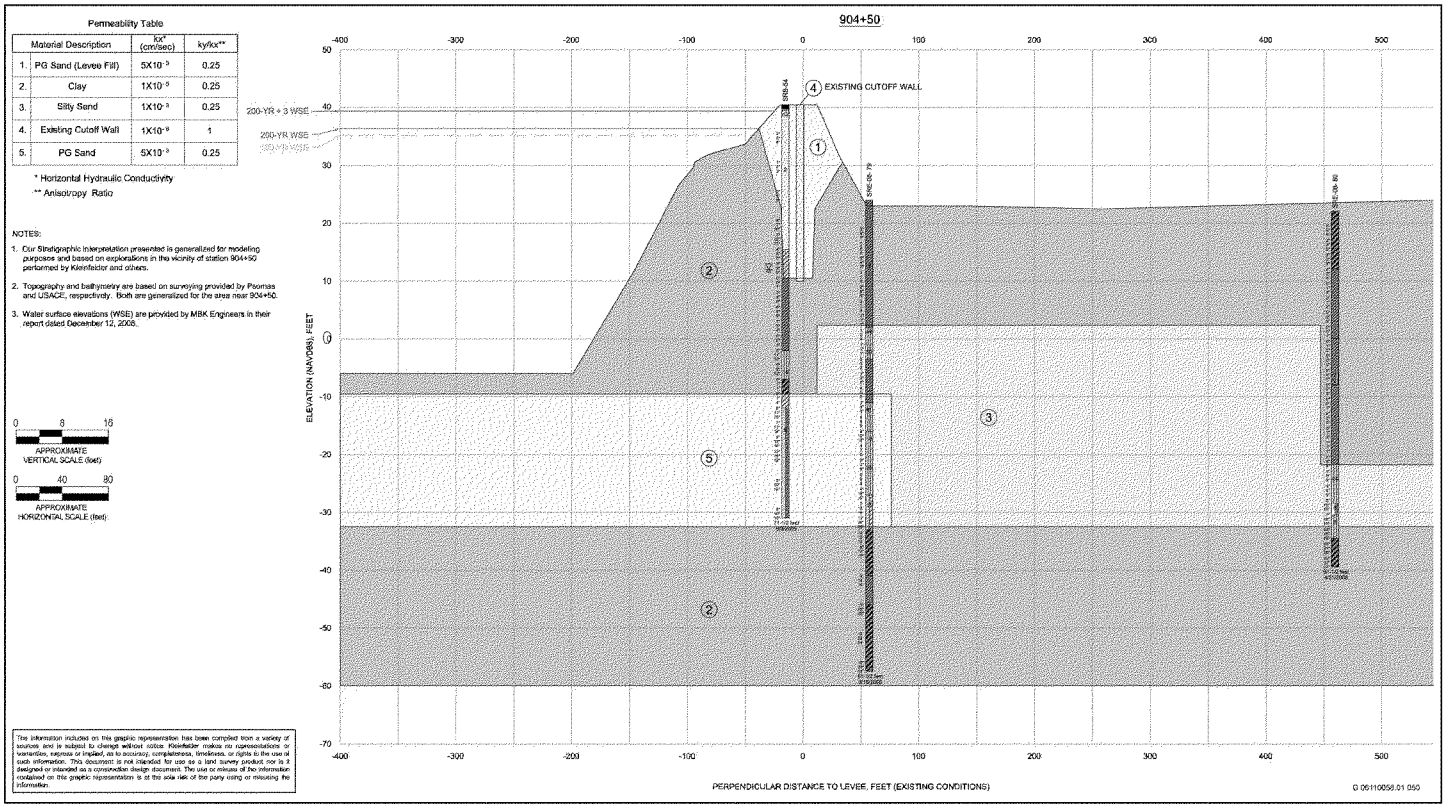
e. 100 foot tall trees depicted represent potential maximum Valley Oak tree height and are not representative of actual field conditions.

f. 5' tap root depicted is representative of the worst case scenario and is unlikely to occur in these site conditions.

Source: Data provided by HDR, NHC, and Kleinfelder; adapted by AECOM in 2010

SREL LM 17.0 Typical Levee Cross Section (LM 16.5 to LM 18.6)

Plate 13 (May 17, 2010)



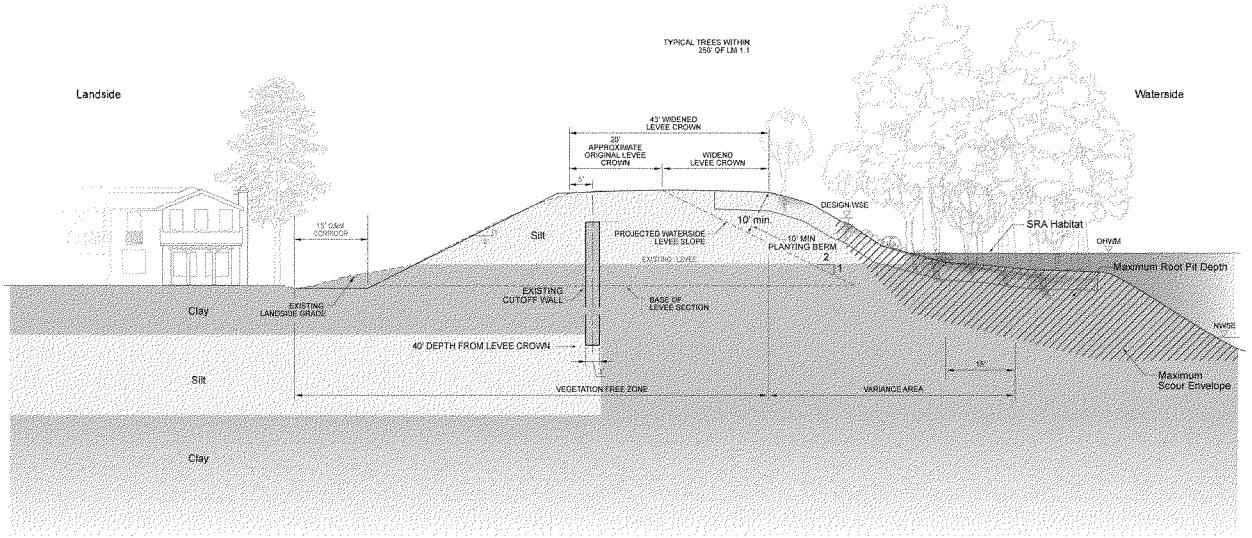
Source: Kleinfelder 2010

SREL LM 17.0 Stratigraphy (LM 16.5 to LM 18.6) **Plate 14**



Source: AECOM 2010

ARNL LM 1.1 Waterside Vegetation (Sacramento River [LM 0] to Northgate Boulevard [LM 2.33]) **Plate 15**



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_e)^{1/2}$ where the Manning's n value and Friction Slope, S_e were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.00014 during the 200-year water level. This approximates a velocity of 2.8 ft/s at the levee toe concurrent with the 200-year water level.

0 10 20
FEET

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Source: HDR, NHC, and Kleinfelder 2010; Adapted by AECOM 2010

ARNL LM 1.1 Typical Levee Cross Section (Sacramento River [LM 0] to Northgate Boulevard [LM 2.33]) **Plate 16 (May 17, 2010)**

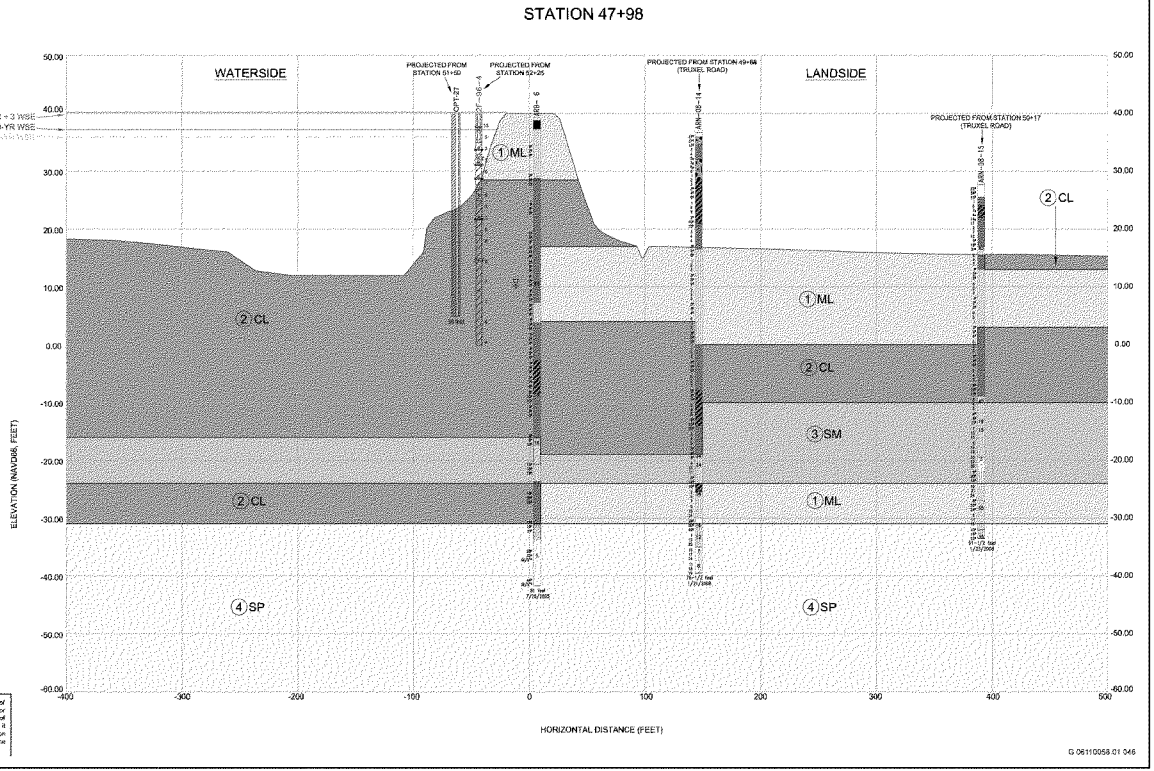
Permeability Table

	Material Description	Ks* (cm/sec)	K-Ratio**
1.	ML	0.56ft/d (2X10^{-4})	0.25
2.	CL	0.028ft/d (1X10^{-5})	0.25
3.	SM	2.8ft/d (1X10^{-3})	0.25
4.	SP	14ft/d (5X10^{-3})	0.25

* Horizontal Hydraulic Conductivity
** Anisotropy Ratio

NOTES:

1. Our stratigraphic interpretation presented is based on explorations in the vicinity of Station 47+98 performed by Kleinfelder and others.
2. Topography and bathymetry in the vicinity of Station 47+98 are based on surveying provided by Psomas, 2009.
3. Water surface elevations (WSE) are provided by MBK Engineers in their report dated December 12, 2008.



0 8 16
APPROXIMATE VERTICAL SCALE (feet)

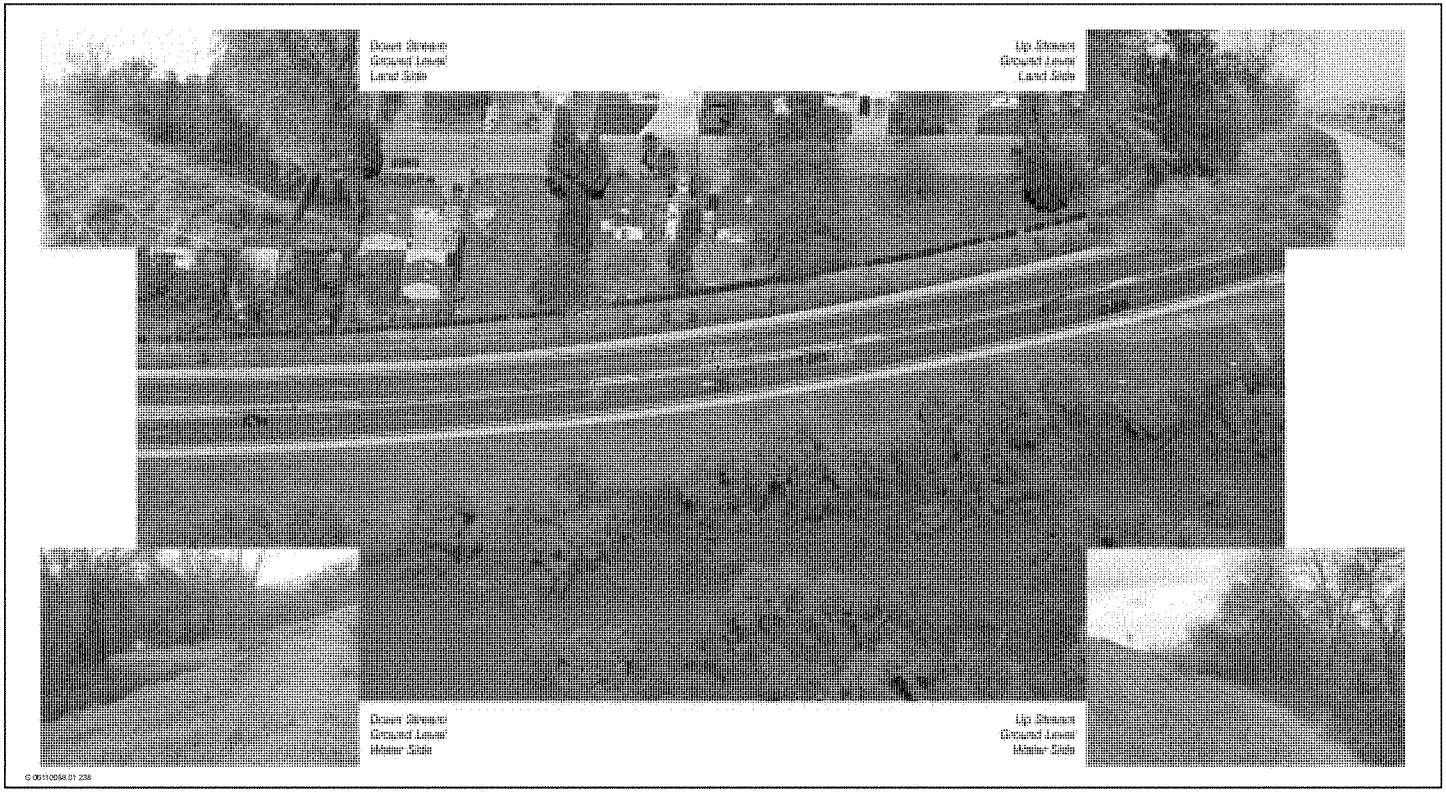
0 40 80
APPROXIMATE HORIZONTAL SCALE (feet)

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Source: Kleinfelder 2010

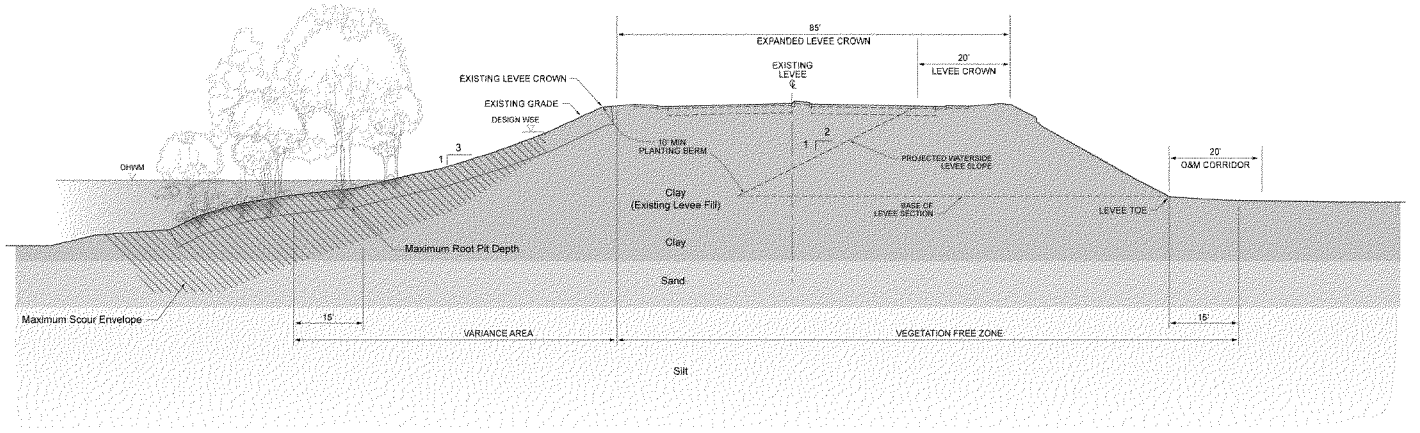
ARNL LM 1.1 Stratigraphy (Sacramento River [LM 0] to Northgate Boulevard [LM 2.33]) **Plate 17**



Source: AECOM 2010

NEMDC LM 0.0 Waterside Vegetation (LM 0 to LM 0.3)

Plate 18



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.00005 during the 200-year water level. This approximates a velocity of 2.0 ft/s at the levee toe concurrent with the 200-year water level.

0 10 20
FEET

G:\60110058.01 261

Source: Wood Rodgers, NHC, and Kleinfelder 2010; Adapted by AECOM 2010

NEMDC LM 0.0 Typical Levee Cross Section (LM 0 to LM 0.3)

Plate 19 (May 17, 2010)

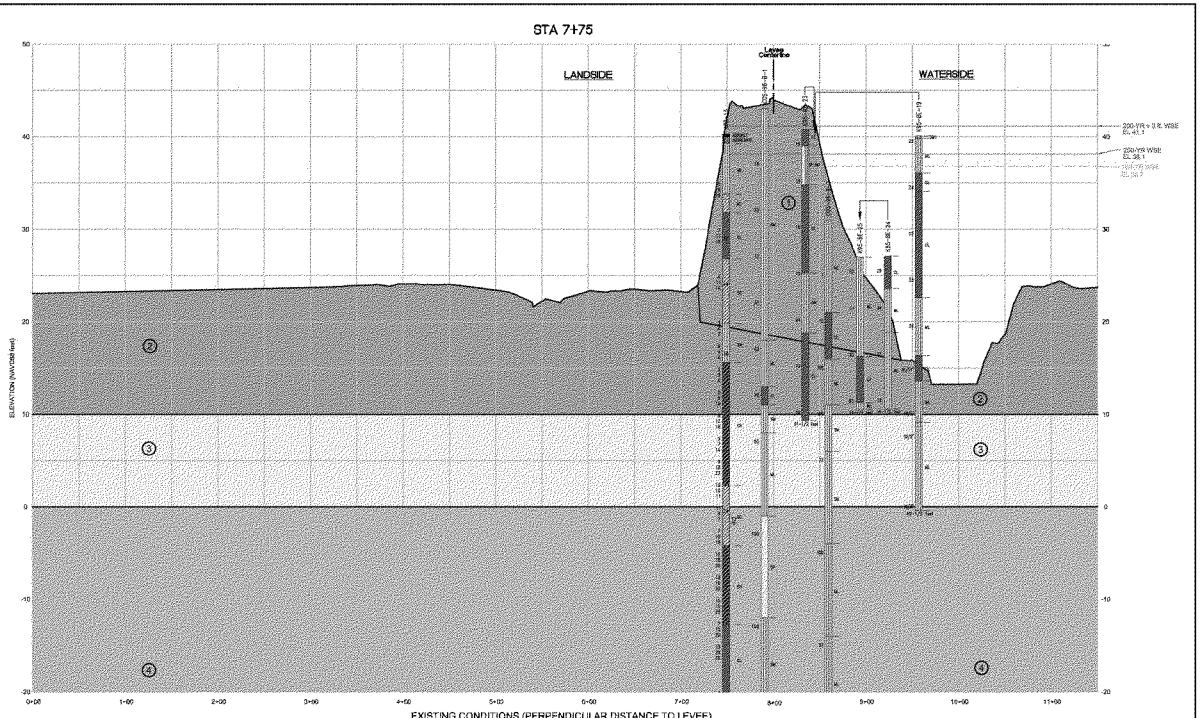
Permeability Table

	Material Description	k_H* (cm/sec)	k_V/k_H**
1.	Clay	$1x10^{-5}$	0.25
2.	Clay	$1x10^{-5}$	0.25
3.	Sand	$1x10^{-3}$	0.25
4.	Silt	$1x10^{-5}$	0.25

*Horizontal Hydraulic Conductivity
**Anisotropy Ratio

NOTES:

1. The stratigraphic interpretation presented is based on evaluation of known explorations within Reach 1 performed by Kleinfelder and others.
2. Topography in the vicinity of Station 7+75 is based on survey provided by Thomas in 2008, which did not include a bathymetric study.
3. Water surface elevations (WSE) are based on MBK Engineers report dated December 12, 2008.



0 10 20
APPROXIMATE VERTICAL SCALE (feet)

0 50 100
APPROXIMATE HORIZONTAL SCALE (feet)

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Source: Kleinfelder 2010

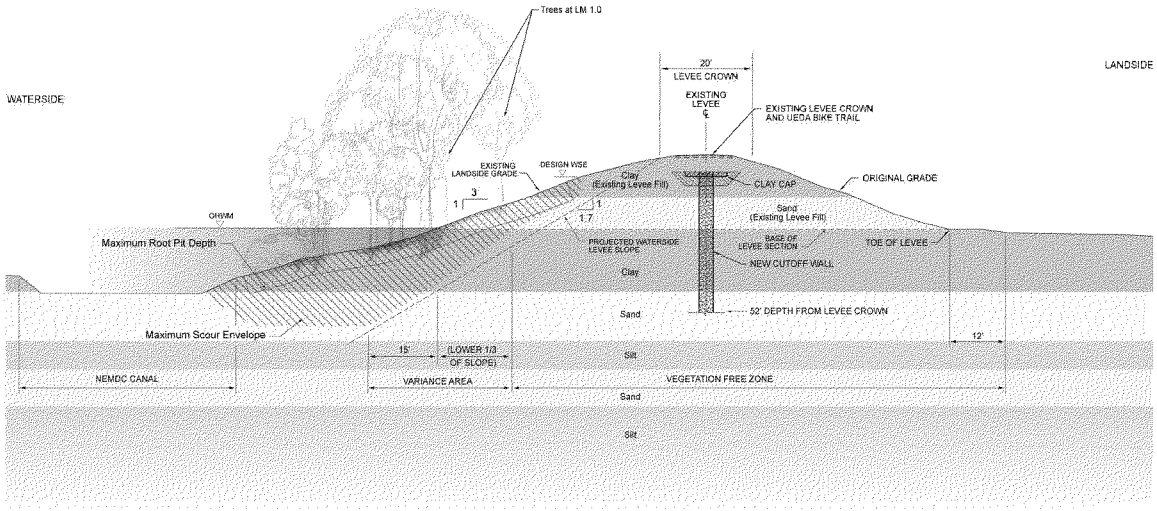
NEMDC LM 0.0 Stratigraphy (LM 0 to LM 0.3)

Plate 20

Source: AECOM 2010

NEMDC LM 0.3 Waterside Vegetation (LM 0.3 to LM 1.1)

Plate 21



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

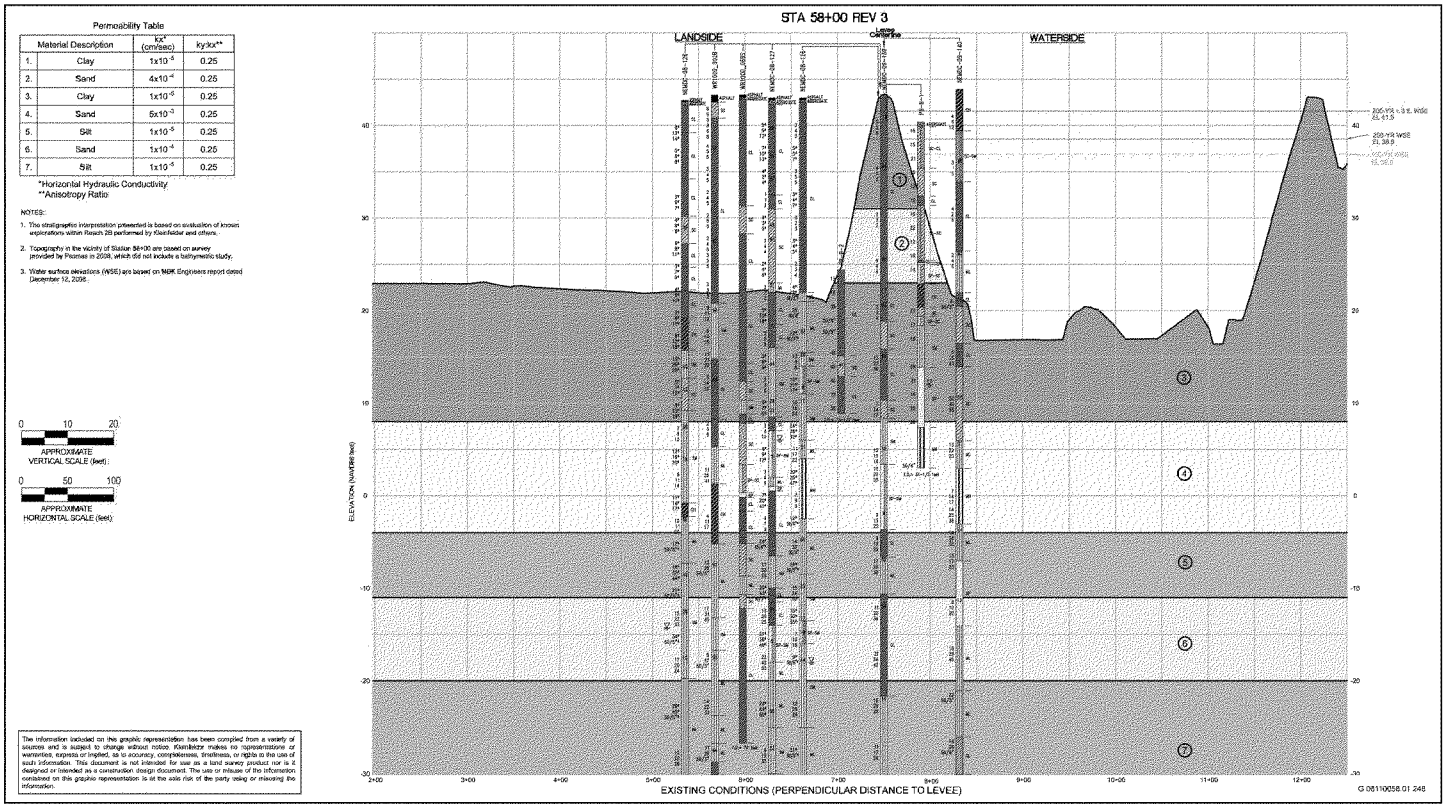
d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.040 and the friction slope was assumed to be 0.00007 during the 200-year water level. This approximates a velocity of 1.9 ft/s at the levee toe concurrent with the 200-year water level.

0 10 20
FEET
G:\81110058\01.262

Source: Wood Rodgers, NHC, and Kleinfelder 2010; Adapted by AECOM 2010

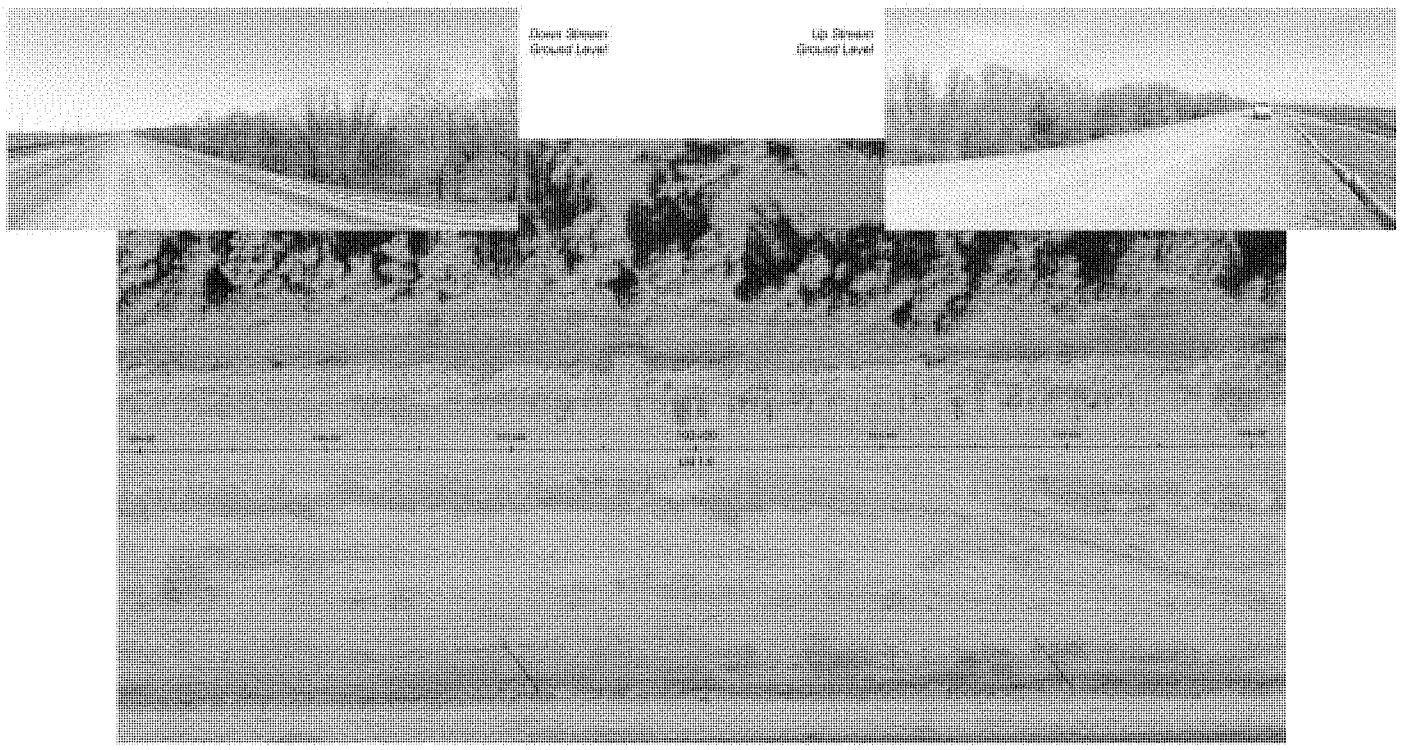
NEMDC LM 0.3 Typical Levee Cross Section (LM 0.3 to LM 1.1)

Plate 22 (June 17, 2010)



Source: Kleinfelder 2010

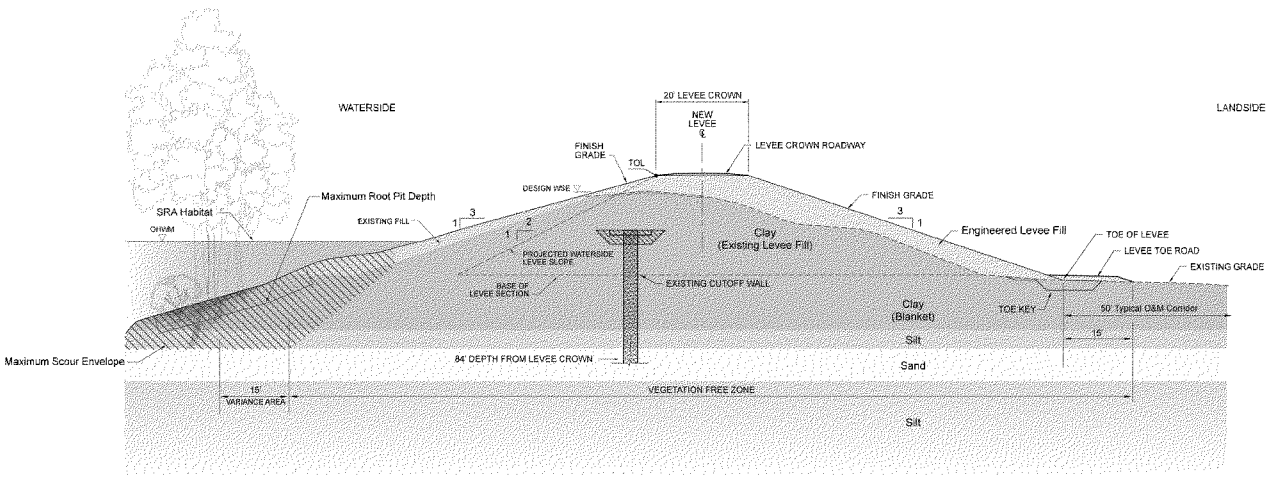
NEMDC LM 0.3 Stratigraphy (LM 0.3 to LM 1.1) **Plate 23**



Source: AECOM 2010

NCC LM 0.7 Waterside Vegetation (LM 0 to LM 3.5)

Plate 24 (May 18, 2010)



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.00005 during the 200-year water level. This approximates a velocity of 2.4 ft/s at the levee toe concurrent with the 200-year water level.

0 10 20
FEET

G:\6110058.01\263

Source: Wood Rodgers, NHC, and Kleinfelder 2010; Adapted by AECOM 2010

NCC LM 0.7 Typical Levee Cross Section (LM 0 to LM 3.5)

Plate 25 (May 18, 2010)

Permeability Table

	Material Description	kx* (cm/sec)	ky:kx**
1.	Clay (Existing Levee)	$1X10^{-5}$	0.25
2.	Clay (Blanket)	$1X10^{-5}$	0.25
3.	Silt	$2X10^{-4}$	0.25
4.	Sand	$1X10^{-2}$	0.25
5.	Clay	$1X10^{-5}$	0.25

* Horizontal Hydraulic Conductivity

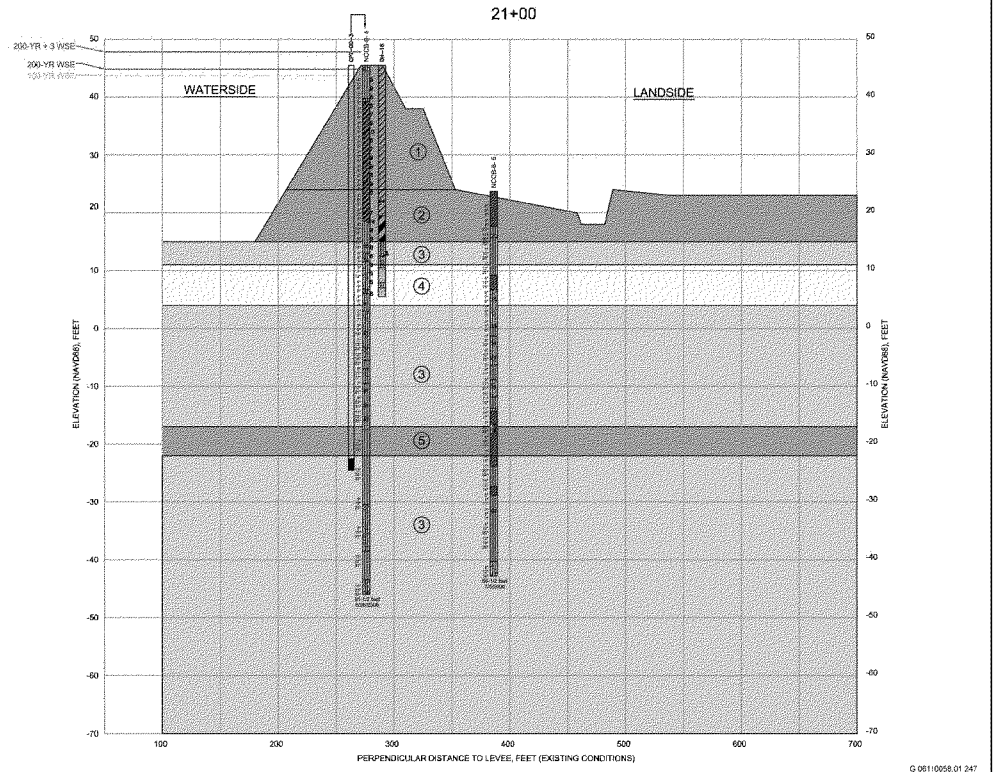
** Anisotropy Ratio

NOTES:

1. The stratigraphic interpretation presented is based on explorations in the vicinity of Station 21+00 performed by Kleinfelder and others.
2. Topography in the vicinity of Station 21+00 are based on surveying provided by Psomas in 2008 and USACE.
3. Water surface elevations (WSE) are based on MBK Engineers report dated December 12, 2008.

0 8 16
APPROXIMATE VERTICAL SCALE (feet)

0 40 80
APPROXIMATE HORIZONTAL SCALE (feet)

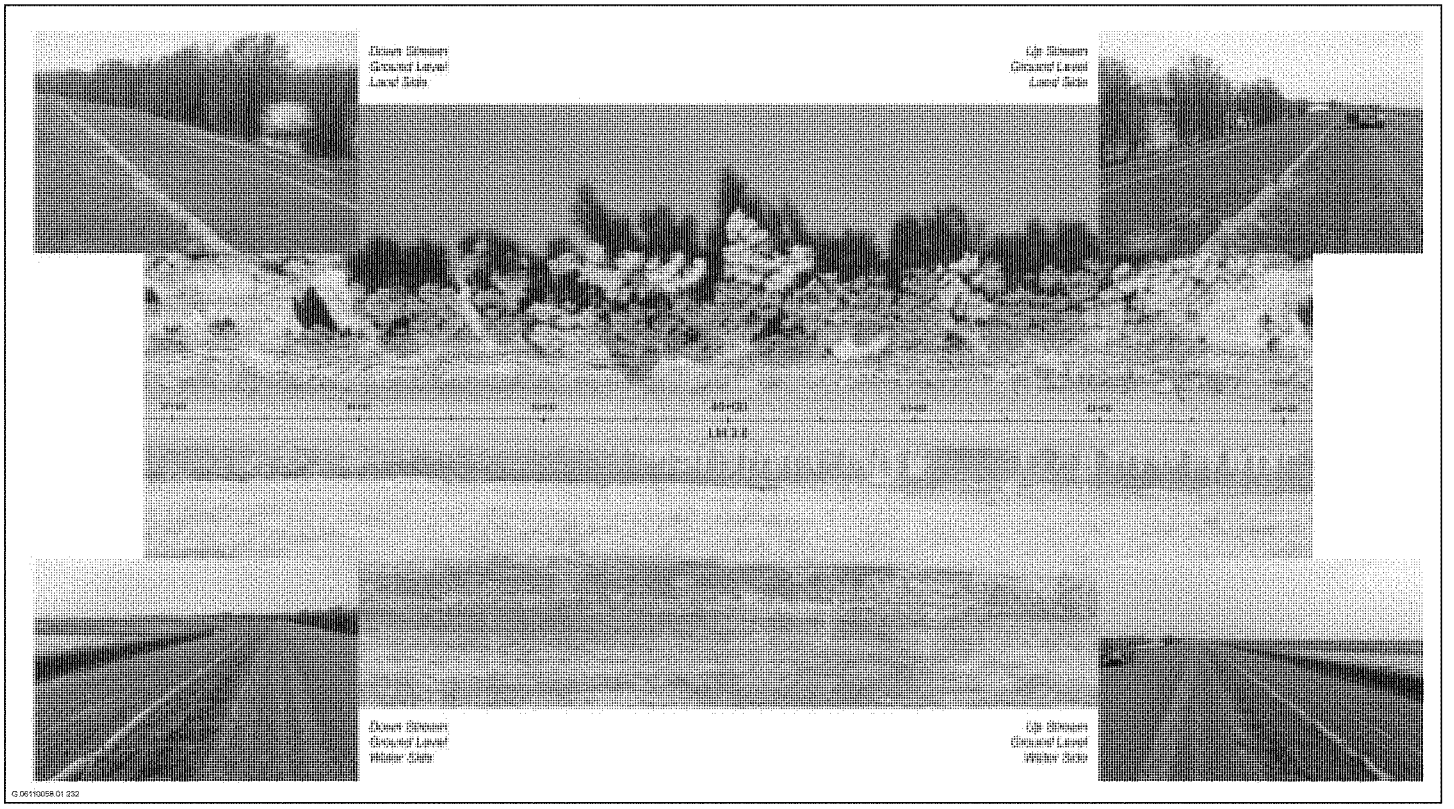


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Source: Kleinfelder 2010

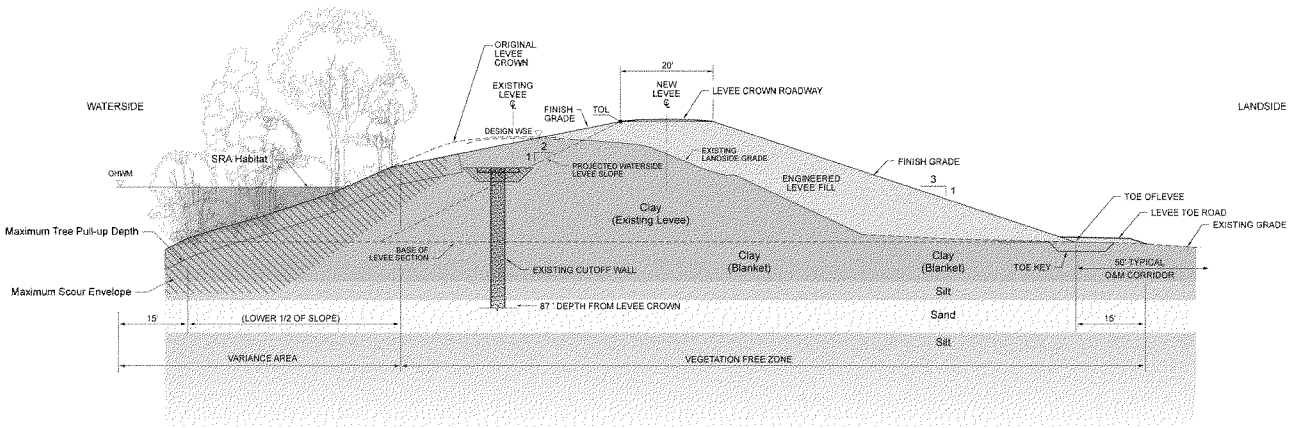
NCC LM 0.7 Stratigraphy (LM 0 to LM 3.5)

Plate 26 (May 18, 2010)



Source: AECOM 2010

NCC LM 3.6 Waterside Vegetation (LM 3.5 to LM 4.38) **Plate 27 (May 18, 2010)**



NOTES:

a. Scour depths were computed using the Melville and Colman Bridge Pier Scour Equation (Appendix F) with hydraulics provided by the USACE Sacramento Basin HEC-RAS model.

b. The Maximum Scour Envelope encompasses the potential maximum scour extents if a large tree were to topple anywhere within the vegetation variance zone. Scour dimensions around a single toppled tree are discussed in Appendix F.

c. Due to the dependence of scour on both depth and velocity, scour may be maximized during events with a more frequent occurrence than the 200-year water level. The event which maximizes scour at any elevation at a given levee cross-section may also vary. The Maximum Scour Envelope shown is the composite results of the maximum scour extents for tree toppling on various elevations on the levee cross-section for events which occur at or more frequently than the 200-year event. The ranges of hydraulic conditions are discussed in Appendix F.

d. Velocities were computed as a function of depth assuming a Manning's relationship: $V=(1.49/n)(y^{2/3})(S_f)^{1/2}$ where the Manning's n value and Friction Slope, S_f, were taken directly from the USACE Sacramento Basin HEC-RAS model, and the depth, y, was computed from WSEL and local ground elevation. For this site, the Manning's n was assumed to be 0.035 and the friction slope was assumed to be 0.00005 during the 200-year water level. This approximates a velocity of 2.4 ft/s at the levee toe concurrent with the 200-year water level.

0 10 20
FEET
G 06110058.01 264

Source: Wood Rodgers, NHC, and Kleinfelder 2010; Adapted by AECOM 2010

NCC LM 3.6 Typical Levee Cross Section (LM 3.5 to LM 4.38)

Plate 28 (May 18, 2010)

Permeability Table

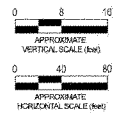
	Material Description	kx* (cm/sec)	ky:kx**
1.	Clay (Existing Levee)	1X10^{-5}	0.25
2.	Clay (Blanket)	1X10^{-5}	0.25
3.	Sand with Silt	5X10^{-3}	0.25
4.	Clay	1X10^{-5}	0.25
5.	Silty Sand	1X10^{-3}	0.25

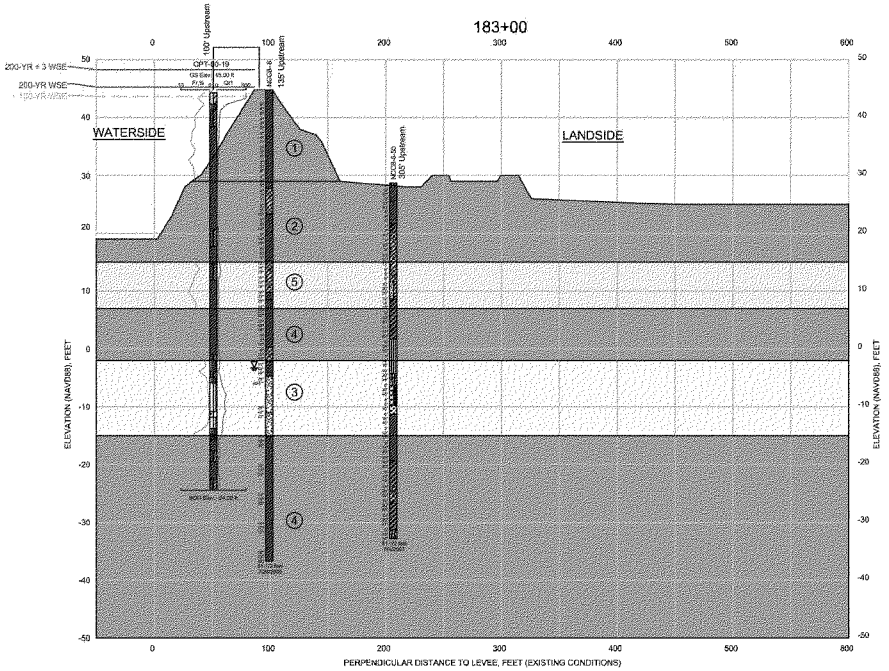
* Horizontal Hydraulic Conductivity

** Anisotropy Ratio

NOTES:

1. The stratigraphic interpretation presented is based on explorations in the vicinity of Station 183+00 performed by Kleinfelder and others.
2. Topography in the vicinity of Station 183+00 are based on surveying provided by Psomas in 2008 and USACE.
3. Water surface elevations (WSE) are based on MBK Engineers report dated December 12, 2008.



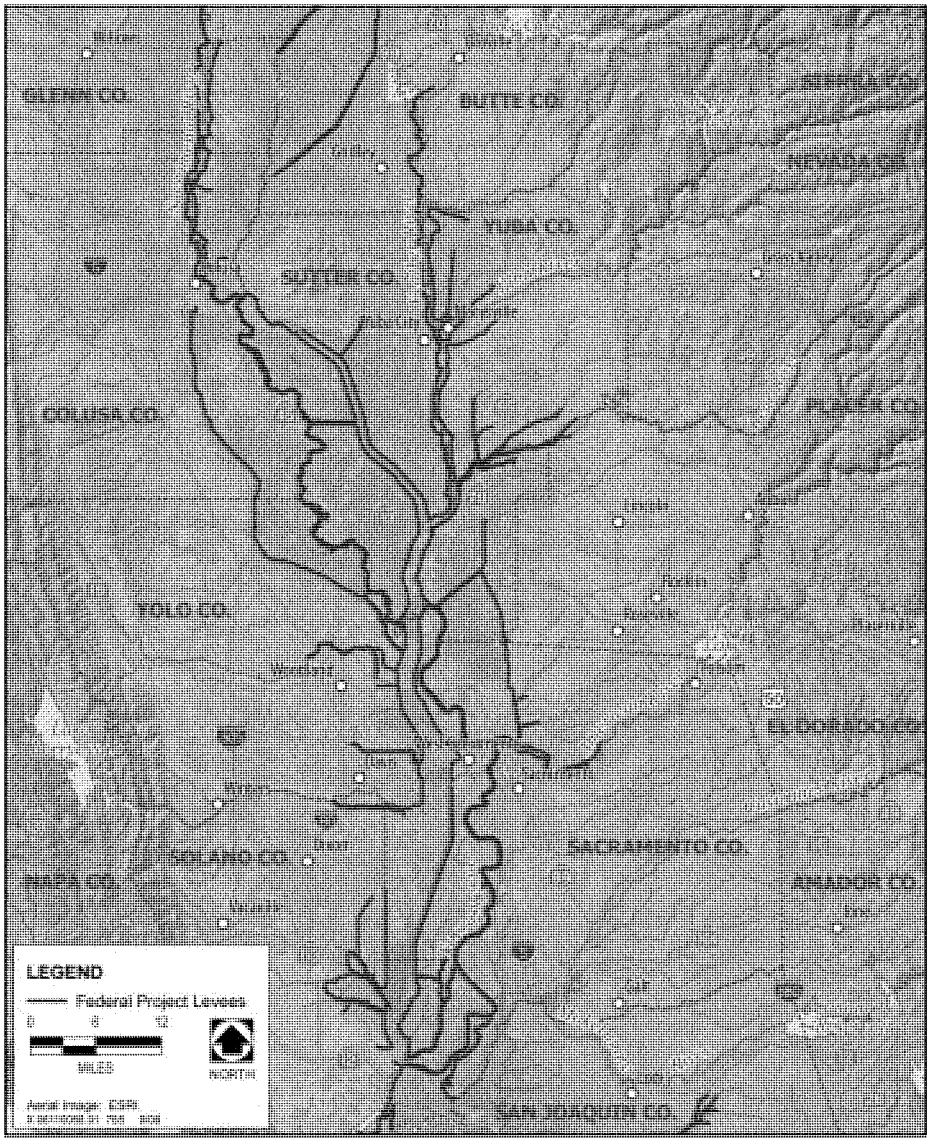


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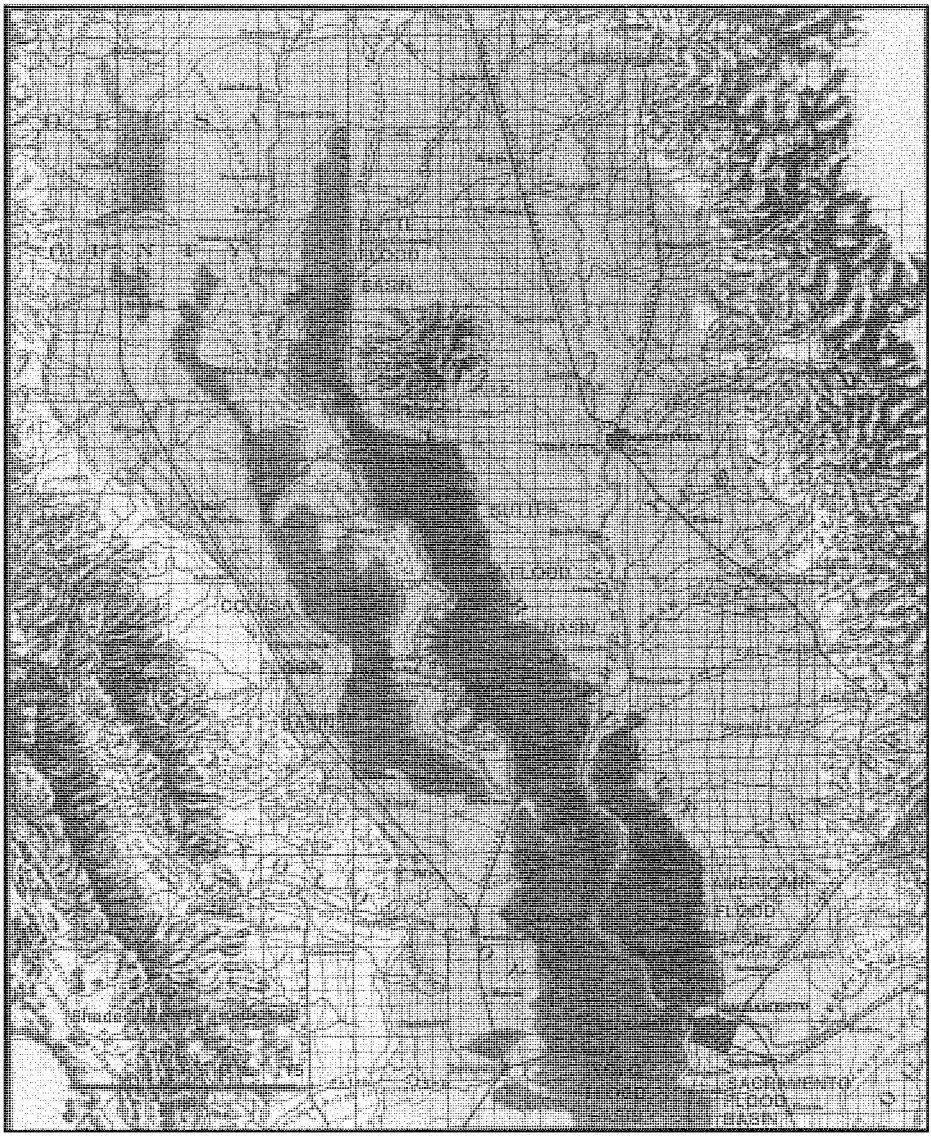
G 06110058.01 045

Source: Kleinfelder 2010

NCC LM 3.6 Stratigraphy (LM 3.5 to LM 4.38) **Plate 29 (May 18, 2010)**



Sacramento River Flood Control Project **Plate 30**



Historic Floodplain of the Sacramento River **Plate 31**

FOR CONTINUATION OF HOUSE DOCUMENT 112-66

AMERICAN RIVER WATERSHED, CALIFORNIA: COMMON FEATURES PROJECT: NATOMAS BASIN

SEE PART 3