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Sacramento District
Engineering Division

Lower San Joaquin Feasibility Study – Environmental Impact Report/ Supplemental Environmental Impacts Statement

San Joaquin County, California

Geotechnical Addendum

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ENCLOSURES

ABBREVIATIONS

ASTM	American Society of Testing and Materials
BTA	blanket theory analysis
bgs	below ground surface
c	cohesion
CB	cement bentonite
cfs	cubic feet per second
CGS	California Geological Survey
cm	centimeters
CPT	cone penetrometer test

CR	Calaveras River
CSRA	Cost and Schedule Risk Assessment
CW	cutoff wall
CVFPB	Central Valley Flood Protection Board
DBSA	Delta Brookside Study Area
DLVSA	Delta Lincoln Village Study Area
DMM	deep mix method
DSM	deep soil mixing
DWR	Department of Water Resources
EM	Engineer Manual
ER	Engineer Regulation
ETL	Engineer Technical Letter
FCS	French Camp Slough
FOS	factor(s) of safety
FOSM	First Order Second Moment
ft	foot/feet
ft/s	feet per second
GDR	Geotechnical Data Report
GER	Geotechnical Engineering Report
GMS	Groundwater Modeling System
H:V	horizontal to vertical ratio
HQ	Headquarters U.S. Army Corps of Engineers
IBC	International Building Code
IWM	in-stream woody material
k	coefficient of permeability
Ka	kiloannum – one thousand years
k_H	horizontal hydraulic conductivity under fully saturated conditions
k_H/k_V	ratio between vertical and horizontal conductivities; anisotropic ratio
k_V	vertical hydraulic conductivity under fully saturated conditions
LiDAR	Light Detection and Ranging
LM	Levee Mile
LSJRFS	Lower San Joaquin River Feasibility Study
LSJR	Lower San Joaquin River
Ma	million years
MCE	Maximum Credible Earthquake
MSWL	Mean Summer Water Level
M_W	Moment Magnitude
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NCEER	National Center for Earthquake Engineering Research
NGA	Next Generation Attenuation
NGVD29	National Geodetic Vertical Datum of 1929
NLD	National Levee Database
NULE	Nonurban Levee Evaluations
PCET	Parametric Cost Estimation Tool
PCF	per cubic foot

PDT	Project Delivery Team
PED	pre-construction engineering and design
PGA	peak ground acceleration
Pr(f)	probability of failure
Pr(U)	probability of poor performance
PSHA	Probabilistic Seismic Hazard Analysis
P1GDR	Phase 1 Geotechnical Data Report
P1GER	Phase 1 Geotechnical Engineering Report
PI	Periodic Inspection
RD	Reclamation District
RM	River Mile
SAFCA	Sacramento Area Flood Control Agency
SJAFCA	San Joaquin Area Flood Control Agency
SB	soil-bentonite
SCB	soil cement bentonite
SDC	Stockton Diverting Canal
SGDR	Supplemental Geotechnical Data Report
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
SRBPP	Sacramento River Bank Protection Project
TEC	Topographic Engineering Center
TM	Technical Memorandum
ULE	Urban Levee Evaluation
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Society
Vs30	velocity of the upper 30 meters
VVR	vegetation variance request
WRDA	Water Resources Development Act
WSE	water surface elevation

1. INTRODUCTION

This report is the geotechnical addendum to the Lower San Joaquin River Feasibility Study (LSJRFS). The LSJRFS area includes portions of the Lower San Joaquin River (LSJR), French Camp Slough (FCS), Stockton Diverting Canal (SDC), Calaveras River (CR), the Delta Brookside Study Area (DBSA), and the Delta Lincoln Village Study Area (DLVSA). The flood plain includes most of the developed portions of North Stockton, Central Stockton, and South Stockton, including areas of Lathrop and Manteca. The San Joaquin watershed drains approximately 31,000 square miles of land, covering an area nearly the expanse of South Carolina, and a population of approximately 4,000,000.

1.1 PURPOSE AND SCOPE

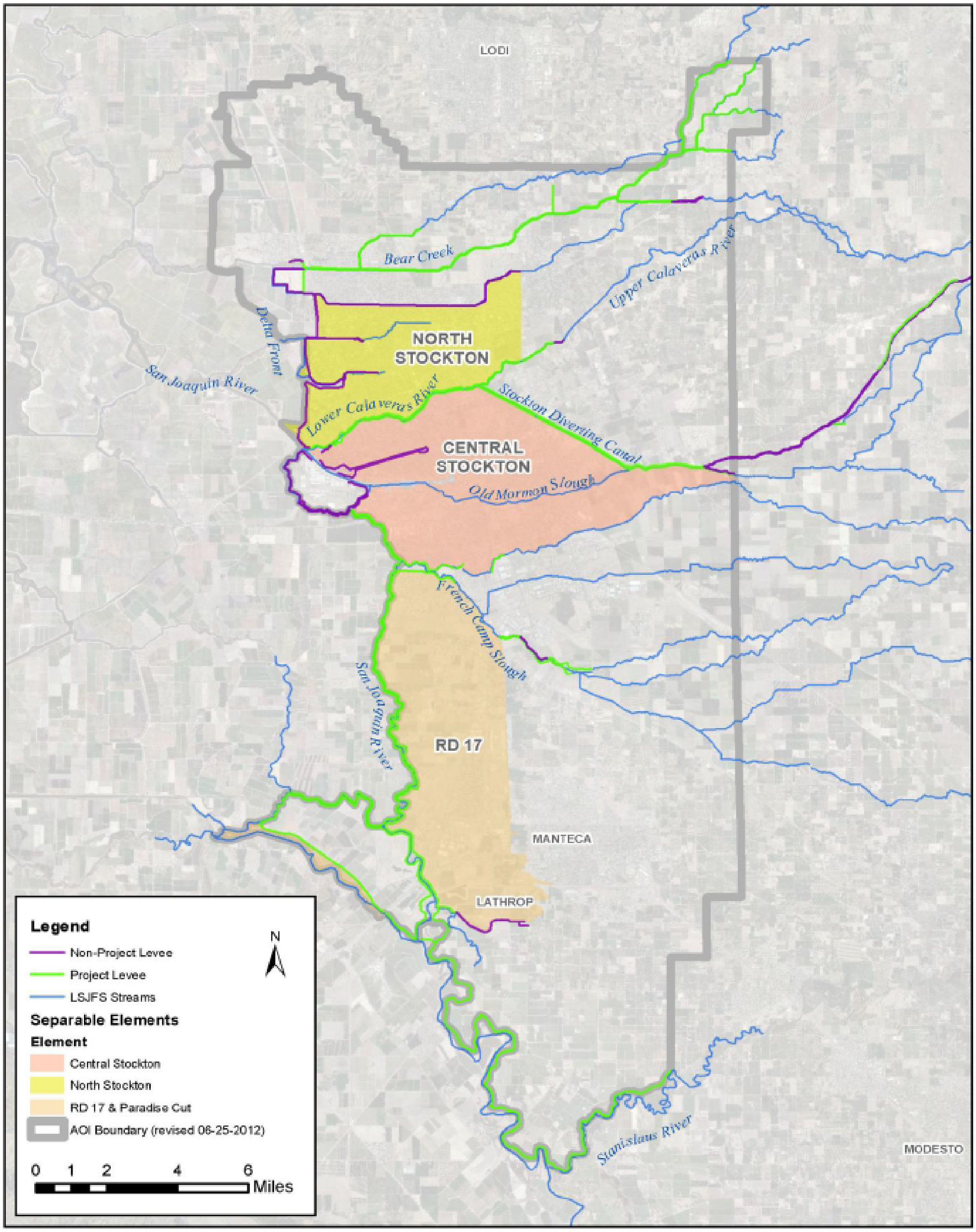
This report presents the results of geotechnical analyses and feasibility level geotechnical recommendations as performed in accordance with Engineer Regulation (ER) 1110-2-1150 to address levee height, geometry, erosion, access, vegetation, seepage, and slope stability deficiencies within the LSJRFS area. Due to the evolving Planning process and the implementation of the 3x3x3 paradigm, this report was prepared using existing information provided by the Department of Water Resources (DWR), San Joaquin Area Flood Control Agency (SJAFCA), URS Corporation, and Kleinfelder. For this geotechnical engineering evaluation of the LSJRFS area, the following tasks were performed and are summarized in this report:

- review currently available geology, geomorphology, and geotechnical information
- review past performance and flood control system construction history/improvements
- identification of levee performance deficiencies through geotechnical analysis and engineering judgment
- probabilistic geotechnical analysis and development of levee performance curves
- seismic study of existing levees
- development of geotechnical conclusions and recommendations

1.2 PROJECT DESCRIPTION

The Lower San Joaquin River and Tributaries Project was first authorized by the Flood Control Act of 1944. The Lower San Joaquin River Feasibility Study was authorized by the Water Resources Development Act (WRDA) of 1986 following the feasibility studies authorized by the Flood Control Act of 1962 and following appropriations in 2004. The Cost-Share agreement signed in February 2009 initiated the multi-year feasibility study of the LSJR between the Corps, Central Valley Flood Protection Board (CVFPB) represented by the State of California Department of Water Resources, SJAFCA, and its partners.

The LSJRFS area, shown in Figure 1-1, has been divided into three basins: North Stockton, Central Stockton, and South Stockton.



Study Area

Lower San Joaquin River Feasibility Study

Figure 1-1: Lower San Joaquin Project Study Area

These three areas include the following stretches of levee, which are covered by this report:

- approximately 15 miles of levee along the east bank of the Lower San Joaquin River, Reclamation District 17 (RD-17), immediately downstream of Weatherbee Lake, north to the confluence of French Camp Slough
- approximately 2 miles of levee along the north (RD-404) and south banks (RD-17) of French Camp Slough (total 4 miles), immediately downstream of I-5, west to the confluence of the Lower San Joaquin River
- approximately 5 miles of levee along the west bank of the Stockton Diverting Canal (SJAFCA), immediately downstream of the confluence of Mormon Slough, northwest downstream to the confluence of Calaveras River
- approximately 6 miles of levee along the north (SJAFCA, RD-2074) and south (SJAFCA, RD-1614) banks of the Calaveras River (total 12 miles), immediately downstream of the Stockton Diverting Canal, southwest downstream to the confluence of the Lower San Joaquin River
- approximately 3.5 miles of levee west and north (RD-2074) of the Brookside Community along the Lower San Joaquin River and Fourteen Mile Slough, respectively
- approximately 2.0 miles of levee on the west side of Fourteen Mile Slough (RD-2119) located west of the Lincoln Village Community

The extents of the areas listed above were developed further by the Project Delivery Team (PDT) over the duration of the study (for example, in identifying with project alternatives).

1.3 REACH IDENTIFICATION

Reach identification (i.e., LR-1, FR-1, etc.) is the primary method used to describe the index point locations; however; for the purposes of the feasibility planning process, these reaches were further subdivided based on common properties, such as geographic features. In general, as stated above, this report presents information either by basin or reach; however, in some cases the report structure deviates from basin or reach-based organization. For instance, geology and geomorphology, construction history, and past performance are better related to channel features than basin related reaches. Therefore, for those topics, the information has been presented in the following groups: North Stockton, Central Stockton, South Stockton, RD-17, RD-404, French Camp Slough, Stockton Diverting Canal, Calaveras River, Tenmile Slough, and Fourteen Mile Slough.

2. SITE CONDITIONS

2.1 SOURCES OF DATA

The subsurface conditions and material properties of the levee embankments and foundation soils have been characterized by several studies in the past. These studies have been prepared as part of reconnaissance and feasibility efforts by the USACE, DWR, SAFCA, and SJAFCA among others. Following the 1986 flood event and the severe flooding of 1997 that resulted in dozens of levee failures throughout the San Joaquin River Basin, several studies were initiated which generated geotechnical data including:

- RD-17 – Phase 1 Geotechnical Engineering Report (P1GER), December 2007, Phase 1 Geotechnical Data Report (P1GDR), September 2008; Supplemental Geotechnical Data Report (SGDR), December 2010; all reports prepared by URS for DWR
- RD-404 – Supplemental Geotechnical Data Report (SGDR), April 2011; prepared by URS for DWR
- Stockton Diverting Canal/Calaveras River – Phase 1 Geotechnical Data Report (P1GDR), July 2008; Phase 1 Geotechnical Engineering Report (P1GER), July 2011, Draft Supplemental Geotechnical Data Report (SGDR), March 2013; all reports prepared by URS for DWR
- Delta Brookside Study Area – Draft Geotechnical Data Report (GDR), August 2012; prepared by Kleinfelder for DWR
- Delta Lincoln Village Study Area – Draft Geotechnical Data Report (GDR), June 2012; prepared by Kleinfelder for DWR
- Geotechnical Assessment Report (GAR) South NULE Study Area, Volumes 1 through 4, May 2011; prepared by Kleinfelder for DWR

These studies consisted of feasibility geotechnical data and design reports that presented the results of engineering studies and investigations prior to plans and specifications for remedial construction of levees within the LSJ Basin.

Between ATR review and HQ review DWR completed evaluation reports (GERs) for Delta Brookside and Delta Lincoln Village study areas. Information from these reports was used to refine the extent of seismic mitigation during the HQ review process. These reports include:

- Delta Brookside Study Area – Geotechnical Evaluation Report (GER) Volume I, January 2015; prepared by Kleinfelder for DWR
- Delta Brookside Study Area – Geotechnical Evaluation Report (GER) Volume II, February 2015; prepared by Kleinfelder for DWR
- Delta Lincoln Village Study Area – Geotechnical Evaluation Report (GER) Volume I, January 2015; prepared by Kleinfelder for DWR
- Delta Lincoln Village Study Area – Geotechnical Evaluation Report (GER) Volume II, February 2015; prepared by Kleinfelder for DWR

The available geotechnical data from the above mentioned sources included subsurface geotechnical borings and Cone Penetrometer Tests (CPT) performed along the levee crest, waterside toe, landside toe, and within 500-feet of the landside toe; other data included geology and geomorphology studies, and geophysical surveys. The levee geometry was based on the existing data in the National Levee Database (NLD) supplemented by recent Light Detection and Ranging (LiDAR) survey and bathymetric survey provided by the DWR as part of the Urban Levee Evaluations (ULE) program.

Elevation references in this report are in feet and are based on the North American Vertical Datum of 1988 (NAVD88) unless otherwise noted. Conversion factors ranging between +2.26 to +2.42 were applied by the organizations mentioned above to convert Geodetic Vertical Datum of 1929 (NGVD29) elevations to NAVD88. All horizontal references in this report are in feet and are based on the California State Plane, Zone III, North American Datum of 1983 (NAD83).

2.2 GEOLOGY, GEOMORPHOLOGY, AND SEISMICITY

2.2.1 Geologic Setting

This section will summarize the geologic and geomorphic assessment developed by USACE, Fugro William Lettis & Associates (FWLA), and Kleinfelder for the LSJRFS area. The complete assessment report(s) are included as Appendix O in each report listed in Section 2.1; except for the GAR South NULE report.

This area of California was part of the early Cretaceous to Paleocene convergent tectonic margin and associated Sierran magmatism. The basement rock in this area consists of Sierran granite or granitoid rocks on the eastern side of the basin and Coast Range ophiolite to the west. Age-dated profiles suggest a migration of plutonism from west to east with the oldest rocks occurring on the margin of the San Joaquin Valley and the youngest appearing on the eastern flank of the Sierra Nevada (Hosford Scheirer and Magoon, 2008). With the end of plutonism, came the beginning of the flat slab subduction mega-sequence about 5 Ma (million years) subsequent. During the late Cretaceous through the beginning of the Paleocene, the Panoche and Moreno formations indicate dominantly marine conditions with periods of scattered and non-aerially extensive terrestrial deposition. The geologic record is incomplete from the late Paleocene to the early Eocene in the Northern Sub-province during which time the Lodo (marine) and Yokut (near shore fluvial deltaic) formations were deposited. The Yokut deposition was followed (conformably) in the north sub-province by the Domengine sand (shallow marine transgressive). Deposition of the Kreyenhagen formation (marine) began concurrently with the Domengine formation and continued long after into the middle Eocene (37 Ma). The geologic record is incomplete in the north sub-province until the deposition of the late Oligocene to early Miocene Zilch formation (terrestrial - period of worldwide regression) which lies unconformably above the Kreyenhagen. The Zilch is unconformably overlain by the upper Miocene Santa Margarita Sandstone (shallow marine clastic). The remaining sequence of sediments are generally Pliocene and Pleistocene terrestrial deposits derived from the uplift of the Sierra Nevada and Coast Range. These younger sediments include the Pliocene Mehrten formation (terrestrial fluvial - derived from volcanic sources), and the Pliocene China Hat formation (terrestrial fluvial – Sierran origin). These are overlain by the Pleistocene Merced, Turlock Lake, Riverbank, and Modesto formations; all of which thin to the west of the basin and interfinger with sediments derived from the coast range to the west. These are in turn incised by Holocene alluvial channels and covered by Holocene fan deposits.

The RD-17 basin follows the Lower San Joaquin River as it flows into the San Joaquin Delta. The LSJR is near a contact of young, fluvial deposits within the Delta (in the west) and a gently west sloping alluvial fan formed by the Stanislaus and Calaveras Rivers (in the east). Upstream of the RD-17 study area, the LSJR splits into multiple channels including Tom Paine Slough and Paradise Cut. All major channels are characterized by several overflow and secondary channels that typically diverge to the north and west from the LSJR. Before agricultural development was introduced into these areas, the channels flowed into and through tidal marshes. Tidal effects, sea-level changes, and subsidence within the Delta have influenced the events along the LSJR over the past thousands of years.

The RD-404 study area occupies a lowland area along the east bank of the Lower San Joaquin River just north of French Camp Slough headed north-west to the Port of Stockton. This area is situated between two large Pleistocene alluvial fans that originated from the Sierra Nevada Range. Lone Tree and Littlejohns Creek fill in the low lying areas of these two large fans with their own alluvial fan sediment and then drain to French Camp Slough traversing the southern boundary of the study area.

The Stockton Diverting Canal and Calaveras River study areas are similar in setting to the other areas in this study. They are situated within two large alluvial fans underlain by materials that originated from the Sierra Nevada Range. The Calaveras River flows along the lateral margin of the Calaveras alluvial fan. The western extents of the study area, west of Highway I-5, are within the eastern part of a tidally influenced Delta. Elevations in this area are at or below sea level. This area at or below sea level is a transition zone of low energy where alluvial materials and organic rich sediment string together (Marchand and Atwater, 1979; Cosby and Carpenter, 1937).

The Delta Brookside study area shares the same geologic setting as the Lincoln Village study area. The majority of the entire study area is underlain by the Delta geomorphic domain except for the southeast portion of the Lincoln Village study area that trends east beyond Highway I-5 onto alluvial fans underlain by materials that originated from the Sierra Nevada Range. The Delta geomorphic domain consists of saucer-shaped islands separated by fluvial channels and tidal sloughs that were connected prior to dredging and levee construction. The western extents of the study areas, including Buckley Cove and Fourteen Mile Slough, are part of the tidally influenced Delta that, prior to reclamation, was part of the inundated Delta characterized by organic-rich peat and peaty mud sediments (Atwater, 1982).

2.2.2 Geomorphology

For a summary description of area geomorphology, the LSJRFS area was broken up into the following areas: Lower San Joaquin River RD-17, RD 404/French Camp Slough, Stockton Diverting Canal, Calaveras River, and North Stockton Delta Brookside and Lincoln Village. Site-specific geomorphology maps produced by FWLA and Kleinfelder are included in Enclosure 1.

Historical deposits along the RD-17 basin overlay Holocene alluvial deposits. The historical channel deposits mapped east of the RD-17 levees suggest a younger sandy material overlain with the RD-17 levee prism (Figure 2-1). Detailed maps completed by Atwater (1980, 1982) showed the deposits of the northward flowing San Joaquin River system are primarily Holocene in age with more recent data suggesting less than 7,000 years of age (Malamoud-Roam et al., 2007). The San Joaquin River deposits were defined by Atwater (1982) as undivided Holocene alluvial floodplain deposits with isolated areas of Holocene basin deposits. These shallow deposits are underlain by a much thicker sequence of alluvial deposits from the Stanislaus River drainage originating from the Sierra Nevada Range and eolian deposits from the Central Valley. The Pleistocene deposits in the east are primarily silts and clayey materials with lenses of gravel all grouped into the Modesto Formation; the age of these deposits have been estimated by Atwater (1980) to be between 14,000 and 40,000 years old. The RD-17 area contains minor historic debris resulting from hydraulic mining. A surficial geologic map created by FWLA for the RD-17 area is included as part of Enclosure 1.

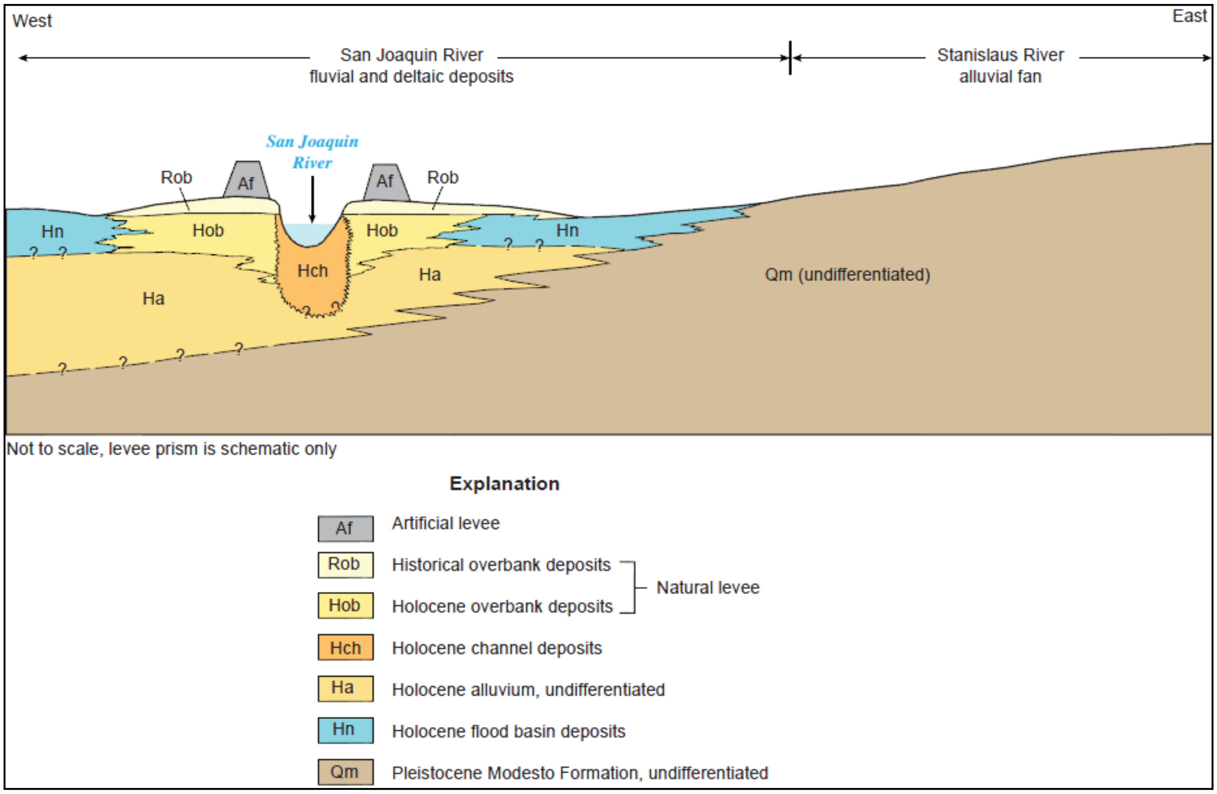


Figure 2-1: Geologic Units of Lower San Joaquin River RD-17

A surficial geologic map of RD-404 shows historical deposits along the Lower San Joaquin River suggesting a younger sandy material overlain with the levee prism along this section of RD-404. The map also shows a blend of silty, clayey, organic material overlain with the RD-404 levee prism along French Camp Slough (Figure 2-2). The oldest geologic unit in the study area is the late Pleistocene Modesto Formation that underlies a low gradient alluvial fan towards the eastern portion of the study area. It consists of unconsolidated to semi-consolidated sands, silts, and clayey materials and is part of a developed clay-rich duripan horizon. This clay-rich horizon likely forms extensive lateral zones of impermeable material in the shallow subsurface. The thickness and age of the Modesto Formation varies; however, the lower member is exposed in this study area and ranges from 29 to 42 Ka (Marchand and Allwardt, 1981). A surficial geologic map of this area is included as part of Enclosure 1.

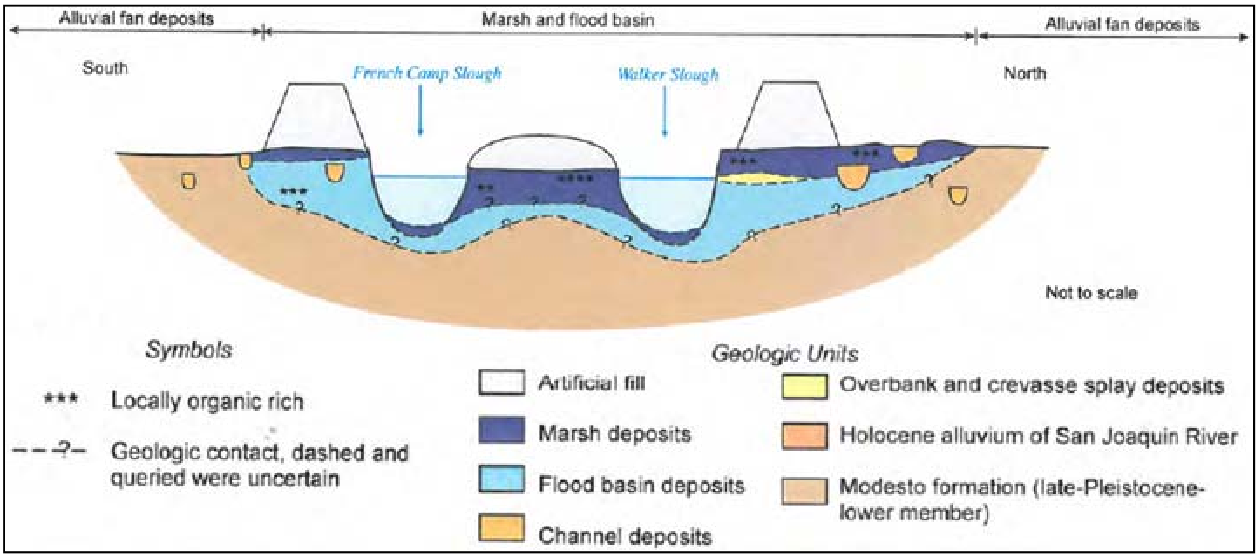


Figure 2-2: Geologic Units of RD-404/French Camp Slough

A surficial geologic map of the Stockton Diverting Canal and Calaveras River (Enclosure 1) show that SDC and a majority of the Calaveras River (from SDC to just east of Highway I-5) are within the domain of an alluvial fan. The area west of Highway I-5 resides within an intertidal domain. The SDC is a linear manmade channel that carries flows from Mormon Slough across the alluvial fan to the Calaveras River. The channel is filled with fine-grained silts and clays and crosses 15 channels that once flowed down the alluvial fan. The Modesto Formation underlies the levees along the canal to a depth of approximately 10 to 25 feet below the levee base; material at these depths consist of very stiff to hard silty clays to sandy clays, and silty sands. Underlying this material is a denser well consolidated Riverbank Formation (Figure 2-3).

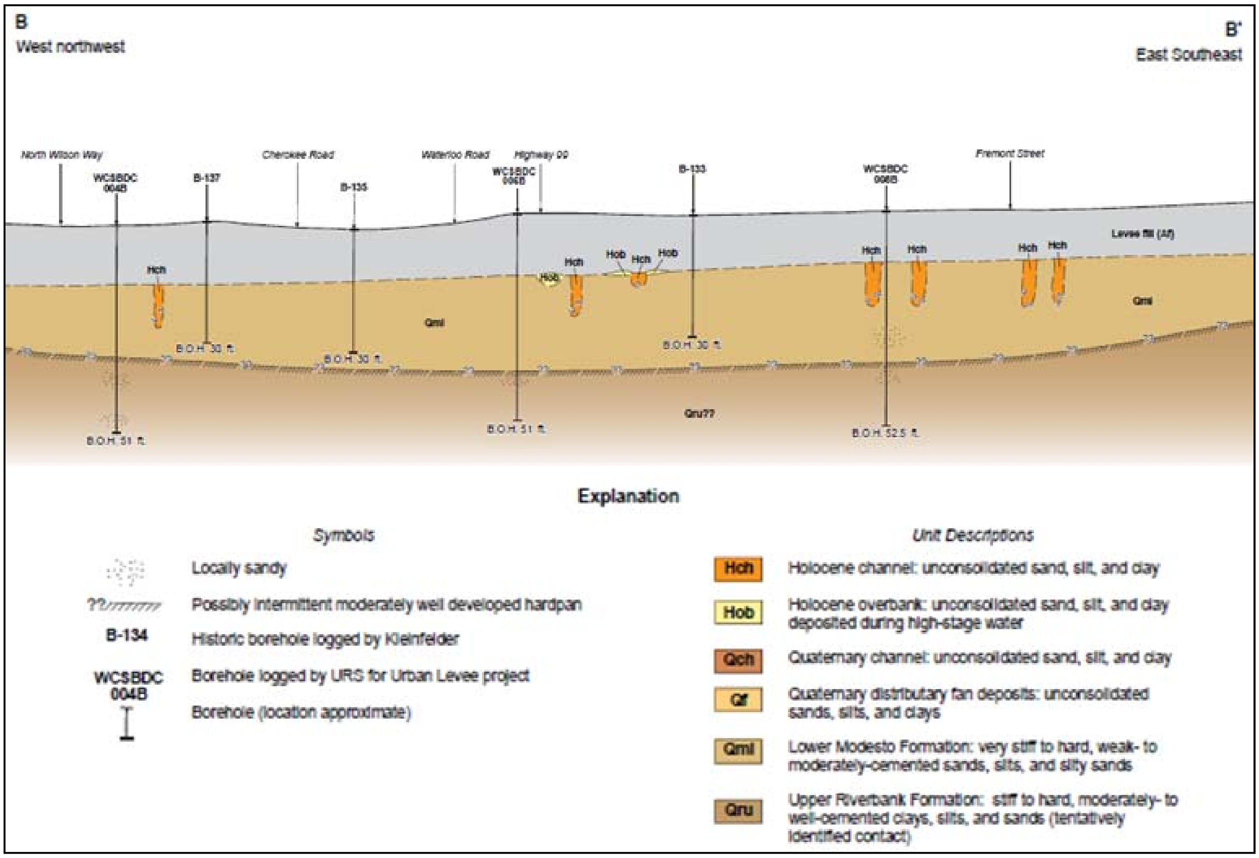


Figure 2-3: Geologic Units of Stockton Diverting Canal

The surficial geologic map shown for SDC (Enclosure 1) shows a portion of the Calaveras River within the alluvial fan. The Calaveras River ranges from 28-feet above sea level in the upstream portion (east) to less than 5 feet above sea level at the downstream end (west southwest). This portion of the Calaveras River crosses 8 channels that once flowed down the alluvial fan. Thin layers of unconsolidated Holocene sands and silts overlay more consolidated deposits of Modesto Formation. Additional deposits of Pleistocene, Holocene, historical channel, overbank, and historic overbank deposits underlie the levees in this portion of the Calaveras River; the Holocene and historic deposits most likely contribute to underseepage issues in these areas. The west-southwest portion of the Calaveras River extends westward from ¼ mile east of Highway I-5 to the confluence of the LSJR. This is a low lying intertidal area that was prone to depositional and erosional forces prior to levee construction. Levees in this area are underlain by Holocene peat and mud. Other materials such as, marsh, historic overbank, crevasse splay deposits, and channel deposits of varying age also exist in this portion of the river. The historic crevasse splay deposits and the historic overbank deposits most likely contribute to underseepage issues in these areas. The areas with the most potential for underseepage would be the crescent-shaped slivers of Holocene channel deposits. Figure 2-4 shows the geologic units of this area.

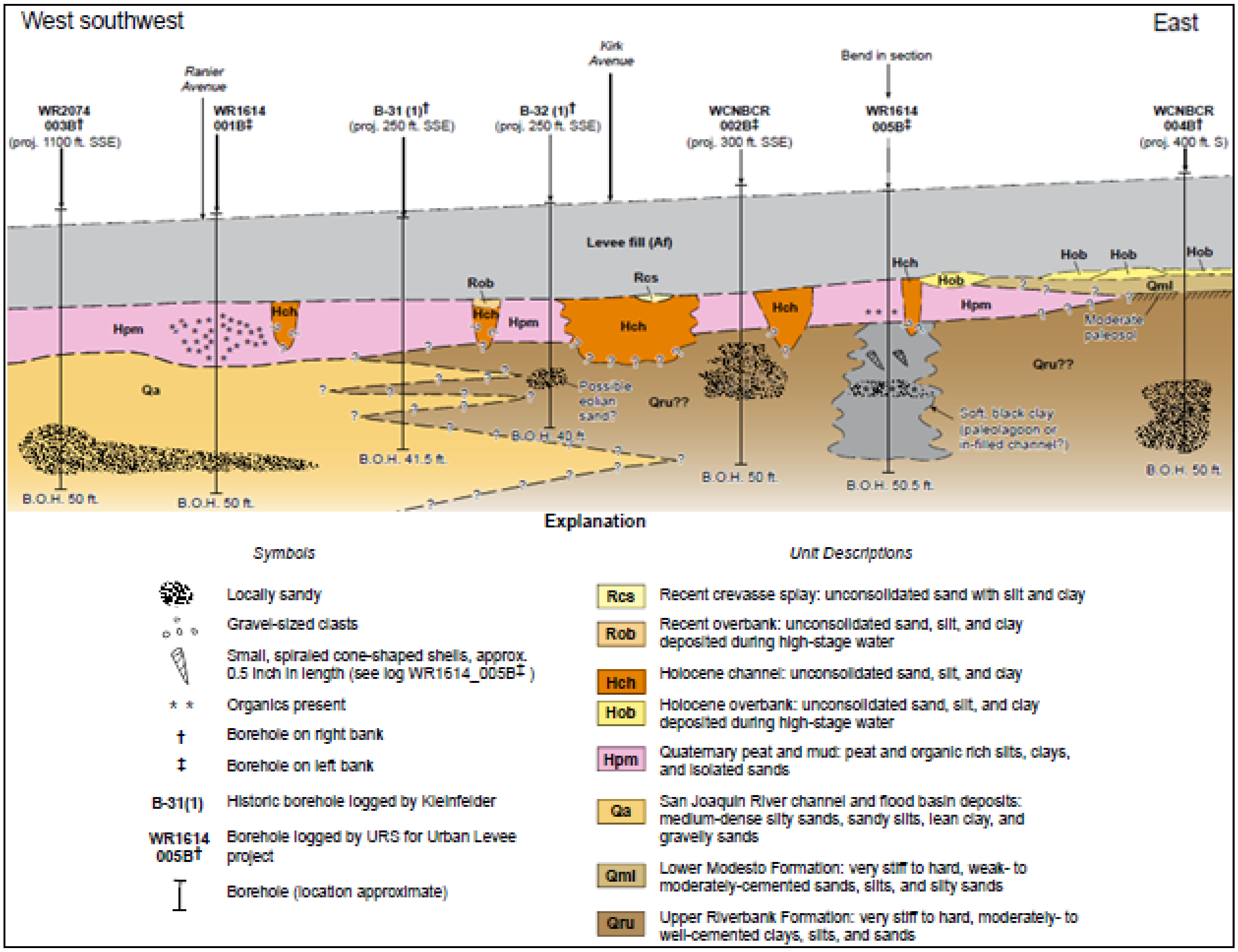


Figure 2-4: Geologic Units of Calaveras River

A surficial geologic map of the Delta Brookside/Delta Lincoln Village study areas (Enclosure 1) shows a northward trending contact just east of Highway I-5 that separates the Delta Geomorphic Domain to the west from the Pleistocene Modesto Formation in the east. The mapped contact between these two domains roughly follows the 1850 tidal line of Atwater (1982). Figure 2-5 shows a cross-sectional view running east to west of the various geologic units. The oldest underlying portions of the Delta islands are late Holocene consisting of unconsolidated organic-rich silts, clays, peat, and mud deposits; these materials accumulated in this intertidal area at or near sea level in these low-flow areas. This material is highly concentrated in both the Delta Brookside and Delta Lincoln Village study areas. Multiple channels of Holocene channel deposits, isolated Holocene overbank deposits, and historical recent overbank deposits crosscut this material flowing across the alluvial fans in a west-southwest orientation; the Holocene and historic deposits most likely contribute to underseepage issues in these areas. The oldest unit within the study area is the late Pleistocene Modesto Formation; this material is unconsolidated, slightly weathered gravels, sands, silts, and clays from upper alluvial fans. The Modesto Formation is exposed along the eastern portions on the study area trending northwest.

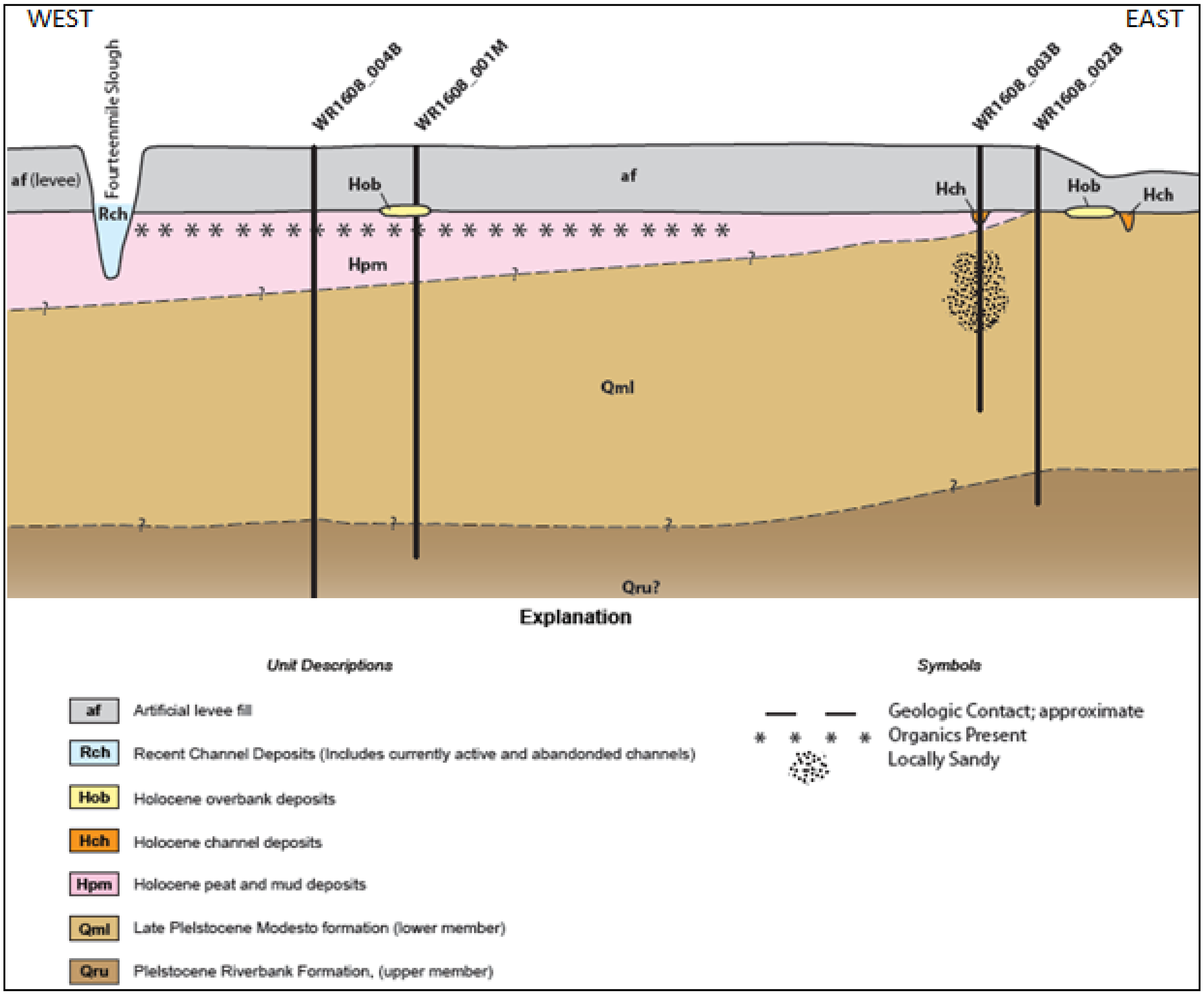


Figure 2-5: Geologic Units of Delta Brookside / Delta Lincoln Village

2.2.3 Seismic Setting

The LSJRFS area lies within the San Joaquin Valley and is exposed to less seismic response during a maximum credible earthquake (MCE) on the nearest active fault than sites in the San Andreas, Hayward, or Calaveras fault zones. Stockton is approximately 65 miles east of the San Andreas Fault. The San Andreas Fault is one of the longest active faults in the world at roughly 600 miles in length, stretching from the coast line in Northern California to the Gulf of California. The San Andreas Fault is capable of generating a moment magnitude (MW) 8.5 MCE. The last major event of record for this strike-slip fault was the moment magnitude (MW) 6.9 MCE Loma Prieta earthquake on October 17, 1989. One of the largest events of record for the San Andreas Fault was the moment magnitude (MW) 7.9 MCE San Francisco earthquake that occurred April 18, 1906.

Stockton is approximately 45 miles east of the Hayward Fault. The Hayward Fault borders the hills of Berkeley and Hayward and extends southeast where it meets up with the Calaveras Fault. The Hayward Fault is capable of generating a moment magnitude (MW) 7.5 MCE. The last major event of record for this right-lateral, strike-slip fault was on October 21, 1868. The moment magnitude (MW) of this event is not known, however, it was very destructive.

Stockton is approximately 40 miles east of the Calaveras fault system. The Calaveras fault is approximately 90 to 100 miles in length, extending from central Contra Costa County southeast to where it meets up with the San Andreas Fault just south of Hollister, CA. The Calaveras Fault is capable of generating a moment magnitude (MW) 7.0 MCE. The last major event of record for this right lateral, strike-slip fault was the moment magnitude (MW) 6.2 MCE Morgan Hill earthquake on April 24, 1984.

The nearest active fault is the Great Valley 7 fault (part of the San Joaquin Fault zone) located approximately 19 miles southwest of Stockton, CA. The San Joaquin Fault marks the physiographic boundary between the Diablo Range and the Central Valley (Unruh and Krug, 2007). The San Joaquin fault parallels the range-front from the Corral Hollow Creek outlet in the north to the Garzas Creek outlet in the south. Estimates of motion for this fault are in the range of 60 meters of west-side uplift over the last 200 to 300-thousand years. Maulchin (1996) has estimated a MW 6.5 MCE for this fault; however, there is little evidence that this fault has moved in Holocene times.

Figure 2.6 displays the various Northern California fault zones as shown in a 2010 fault map from California Geological Survey (CGS).

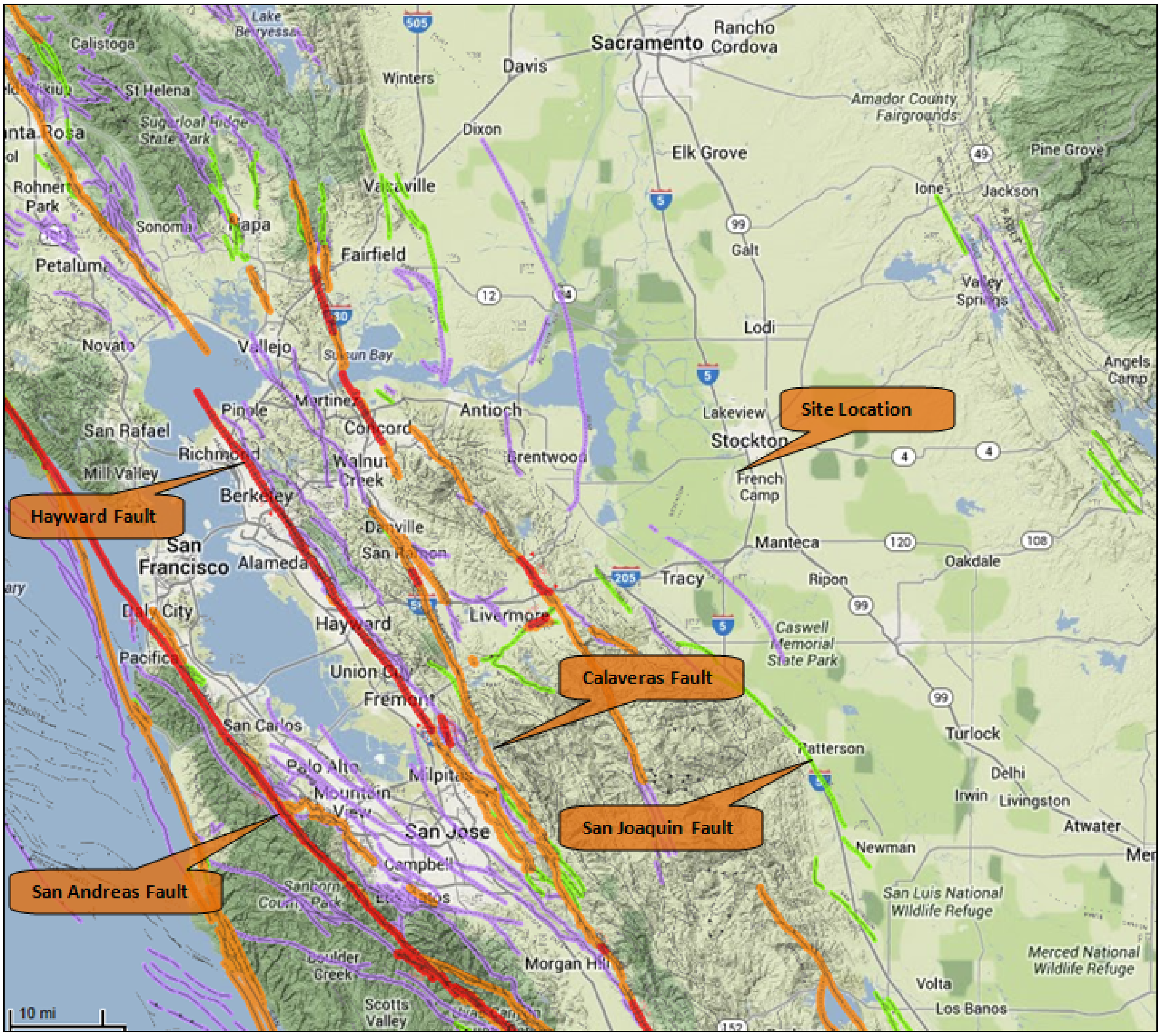


Figure 2-6: Northern California Fault Activity Map, CGS 2010

2.3 LEVEES

2.3.1 Construction History

A mix of Federal, State, and local agencies have been involved in flood control project construction and operation since levees were first constructed in California in the mid to late-1800's. Since the creation of the State Reclamation Board (now the Central Valley Flood Protection Board or CVFPB) in 1911 and the authorization of the California Central Valley Project Act in 1933, most levee improvements have been first Federally authorized by Congress, and then subsequently authorized by the State Legislature.

The first levees along the Lower San Joaquin River were most likely constructed under the California Central Valley Project Act or the Lower San Joaquin River Flood Control Project using clamshell dredges with material sourced from the channel. The levees were usually constructed at least 20 to 50 feet from the river with dredge material placed in the form of a pyramid. The base of the pyramidal shape was up to eighty (80) feet wide built to a height four (4) feet above the 1862 high-water mark. Willows were usually planted along the banks of the river and alfalfa was grown on the slopes of the levee to control erosion. This method of construction usually resulted in loose, sandy fill material that was deepest below the center of the levee. Historic logs show the levee sections were composed of silt to sandy silt, silty sand sometimes interbedded with lean clay, poorly graded sand, and well graded sand. Figure 2-7 shows an example of clamshell dredging performed along the Sacramento River at RM 57.3 in 1942.

Figure 2-7: Clamshell Dredge Along Sacramento River 1942

Many of these levees were then reconstructed, repaired, or reshaped with materials sourced from waterside borrow pits using scrapers, dozers, and compactors between 1947 and 1957. Figure 2-8 below represents a typical levee section constructed on the Lower San Joaquin River in the 1940's through 1950's.

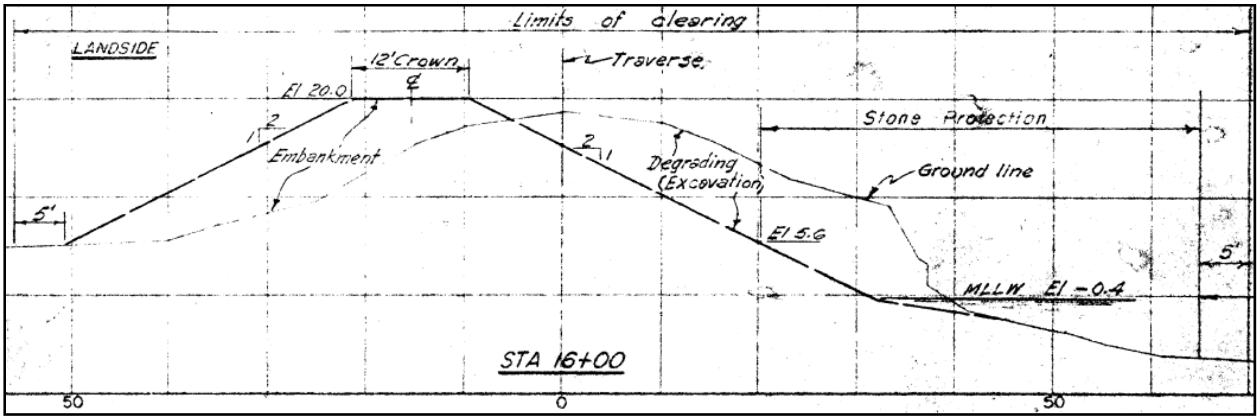


Figure 2-8: Lower San Joaquin River Typical Section, 5 March 1957

It should be noted that because of the construction history outlined above, the upper portion of the semi-pervious blanket beneath the center of the levee has been removed and commonly replaced with sand. Typically, the sand core extends to a greater depth beneath the center of the levee than beneath either of the flanks or the surrounding ground. Most of the levee material was hydraulically dredged from the Lower San Joaquin River and piled or pushed into place with no mechanical compaction. Some mechanical shaping of the upper and outer portions of the sand core likely occurred during establishment of the general levee geometry.

2.3.2 Past performance

The LSJRFS area has experienced several high-water events in recorded history. Journals and legends from Native Americans and explorers document flood events as far back as the 1800's. One of the larger events of record occurred in the winter of 1950 with another following in 1955, and the most recent notable flooding occurring in 1986 and 1997. Though these flood events were documented, past performance history of the individual study areas was not always documented and/or preserved for future use. The following past performance history was obtained from NULE and ULE data reports. It should be noted that during the development of the fragility curves, the past historical performance for each reach was incorporated as part of the judgment based probability used to develop the fragility curve for that reach, rather than focusing on a specific point of historical significance.

The RD-17 basin has experienced several large flood events. Data reports document interviews with local residents that state several floods occurred in the early 1900's before local farmers purchased their own dredging equipment in attempts to protect their land. Early records document significant seepage erosion, flood fighting, and a levee breach during the flood of December 1950. The failure, approximately 300 feet in length, occurred south of Dos Reis

Road. The levees were subjected to record levels again in the 1997 flood event. Emergency flood fighting was initiated when large amounts of seepage and boils were discovered along the landside of the levee. The waterside experienced undercutting, and erosion related to wave run-up. An intentional breach upstream in RD-2094 was made in an effort to halt backwater from outflanking the Dryland Levee and entering RD-17 and flooding significantly populated areas. Figures 2-9 and 2-10 documented landside seepage between River Mile (RM) 8.0 and 10.0 of the RD-17 levee along the east bank of the Lower San Joaquin River in 1997.

Figure 2-9: Areas of Seepage 1997, RD-17 (≈RM 8.5)

Figure 2-10: Seepage and Sack Rings 1997, RD-17 (≈RM 9.5)

Data reports document some historical performance issues of the levees along RD-404 from interviews of local residents. The most notable events of record for this area are the January 1997, February 1998, and the early 2006 flood events. The levees experienced landside seepage, boils, and waterside erosion.

Data documenting historical levee performance along the left bank of the Stockton Diverting Canal and Calaveras River are sparse; however, existing data reports document erosion along the left bank of the Stockton Diverting Canal between Waterloo Road and East Fremont Street. The South NULE report addresses the right bank of the Stockton Diverting Canal; the report lists five high-water events (1967, 1969, 1997, 1998, and 2006) for which there were no documented reports of seepage, instability, boils, breaches, or overtopping. Data reports document erosion along both the right and left banks of the Calaveras River between North El Dorado Street, and Brookside Road. Isolated areas of seepage were observed along the Calaveras River (areas were not specified) and did not require emergency flood fighting. A section of levee was reconstructed along the north bank of the Calaveras River (approximately 100 feet in length just south of Brookside School) due to settlement.

Data reports indicate the predominant performance issues for the Delta Brookside Study Area to be settlement, seepage, bank erosion, and rodent activity. Past levee raises, as a result of dredging the Deep Water Channel, induced settlement of the organic soil layers along Tenmile Slough. Areas of historic seepage were documented during the 1997 event and include areas along the San Joaquin River Deep Ship Channel, Buckley Cove, and the south and east banks for Fourteen Mile Slough.

Data reports indicate the predominant performance issues for the Delta Lincoln Village Study Area to be seepage and bank erosion. Bank erosion has steadily increased as boating activities have increased on Fourteen Mile Slough. Bank protection has been an ongoing maintenance activity mitigated with the installation of rip-rap bank protection. The extents of the existing bank protection are not known. Historic seepage has been documented along the southern portion of Lincoln Village along Fourteen Mile Slough (Station 136+70 and 154+10). The data report states that seepage mitigation in the form of cutoff walls were installed in the vicinity of these areas in 1999; however, no As-Builts were obtained to confirm the installation of these measures.

2.4 HYDRAULIC LOADING CONDITIONS

Water surface profiles for the LSJRFS area were obtained from developed cross-sections within existing P1GDR's, P1GER's, and SGDR's provided by the DWR, URS, and Kleinfelder. The cross-sections provided 200 year and sometimes 500 year flood frequencies.

During the preparation of this report, the hydraulic models for these areas were in the process of being revised and updated. Due to the detailed review process required of the hydraulic model update, the decision was made to use design water surface elevations developed in the earlier reports prepared by URS and Kleinfelder as stated in Section 2.1.

Tables 2-1, 2-2, and 2-3 below summarize the water surface elevations deterministically analyzed at each index point, by basin (i.e., South Stockton, Central Stockton, and North Stockton). Subsequent sections of this report provided more information regarding water surface elevations used for geotechnical analyses. Index points are further described in Section 3.3.4 of this report. All water surface elevations are in NAVD 88.

Table 2-1: South Stockton Basin Analyses Water Surface Elevations (RD-17)

Index Point	Event	Stage	Head
LR-1 RD-17 LSJR	Crest	25.0	15.7
	El.22.4	22.4	14.1
	200yr	19.8	12.6
	El.17.0	17.0	10.9

Index Point	Event	Stage	Head
LR-2 RD-17 LSJR	Crest	27.8	14.7
	El.24.6	24.6	14.3
	200yr	21.5	13.8
	El.17.0	17.0	13.0

Index Point	Event	Stage	Head
LR-3 RD-17 LSJR	Crest	31.0	29.9
	El.28.9	28.9	28.0
	200yr	26.9	26.1
	El.24.0	24.0	23.4

Index Point	Event	Stage	Head
LR-4 RD-17 LSJR	Crest	33.9	23.3
	200yr	31.3	22.4
	El.27.5	27.5	21.1
	El.23.7	23.7	19.9

Index Point	Event	Stage	Head
FL-1 RD-17 French Camp Slough	Crest	21.4	12.2
	El.18.6	18.6	11.5
	200yr	15.9	10.9
	El.13.0	13.0	10.3

Table 2-2: Central Stockton Basin Analyses Water Surface Elevations (RD-404, Stockton Diverting Canal, Left Bank of Calaveras River)

Index Point	Event	Stage	Head
FR-1 RD-404 French Camp Slough	Crest	21.8	5.7
	El.18.8	18.8	5.3
	200yr.	15.9	4.8
	El.12.9	12.9	4.3

Index Point	Event	Stage	Head
SL-1 Stockton Diverting Canal	Crest	39.2	30.5
	El.36.1	36.1	29.3
	El.33.1	33.1	28.0
	200yr.	30.2	26.7

Index Point	Event	Stage	Head
SL-2 Stockton Diverting Canal	Crest	44.6	39.5
	200yr	40.4	37.5
	El.38.8	38.8	36.7
	El.37.2	37.2	35.9

Index Point	Event	Stage	Head
CL-1/CL-2 Calaveras River	Crest	31.4	23.3
	El.29.4	29.4	22.9
	El.27.4	27.4	22.4
	200yr.	25.5	21.7

Index Point	Event	Stage	Head
D-5 Calaveras River	Crest	17.5	9.2
	200yr.	13.2	7.4
	El.10.0	10.0	6.1
	El.7.2	7.2	4.9

Table 2-3: North Stockton Basin Analyses Water Surface Elevations (Right Bank of Calaveras River, Delta Brookside Community and Delta Lincoln Village)

Index Point	Event	Stage	Head
CR-1/CR-2 Calaveras River	Crest	29.7	25.2
	El.28.2	28.2	24.8
	200yr	26.9	24.2
	El.25.3	25.3	23.1

Index Point	Event	Stage	Head
D-4 Calaveras River	Crest	18.8	12.3
	El.16.5	16.5	11.1
	200yr.	14.2	9.9
	El.11.8	11.8	8.6

Index Point	Event	Stage	Head
D-BS Delta Brookside Community	Crest	18.0	3.3
	El.14.0	14.0	2.0
	El.10.0	10.0	0.7
	El.6.0	6.0	0.6

Index Point	Event	Stage	Head
D-LV Delta Lincoln Village	Crest	13.2	3.2
	El.11.0	11.0	2.8
	El.8.5	8.5	2.4
	El.6.0	6.0	2.0

3. WITHOUT PROJECT CONDITIONS

Levee construction and remediation has occurred within the study area since the middle of the 19th century. While the modern levee systems were constructed in the early 20th century and remediated in the 1940's through 1950's, the vast majority of the construction and remediation consisted of crest widening and slope flattening. Beginning in the early 1990s and continuing through present day, some internal improvements have been, and continue to be constructed in the form of cutoff walls and other improvements consisting of seepage and/or stability berms. The without project conditions documented by the sources listed in Section 2.1 are given below.

3.1 POTENTIAL FAILURE MODES

For the purposes of problem identification and alternatives analysis, several different failure modes have been evaluated for the without-project condition. The failure modes included: erosion, overtopping, seepage (under and through), slope stability, and seismic.

3.1.1 Overtopping

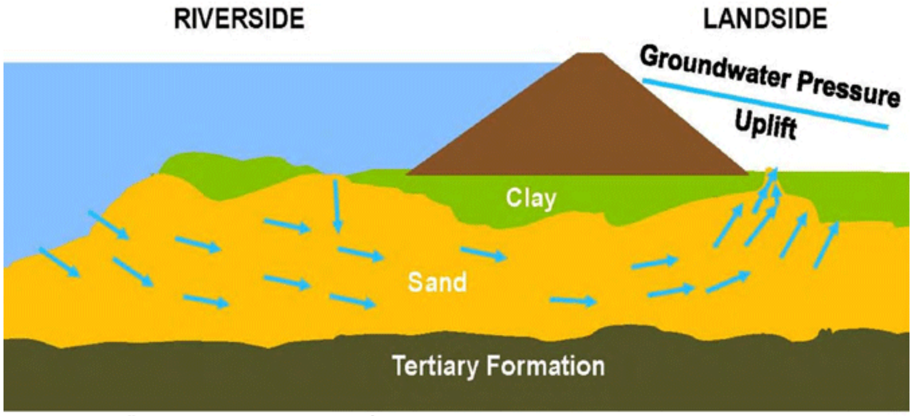
Overtopping occurs when the water surface elevation is greater than the elevation of the levee crest. In this case, water will flow over the crest and onto the landside of the levee. As the levee is overtopped, the action of the water flowing down the landside levee slope and into the basin may cause backside erosion of the landside levee slope and levee toe. This backside erosion may lead to sloughing of the levee and/or a breach condition. For the LSJRFS, the assumption is made that if a levee overtops it fails.

3.1.2 Erosion

Erosion is the wearing away of the riverbank and/or waterside levee slope due to high flows. Erosion can also cause the degradation of the channel invert (scour) causing slope instability. Erosion can occur on the landside of the levee due to overtopping. Erosion occurs when the velocity of the river generates an effective hydraulic shear stress greater than the critical shear stress of the soil over which it flows. As the critical shear stress of the soil is exceeded, soil-particle movement begins. Loosely compacted cohesionless soils are more susceptible to erosion; whereas, cohesive engineered fill is less susceptible. The LSJRFS did not perform explicit analyses for this potential failure mode; erosion was captured as a judgment based curve as part of the performance curves based on historical information and Periodic Inspection (PI) reports.

3.1.3 Seepage

Seepage is subdivided into two categories: seepage through the levee embankment (through-seepage) and seepage beneath the levee embankment through foundation layers (underseepage). Through-seepage occurs when water from the river passes through a pervious levee and weakens the interior of the existing levee causing internal erosion that leads to slope instability or movement of embankment material. Concentrated underseepage that carries silt and sand up to the surface through a more or less open channel in the top stratum (usually of clays and/or silts) is known as a sand boil. Active erosion of sand or other soils from under a levee or top stratum, as a result of substratum pressure and concentration of seepage in localized channels, is known as piping. If the hydrostatic pressure in the pervious substratum landward of a levee becomes greater than the submerged weight of the top stratum, the excess pressure will cause heaving of the top stratum or a rupture at one or more weak spots. This results in a concentration of seepage flow that may cause sand boils and/or underground piping as shown in Figure 3-1.



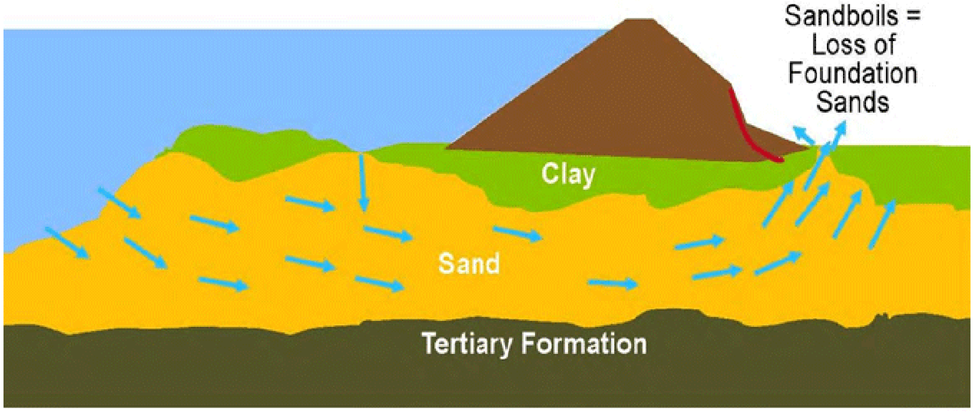
Source: Cory Williams, P.E. – U.S. Army Corps of Engineers

Figure 3-1: Underseepage Distress

3.1.4 Slope Stability

Hydraulic loading of the levee during a flood event reduces the strength of the levee embankment materials causing instability in the embankment slope. Additionally, uplift pressures caused by an excess in pore water pressure at the landside levee toe can lead to the movement of embankment material within the levee due to seepage causing levee instability, as shown in Figure 3-2.

Levee instability can occur on both the waterside and landside of the embankment. Slope stability of the landside slope is typically analyzed, and in instances where the waterside slope is somewhat steep, waterside slope stability may be analyzed as well. Cases will also exist where a rapid drawdown condition occurs. Rapid drawdown conditions arise when a submerged slope experiences a sudden reduction in water level. This change in water surface elevation causes a change in pore water pressure within the embankment. The excess pore water pressure contained in the embankment may lead to a waterside slope stability failure. Even though waterside slope stability and rapid drawdown are potential failure modes, they typically have limited affect on feasibility level designs and are therefore considered design-level analysis.



Source: Cory Williams, P.E. – U.S. Army Corps of Engineers

Figure 3-2: Underseepage Induced Slope Instability Distress

3.1.5 Seismic

Levees can fail as result of a seismic load which may cause degradation due to liquefaction. Liquefaction can lead to detrimental consequences such as loss of freeboard due to embankment instability, transverse crack-induced piping, and loss of freeboard due to settlement. Evaluations are typically completed to determine the liquefaction resistance of soils; this is known as liquefaction triggering. Other seismically induced failure modes include lateral spreading, which can cause vertical displacement of the levee leading to loss of freeboard and levee stability. The seismic analyses performed for this study focuses on liquefaction and vertical displacement as potential seismic failure modes; this analysis is included as Enclosure 4.

3.1.6 Other Minor Failure Modes

Other failure modes not explicitly analyzed for the deterministic analysis, are considered in the judgment portion of the probabilistic levee fragility curves. A summary of each mode is presented below, and additional information is located in 3.5.4.

- **Vegetation**: The presence of vegetation can effect performance based on the density of the growth, proximity to the embankment, and type of vegetation. The root systems can shorten seepage paths in the embankment, or can extend through an impervious land- or water-side blanket to shorten seepage paths. Factors that increase risk of failure for this mode include: evidence of past performance problems at areas with significant vegetation, presence of root systems capable of penetrating impervious material, locations where floodwater is known to persist for long periods of time, and improperly removed trees.
- **Animal Burrows**: The presence of burrowing animals can contribute to seepage failure by creating voids and pipes in the embankment, shortening seepage paths leading to piping of material. Factors that increase risk of failure include: locations with a high density of animal burrows, large animal burrows, multiple holes or dens in close vicinity (particularly on both sides of the embankment at the same location along the levee), situations with impervious materials in the embankment over coarse-grained foundations, holes low in the levee, and

locations where floodwater is known to persist for long periods of time.

- **<u>Encroachments</u>**: Encroachments include structural features within the levee easement that affect the performance of the levee, or contribute to masking levee performance. These consist of canals, pump stations, roads, buildings or other structures. In the case of canals or other excavations, these features can penetrate the impervious blanket, shortening the seepage path, or concentrate seepage at a point or line. For the cases of roads or buildings, these features and their appurtenant structures may hide problems because they render critical areas inaccessible to required period inspections, or flood monitoring.
- **<u>Utilities</u>**: Utility pipes and other conduits are frequently associated with seepage and piping problems. These may be due to improper design of closure structures, improper backfill around the utility, or by failure of the utility itself by improper operation, lack of maintenance, or exceedance of service life. The risk of failure for utilities increases with age since construction. The lack of documentation of these listed items often increases uncertainty about the condition of the utility. These problems are aggravated because typically local sponsors do not have funding, equipment or expertize in evaluation of utilities. The risk of failure for this mode is increased where the assessment has identified these indicators.
- **<u>Erosion</u>**: Erosion is typically evaluated with the hydraulic and geotechnical engineers coordinating an assessment jointly. Risk factors that increase erosion risk include: past history of erosion problems, expected high channel velocities and scour-critical areas.

3.2 GEOTECHNICAL REACH DESCRIPTION

The following subsections describe the conditions that comprise, and were used to distinguish, reaches for this study that are represented by the Index Points. Table 3.1 summarizes the reach of levee represented by each Index Point.

Table 3-1: LSJRFS Area Levees

Basin	Reaches	Channel	Maintaining Agency	Length (mi)
South Stockton	LR-1	Lower San Joaquin River	RD-17	6.4
	LR-2			3.8
	LR-3			1.5
	LR-4			1.5
	FL-1	French Camp Slough		1.9
Central Stockton	FR-1	French Camp Slough	RD-404	2.1
	SL-1	Stockton Diverting Canal	SJAFCA	2.2
	SL-2		SJAFCA	2.9
	CL-1/CL-2	Calaveras River (left bank)	SJAFCA	2.9
	D-5		RD-1614	3.1
North Stockton	CR-1/CR-2	Calaveras River (right bank)	SJAFCA	2.9
	D-4		RD-2074	3.2
	D-BS	LSJR/Tenmile Slough/Fourteen Mile Slough	RD-2074	3.7
	D-LV	Fourteen Mile Slough	RD-2119	2.0

3.2.1 RD-17 Basin

The RD-17 levees, including the east bank of the Lower San Joaquin River and the left bank of French Camp Slough, extend for approximately 15 miles. The levee crest height ranges from 8 to 16 feet above the landside levee toe. The crest width varies from 12 to 20 feet. The landside and waterside slopes are predominantly 2H:1V or flatter (H:V, Horizontal: Vertical); however, there are areas throughout the system with slopes steeper than 2H:1V. The RD-17 levee system resides in both a high density housing urban area and rural agricultural area. In the northern area, there is significant waterside vegetation (mostly large trees and riparian habitat) that thins out to sparse waterside vegetation heading south along the embankment. In some areas, landside vegetation (mostly trees) exists near the levee toe or on the levee slopes. On the landside, numerous encroachments include: fences at or near the landside levee toe, out buildings, residences, parks, pump stations, agricultural land, power poles, road crossings, Highway/Freeway I-5, and 120, railroad crossings, ditches, treatment plants, and water bodies.

- At index point location FL-1 the levee embankment is predominantly sandy lean clay with a lean clay to sandy lean clay blanket underlain by an aquifer composed of silty sand. Geomorphology in this area shows stringers of Historical channel deposits.
- At index point location LR-1 the levee embankment varies from lean clay to silt with a lean clay blanket underlain by an aquifer composed of poorly graded sand with silt to silty sand. Geomorphology in this area shows stringers of Historical channel deposits.
- At index point location LR-2 the levee embankment varies from poorly graded sand with silt to clayey sand with a thin lean clay to silty sand blanket underlain by an aquifer composed of poorly graded sand with silt. Geomorphology in this area shows significant areas of overbank and basin deposits.
- At index point location LR-3 the levee embankment varies from lean clay to silty sand with a silty sand blanket underlain by an aquifer composed of poorly graded sand with silt to silty sand. Geomorphology in this area shows significant areas of Holocene and Historical alluvial fan deposits.
- At index point location LR-4 the levee embankment is predominantly clayey sand with a lean clay to sandy lean clay blanket underlain by an aquifer composed of poorly graded sand with silt. Geomorphology in this area shows significant areas of Holocene alluvial fan deposits.

3.2.2 RD-404

The RD-404 levee along the right bank of French Camp Slough extends for approximately 2 miles. The levee crest height ranges from 10 to 13 feet above the landside levee toe. The crest width varies from 15 to 25 feet. The landside slopes are predominantly 2H:1V or flatter. The waterside slopes are predominantly steeper than 2H:1V. There is vegetation along both the landside and waterside of the levee embankment; mostly shrubs, small trees, and riparian habitat along the waterside, and large trees along the landside levee toe and slopes. On the landside, there are some encroachments due to outbuildings, power poles, water bodies, and parking areas related to Van Buskirk Park Golf Course, as well as the I-5 Highway.

- At index point location FR-1 the levee embankment is predominantly lean clay and silt with a thin clayey sand blanket underlain by an aquifer composed of silty sand. Geomorphology in this area shows predominantly marsh deposits with stringers of Historical channel deposits.

3.2.3 Stockton Diverting Canal

The levee along the left bank of the Stockton Diverting Canal extends for approximately 5 miles. The levee crest height ranges from 10 to 16 feet above the landside levee toe. The crest width varies from 14 to 25 feet. The landside and waterside slopes are predominantly 2H:1V; however, there are areas throughout the system with slopes steeper than 2H:1V. A waterside bench, approximately 20 feet wide, is present. The levee system resides in both a high density housing urban area and an industrial area. Areas of landside vegetation are present in the urban area. In some areas, landside vegetation (mostly trees) exists near the levee toe or on the levee slope. Waterside vegetation consists of sparse grasses and shrubs. On the landside, numerous encroachments include: fences at or near the landside levee toe, out buildings, residences, railroad tracks/rail yard, pump stations, power poles, road crossings, railroad crossings, industrial areas, parking and storage areas, and Highway/Freeway 99, 88, and 26.

- At index point location SL-1 the levee embankment is predominantly sandy lean clay with a thin lean clay blanket underlain by an aquifer composed of silty sand. Geomorphology in this area shows stringers of Historical and Holocene channel deposits.
- At index point location SL-2 the levee embankment is predominantly sandy silt with a lean clay blanket underlain by an aquifer composed of silty sand. Geomorphology in this area shows stringers of Holocene overbank and channel deposits.

3.2.4 Calaveras River South Bank

The levee along the left (south) bank of the Calaveras River extends for approximately 6 miles. The levee crest height ranges from 8 to 14 feet above the landside levee toe. The crest width is predominantly 12 feet that widens towards road crossings. The landside and waterside slopes are predominantly 2H:1V or flatter; however, there are areas throughout the southern alignment with slopes steeper than 2H:1V, and an area along the waterside that is roughly 1H:1V. A waterside bench from 10 to 20 feet wide is present throughout the southern alignment. The levee system resides in various settings. Urban area high density housing is present throughout most of the alignment; however, agricultural land, industrial areas, educational areas, and recreational areas are also present. Landside vegetation (mostly trees) is present in the urban, agricultural, educational, and recreational areas. In some areas, landside vegetation exists near the levee toe, on the levee slope, or on the crest of the levee. Waterside vegetation consists of sparse grasses, shrubs, and a few trees along the toe and slopes in the eastern portion of the alignment; more dense waterside vegetation (mostly trees) is present west of University of the Pacific to the confluence of the LSJR. On the landside, numerous encroachments include: fences at or near the landside levee toe, out buildings, residences, stairs on slopes, railroad crossings, pump stations, road crossings, power poles, industrial areas, parking lots, Highway I-5, recreational facilities including Stockton Golf and Country Club; waterside encroachments include: stairs on slopes, boat docks, and recreational facilities including Stockton Yacht Club.

- At index point location CL-1/CL-2 the levee embankment is predominantly sandy silt with an elastic silt blanket underlain by a deeper aquifer composed of poorly graded sand with silt. Geomorphology in this area shows stringers of Historical and Holocene channel deposits.
- At index point location D-5 the levee embankment is predominantly silt with a lean clay blanket underlain by an aquifer composed of silty sand. Geomorphology in this area shows an abundance of peat, mud, and organic material with stringers of Holocene overbank and channel deposits.

3.2.5 Calaveras River North Bank

The levee along the right (north) bank of the Calaveras River extends for approximately 6 miles. The levee crest height ranges from 6 to 12 feet above the landside levee toe. The crest width varies from 12 to 15 feet and widens towards road crossings. The waterside slopes are predominantly 2H:1V or flatter; however, there are a few areas throughout the northern alignment with slopes steeper than 2H:1V; and an area along the waterside that is roughly 1H:1V. The landside slopes are predominantly 2H:1V or steeper throughout the northern alignment. A waterside bench 30 to 50 feet wide is present throughout the northern alignment. The levee system resides predominantly in an urban area with high density housing, churches, and several schools. Landside vegetation (mostly trees) is present in the urban and educational areas. In some areas, landside vegetation exists near the levee toe, on the levee slope, or on the crest of the levee. Waterside vegetation consists of sparse grasses, shrubs, and a few trees along the toe and slopes in the eastern portion of the alignment; more dense waterside vegetation (mostly trees) is present west of Stagg High School to the confluence of the LSJR. On the landside, numerous encroachments include: fences at or near the landside levee toe, fences on slopes, out buildings, residences, swimming pools, stairs on slopes, railroad crossings, pump stations, power poles, road crossings, parking lots, and Highway I-5; waterside encroachments include stairs on slopes, and boat docks.

- At index point location CR-1/CR-2 the levee embankment is predominantly sandy lean clay with a thin blanket of sandy lean clay underlain by an aquifer composed of sandy silt. Geomorphology in this area shows an abundance of alluvial deposits with stringers of Holocene channel deposits.
- At index point location D-4 the levee embankment varies from sandy silt to sandy lean clay with a thin blanket of sandy fat clay and sandy silt underlain by an aquifer composed of poorly graded sand with silt. Geomorphology in this area shows stringers of Holocene overbank and channel deposits.

3.2.6 Delta Brookside Study Area

The Delta Brookside Study Area levee extends approximately 3.5 miles along the west and north of the Brookside community, an urban high density housing development. The levees reside along the Stockton Deep Water Channel of the LSJR, Buckley Cove, Tenmile Slough, and Fourteen Mile Slough. Along the Deep Water Channel, the levee crest height ranges from 6 to 12 feet above the landside levee toe. The crest width varies from 12 to 16 feet and widens towards Buckley Cove. The landside and waterside slopes are predominantly 2H:1V or flatter;

however, there are a few areas along the waterside with slopes steeper than 2H:1V. Along Buckley Cove, the levee crest height ranges from 8 to 18 feet above the landside levee toe. The crest width varies from 14 to 20 feet. The landside and waterside slopes are predominantly 2H:1V or flatter. Along Tenmile Slough, the levee crest height ranges from 16 to 20 feet above the landside levee toe. The crest width varies from 14 to 18 feet. The landside and waterside slopes are predominantly 2H:1V or flatter. Along Fourteen Mile Slough, the levee crest height ranges from 8 to 14 feet above the landside levee toe. The crest width varies from 18 to 40 feet. The landside and waterside slopes are predominantly 2H:1V or flatter. Landside vegetation (mostly trees) is present throughout the highly urbanized area at most residences, and in most cases near the levee toe. Waterside vegetation consists of a few trees at the toe within the Deep Water Channel, grasses, shrubs, and trees along Buckley Cove, shrubs and brush along Tenmile Slough, and a few trees along Fourteen Mile Slough. On the landside, numerous encroachments include: fences at or near the landside levee toe, fences on slopes, decks and/or retaining walls on slopes and crest, out buildings, residences, swimming pools, stairs on slopes, and pump stations; waterside encroachments include: stairs on slopes, concrete patios/decks, boat docks, road crossings, and Highway I-5.

- At index point location D-BS the levee embankment is predominantly lean clay with portions of an older levee constructed of organic clay. The thin blanket varies from organic clay to lean clay underlain by an aquifer composed of silty sand. Geomorphology in this area shows an abundance of peat, mud, and organic material with stringers of Holocene channel deposits and overbank deposits.

3.2.7 Delta Lincoln Village Study Area

The Delta Lincoln Village Study Area levee extends approximately 2.5 miles along the west and south of the Lincoln Village community on Fourteen Mile Slough, an urban high density housing development. The levee crest height ranges from 6 to 12 feet above the landside levee toe. The crest width varies from 12 to 14 feet and widens towards road crossings. The waterside slopes are predominantly 2H:1V or flatter; however, there are a few areas near Station 200+00 with slopes steeper than 2H:1V; and two areas roughly 1H:1V. The landside slopes are predominantly 2H:1V or flatter throughout the alignment. Landside vegetation (mostly trees) is present throughout the highly urbanized area at most residences, and in most cases near the levee toe. Waterside vegetation (mostly trees) begins moving south along the alignment just before Village West Yacht Club; the waterside vegetation (mostly trees) becomes denser heading south then east along Fourteen Mile Slough. On the landside, numerous encroachments include: fences at or near the landside levee toe, fences on slopes, fences on crest, decks and/or retaining walls on slopes and crest, out buildings, residences, power poles, swimming pools, stairs on slopes, and pump stations; waterside encroachments include: stairs on slopes, concrete patios/decks, boat docks, Village West Yacht Club, road crossings, and Highway I-5.

- At index point location D-LV the levee embankment is predominantly lean clay with a thin blanket of lean clay underlain by a deep aquifer was comprised of silty sand to poorly graded sand with silt. Geomorphology in this area shows an abundance of peat, mud, and organic material with stringers of Holocene channel deposits, overbank deposits, and marsh deposits.

Subsequent to completion of this study, an alternative alignment was presented on the west side of Fourteen Mile Slough to minimize real estate impacts to the densely populated Lincoln Village community. This alignment extends approximately 2.0 miles and includes a new levee, improvements to existing levees, and a closure structure. Index point D-LV was utilized for site characterization.

3.3 SEEPAGE AND STABILITY METHODOLOGY

Deterministic seepage and stability analyses were performed for various water surface elevations, including top of levee. The probabilistic analyses were performed for a range of stages not correlated to flood frequency, but which represented stages from no head (landside toe of levee) to maximum head (top of levee). Refer to Section 2.4 for water surface elevations used at each Index Point for seepage and stability analyses.

3.3.1 Steady State Seepage Analysis

Deterministic steady state seepage analysis was performed using SEEP2D within GMS 6.5 (Groundwater Modeling System), a finite element program. Results from the seepage analysis were used to calculate average vertical exit gradients at the landside levee toe and/or at a more critical location near the levee toe if applicable; for example, at the invert of the empty drainage ditch. The pore pressures and/or phreatic surfaces were exported to UTEXAS4 for use in slope stability analysis.

Boundary conditions along the waterside ground surface from the waterside model extents to the levee slope were assigned as fixed total head conditions corresponding to the analyzed water elevation. On the landside, exit face boundary conditions are applied from the crest hinge point to landside extents of the model. All other boundaries not explicitly assigned a condition are assumed by the program to be no flow; this includes both vertical faces of the model and the bottom nodes. The landside model extents were extended 2,000 feet from the levee centerline and to the end of available topographic information on the waterside. Figure 3-3 shows a typical GMS SEEP2D seepage model.

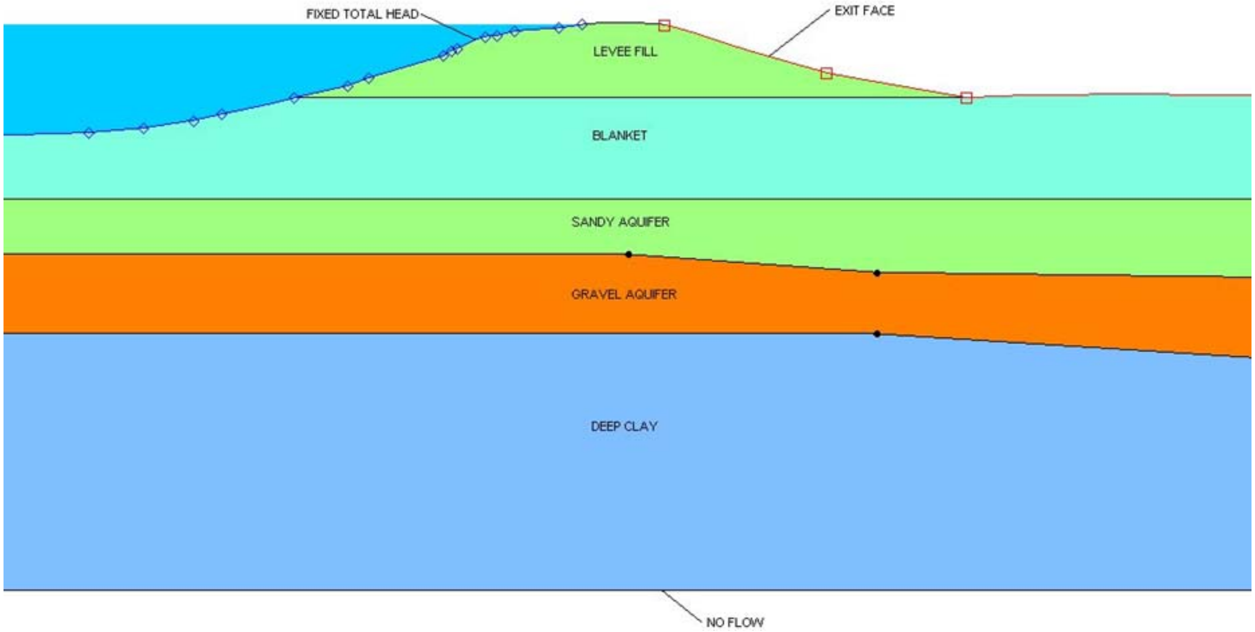


Figure 3-3: Typical GMS SEEP2D Seepage Analysis Model

Levees constructed of fine grained clays having stability berms with drainage layers that capture any seepage through the levee, or having cutoff walls constructed through the levee embankment, are unlikely to be susceptible to through-seepage caused internal erosion. Levees of silt, silty sand, and/or sand were considered to be susceptible to internal erosion caused by through-seepage and were considered as deficient from a through-seepage perspective.

3.3.2 Steady State Slope Stability Analysis

Embankment stability against shear failure was analyzed using the UTEXAS4 software package for steady state conditions. Analyses to find factors of safety against sliding were conducted using a floating grid automatic circular failure surface search routine to identify the critical failure surfaces with the Spencer Procedure within the embankment and/or foundation. The Spencer Procedure satisfies both force and moment equilibrium for each slice. A minimum weight restriction was applied to the slices within the failure surface to eliminate surficial failure surfaces. Where tensile stresses exist on the failure surface, a crack depth was introduced to eliminate the tensile stresses, but not compressive stresses. The appropriate depth for a crack is the one producing the minimum factor of safety (FOS), which corresponds to the depth where tensile, but no compressive stresses are eliminated. If a crack was required, the maximum crack depth was set to producing the lowest FOS; typically, two to four feet. Figure 3-4 shows a typical UTEXAS4 model.

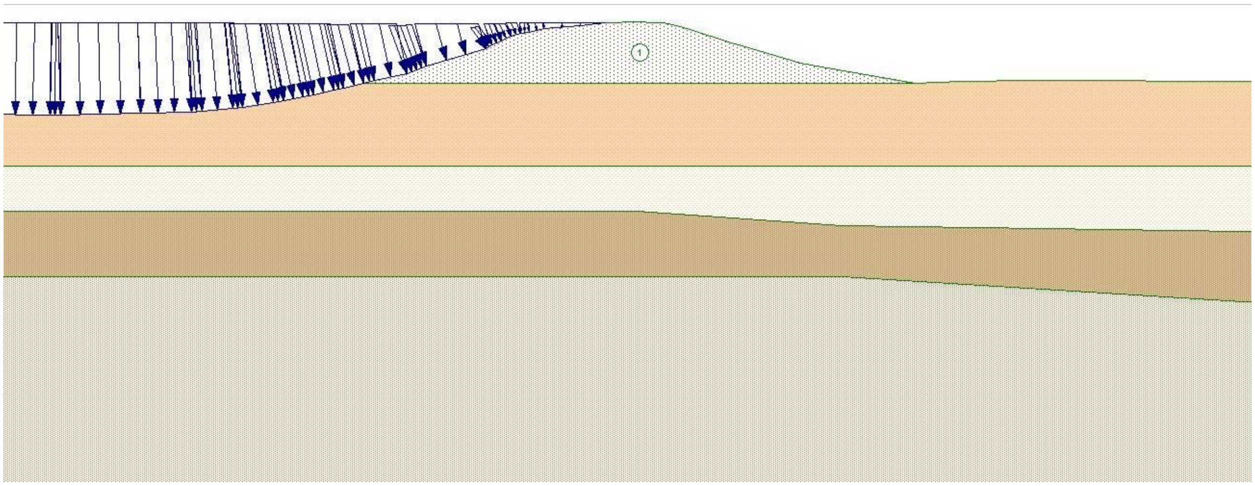


Figure 3-4: Typical UTEXAS4 Slope Stability Analysis Model

The long term evaluation was considered with steady state seepage and is based on the assumption of a fully developed phreatic surface through the embankment. Saturated unit weights are used in the embankment and the pore water pressure is imported from SEEP2D. External water pressures from the channel are applied as a distributed load against the landside slope. Effective shear strength parameters c' and Φ' were used for all materials.

3.3.3 Material Properties

In order to develop geotechnical products for the LSJRFS area in a timely manner, the PDT and Sponsors agreed to use existing subsurface information (i.e., Geotechnical Data Reports (GDR) and Geotechnical Engineering Reports (GER)) developed by both URS and Kleinfelder for DWR. Cross sections, material properties, including hydraulic conductivity for seepage analysis and drained (effective) shear strength and unit weight for slope stability analysis, were obtained from existing P1GER's provided by DWR, URS, and Kleinfelder. The stratigraphy of the existing levee cross-sections were divided into unique layers typically consisting of levee embankment fill, a foundation or blanket layer, pervious aquifer layers separated by an aquitard, and a deeper fine grained layer.

The hydraulic conductivities developed in the earlier GER's were reevaluated and assigned based on soil classification and fines content using typical values developed and evolved from soil index property and hydraulic conductivity testing on samples gathered from numerous subsurface investigations coupled with limited in-situ testing and engineering judgment performed by USACE, DWR, URS, Kleinfelder, and others on similar levees and in similar geologic conditions to this project. These typical values have been adopted for this project and are presented in Table 3-2 below.

Many soil deposits have a different horizontal hydraulic conductivity than vertical hydraulic conductivity. The ratio of horizontal hydraulic conductivity divided by vertical hydraulic conductivity is referred to as anisotropy ratio (k_H/k_V). Anisotropy between horizontal and vertical conductivities is influenced by a number of factors including a variation in material properties within a modeled layer (inter-bedded lenses of sand in a silt or clay layer), cracks within the layer, etc. The analyses were performed using a soil anisotropy ratio of 4 for sands, clays and silty material; some gravels were given an anisotropy ratio of 10 based on decreased fines content.

Table 3-2: Hydraulic Conductivities

Material Type	Soil Description	Hydraulic Conductivity				
		k_H (cm/sec)	k_H (ft/day)	k_H/k_V	k_V (cm/sec)	k_V (ft/day)
Clay	Engineered Embankment	1.0E-06	0.0028	4	2.5E-07	0.0007
	Non-Engineered Embankment	1.0E-05	0.028	4	2.5E-06	0.0071
	Blanket ≥10ft Thick	1.0E-05	0.028	4	2.5E-06	0.0071
	Blanket 5ft<>10ft Thick	1.0E-05	0.028	4	2.5E-06	0.0071
	Blanket ≤5ft Thick	1.0E-05	0.028	4	2.5E-06	0.0071
Silt	Elastic (plastic)	5.0E-05	0.142	4	1.3E-05	0.035
	Non-plastic	2.0E-04	0.57	4	5.0E-05	0.14
Clayey Sand to Sand	30-49% fines	5.0E-05	0.14	4	1.3E-05	0.035
	13-29% fines	1.0E-04	0.28	4	2.5E-05	0.071
	8-12% fines	1.0E-03	2.8	4	2.5E-04	0.71
	0-7% fines	5.0E-03	14	4	1.3E-03	3.5
Silty Sand to Sand	30-49% fines	5.0E-04	1.4	4	1.3E-04	0.35
	13-29% fines	1.0E-03	2.8	4	2.5E-04	0.71
	8-12% fines	5.0E-03	14	4	1.3E-03	3.5
	0-7% fines	1.0E-02	28	4	2.5E-03	7.1
Gravel	28-49% fines	4.0E-04	1.1	4	1.0E-04	0.28
	18-27% fines	1.0E-03	2.8	4	2.5E-04	0.71
	13-17% fines	6.0E-03	17	4	1.5E-03	4.3
	8-12% fines	1.2E-02	34	4	3.0E-03	8.5
	0-7% fines	2.5E-02	71	4	6.3E-03	17.7
Gravel with Cobbles and Sand	28-49%fines	4.0E-04	1.1	4	1.0E-04	0.28
	18-27% fines	1.0E-03	2.8	4	2.5E-04	0.71
	13-17% fines	1.0E-02	28	10	1.0E-03	2.8
	8-12% fines	1.0E-01	283	10	1.0E-02	28
	0-7% fines	2.0E-01	567	10	2.0E-02	57

The resistance to penetration of the soils measured in blows per foot (field N-value) during the driving of Standard Penetration Test (SPT) samplers and Cone Penetrometer Test (CPT) tip resistance served as a site specific data source for the determination and verification of shear strength parameters for granular, cohesionless soils through empirical correlations. Empirical correlations with SPT N-values by Uchida (1996) and Peck (1974) were used for the estimation of the drained (effective stress) angle of internal friction Φ'. For cohesive soils (including clays and plastic silts), the empirical correlations by Mitchell (1976) and Bowles (1996) were used for estimation of Φ' using the Plasticity Index (PI) of the soil.

For both cohesive and cohesionless materials, shear strengths predicted by correlations were compared to typical published values and values used in previous analysis in similar materials, and then adjusted based on engineering judgment. Typical shear strengths by material classification used in steady state slope stability analysis are shown in Table 3-3.

Table 3-3: Shear Strength of Soils

Material Type	Soil Description	Shear Strength		
		c' (psf)	Φ' (^{o})	γ(pcf)
Cutoff Wall	SB	50	0	85
	SCB	500		
	CB	5000		
Clay	Clay Foundation	50-100	20-30	115
	Clay Engineered Embankment	50-200	28-30	115
	Clay Non-engineered Embankment	50-100	22-26	115
Silt		0	28-32	120
Clayey Sand and Silty Sand		0	28-33	125
Sand		0	30-35	130
Gravel and Drain Rock		0	35-40	135

3.3.4 Representative Cross Sections

Typically, cross-sections for geotechnical analysis are selected to represent critical surface and subsurface conditions of each reach. The topography of each reach is inherently variable. The existence of access ramps on both the landside and waterside of the levee, roadways and railroads running perpendicular and parallel to the levee, and/or pump stations or other structures built up adjacent to the levee section create difficulties to discern the typical versus critical cross-section.

For the LSJRFS area, the sections were selected based on subsurface data, laboratory test results, geomorphology, surface conditions, field reconnaissance, historical performance, and levee geometry. The ground surface elevations used in the cross-sections were based on the LiDAR and bathymetric surveys performed by URS, Kleinfelder, and Fugro for DWR from 2007 and 2008. The natural soil layers were delineated based on boring logs and laboratory test results. Typically one cross section per reach was selected for analysis and referred to as an index point.

In some cases, multiple cross sections were analyzed in each reach to verify the initial location. Table 3-4 and Figure 3-5 present the location of the cross-sections representing the LSJRFS index points. A total of fourteen (14) cross-sections were analyzed, 4 cross-sections were analyzed in the RD-17 Basin along the east bank of the LSJR, 2 cross-sections were analyzed in the French Camp Slough area (one section in the northern portion of RD-17, one section in the southern portion of RD-404); 2 cross-sections were analyzed along the west bank of the SDC; 4 cross-sections were analyzed along the Calaveras River (two sections along the right bank, two section along the left bank); and 2 cross-sections were analyzed in the Delta Front area (one section in the Brookside area, one section in the Lincoln Village area).

Table 3-4: Index Point Locations ([1]200-yr. WSE not given)

Index Point	Station	State Plane (ft) Northing	State Plane (ft) Easting	Crest Elev. (ft)	≈200-yr DWSE (ft) NAVD88	River
CL1/CL2	6757+00	2185288	6336628	31.4	25.5	Calaveras River
CR1/CR2	3306+00	2185583	6337043	29.7	26.9	Calaveras River
D4	3092+00	2180295	6319366	18.8	14.2	Calaveras River
D5	6535+00	2178738	6317908	17.5	13.2	Calaveras River
SL1	846+68	2183207	6340943	39.2	30.2	Diverting Canal
SL2	976+00	2176913	6352470	44.6	40.4	Diverting Canal
FR1	1164+20	2158156	6329042	21.8	15.9	French Camp Slough
FL1	1049+00	2156653	6329984	21.4	15.9	French Camp Slough
LR1	1292+00	2139808	6322846	25.0	19.8	San Joaquin River
LR2	1417+00	2131643	6324275	27.8	21.5	San Joaquin River
LR3	1685+00	2116984	6326321	31.0	26.9	San Joaquin River
LR4	1815+00	2105994	6330785	33.9	31.3	San Joaquin River
D-LV	162+50	2185939	6315555	13.6	11.0[1]	14-Mile Slough
D-BS	166+50	2183200	6311320	18.2	10.0[1]	LSJ/14-Mile Slough

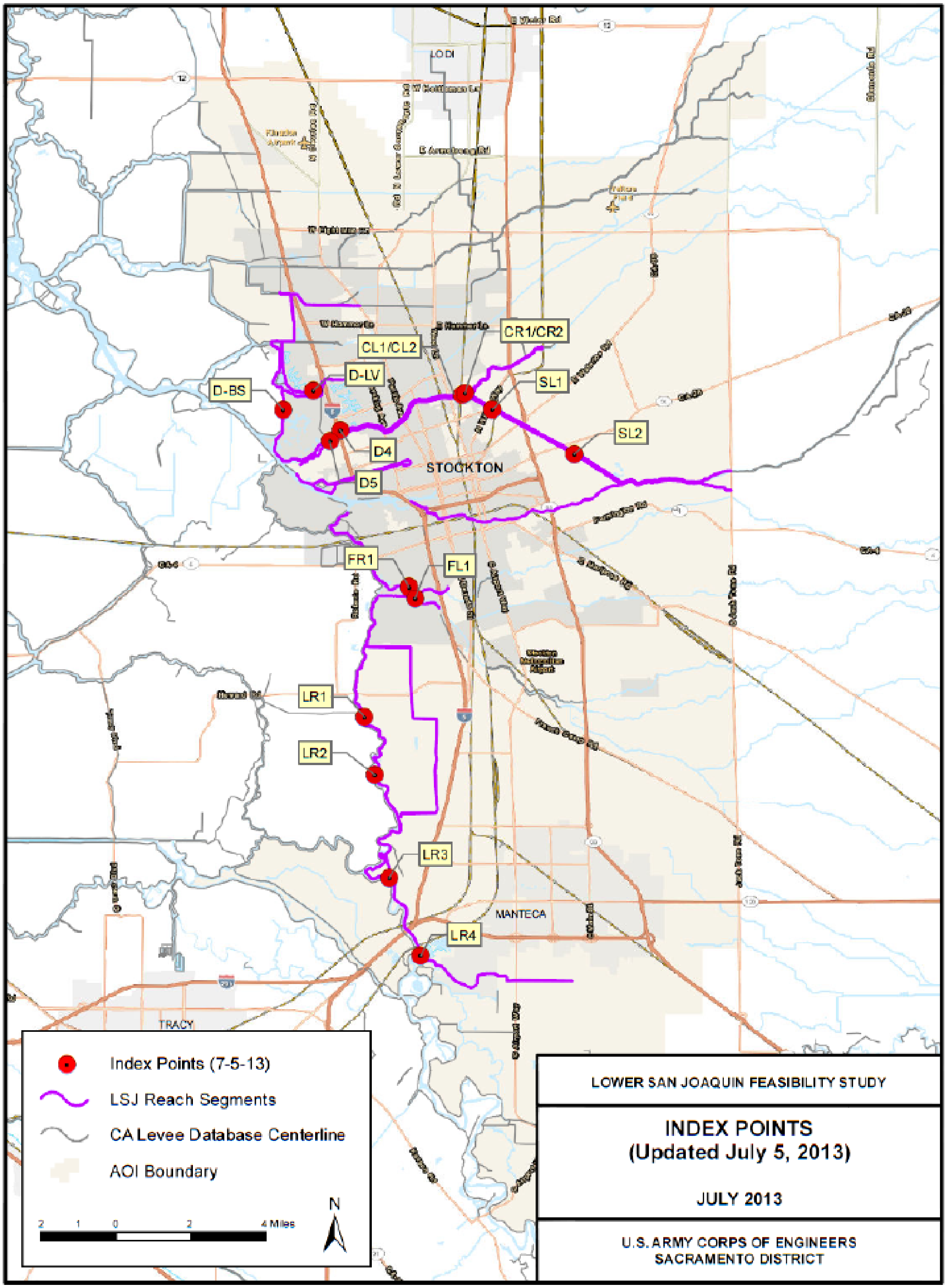


Figure 3-5: LSJRFS Index Point Location Map

3.4 SEEPAGE AND STABILITY ANALYSIS RESULTS

The following section presents the results of geotechnical steady state seepage and slope stability analyses performed in accordance with the methodology described in Section 3.3. The analyses cross-sections were evaluated in accordance with design criteria described in Section 4.3.2 for various water surface elevations, including top of levee, as indicated in Section 2.4. The analyses for each location were performed for the without-project condition as described in Section 3.3.

Enclosure 2 contains a tabulation of the analyses results including: the hydraulic conductivities and material strength parameters assigned for each cross-section used in analysis; seepage gradients and slope stability factors of safety for various WSE; plates of cross-section geometry, stratigraphy, total head contours (seepage analysis), and failure surfaces (slope stability analysis) for a crest water surface elevation are included.

The following subsections present the analyses results for without project conditions at each of the cross-section locations. Figures presented for each cross-section display underseepage average vertical exit gradient calculated at the landside levee toe and slope stability FOS for the analyzed water surface elevations.

3.4.1 South Stockton – Lower San Joaquin River East Bank RD-17

The without-project conditions analyses for south Stockton includes five (5) index points; four (4) along the right (east) bank of the Lower San Joaquin River, and one (1) index point along the left (south) bank of French Camp Slough; these five (5) index points represent RD-17. The index point locations, LR-1, LR-2, LR-3, LR-4, and FL-1, are shown in Figure 3.5. As the results show below, LR-1, LR-2 and LR-3 display exit gradients and slope stability factors of safety (FOS) that do not meet design criteria at various water surface elevations. Figure 3-6 to Figure 3-10 displays steady state seepage and landside slope stability results for the analyzed water surface elevations.

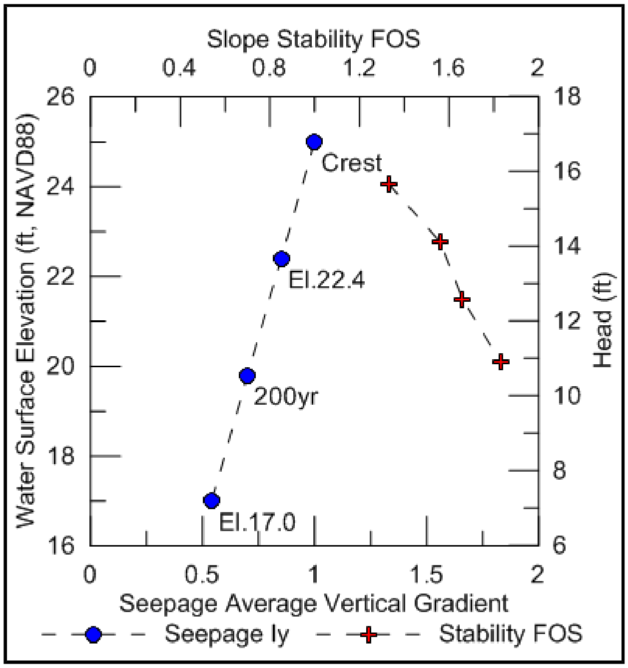


Figure 3-6: RD-17 Index Point LR-1 Without-Project Analyses Results

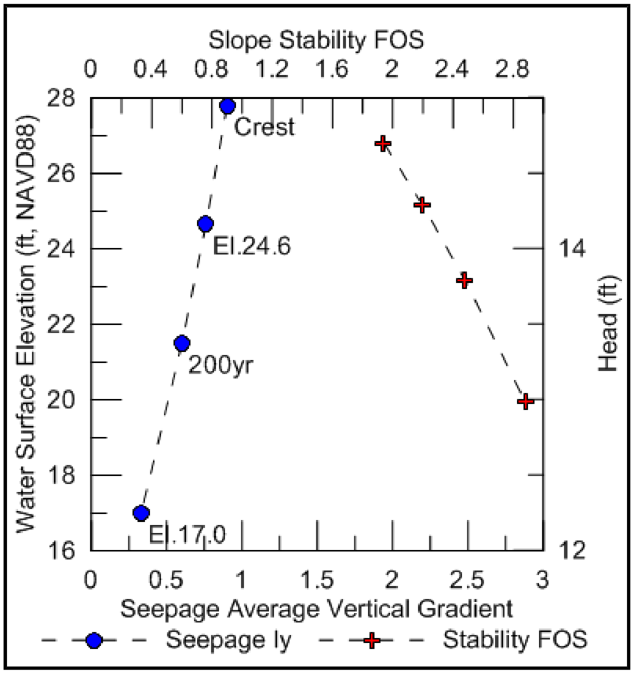


Figure 3-7: RD-17 Index Point LR-2 Without-Project Analyses Results

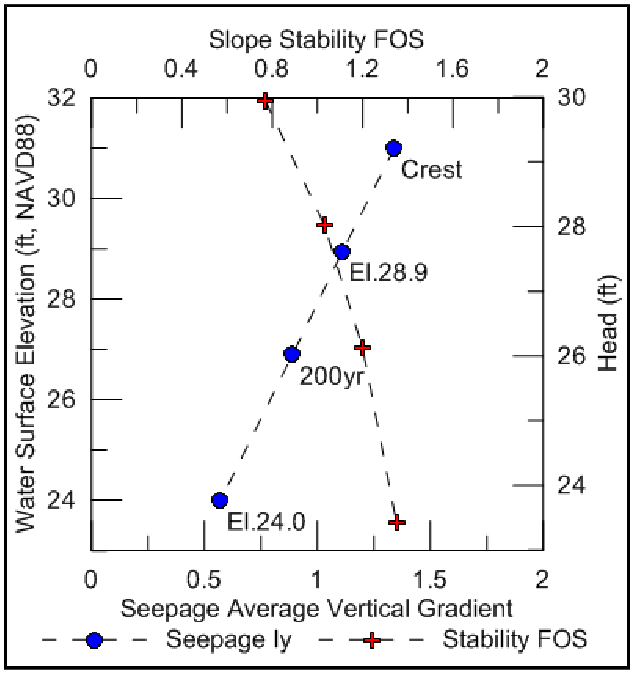


Figure 3-8: RD-17 Index Point LR-3 Without-Project Analyses Results

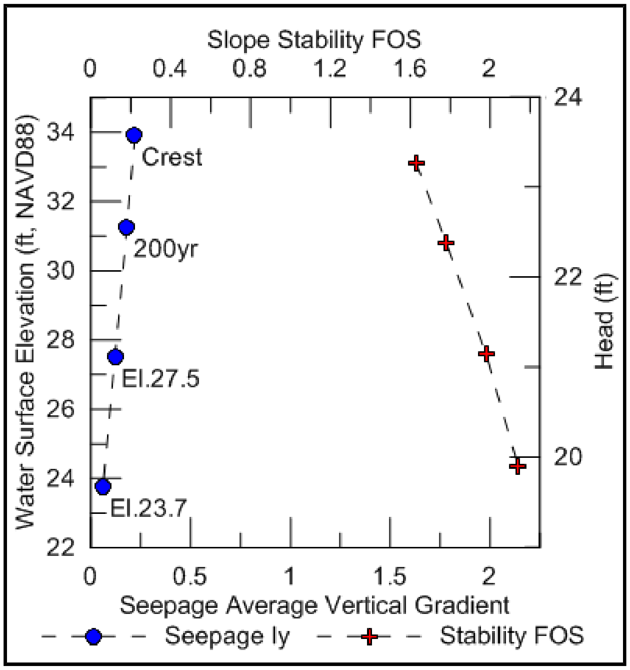


Figure 3-9: RD-17 Index Point LR-4 Without-Project Analyses Results

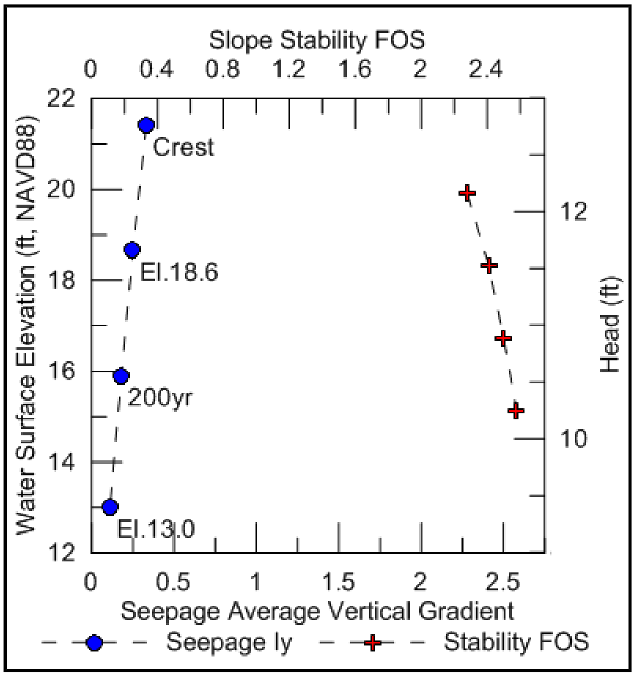


Figure 3-10: RD-17 Index Point FL-1 Without-Project Analyses Results

3.4.2 Central Stockton – RD-404 French Camp Slough/Stockton Diverting Canal, Left Bank Calaveras River

The without-project conditions analyses for central Stockton includes a total of five (5) index points; one (1) along the right (north) bank of French Camp Slough in RD-404, two (2) along the left (west) bank of the Stockton Diverting Canal, and tow (2) along the Left (south) bank of the Calaveras River. The index point locations for FR-1, SL-1, SL-2, CL-1/CL-2, and D-5, are shown in Figure 3.5. As the results show below, FR-1, SL-1 and SL-2 display exit gradients, and in some cases slope stability FOS, that do not meet design criteria at various water surface elevations. Figure 3-11 to Figure 3-15 displays steady state seepage and landside slope stability results for the analyzed water surface elevations.

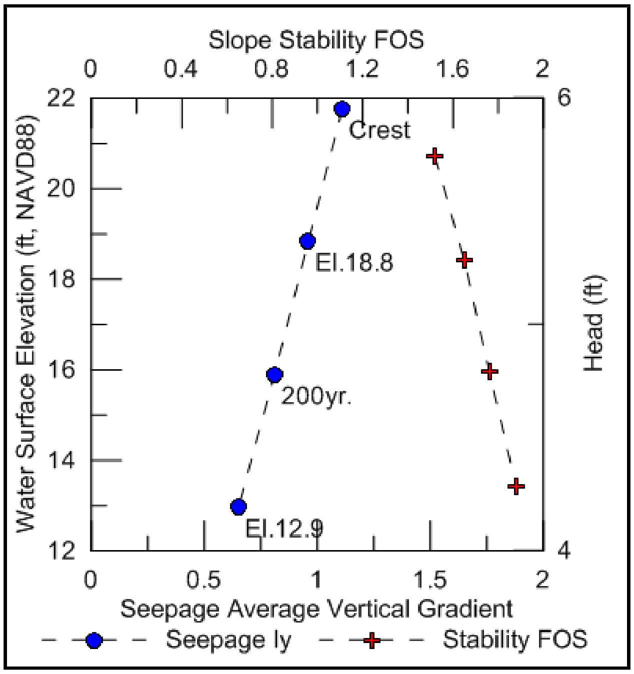


Figure 3-11: RD-404 Index Point FR-1 Without-Project Analyses Results

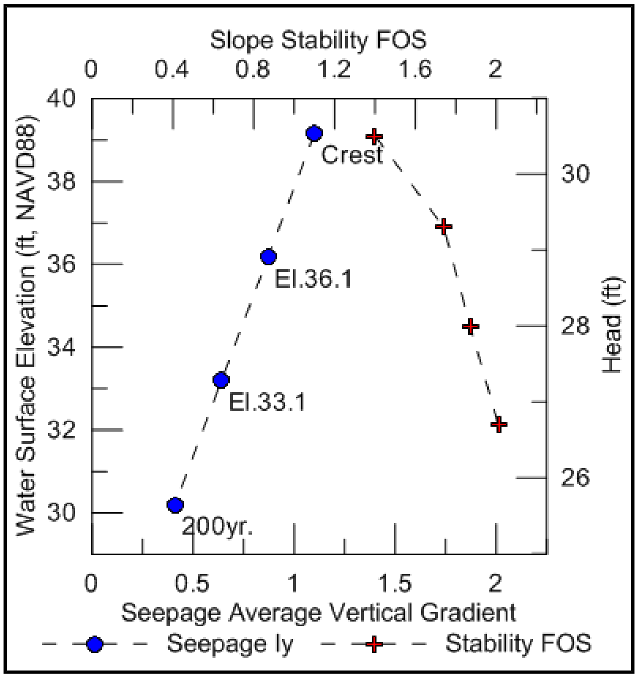


Figure 3-12: SDC Index Point SL-1 Without-Project Analyses Results

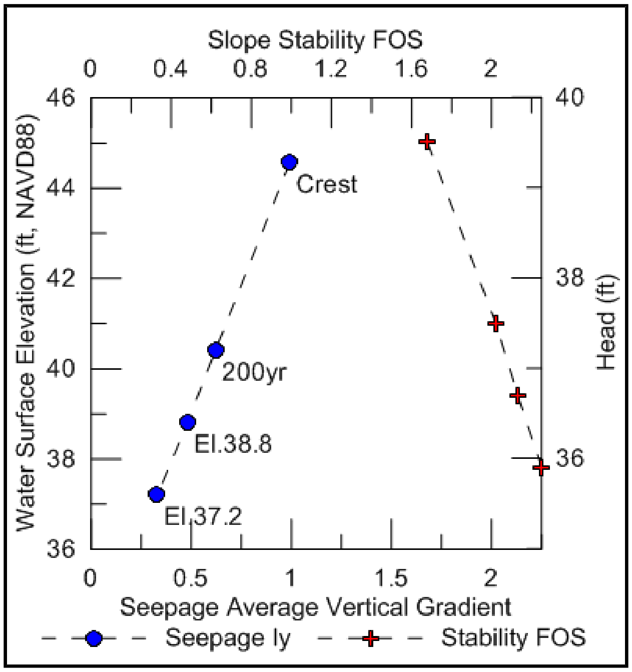


Figure 3-13: SDC Index Point SL-2 Without-Project Analyses Results

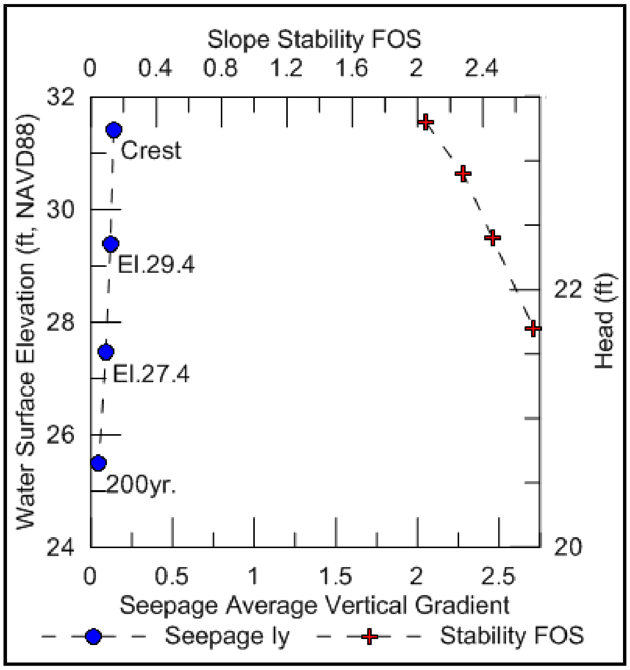


Figure 3-14: Calaveras River Index Point CL-1/CL-2 Without-Project Analyses Results

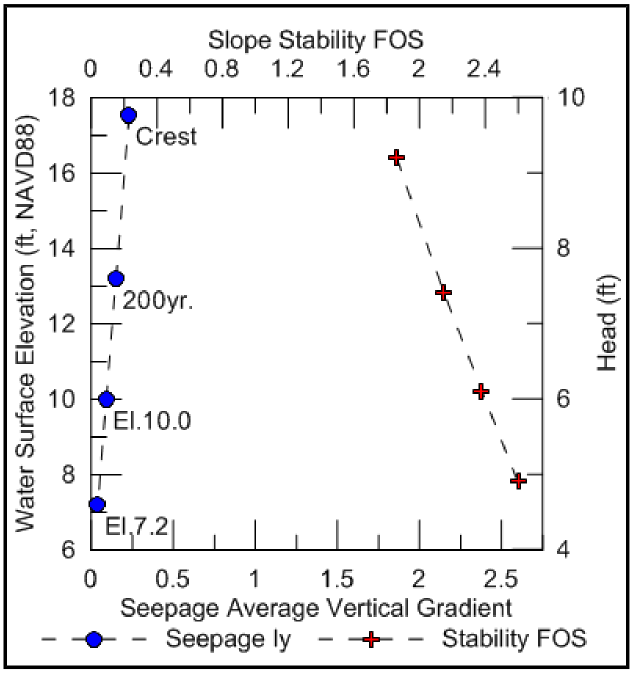


Figure 3-15: Calaveras River Index Point D-5 Without-Project Analyses Results

3.4.3 North Stockton – Right Bank Calaveras River, Delta Brookside, Delta Lincoln Village

The without-project conditions analyses for North Stockton includes a total of four (4) index points; two (2) along the right (north) bank of the Calaveras River, one (1) along the Delta Brookside Study Area, and one (1) along the Delta Lincoln Village Study Area. The index point locations for CR-1/CR-2, D-4, D-BS, and D-LV are shown in Figure 3.5. As the results show below, CR-1/CR-2, D-4, and D-BS display exit gradients, and in some cases slope stability FOS, that do not meet design criteria at various water surface elevations. Figure 3-16 to Figure 3-19 displays steady state seepage and landside slope stability results for the analyzed water surface elevations.

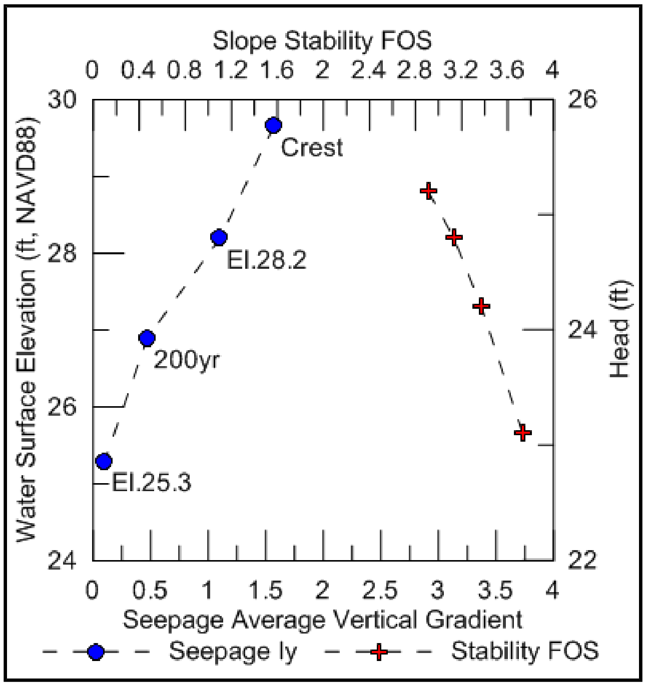


Figure 3-16: Calaveras River Index Point CR-1/CR-2 Without-Project Analyses Results

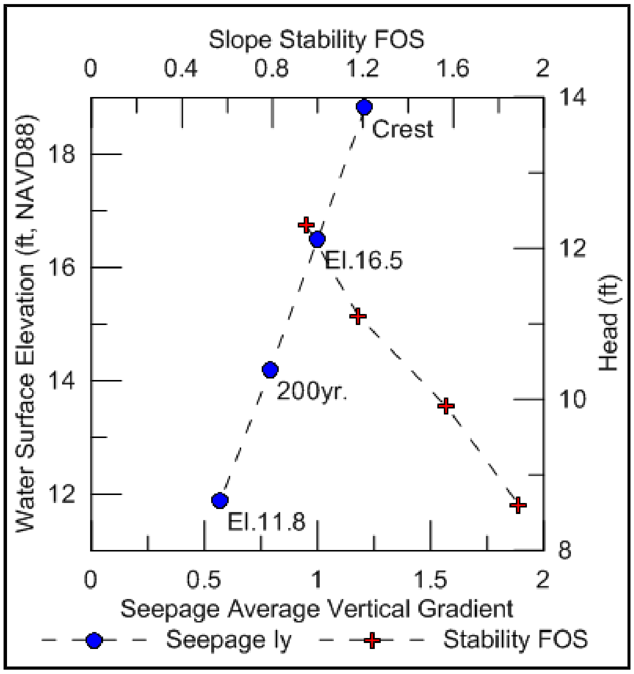


Figure 3-17: Calaveras River Index Point D-4 Without-Project Analyses Results

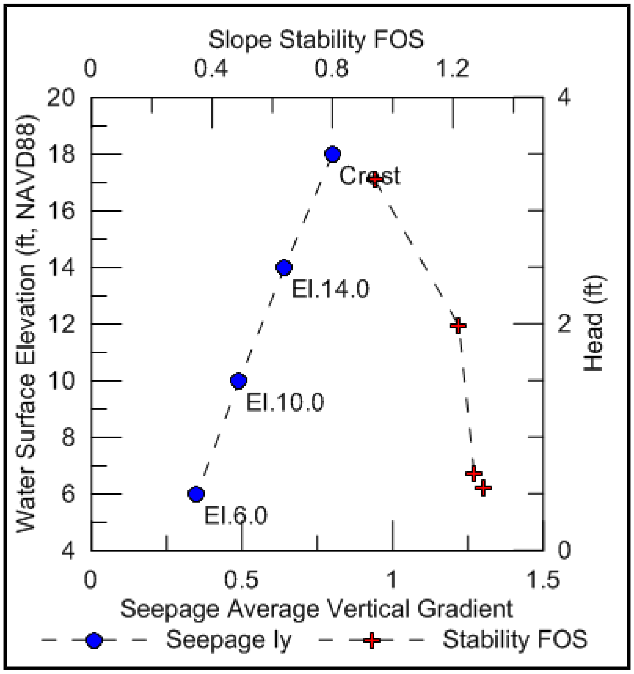


Figure 3-18: Delta Brookside Index Point D-BS Without-Project Analyses Results

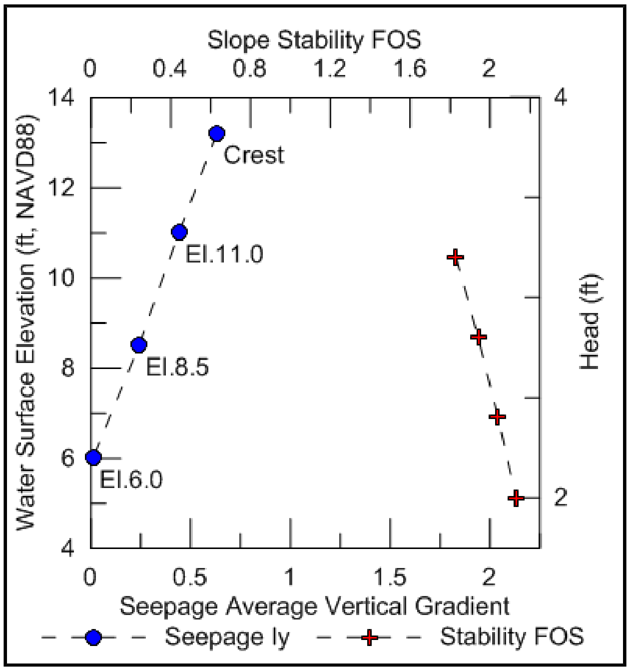


Figure 3-19: Delta Lincoln Village Index Point D-LV Without-Project Analyses Results

3.5 PROBABILISTIC ANALYSIS METHODOLOGY

Index points were selected for geotechnical analysis to represent the critical surface and subsurface conditions of each planning reach in order to identify the geotechnical deficiencies of the reach. The sections were selected based on previous geotechnical analysis, past levee performance, existing levee improvements, subsurface data, laboratory test results, surface conditions, field reconnaissance, and levee geometry. A critical section representing each reach was developed using existing subsurface data spread throughout the reach to establish a mean blanket and aquifer thickness. Analysis of underseepage, through-seepage, and slope stability make up the analytical components of the curve; whereas, judgment-based probabilities (i.e. vegetation, rodent activity, encroachments, and erosion) are based on site conditions as determined from periodic inspection reports, photographs, historical reporting, data reports, and expert opinion elicitations. The ground surface elevations used in the cross-sections were based on the LiDAR and bathymetric surveys performed by URS, Kleinfelder, and Fugro for DWR from 2007 and 2008. The analysis model stratigraphy was interpreted based on existing boring logs near the index point.

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 probabilistic evaluation of each index point. 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 underseepage, through-seepage, and slope stability.

The final result of the FOSM method 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 was defined using a FOS 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 series method based on a Taylor 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. The probability of poor performance, Pr(U), of the levee was expressed as a function of the river water elevation and the random variables of each performance function.

Potential sources of levee distress, or poor performance, considered in the analyses were underseepage through the levee foundation, through-seepage through the levee embankment, and instability of the landside levee slope under steady state conditions. The levees were evaluated against the above mentioned performance modes at five different water surface elevations. The loading conditions in most cases included the levee crest, levee crest minus three feet, half levee height, toe plus three feet, and landside levee toe where the probability of poor performance was considered to be zero. Using this method of selecting loading conditions, the levee performance curves would theoretically represent probability of poor performance at multiple flood frequencies.

Sudden drawdown conditions may result in levee slope failure; however, flooding is unlikely to occur when the water is at low elevation. Sudden drawdown was not considered in the analysis. Additionally, a judgment based conditional probability of poor performance curve is included in the risk and uncertainty analysis. This analysis considers: existing and past erosion history of the levee and riverbank, maintenance, encroachments, vegetation on the levee slopes and within the levee critical area, animal burrows and other external damaging conditions.

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. Random variables for underseepage included the ratio of the horizontal permeability of the aquifer to the vertical permeability of the blanket, blanket thickness, and aquifer thickness. Random variables for through-seepage included critical tractive stress, porosity, and intrinsic permeability of the levee embankment material. Random variables for slope stability included effective friction angle, effective cohesion, and total unit weight of the levee embankment, and effective friction angle and cohesion of the foundation material.

3.5.1. Underseepage

Underseepage analysis was performed using blanket theory analysis (BTA) as described in ETL 1110-2-556, EM 1110-2-1913, and TM 3-424. Finite element analyses using the SEEP2D program, part of the GMS version 6.5 software package, were developed to independently check the blanket theory results. In general, the finite element and the empirical seepage calculations supported each other, predicting qualitatively similar results. Statistical analysis was used for each reach in determination of the coefficients of variation and standard deviation of the permeability ratios, blanket thickness, and thickness of the underlying aquifer. A critical gradient of 0.80 was used, considering 112 pounds per cubic foot (pcf) unit weight of the blanket. The unit weight of the blanket was considered the same at all index points. Values of vertical and horizontal permeability based on material classification and fines content are shown in Table 3-5 below (a reduced version of Table 3-2).

Table 3-5: Vertical and Horizontal Hydraulic Conductivity

Material Type	Soil Description	Hydraulic Conductivity				
		k_H (cm/sec)	k_H (ft/day)	k_H/k_V	k_V (cm/sec)	k_V (ft/day)
Clay	Engineered Embankment	1.0E-06	0.0028	4	2.5E-07	0.0007
	Non-Engineered Embankment	1.0E-05	0.028	4	2.5E-06	0.0071
	Blanket ≥10ft Thick	1.0E-05	0.028	4	2.5E-06	0.0071
	Blanket 5ft<>10ft Thick	1.0E-05	0.028	4	2.5E-06	0.0071
	Blanket ≤5ft Thick	1.0E-05	0.028	4	2.5E-06	0.0071
Silt	Elastic (plastic)	5.0E-05	0.142	4	1.3E-05	0.035
	Non-plastic	2.0E-04	0.57	4	5.0E-05	0.14
Peat	Organic Soil	4.0E-06	0.01	4	1.0E-06	0.0028
Clayey Sand to Sand	30-49% fines	5.0E-05	0.14	4	1.3E-05	0.035
	13-29% fines	1.0E-04	0.28	4	2.5E-05	0.071
	8-12% fines	1.0E-03	2.8	4	2.5E-04	0.71
	0-7% fines	5.0E-03	14	4	1.3E-03	3.5
Silty Sand to Sand	30-49% fines	5.0E-04	1.4	4	1.3E-04	0.35
	13-29% fines	1.0E-03	2.8	4	2.5E-04	0.71
	8-12% fines	5.0E-03	14	4	1.3E-03	3.5
	0-7% fines	1.0E-02	28	4	2.5E-03	7.1
Gravel	28-49% fines	4.0E-04	1.1	4	1.0E-04	0.28
	18-27% fines	1.0E-03	2.8	4	2.5E-04	0.71
	13-17% fines	6.0E-03	17	4	1.5E-03	4.3
	8-12% fines	1.2E-02	34	4	3.0E-03	8.5
	0-7% fines	2.5E-02	71	4	6.3E-03	17.7

3.5.2 Through-Seepage

Levees constructed either of fine grained clays, having stability berms with drainage layers that extend along the levee slope that captures seepage through the levee, or having cutoff walls constructed through the levee embankment are unlikely to be susceptible to through-seepage caused internal erosion. Levees of silt, silty sand, and sand were considered to be susceptible to internal erosion and were evaluated using the modified Khilar, Folger, and Gray erosion model as prescribed in ETL 1110-2-556. Using this method, the critical gradient through the levee embankment was calculated based on variations in the critical tractive stress, porosity, and intrinsic permeability of the levee material and compared with the predicted horizontal gradient through the levee embankment from the SEEP2D model. Table 3-6 shows the mean values of the random variables of the levee embankment material used to calculate the critical gradient were critical tractive stress (dynes/cm^2) which was taken as ten times the d_{50} (mm), the porosity based on material classification as proposed by Weight and Sonderegger in "Manual of Applied Field Hydrology", and intrinsic permeability was taken as approximately 1x10^{-5} times the horizontal permeability (cm/sec). Table 3-7 presents coefficients of variation for the through-seepage analysis random variables that were obtained using methodologies outlined in ETL 1110-2-556.

Table 3-6: Through-Seepage Random Variables

Material	Tractive Stress (dynes/cm^2)	Porosity (%)	Intrinsic Permeability (cm^2)
Clay	5 – 50	40 - 70	1.0E^{-10}
Silt	0.5 – 50	35 - 50	2.0E^{-9} – 5.0E^{-10}
Sand	1 – 20	25 - 50	1.0E^{-6} – 5.0E^{-9}
Gravel	15 – 250	20 - 40	2.5.0E^{-6} – 4.0E^{-9}
Sand and Gravel	15 – 250	15 - 35	

Table 3-7: Variation of Through-Seepage Random Variables

Random Variable	Coefficient of Variation (%)
Critical Tractive Stress (T_c dynes/cm^2)	10
Porosity (n)	10
Intrinsic Permeability (k_o cm^2)	30

3.5.3 Landside Slope Stability

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 and pore water pressures were developed for the steady state condition using the SEEP2D finite element computer program developed as part of GMS version 6.5. The limit equilibrium computer program UTEXAS4 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.

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 soil strength in the foundation. Statistical descriptors for these variables were determined using available site-specific information and published statistical data. The piezometric lines or pore water pressures for each water elevation were determined using the finite element program SEEP2D for the levee embankment and its foundation.

The drained soil strength parameters used in the stability analyses are shown in Table 3-8; these values were based on a generalized conservative assumption of shear strength by soil type from previous studies in the project area. For each index point the generalized assumption was compared with available field and laboratory testing from nearby explorations. The coefficients of variation for soil strength parameters and unit weight of the fill material in the levee or the top impervious blanket are shown in Table 3-9 and 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”.

Table 3-8: Drained Shear Strength of Soil

Material Type	Soil Description	Shear Strength		
		c' (psf)	Φ' (°)	γ (pcf)
Cutoff Wall	SCB, SB, CB	50	0	85
Clay	CH Levee Embankment	100	22	115
	CH Foundation	100	26	115
	CL Levee Embankment	50	24	115
	CL Foundation	50	28	115
Silt	ML Levee Embankment-	0	28	115
	ML Foundation	0	30	120
Clayey Sand and Silty Sand	-	0	33	125
Sand	-	0	35	130
Gravel and Drain Rock	-	0	35	135

Table 3-9: Variation of Drained Shear Strength Parameters

Random Variable	Coefficient of Variation (%)
Effective Friction Angle (Φ)	13
Effective Cohesion (c psf)	40
Total Unit Weight (γ pcf)	7

3.5.4 Judgment

A judgment based conditional probability function was based on the existing and past erosion history of the levee and riverbank, maintenance, encroachments, vegetation on the levee slopes and within the levee critical area, animal burrows and other external damaging conditions. Generally, past experience with poor performance at utility crossing and rodent activity indicates the risk of failure is somewhat significant in the analyzed areas. The judgment based curve is included for each analyzed levee cross section and in the combined curve of failure.

In June 2009, an expert elicitation was conducted for the purpose of developing the geotechnical judgment portion of the curves; the meeting minutes are included as Enclosure 6. 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 in erosion and geotechnical issues. The expert elicitation focused on the judgment part of the geotechnical risk and uncertainty curves for flood control structures; the team discussed and reached consensus on the impact of different factors of the judgment curve, such as:

- the vegetation on the levees and within the levee right of way
- penetrations through the levee and foundation
- encroachments into the levee and levee right-of-way
- erosion of the riverbank and waterside slopes of the levee
- 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 necessarily coincide with the risk of failure. Based on historical performances of levees, it appears 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 needed to be repaired after a 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.

3.5.5 Combined Curves

The total conditional probability of poor performance as a function of floodwater elevation has been developed by combining the probability of poor performance functions for four failure modes; underseepage, through-seepage, slope instability, and judgment.

3.6 PERFORMANCE CURVES

The results of the geotechnical risk and uncertainty analyses are briefly discussed in the following sections. As previously discussed, underseepage, through-seepage, and slope stability probabilities of failure were calculated analytically based on site specific subsurface information used to select material parameters and coefficients of variation. Included as Enclosure 3 are the spreadsheet analyses used to calculate the probabilities of poor performance. These spreadsheets include data from borings used to select parameters, the selected parameters, and the calculated results including the combined performance curve. The judgment curve remains as the non-analytical component to the curve; those probabilities of poor performance were based on site specific conditions regarding vegetation, penetrations, encroachments, erosion, and animal burrows. The Reach Description section (Section 3.2) of this report describes in general terms the levee conditions regarding vegetation, penetrations, encroachments, and animal burrows.

3.6.1 RD-17 – Lower San Joaquin River, East Bank

The subsurface explorations for LR-1 used in probabilistic analyses resulted in a mean blanket thickness of 13.0-ft with a coefficient of variation of 46, and a mean aquifer thickness of 28.0-ft with a coefficient of variation 0.57. The levee embankment was comprised of lean clay and silt. The blanket was comprised of predominantly lean clay. The aquifer was comprised of poorly graded sand with silt to silty sand. Past performance indicates the embankment has experienced seepage, sand boils, and cracking.

The underseepage and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 24.3% and the underseepage curve contributed 49.0% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of encroachments, animal burrows, and utilities. Figure 3-20 presents the without-project conditions combined curve for LR-1.

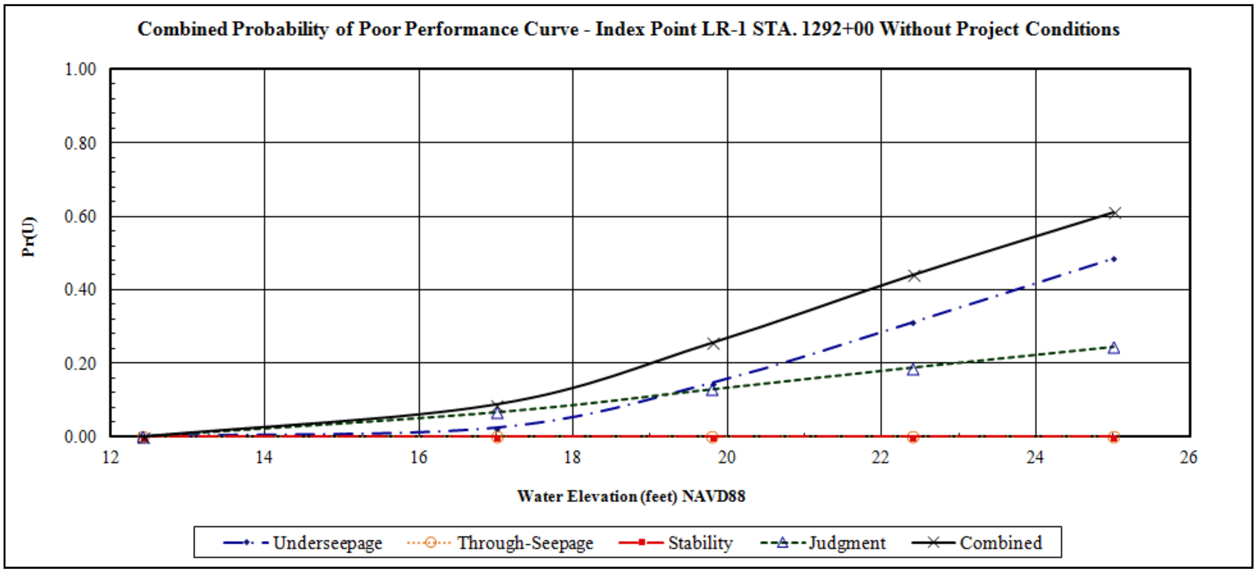


Figure 3-20: Index Point LR-1 Combined Probability of Poor Performance Curve for Without Project Conditions

The subsurface explorations for LR-2 used in probabilistic analyses resulted in a mean blanket thickness of 7.0-ft with a coefficient of variation of 57, and a mean aquifer thickness of 18.0-ft with a coefficient of variation 0.39. The levee embankment was comprised of lean clay to silty sand. The blanket was comprised of predominantly silty sand. The aquifer was comprised of poorly graded sand with silt to silty sand. Past performance indicates the embankment has experienced seepage, and sand boils.

The underseepage and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 28.2% and the underseepage curve contributed 56.9% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of encroachments, vegetation, utilities, and animal burrows. Figure 3-21 presents the without-project conditions combined curve for LR-2.

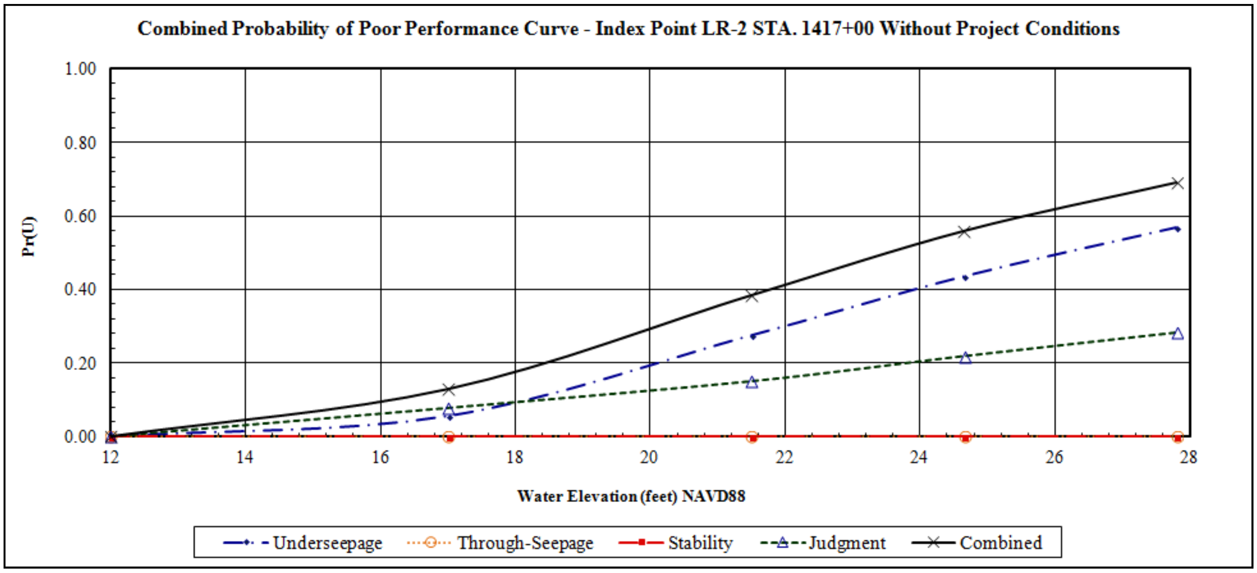


Figure 3-21: Index Point LR-2 Combined Probability of Poor Performance Curve for Without Project Conditions

The subsurface explorations for LR-3 used in probabilistic analyses resulted in a mean blanket thickness of 11.0-ft with a coefficient of variation of 55, and a mean aquifer thickness of 35.0-ft with a coefficient of variation 0.34. The levee embankment was comprised of poorly graded sand with silt to clayey sand. The thin blanket was comprised of predominantly lean clay to silty sand. The aquifer was comprised of poorly graded sand with silt. Past performance indicates the embankment has experienced seepage, sand boils, and breach conditions.

The underseepage, through-seepage, slope stability, and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 20.2%, the underseepage curve contributed 48.6%, the through-seepage curve contributed 68.0%, and the slope stability curve contributed 99.9% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of vegetation, utilities, and animal burrows. Figure 3-22 presents the without-project conditions combined curve for LR-3.

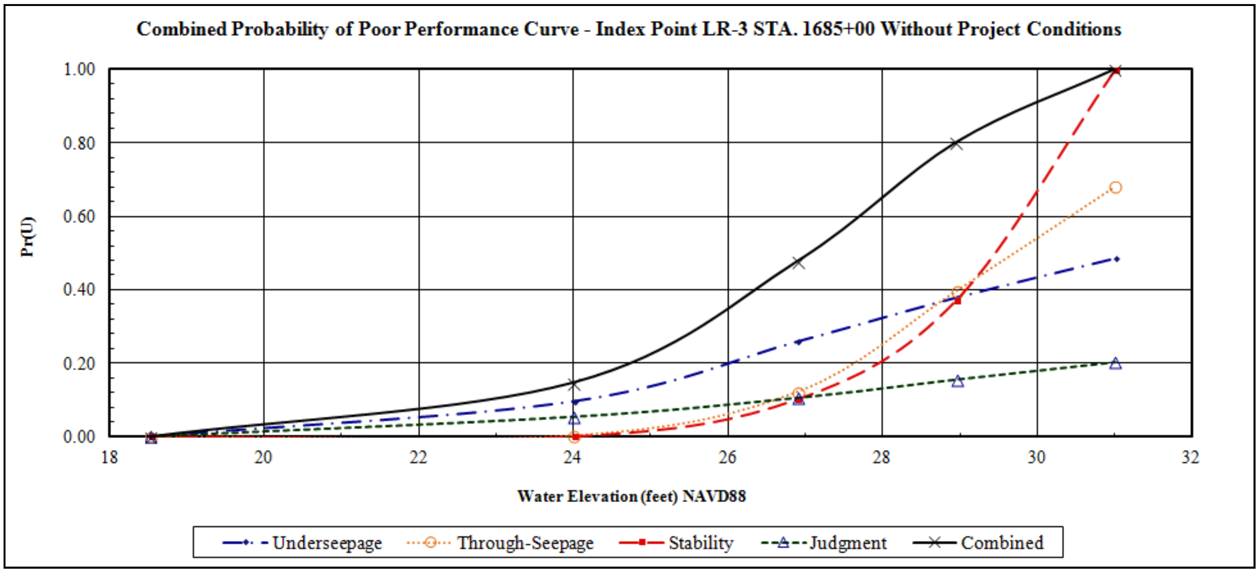


Figure 3-22: Index Point LR-3 Combined Probability of Poor Performance Curve for Without Project Conditions

The subsurface explorations for LR-4 used in probabilistic analyses resulted in a mean blanket thickness of 23.0-ft with a coefficient of variation of 13, and a mean aquifer thickness of 33.0-ft with a coefficient of variation 0.24. The levee embankment was comprised of clayey sand. The blanket was comprised of lean clay to sandy lean clay. The aquifer was comprised of poorly graded sand with silt. Past performance indicates the embankment has experienced seepage, and sand boils.

The judgment component curve accounted for the majority of the combined without-project curve. The judgment curve contributed 22.7% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of vegetation, encroachments, and animal burrows. Figure 3-23 presents the without-project conditions combined curve for LR-4.

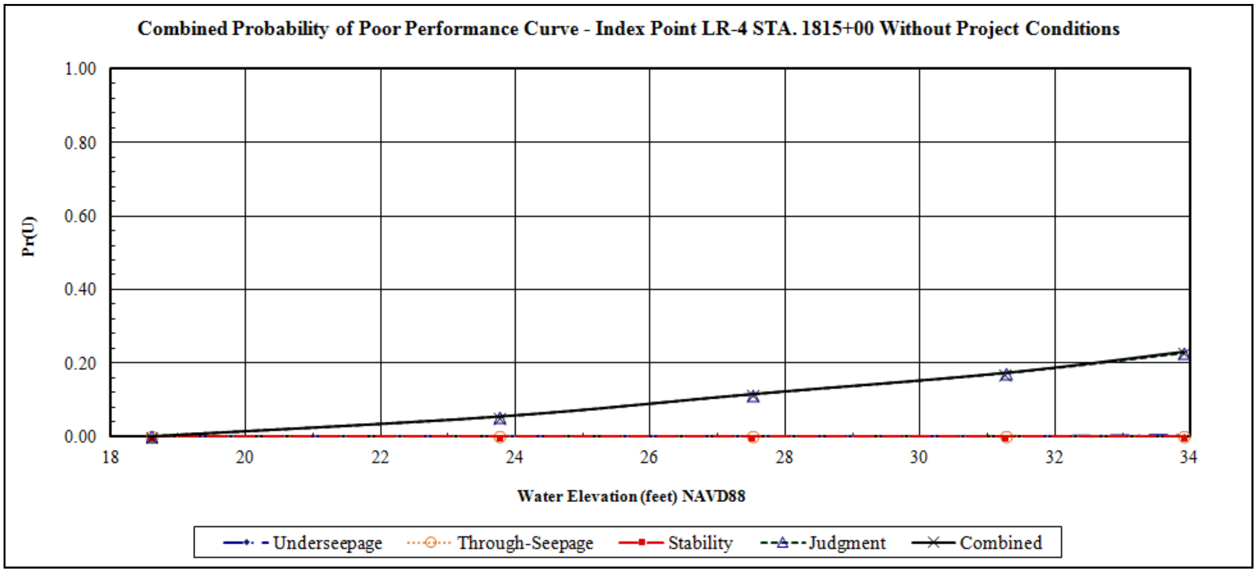


Figure 3-23: Index Point LR-4 Combined Probability of Poor Performance Curve for Without Project Conditions

3.6.2 French Camp Slough, North and South Bank

The subsurface explorations for FL-1 used in probabilistic analyses resulted in a mean blanket thickness of 10.0-ft with a coefficient of variation of 10, and a mean aquifer thickness of 9.0-ft with a coefficient of variation 0.67. The levee embankment was comprised of sandy clay. The blanket was comprised of lean clay to sandy lean clay. The aquifer was comprised of silty sand. Past performance indicates the embankment has experienced seepage, and sand boils.

The judgment component curve accounted for the majority of the combined without-project curve. The judgment curve contributed 23.5% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of vegetation, encroachments, and animal burrows. Figure 3-24 presents the without-project conditions combined curve for FL-1.

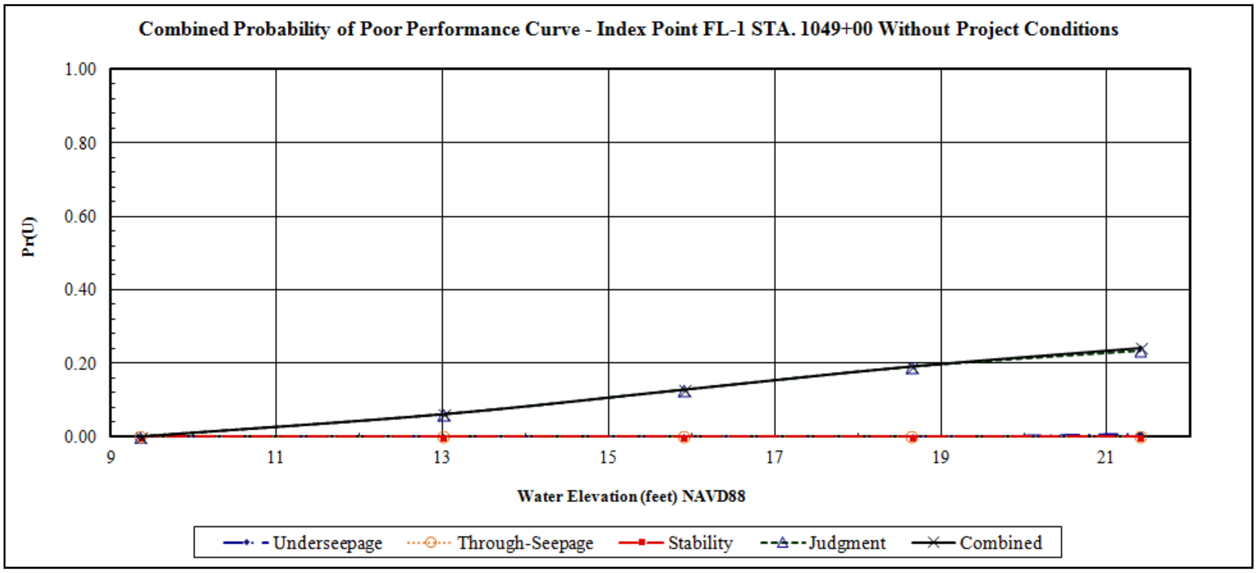


Figure 3-24: Index Point FL-1 Combined Probability of Poor Performance Curve for Without Project Conditions

The subsurface explorations for FR-1 used in probabilistic analyses resulted in a mean blanket thickness of 7.0-ft with a coefficient of variation of 29, and a mean aquifer thickness of 8.0-ft with a coefficient of variation 0.25. The levee embankment was comprised of lean clay and silt. The thin blanket was comprised of predominantly clayey sand. The aquifer was comprised of silty sand. Past performance indicates the embankment has experienced seepage, sand boils, and bank erosion.

The underseepage and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 21.9% and the underseepage curve contributed 63.9% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of encroachments, vegetation, animal burrows, and erosion. Figure 3-25 presents the without-project conditions combined curve for FR-1.

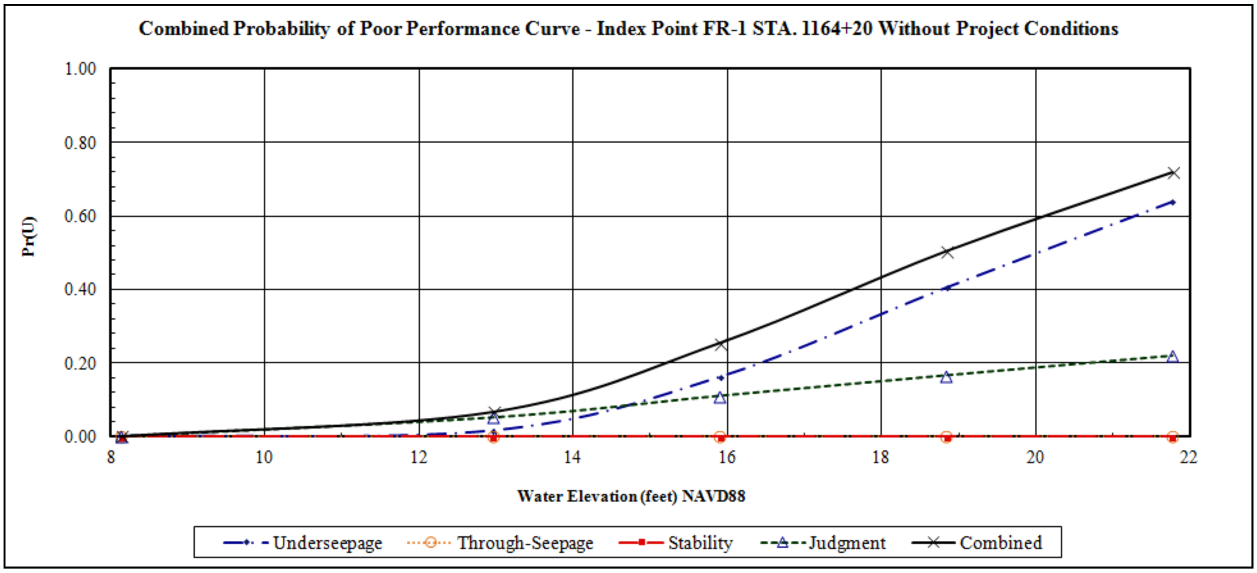


Figure 3-25: Index Point FR-1 Combined Probability of Poor Performance Curve for Without Project Conditions

3.6.3 Stockton Diverting Canal, Left Bank

The subsurface explorations for SL-1 used in probabilistic analyses resulted in a mean blanket thickness of 10.0-ft with a coefficient of variation of 50, and a mean aquifer thickness of 17.0-ft with a coefficient of variation 0.65. The levee embankment was comprised of sandy lean clay. The thin blanket was comprised of predominantly lean clay. The aquifer was comprised of silty sand. Past performance indicates the embankment has experienced no known issues with seepage or stability.

The underseepage and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 19.3% and the underseepage curve contributed 30.9% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of animal burrows, encroachments, and utilities. Figure 3-26 presents the without-project conditions combined curve for SL-1.

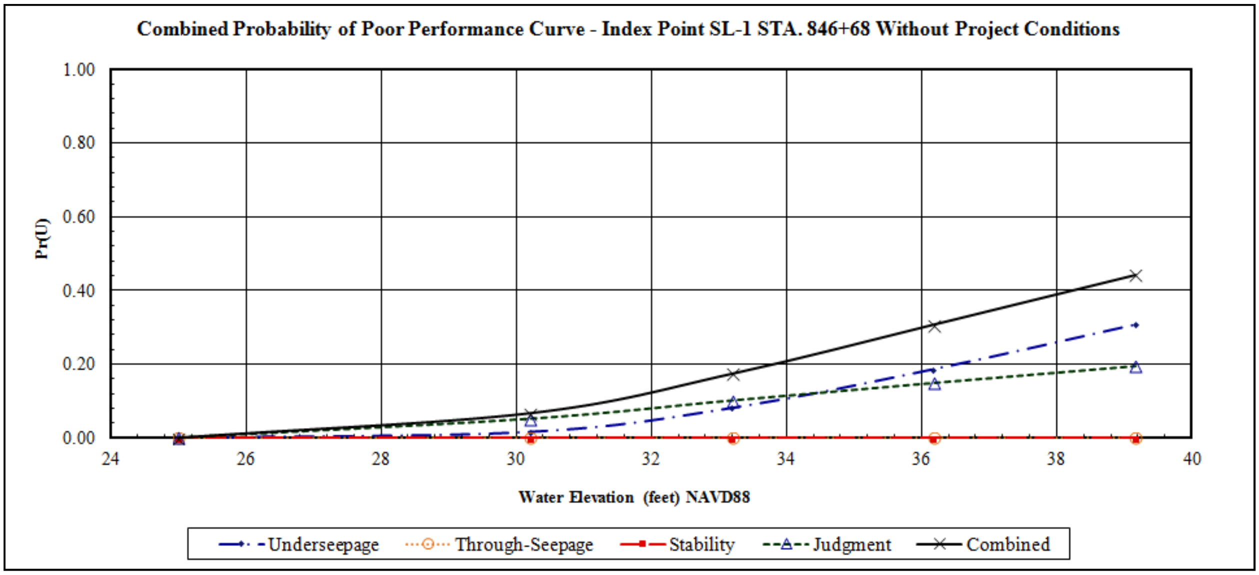


Figure 3-26: Index Point SL-1 Combined Probability of Poor Performance Curve for Without Project Conditions

The subsurface explorations for SL-2 used in probabilistic analyses resulted in a mean blanket thickness of 7.0-ft with a coefficient of variation of 29, and a mean aquifer thickness of 10.0-ft with a coefficient of variation 0.60. The levee embankment was comprised of sandy silt. The blanket was comprised of predominantly lean clay. The aquifer was comprised of silty sand. Past performance indicates the embankment has experienced no known issues with seepage or stability.

The underseepage and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 19.3% and the underseepage curve contributed 22.4% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of animal burrows, encroachments, and utilities. Figure 3-27 presents the without-project conditions combined curve for SL-2.

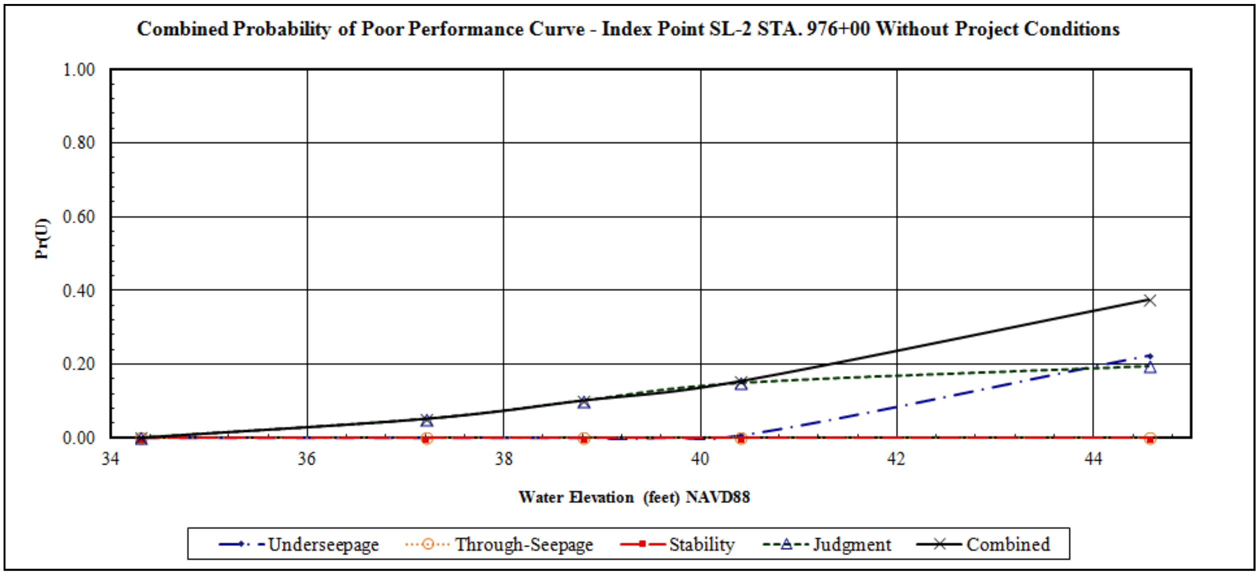


Figure 3-27: Index Point SL-2 Combined Probability of Poor Performance Curve for Without Project Conditions

3.6.4 Calaveras River, North and South Bank

The subsurface explorations for CL-1/CL-2 used in probabilistic analyses resulted in a mean blanket thickness of 19.0-ft with a coefficient of variation of 42, and a mean aquifer thickness of 15.0-ft with a coefficient of variation 0.73. The levee embankment was comprised of sandy silt. The blanket was comprised of predominantly elastic silt. The aquifer was deep and appeared in a few borings as poorly graded sand with silt. Past performance indicates the embankment has experienced seepage, settlement, and bank erosion.

The through-seepage and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 32.7% and the through-seepage curve contributed 7.7% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of encroachments, erosion, animal burrows, utilities, and vegetation. Figure 3-28 presents the without-project conditions combined curve for CL-1/CL-2.

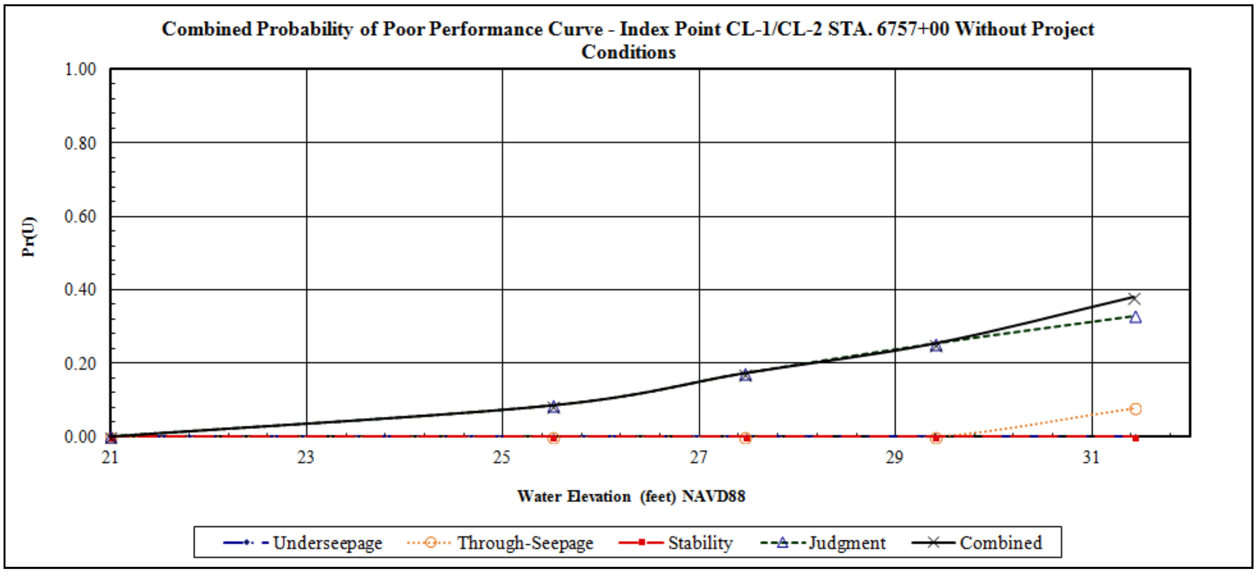


Figure 3-28: Index Point CL-1/CL-2 Combined Probability of Poor Performance Curve for Without Project Conditions

The subsurface explorations for CR-1/CR-2 used in probabilistic analyses resulted in a mean blanket thickness of 5.0-ft with a coefficient of variation of 40, and a mean aquifer thickness of 14.0-ft with a coefficient of variation 0.57. The levee embankment was comprised of sandy lean clay. The thin blanket was comprised of predominantly sandy lean clay. The aquifer was comprised of sandy silt. Past performance indicates the embankment has experienced seepage, settlement, and bank erosion.

The underseepage and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 32.0% and the underseepage curve contributed 24.4% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of encroachments, utilities, erosion, and vegetation. Figure 3-29 presents the without-project conditions combined curve for CR-1/CR-2.

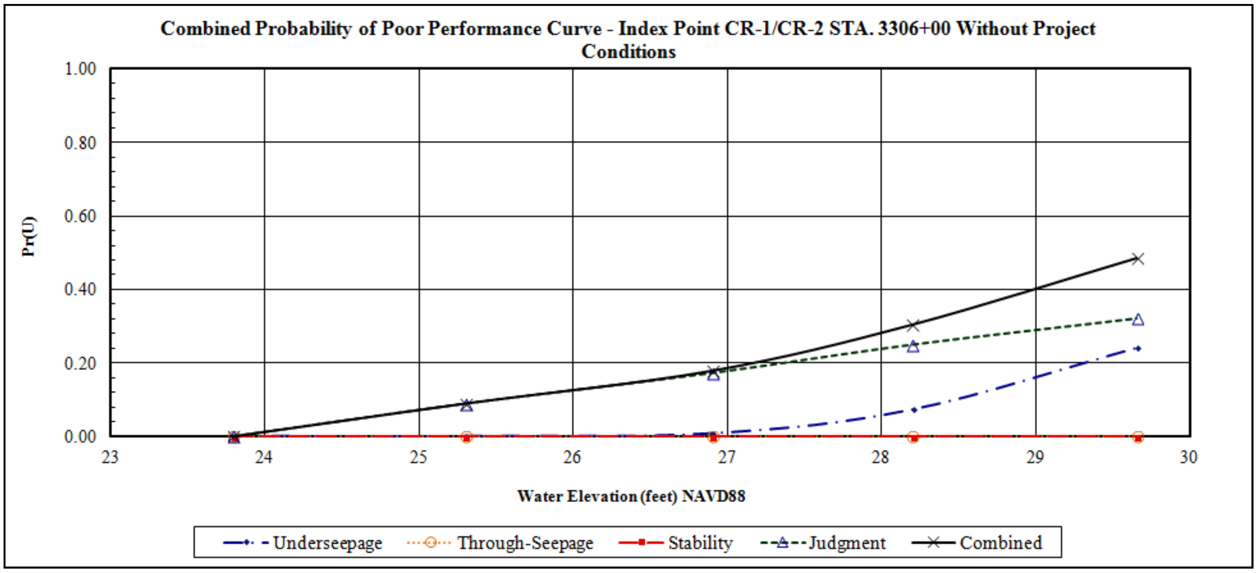


Figure 3-29: Index Point CR-1/CR-2 Combined Probability of Poor Performance Curve for Without Project Conditions

The subsurface explorations for D-4 used in probabilistic analyses resulted in a mean blanket thickness of 15.0-ft with a coefficient of variation of 47, and a mean aquifer thickness of 30.0-ft with a coefficient of variation 0.07. The levee embankment was comprised of sandy silt and sandy lean clay. The thin blanket was comprised of predominantly sandy fat clay to sandy silt. The aquifer was comprised of poorly graded sand with silt. Past performance indicates the embankment has experienced seepage, settlement, sand boils, and bank erosion.

The underseepage, through-seepage, slope stability, and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 30.5%, the underseepage curve contributed 37.4%, the through-seepage curve contributed 8.5%, and the slope stability curve contributed 66.9% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of encroachments, vegetation, utilities, and animal burrows. Figure 3-30 presents the without-project conditions combined curve for D-4.

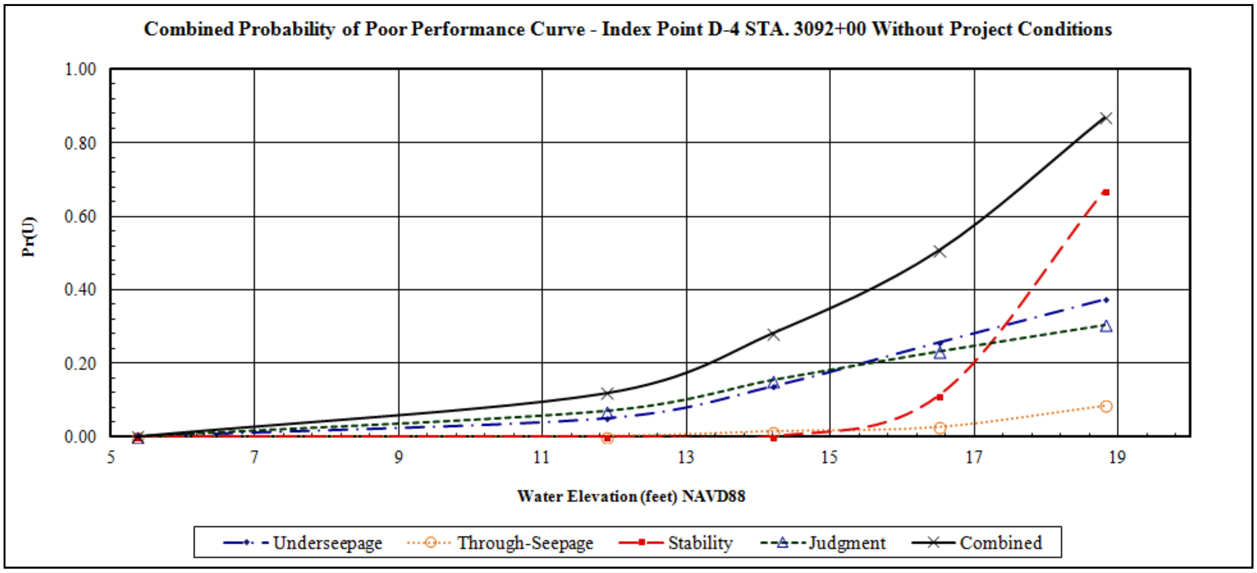


Figure 3-30: Index Point D-4 Combined Probability of Poor Performance Curve for Without Project Conditions

The subsurface explorations for D-5 used in probabilistic analyses resulted in a mean blanket thickness of 20.0-ft with a coefficient of variation of 45, and a mean aquifer thickness of 15.0-ft with a coefficient of variation 0.67. The levee embankment was comprised of silt. The blanket was comprised of predominantly lean clay. The aquifer was comprised of silty sand. Past performance indicates the embankment has experienced seepage, settlement, and bank erosion.

The through-seepage and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 31.2% and the through-seepage curve contributed 12.8% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of encroachments, erosion, utilities, and vegetation. Figure 3-31 presents the without-project conditions combined curve for D-5.

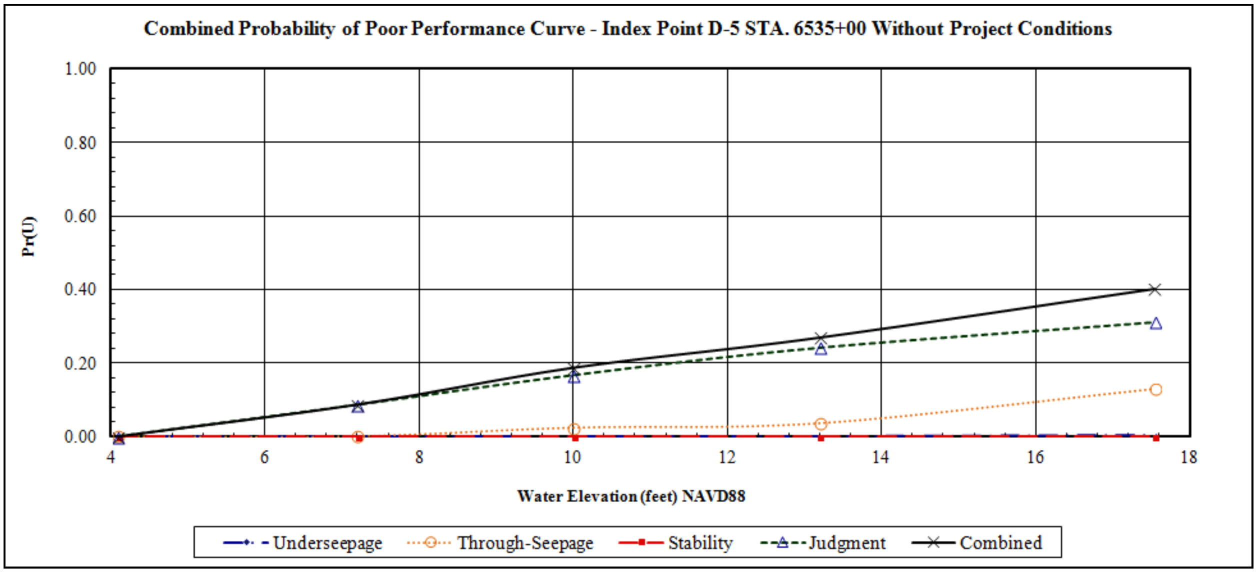


Figure 3-31: Index Point D-5 Combined Probability of Poor Performance Curve for Without Project Conditions

3.6.5 Delta Front Brookside / Delta Lincoln Village

The subsurface explorations for D-BS used in probabilistic analyses resulted in a mean blanket thickness of 18.0-ft with a coefficient of variation of 33, and a mean aquifer thickness of 20.0-ft with a coefficient of variation 0.45. The levee embankment was comprised of lean clay and portions of an older levee constructed of organic clay. The thin blanket was comprised of predominantly organic clay and lean clay. The aquifer was comprised of silty sand. Past performance indicates the embankment has experienced seepage, settlement, bank erosion, and animal burrows.

The underseepage, slope stability, and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 25.9%, the underseepage curve contributed 41.8%, and the slope stability curve contributed 65.9% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of encroachments, erosion, vegetation, and utilities. Figure 3-32 presents the without-project conditions combined curve for D-BS.

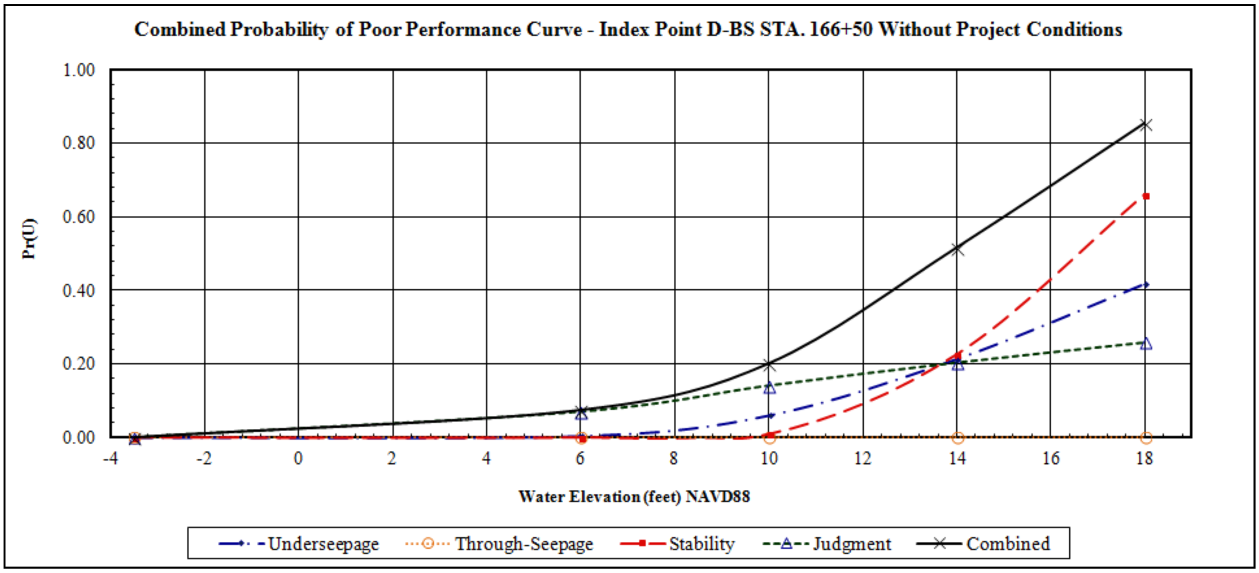


Figure 3-32: Index Point D-BS Combined Probability of Poor Performance Curve for Without Project Conditions

The subsurface explorations for D-LV used in probabilistic analyses resulted in a mean blanket thickness of 12.0-ft with a coefficient of variation of 58, and a mean aquifer thickness of 21.0-ft with a coefficient of variation 0.43. The levee embankment was comprised of lean clay. The thin blanket was comprised of predominantly lean clay. The deep aquifer was comprised of silty sand to poorly graded sand with silt. Past performance indicates the embankment has experienced seepage, and bank erosion.

The underseepage and judgment component curves accounted for the majority of the combined without-project curve. The judgment curve contributed 29.8% and the underseepage curve contributed 23.0% to the combined without-project curve at the levee crest WSE. The without-project judgment curve was primarily comprised of encroachments, vegetation, utilities, and animal burrows. Figure 3-33 presents the without-project conditions combined curve for D-LV.

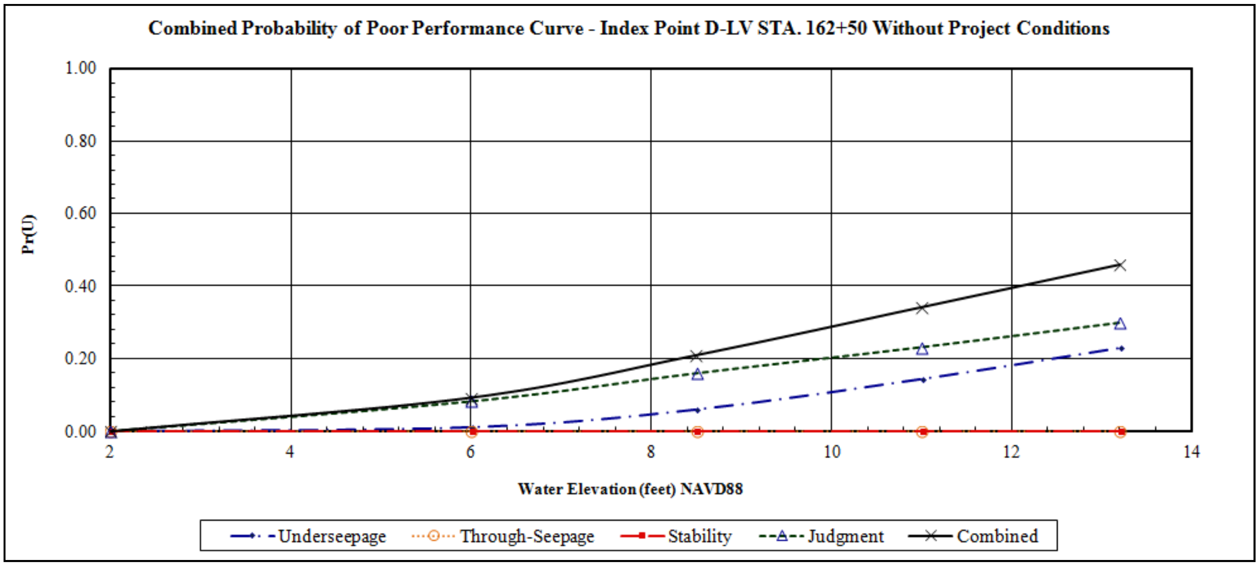


Figure 3-33: Index Point D-LV Combined Probability of Poor Performance Curve for Without Project Conditions

3.7 SEISMIC PERFORMANCE AND LIQUEFACTION ANALYSIS

The main purpose of seismic vulnerability analyses was to identify the potential seismic performance of a levee. Major concerns during and after seismic events are liquefaction induced settlement and displacement, transverse cracks that may develop between liquefiable and non-liquefiable reaches, and at locations where liquefiable zones abut appurtenant structures with deep rigid foundations. Such zones should be identified and given special consideration.

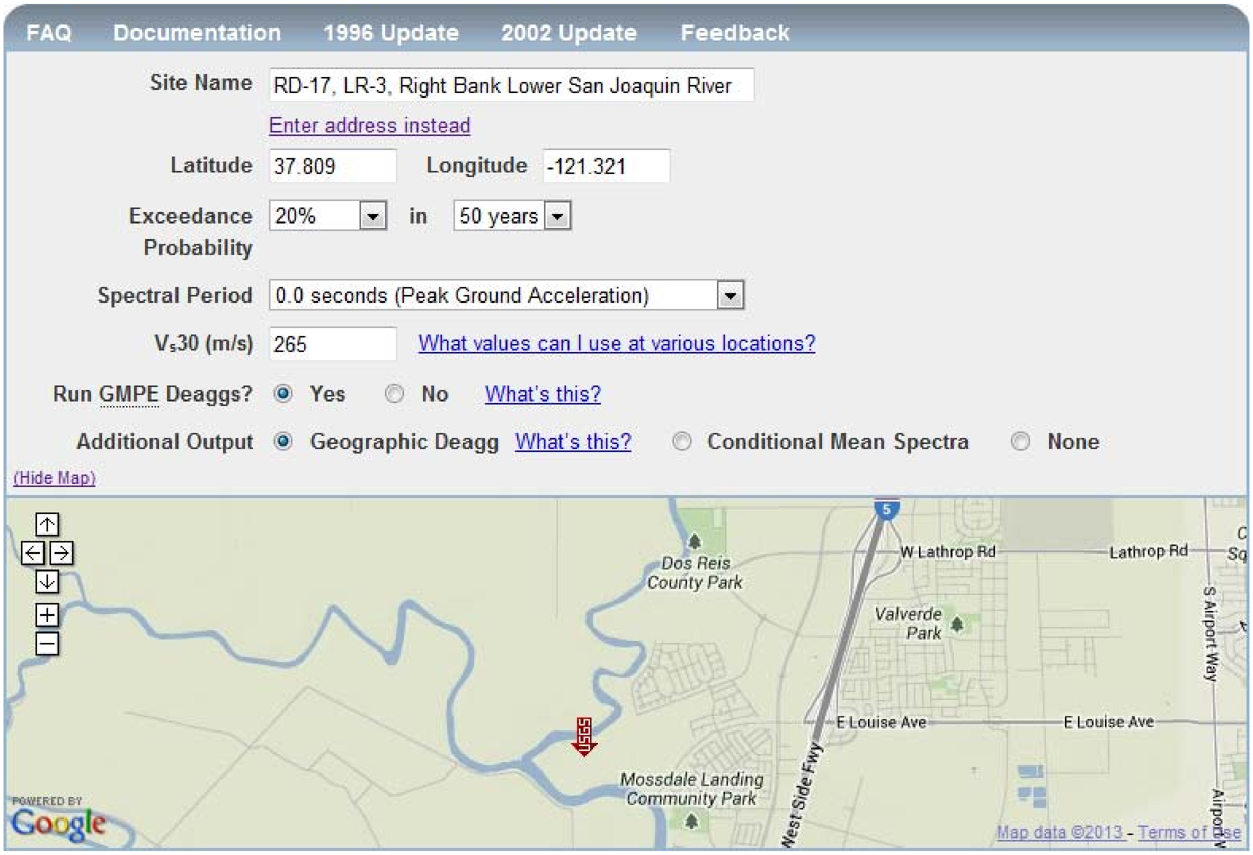
Seismic analysis was performed for potions of the project that are loaded every day where tides (ranging from elevation 2.5 to 6.5 feet) are higher than the landside levee toe elevation (as low as elevation -1 to -4 feet in some locations). Policy regarding the need for this analysis is contained in ER 1110-2-1150 Engineering and Design for Civil Works Projects C-4.1.7. Feasibility level analysis was performed in accordance with ER 1110-2-1806 Earthquake Design and Evaluation for Civil Works Projects. More detailed analysis and refinement of seismic mitigation measures will be performed during PED in accordance ER 1110-2-1150 D-7.10. This PED effort should be closely coordinated with the geotechnical vertical team due to the unique nature of this analysis and the high cost of mitigation and is required by ER 1110-2-1806 Section 12 for existing projects.

3.7.1 Site Specific Seismic and Liquefaction Analysis

To evaluate the potential to liquefaction resistance of soils, liquefaction triggering analysis was performed based on a procedure from the summary report of the 1996 National Center for Earthquake Engineering Research (NCEER) and 1998 NCEER/National Science Foundation (NSF) Workshops on Evaluation of Liquefaction Resistance of Soils, published as part of the Journal of Geotechnical and Geoenvironmental Engineer, dated October 2001 (Youd, Idriss, Andrus, & Arango, October 2001).

Probabilistic Seismic Hazard Analysis (PSHA) based on the 2008 Next Generation Attenuation (NGA) relationships was used to develop seismic parameters for the LSJRFS area. The deaggregations are from the United States Geologic Society (USGS) developed 2008 Interactive Deaggregations web program. Figure 3-34 and Figure 3-35 presents an example of the interactive input screen and obtained results for index point LR-3 within the LSJRFS area. The following data were input:

- location, through latitude and longitude (up to three decimals each are considered)
- exceedance probability of the seismic event
- desired spectral period
- shear wave velocity of the upper 30 meters (V_{s30}) of the site



Site Name RD-17, LR-3, Right Bank Lower San Joaquin River

Latitude 37.809 Longitude -121.321

Exceedance Probability 20% in 50 years

Spectral Period 0.0 seconds (Peak Ground Acceleration)

V_s30 (m/s) 265

Run GMPE Deaggs? ● Yes ○ No

Additional Output ● Geographic Deagg ○ Conditional Mean Spectra ○ None

Figure 3-34: USGS 2008 Interactive Deaggregations (Beta) Input

The peak horizontal ground horizontal acceleration (PGA) for 20% exceedance in 50 years (224 -year average return period) at index point LR-3 was found to be 0.49g. The 20% probability of exceedance in 50 years (or 224 year average return period) was used in this study to be consistent with flood protection, per DWR. Seismic design is assumed to be based on ground motion probabilities that are equivalent to the high-water event exceedance probabilities that the project will be designed to withstand. For example, the project is expected to be designed for a 200-year high-water event, the expected seismic criteria is based on designing for the 200-year event. Vs30 was estimated as an average from several deep borings in the area through correlation with SPT blow counts. Figure 3-35 shows the peak horizontal ground acceleration and the contributions of various seismic sources based on USGS deaggregations.

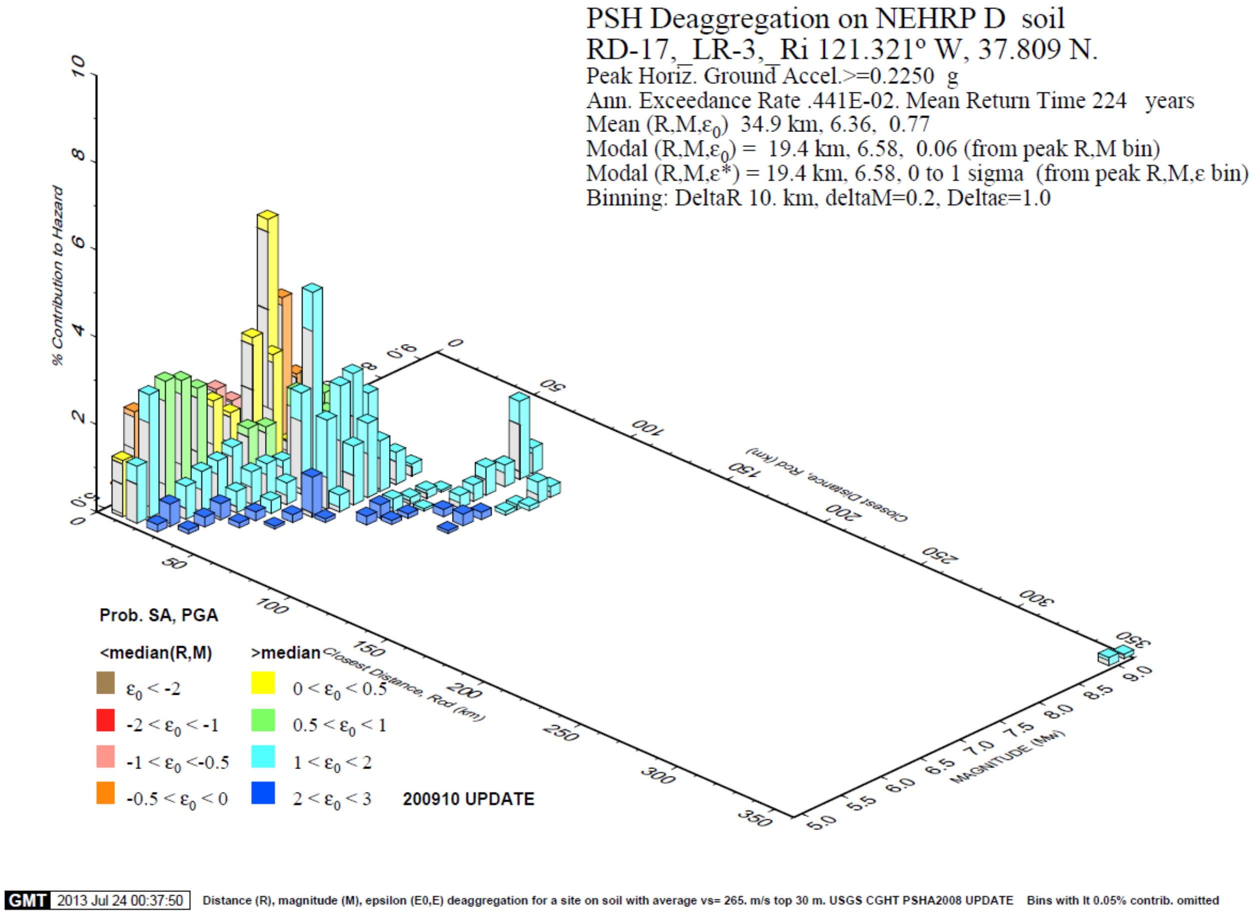


Figure 3-35: USGS 2008 Interactive Deaggregations (Beta) Output

The mean magnitude or the weighted average considering the percent contribution to the total hazard for the study levees is 6.4. The most significant contributions are induced by The Great Valley 7 Char Fault System and the Great Valley 7 GR Fault System. The Great Valley 7 Char Fault System is capable of M = 6.7 and located approximately 20 km from the site, while the Great Valley 7 GR Fault System is capable of M = 6.6 and located approximately 21 km from the site.

3.7.2 Liquefaction And Ground Deformation

Many of the levees within the LSJRFS area are constructed over alluvial deposits and may be susceptible to liquefaction or degradation due to a seismic event. Levees meeting static stability criteria likely have sufficient factors of safety to resist the additional loading from earthquakes unless the levee or foundation materials lose significant strength due to liquefaction. The LSJRFS area is unusual in that it contains infrequently loaded levees in Central and South Stockton, but also frequently loaded levees in North Stockton. Infrequently loaded levees are likely to be unsaturated at the time of a large seismic event; the material in the levee often can be considered non-liquefiable due to lack of saturation. Frequently loaded levees are tidally influenced and experience a water surface elevation at least one foot above the landside toe elevation at least once a day. Frequently loaded levees are likely to be sensitive to seepage leading to breach with seismic-event induced transverse cracking or displacement.

The seismic and liquefaction evaluation for the LSJRFS area primarily focused on examining potential layers that could experience liquefaction and their associated impact to global slope stability of the levee section. In most of the cases/Reaches it was determined that liquefaction was primarily isolated to the deeper foundation layers and that it had minimal effect on the global stability of the levee and foundation. In six (6) cases within RD-17, RD-404, Delta Brookside, and the Deep Water Ship Channel, the liquefiable layers were shallow enough such that they could pose a significant effect on the stability of the levee.

Even though global instability resulting from liquefaction does not appear to be a primary concern when the liquefiable layers are located at greater depths, there could be other seismic performance concerns given the geologic nature of the area and the potential for differential settlement. The foundations for many of the segments, especially in the North Stockton areas underlain by unconsolidated organic-rich silts, clays, peat, and mud deposits, consist of numerous geomorphologic braided channels that run orthogonal to the levee axis. As a result, there are variable foundation conditions along the axis of these levees. The variability of the foundation coupled with the potential for transverse cracking due to liquefaction, differential settlement, and areas that are frequently loaded that are protecting dense populations, are a concern and should be carefully considered in the alternatives. The results of the Seismic and liquefaction analysis for the LSJRFS are included as Enclosure 4.

4. WITH PROJECT CONDITIONS DESCRIPTION

The LSJRFS is evaluating Federal interest in alternatives to reduce flood risk in the study area. The geotechnical analyses performed have identified several technical deficiencies associated with the flood risk management system protecting the study area. There are various alternatives under consideration to address these deficiencies and the geotechnical components of those alternatives are discussed in the following sections of this report. Most of the alternatives consist of various structural measures to remediate existing levees for seepage, slope stability, and/or erosion, and some alternatives include measures to improve conveyance.

4.1 TYPICAL LEVEE IMPROVEMENT MEASURES

Where levee height, geometry, erosion, access, vegetation, seepage, and/or slope stability deficiencies were identified (criteria not met), improvement measures were assigned to the affected reaches of levees. Improvement measures for geotechnical deficiencies consisting primarily of cutoff walls, seepage berms, stability berms, and slope flattening were included in development of conceptual alternative cross-sections. This section of the report discusses the various improvement measures considered at a conceptual level, and not as applied to a specific reach.

4.1.1 Cutoff Walls

Seepage cutoff walls are vertical walls of low hydraulic conductivity material constructed through the embankment and foundation to cut off potential through-seepage and underseepage. In order to be effective for underseepage mitigation, cutoff walls usually tie into an impervious sub-layer. Cutoff walls generally require no additional permanent levee footprint. The levee typically is degraded by one half the levee height to provide a sufficient working surface (minimum about 30 feet) and prevent hydraulic fracture of the levee. Following construction of the cutoff wall, the levee is then rebuilt either with the existing levee material with an impervious cap above the cutoff wall, or with imported impervious levee fill material. Cutoff walls are typically constructed of either a soil bentonite (SB), soil cement bentonite (SCB), or cement bentonite (CB) mixture depending on in-situ soil conditions and desired construction method.

The conventional slurry method for SB or SCB walls is an open trench method that uses an excavator with a long-stick boom to excavate the slurry trench. A bentonite-water slurry is used to keep the trench open and stable prior to backfilling with the permanent wall material. Soil is mixed with bentonite (SB) or with bentonite and cement (SCB) then pushed into the trench, displacing the bentonite-water slurry. Alternatively, the open trench method can be used for CB walls, whereby the trench is backfilled with the self-hardening slurry mixture. The self-hardening slurry backfill is used to keep the trench open and stable, allowing excavation of a new section without waiting for the entire trench to be excavated. The conventional method using a long stick boom excavator has a maximum depth of about 70 to 80 feet.

Deeper cutoff walls can be constructed using the Deep Soil Mixing (DSM) or Deep Mix Method (DMM), jet grouting, and soil cutter mixing. These deeper cutoff walls use specialized construction equipment to mix the soil with low permeability materials, typically bentonite and/or cement, in-situ and are capable of depths of more than 100 feet. DSM and DMM use augers to mix low permeability materials into the subsurface soils, iteratively performed along a linear layout, to create overlapping columns of treated soil that form a wall within the subsurface soils. Jet grouting uses the injection of grout from vertical holes to create overlapping columns or panels that form a wall within the subsurface soils. Cutter soil mixing uses a cutter head equipped with cutter wheels that allow vertical penetration within the subsurface soils and mixing of bentonite and/or cement slurry that is injected during the penetration and withdrawal of the cutter head; iterative performance along a linear layout creates overlapping panels that form the cutoff wall.

4.1.2 Seepage Berms

Seepage berms are earth structures built along the levee landside toe that provide additional weight to prevent blanket layer heave, reduce exit gradients, and allow for safe exit of underseepage. Seepage berms can be pervious, semi-pervious, or impervious, and may require a significant amount of land. For some sites, due to adjacent property uses, there is not sufficient room along the landside toe for a seepage berm. The required dimensions of a seepage berm (width and thickness) depend on site specific conditions and may vary over the length of a levee. Seepage berm widths commonly range from a few tens of feet to a few hundred feet. Berm thickness typically ranges from a few feet to several feet. It was beyond the scope of the LSJRFS to perform site specific analyses to dimension seepage berms throughout the study area. Instead, typical berm dimensions were used, and levee height was used as a proxy for underseepage demand (indicating needed berm width). For the LSJRFS, the required seepage berm width was taken as ten times the levee height, with a maximum width of 300 feet. The thickness of the berm is 5 feet at the levee toe and 3 feet at the toe of the berm.

4.1.3 Slope flattening

Slope flattening is a mechanical method to repair a slope that may not have stable slopes by reducing the steepness of the slopes. Waterside and landside slopes can be graded using construction equipment to flatten slopes. In most cases, this process requires the removal of all vegetation and encroachments from the levee slope being flattened. Slopes are typically flattened to 3H:1V or flatter; for the LSJRFS, slope flattening was set at 3H:1V.

4.1.4 Stability Berms

Stability berms are earth structures built against the levee landside slope to stabilize unstable slopes, or in some cases to capture seepage through the levee. Stability berms may be constructed of a random fill material placed over blanket and chimney drainage features to capture seepage through the levee. A thin filter sand layer may be placed between the drainage layer and the levee embankment and native soils. Geotextile fabric may be placed between the free drainage layer and the levee fill. Typically, the height of the stability berm is on the order of two-thirds of the height of the levee. Drained stability berms have the benefit of also reducing susceptibility to through-seepage.

4.1.5 Floodwall/Retaining Wall

A floodwall is a structural wall that is constructed either in lieu of a levee or on top of a levee (to raise the elevation of the top) to separate the waterside from the protected side. Floodwalls are an efficient, space-conserving method for containing unusually high water surface elevations. They are often used in highly developed areas where space is limited. They are primarily constructed from pre-fabricated materials, although they may be cast or constructed in place, and are constructed almost completely upright. Floodwalls consist of relatively short elements (in plan view), making the connections very important to their stability. Floodwalls on top of levees are typically located along a levee hinge point to allow vehicular access along the crown. The drawback is that floodwalls prohibit access to or from the levee slopes, and may inhibit visual inspection of the slope and toe areas from the crown if the wall is of sufficient height.

At the time this report was authored, floodwalls were not part of the proposed alternatives; however, they still remain a topic of consideration.

4.1.6 Embankment Fill/Levee Raise

To address deficiencies found in the required levee height, various methods of raising the existing levee crown elevation may be implemented. Two options are forms of embankment fill placement: a crown-only levee raise, and a full levee raise. A crown-only levee raise is feasible where the levee crown is currently wide enough to support the placement of additional embankment material while maintaining the minimum allowable crown width upon the completion of the raise. A full levee raise includes an embankment raise from the waterside crown hinge point upward at an appropriate waterside slope angle, establishing a new crown width to meet criteria, and placement of fill against the landside slope such that the levee is widened to the landside and the new landside slope extends up to meet the newly established crown.

4.1.7 Bank Protection

In areas that have no or minimal waterside berm, on bank rip-rap is placed on the waterside levee slope to protect against erosion. This entails filling the eroded portion of the bank and installing stone protection along the levee slope from the base of the erosion area to the top of the erosion area. Vegetation would be limited to grass. If there is a natural bank distinct from the levee that requires erosion protection, it would be treated with stone protection. Existing woody vegetation would be removed within the vegetation-free zone. Grass would be allowed in this area.

Additionally, a rip-rap waterside berm may be constructed from the base of the erosion to above the mean summer water level (MSWL) and then placing stone protection on the levee or bank slope above the MSWL. The stone berm may support riparian vegetation and provide a place to anchor in-stream woody material (IWM). This design provides near-bank, shallow-water habitat for fish.

4.1.8 Anticipated Borrow Source

Excavated and borrow material will be sourced from within a 25-mile radius and would be stockpiled at staging areas. To the extent feasible, borrow material would be obtained from a licensed, permitted facility that meets all Federal and State standards and requirements. In addition, many acres of farmland and vacant lands currently exist near the project; borrow could be obtained from these lands. In selecting borrow areas, lands closest to the construction sites would be evaluated for availability and suitability first before evaluating lands further from the project.

No USACE investigation or laboratory testing has been performed in these areas to verify that the materials meet the requirements for borrow materials as stated in Section 4.3.2. Depending on the selected improvements, it is possible that existing levee material may be used as a source of borrow material. Typically, the existing levee is composed of poorly graded sands, silty sands, and sandy silts on the rivers and streams, while bypass levees were usually constructed of lean to fat clays. This material can be considered suitable for use in the construction of some stability berms, seepage berms, and for reconstructing the levee embankment where a cutoff wall is proposed; however, existing levee material is subject to the material requirements given in Section 4.3.2. Significant quantities of engineered fill of various specifications will be required to construct the proposed project. Refer to other Appendices for the estimated quantities needed for construction.

4.2 OTHER STRUCTURAL MEASURES

Other structural measures proposed for the LSJRFS area include closure structures, weirs, and proposed channel improvements.

4.2.1 Closure Structures/Gates

Some of the current project alternatives utilize closure structures at various locations within the LSJRFS area.

Fourteen Mile Slough would require an operable closure gate with the western-alignment levee configuration (refer to other appendices for description of the western alignment configuration). The closure structure would be operable to passing vessels and rising water surface elevations. With the western alignment configuration, the levees protecting Delta Lincoln Village on its western and southern sides, as well as the levee north of Delta Brookside, would remain both geotechnically and seismically vulnerable if the closure structure were not constructed and appropriately operated.

Excessive encroachments throughout the north and south banks of Smith Canal may necessitate a closure gate for controlling a high water event that may otherwise jeopardize existing levee performance. The gate for Smith Canal would be operable to passing vessels and rising water surface elevations.

The Mormon Slough Bypass would require a closure gate to convey an additional 2000 cfs of flow diverted from the Mormon Channel into the Bypass.

During this feasibility study, no geotechnical investigation or analyses were performed in these areas in support of evaluating or developing designs for closure structures. During the Pre-Construction Engineering and Design phase (PED) of this project, subsurface investigations would need to be performed in the areas of the proposed closure structures to determine foundation conditions for design, the need to mitigate any potential seepage, and further define constraints and requirements.

4.2.2 Channel Improvements/Weirs

Channel improvements are being considered as part of the project alternatives for Mormon Slough Bypass and Paradise Cut.

Currently, Mormon Slough Bypass receives no flow from Mormon Channel as it turns north-west into the Stockton Diverting Canal. The current flows in Mormon Slough Bypass are due to interior drainage with a maximum flow of approximately 1,000 cfs. The current project alternative would propose channel improvements to convey an additional 2,000 cfs of flow diverted from Mormon Channel (instead of that flow entering the Stockton Diverting Canal). Channel improvements would consist principally of channel widening and modification of potential obstructions (e.g., bridges, utilities). A gate would be constructed to divert flows greater than roughly the 5 or 10 year event that flow down the SDC to the Calaveras River.

Channel improvements to Paradise Cut would include dredging and widening to the area to increase flows and reduce stage downstream on the LSJR. Levees along the left bank of Paradise Cut would be set back further from the existing channel location. This process would also include improvements to widen the uncontrolled weir on the LSJR to allow for increased flows into Paradise Cut.

During this feasibility study, no geotechnical investigation or analysis was performed in these areas in support of evaluating or developing designs for weirs/diversion structures. During the Pre-Construction Engineering and Design phase (PED) of this project, subsurface investigations would need to be performed in the areas of the proposed structures to determine foundation conditions for design, the need to mitigate any potential seepage, and further define constraints and requirements.

4.3 LEVEE IMPROVEMENT MEASURES

Levee improvement measures constitute the vast majority of measures that comprise most alternatives for the LSJRFS. The following sections of this report describe the methodology, criteria, and resulting levee improvement templates developed to mitigate for levee performance issues within the LSJRFS area.

4.3.1 Methodology

The without-project conditions were initially characterized by roughly 40 miles of existing levees within the study area. As part of the Planning process of generating Management Measures and Alternatives, additional lengths of existing levees and also potential new levee alignments were added, expanding the project study area to roughly 90 miles. For all of the existing and proposed levee with-project conditions, the original 14 reaches were expanded to capture the added lengths of levees and then were further divided into 124 smaller reaches, the further division into smaller reaches was done to allow for flexibility in assigning mitigation measures and estimating project costs.

For each of the 124 reaches, the reach was assigned mitigation considering two primary factors: (1) the intent of the Management Measure for the reach, and (2) the geotechnical potential failure modes that need to be mitigated for the reach. For the LSJRFS alternatives, there are four different Management Measure intents for levees:

- Raise existing levee
- Strengthen existing levee
- Raise and Strengthen Existing Levee
- Construct New Levee

For any particular reach of existing levee, different Management Measure intents maybe needed for different alternatives. The geotechnical potential failure modes are the modes discussed in Section 3.1 of this report, mainly: underseepage, through-seepage, slope instability, erosion, and seismicity/liquefaction. The type of mitigation assigned to the reach depended on which potential failure mode(s) had been identified as present at the reach.

Flexibility was designed into the assigned mitigation measures by providing two different template options to mitigate performance issues per reach, not including seismic. For example, the option for a cutoff wall vs. the option for a seepage berm would each mitigate underseepage; the flexibility to choose how a performance issue is mitigated allowed for selection of an option that would minimize costs and/or impacts. Seismic mitigation did not allow for two different options due to the project location and unique soil conditions; the area is constrained on both sides by homes, streets, pump stations and the slough itself and underlain by organic-rich silts, clays, peat, and mud deposits.

Eleven different template options were developed to address a variety of levee performance issues for this project. These templates are part of a Parametric Cost Estimation Tool (PCET) developed for the Urban Levee Evaluation Program (ULE) by URS Inc. The PDT leveraged the PCET's flexibility to incorporate the various USACE design criteria and implement a more efficient method of developing project costs and study execution while following the implementation of 3x3x3. The ground improvement mitigation template within the PCET is the only template with the ability to address seismic issues. The template is versatile and addresses seismic as well as a combination of other possible failure modes, such as through-seepage, underseepage, and slope stability that exist within the project area. Other options such as slope flattening/widening would not address the existing combination of issues (i.e. seismic and underseepage) and the densely populate area cannot provide needed real estate for extended seepage berms.

Discussion of design criteria used to develop the template options follows in Section 4.3.2. The eleven template options assigned as mitigation measures are described in detail in Section 4.3.3 and are included as Enclosure 5. The templates were created following USACE levee design criteria for the purpose of establishing project costs only, the templates are not intended for design.

With-project analyses were not completed on the templates shown in Section 4.3.3. Each of the templates was developed using standard levee criteria, constituents, and configurations. Similar projects with site conditions analogous to this area have used comparable mitigation measures yielding with-project analyses satisfying design requirements and criteria.

4.3.2 Criteria

The following paragraphs present USACE standard levee design and construction criteria as established in both national (HQ) and local (District and Division) policy documents and a discussion of how the PDT has made assumptions in applying those criteria to the LSJRFS area. As stated earlier, it is anticipated that significant quantities of material will be required for construction of the proposed project. Several different performance improvement measures, such as seepage berms, cutoff walls, embankment construction/reconstruction, and erosion protection are proposed. This section describes the proposed minimum material requirements and design criteria for the LSJRFS area.

TYPE I LEVEE FILL (SELECT LEVEE FILL)

The Sacramento District Geotechnical Engineering Branch SOP-03 established the requirements of engineered fill to be used for the construction of levee embankments. This is referred to as either Type I Levee Fill or Select Levee Fill and meets the following requirements:

- 100% passing the 2-inch sieve
- minimum 20% fines content (material passing the #200 sieve, i.e., silt and clay size particles)
- fines must have a liquid limit less than 45 and a plasticity index between 8 and 40
- no organic material or debris may be present

RANDOM FILL

It is acknowledge that not all improvement features will require Type I Levee Fill and that a less stringent material specification is required for some seepage berms, some stability berms, and in some cases reconstructed embankment slopes. The actual specification of this material will be based on the type of material available at project borrow sites, but in general would conform to the following requirements:

- 100% passing the 2-inch sieve
- minimum 12% fines content (material passing the #200 sieve, i.e., silt and clay size particles)
- no organic material or debris may be present

RIP-RAP

Since 1936, the Sacramento District has placed rock erosion protection on the banks and levees and associated tributaries. The Sacramento River Bank Protection Project (SRBPP) uses a standard rip-rap and filter gradation for repair sites which may be appropriate within the LSJRFS area. However, preliminary calculations of rip-rap requirements for a typical channel section with an average channel velocity of 7.0 fps and for 12.0 fps result in a D100 of 18.0 and 36.0 inches with a D15 of 7.1 and 14.3 inches, respectively. If erosion protection is to be part of the LSJRFS area mitigation alternatives, the actual gradations will need to be determined during design. Rip-rap erosion protection would adhere to the following: the rip-rap should be angular in shape, sound, durable, and hard; the rip-rap should also be free from laminations, weak cleavages, undesirable weather, blasting or handling induced fractures; the rip-rap stone should be of such character that it will not disintegrate from the action of air, water, or conditions of handling and placing and should be free from earth, clay, refuse, or adherent coatings.

GEOMETRY

The typical USACE levee section established by the USACE guidance document EM 1110-2-1913 is nationally considered to have a minimum 10-foot crest width with waterside and landside slopes no steeper than 2H:1V. The Sacramento District guidance document, SOP-03 (Standard Operating Procedure), suggests a minimum crest width of 20 feet for mainline and major tributary levees and 12 feet for minor tributary levees; the levee section should have 3H:1V waterside and landside slopes, except existing levees with good past performance where existing 2H:1V slopes are acceptable. The use of Sacramento District standard sections is generally limited to levees of moderate height, less than 25 feet, in reaches where there are no serious underseepage problems, weak foundation soils, or constructed of unsuitable materials. The standard levee section may have more than the minimum allowable FOS relative to slope stability and seepage, its slopes being established primarily on the basis of construction and maintenance considerations.

For the LSJRFS area, the minimum crest width for mainline or major tributary levees is 20 feet; the minimum crest width for minor tributaries levees is 12 feet. Existing levees with landside and waterside slopes as steep as 2H:1V may be used in rehabilitation projects if slope performance has been good and if the slope stability analyses determined the factors of safety to be adequate. Newly constructed levees should have 3H:1V waterside and landside slopes.

VEGETATION AND ACCESS

Vegetation, encroachment, and access policy includes EM 1110-2-1913, SOP-03, and ETL 1110-2-583 *Guidelines for Landscaping and Vegetation Management at Levees, Floodwalls, Embankments Dams, and Appurtenant Structures*. The vegetation-free zone, as established by ETL 1110-2-583, is a three-dimensional corridor surrounding all levees, floodwalls, and critical appurtenant structures in a flood damage reduction system. The vegetation-free zone applies to all vegetation except grass. The minimum height of the corridor is 8 feet, measured vertically from any point on the ground. The minimum width of the corridor is the width of the flood-control structure (Levee toes or floodwall stem), plus 15 feet on each side, measured from the outer edge of the outermost critical structure. Figure 4-1 taken from Appendix A of ETL 1110-2-583 shows a two dimensional representation of the vegetation-free zone of a basic levee cross-section.

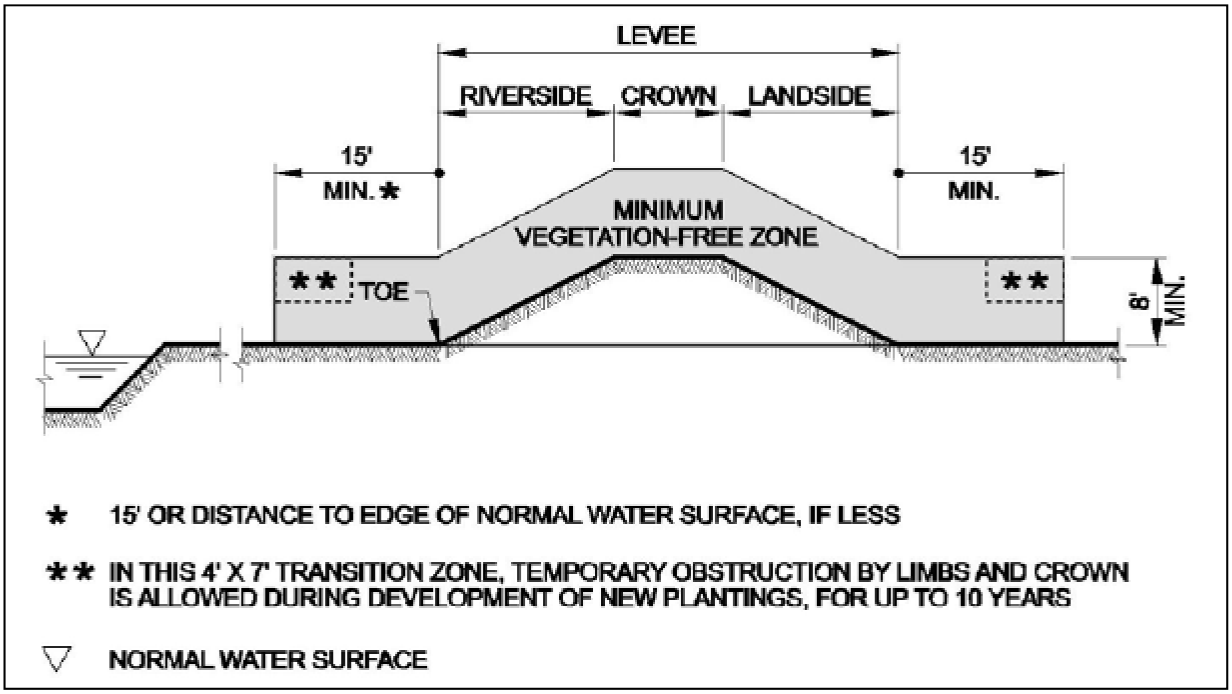


Figure 4-1: Vegetation-Free Zone of Basic Levee

The primary purpose of the vegetation-free zone is to prevent any damages of the levee embankment due to vegetation (including seepage along the woody vegetation root system, additional scouring of the waterside slope due to trees uprooting, and attraction of rodents) and to provide a reliable corridor of access to and along the flood-control structure for flood fighting, inspection, and maintenance of the flood control structures. The access corridor must be an all-weather corridor free of obstructions to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood-fighting. In the case of flood-fighting, this access corridor must also provide the unobstructed space needed for the construction of temporary flood-control structures. Access is typically by four-wheel-drive vehicles, but for some purposes, such as maintenance and flood-fighting, access is required for larger equipment, such as tractors, bulldozers, dump trucks, and helicopters. Accessibility is essential to the reliability of flood damage reduction systems. The Sacramento District guidance document, SOP-3, suggest easements consist of a minimum 20 foot landside clear access easement and a minimum 15 foot waterside easement.

For new levees constructed in the LSJRFS area, a minimum landside toe clear access easement of 20 feet is required; for existing levees within the LSJRFS area, a minimum landside toe clear access easement of 10 feet is required. For both new and existing levees in the LSJRFS a minimum waterside toe vegetation-free zone of 15 feet is required.

For a levee section to be considered compliant with USACE vegetation policy it must either have been cleared of vegetation within the vegetation-free zone or eligible for a variance from USACE policy on vegetation in ETL 1110-2-583. The variance must be necessary, and the only feasible means to preserve, protect, and enhance natural resources, and/or protect the rights of

Native Americans, pursuant to treaty, statute, or executive order. The variance must assure that safety, structural integrity, and functionality are retained, and accessibility for maintenance, inspection, monitoring, and flood-fighting are retained. The variance may require structural measures to mitigate vegetation, such as overbuilt sections, to improve levee system reliability, redundancy, or resiliency with respect to the detrimental impacts of the vegetation.

SEEPAGE AND STABILITY

Seepage and slope stability criteria for geotechnical analysis were established based on ETL 1110-2-569 Design Guidance for Levee Underseepage, EM 1110-2-1913 Design and Construction of Levees, and the Sacramento District's SOP-03. Steady state seepage analysis for a design water surface elevation considered a maximum allowable vertical exit gradient at the toe of the levee to be 0.5. In general, this provides a FOS against uplift failure of about 1.6, considering an impervious blanket saturated unit weight of 112 pcf. Steady state seepage analysis for a top-of-levee water elevation considered a maximum allowable vertical exit gradient at the toe of the levee to be 0.8. In general, this provides a FOS against uplift failure of about 1.0, considering the impervious blanket saturated unit weight of 112 pcf. The minimum required FOS for the design water surface elevation for the landside steady state slope stability analysis is 1.4. The minimum required FOS for the top-of-levee water surface elevation for the landside steady state slope stability analysis is 1.2. For landside seepage berms, a maximum allowable vertical exit gradient at the toe of the berm is considered to be 0.8. The analysis cases of during construction, post construction, rapid drawdown, and waterside partial pool were considered to be design level analyses and were not performed for this feasibility study.

As discussed in Section 4.3.1, geotechnical seepage and stability analyses were not performed in this study for the with-project template configurations. The template configurations were developed using standard levee criteria, constituents, and configurations. Configurations similar to the templates have been used in many previous projects and been shown to meet the seepage and stability criteria listed here. Some refinements to the configurations may be needed and should be expected; such refinements are design-level analysis and are beyond the scope of this feasibility study.

SEISMICITY AND LIQUEFACTION

As stated in Section 3.7.2, the LSJRFS area is unlike most levee system locations in that the study area contains both infrequently loaded levees (Central and South Stockton) and frequently loaded levees (North Stockton). The presence of frequently loaded levees in the study area creates special concern with respect to seismic events. In particular, the presence of frequently loaded levees means that it is not unlikely that a seismic event will occur concurrently with a high-water event. For most other study areas, it is very unlikely to have a concurrent seismic event and a high-water event. For such areas, a seismic event may damage levees, but since there is no water high on the levees when the damage occurs, flooding due to breach of the levees is very unlikely. For areas like North Stockton, the levees are loaded daily due to the tidal cycle; therefore, it is feasible that a seismic event and a high-water event could occur concurrently. During such an event, if the seismic event damages the levees, the damage may indeed cause flooding due to breaching of the levees.

For the LSJRFS levees, the most likely damage inducing mechanism during a seismic event is liquefaction. The consequences of triggering liquefaction may include flow slide or post-earthquake instability and lateral spreading. Where static driving shear stress is greater than the resisting strengths after liquefaction (residual strength), a global or structural failure can occur leading to loss of freeboard, cracking, and increased vulnerability to piping. Lateral deformation can also develop as a consequence of instability due to partial loss of shear strength or accumulation of shear strains throughout the soil profile. Lateral spreading towards any open channel or face can occur in mildly sloping ground and extend to very large distances away from the open face. Vertical displacement can develop as a consequence of reconsolidation of the liquefied soil. Areas of concern during and after a seismic event would include those where transverse cracking might develop between liquefiable and non-liquefiable reaches and where these zones may abut infrastructure.

As stated in Section 3.7.1, seismic loading parameters are developed using the USGS 2008 PSHA Interactive Deaggregation web program, and analyses to determine liquefaction potential are based on a procedure from the summary report of the 1996 National Center for Earthquake Engineering Research (NCEER) and 1998 NCEER/National Science Foundation (NSF) Workshops on Evaluation of Liquefaction Resistance of Soils; published as part of the Journal of Geotechnical and Geoenvironmental Engineer, dated October 2001 (Youd, Idriss, Andrus, & Arango, October 2001).

For the LSJRFS study, global or structural stability was evaluated where liquefiable layers with factors of safety less than 1.0 were found. Lateral spreading and post-liquefaction reconsolidation settlement were considered only when structural stability had a FOS greater than 1.0 but not greater than 1.2. Where liquefiable layers were found to have a FOS less than 1.0, static limit equilibrium stability analysis using UTEXAS4 based on Spencer's method was performed; if an adjacent zone had a FOS less than 1.4, it was included with the zone containing liquefiable layers. Automatic circular shear surface search and non-circular or wedge shear surface search were performed for both the landside and waterside in UTEXAS4. Post-earthquake residual shear strength was used for the liquefiable layers. The residual strength was estimated per Seed and Harder, 1990.

A more detailed description of the design criteria used for the LSJRFS area is displayed in the graphics in Section 4.3.3 and included as Enclosure 5.

4.3.3 Mitigation Measure Templates

The eleven (11) templates described below were developed to address a variety of levee performance issues while following current USACE levee design criteria as described in the preceding sections of this report. For the LSJRFS, the purpose of the assigned template was to develop quantities for establishing project costs. The templates are not intended for design or construction.

Template Option 1, Landside Slope Reconstruction, has a reconstructed landside slope and includes an internal drainage layer to mitigate for through-seepage of the levee embankment and/or seepage-related landside slope instability. This template has the flexibility to accommodate varying levee heights and crest widths. The variables shown in Figure 4-2 were assigned values when submitted as a mitigation measure based on location (e.g., geotechnical conditions within the reach, geometry of existing levees within and adjacent to the reach, etc.) and USACE levee design criteria. This template would be assigned in areas where the landside of the embankment was identified as having potential deficiencies of landside slope instability and/or through-seepage, but without an underseepage deficiency.

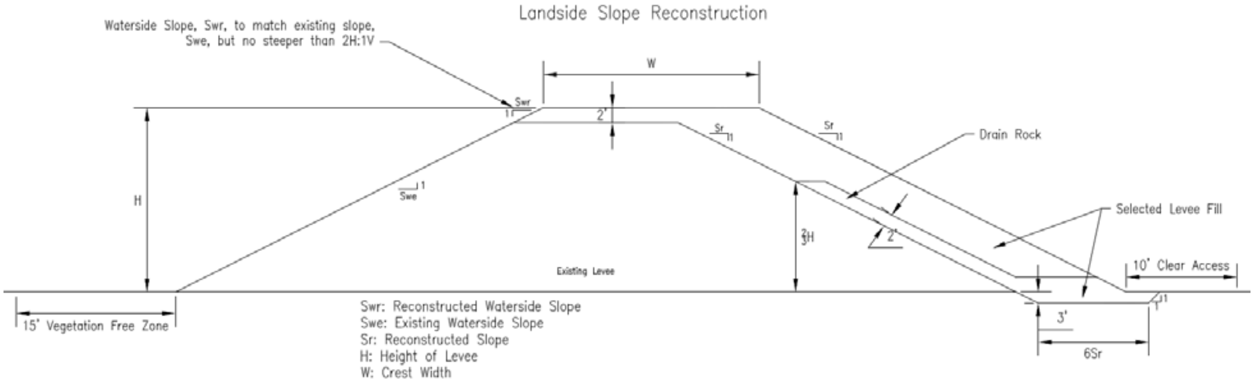


Figure 4-2: Template Option 1 – Landside Slope Reconstruction

Template Option 2, Centerline Cutoff Wall, contains a cutoff wall (usually SB or SCB) to mitigate for through-seepage and underseepage. This template provides secondary benefits by reducing pore pressures that could lead to internal erosion, and improved landside slope stability. This template has the flexibility to accommodate varying levee heights, and depth of cutoff wall. Traditional methods of cutoff wall excavation involve a long-arm excavator with maximum depths of excavation between 75 to 80 feet below ground surface (BGS) of the working platform; depths beyond 75 to 80 feet BGS would require a DSM method with increased associated costs. The variables shown in Figure 4-3 were assigned values when submitted as a mitigation measure based on location and USACE levee design criteria. This template would be assigned in areas that were identified as having an underseepage and/or through-seepage deficiency. If crest width (W) does not meet USACE levee design criteria, Template Option 3, Cutoff Wall with Landside Slope Reconstruction, would supersede this template option.

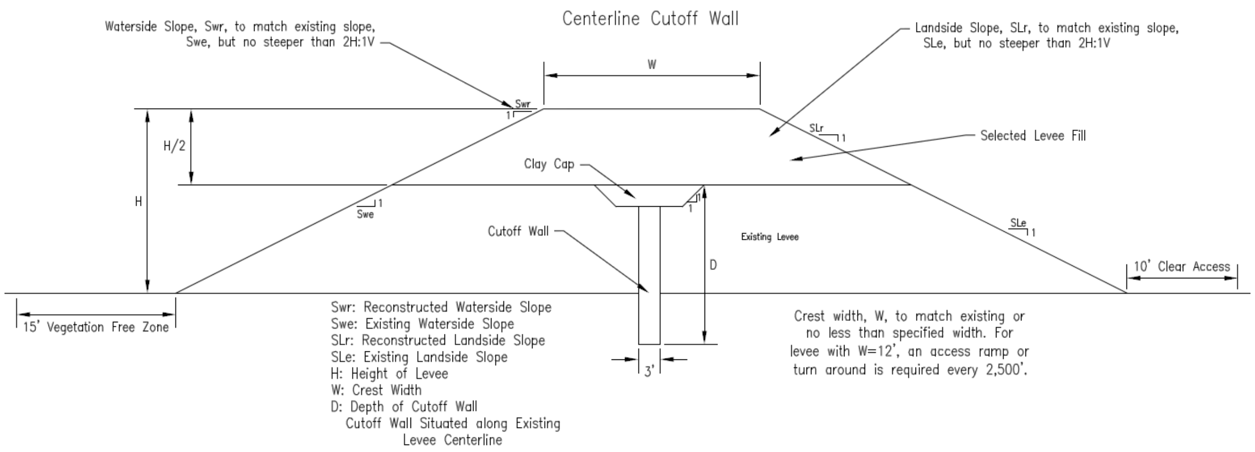


Figure 4-3: Template Option 2 – Centerline Cutoff Wall

Template Option 3, Cutoff Wall with Landside Slope Reconstruction, has a reconstructed landside slope and contains a cutoff wall (usually SB or SCB) to mitigate for through-seepage and underseepage. This template provides secondary benefits by reducing pore pressures that could lead to internal erosion, and improved landside slope stability. The presence of the cutoff wall negates the need for the internal drainage layer at the reconstructed landside slope. The template includes a half-levee degrade/reconstruction, as described in Section 4.1.1. This template has the flexibility to accommodate varying levee heights, crest widths, and depth of cutoff wall. Traditional methods of cutoff wall excavation involve a long-arm excavator with maximum depths of excavation between 75 to 80 feet below ground surface (BGS) of the working platform; depths beyond 75 to 80 feet BGS would require a DSM method with increased associated costs. The variables shown in Figure 4-4 were assigned values when submitted as a mitigation measure based on location and USACE levee design criteria. This template would be assigned in areas that were identified as having an underseepage and/or through-seepage deficiency along with a levee crest that is narrow (i.e., that needs to be widened).

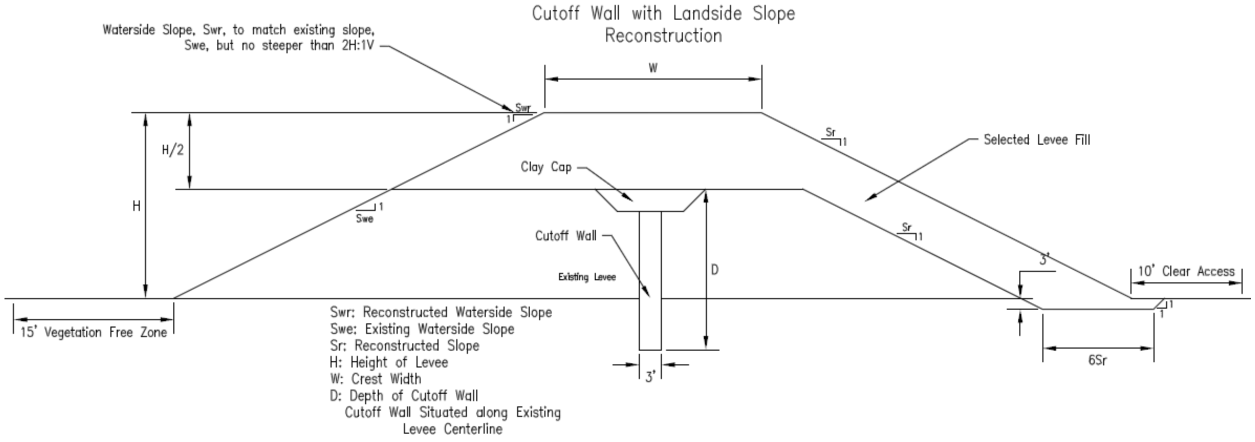
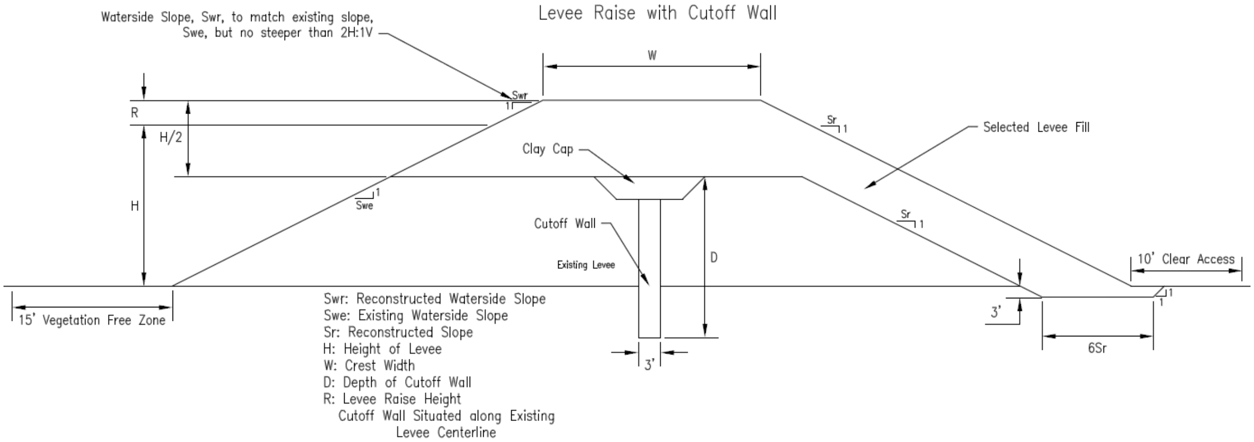


Figure 4-4: Template Option 3 – Cutoff Wall with Landside Slope Reconstruction

Template Option 4, Levee Raise with Cutoff Wall, is similar to Template Option 3 (Cutoff Wall with Landside Slope Reconstruction) but also includes components to raise the height of the levee to address height deficiency. The variables shown in Figure 4-5 were assigned values when submitted as a mitigation measure based on location and USACE levee design criteria. This template would only be assigned in an area with a height deficiency where there was also an underseepage and/or through-seepage deficiency. Template Option 3 would supersede this option if no height deficiency were present.

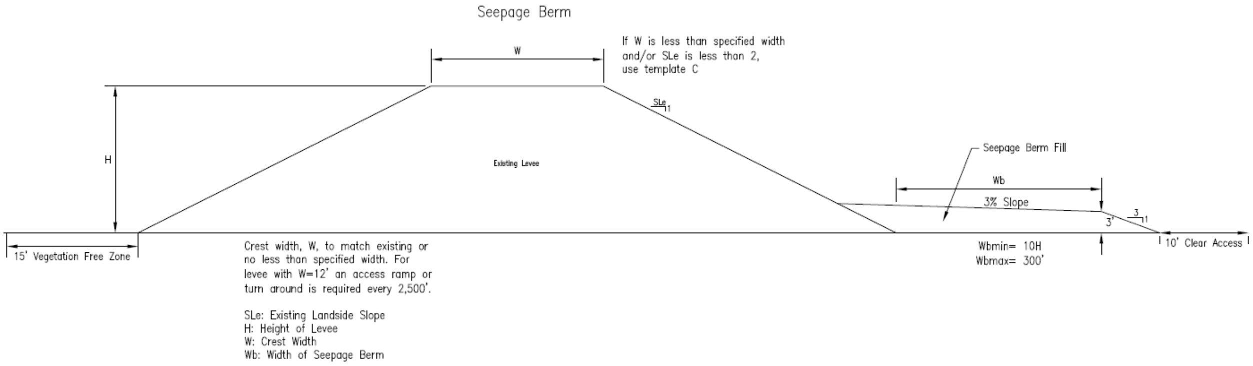


Waterside Slope, Swr, to match existing slope, Swe, but no steeper than 2H:1V

Swr: Reconstructed Waterside Slope
Swe: Existing Waterside Slope
Sr: Reconstructed Slope
H: Height of Levee
W: Crest Width
D: Depth of Cutoff Wall
R: Levee Raise Height
Cutoff Wall Situated along Existing Levee Centerline

Figure 4-5: Template Option 4 – Levee Raise with Cutoff Wall

Template Option 5, Seepage Berm, includes a landside seepage berm to mitigate for underseepage. This template would be for existing levees with an underseepage deficiency but not through-seepage or landside slope instability. Even though this template has the flexibility to accommodate varying levee heights and crest widths, the width of the seepage berm, W_b, shown in Figure 4-6 follows USACE levee design criteria and adjusts to varying levee heights per site conditions. The seepage berm width, W_b, was set at 10H (where H is the levee height) for cost estimating purposes. Actual seepage berm widths depend largely on site specific geotechnical conditions; calculation of actual widths that would be needed was beyond the scope of this study.



If W is less than specified width and/or SLe is less than 2, use template C

Crest width, W, to match existing or no less than specified width. For levee with W=12' an access ramp or turn around is required every 2,500'.

SLe: Existing Landside Slope
H: Height of Levee
W: Crest Width
Wb: Width of Seepage Berm

Figure 4-6: Template Option 5 – Seepage Berm

Template Option 6, Combination Berm, has a reconstructed landside slope and includes a landside seepage berm to mitigate for underseepage and also through-seepage and/or landside slope instability and/or crest widening. This template was included as an alternative option to the Cutoff Wall with Landside Slope Reconstruction option, Template Option 3. This template has the flexibility to accommodate varying levee heights, crest widths, and seepage berm widths. The variables shown in Figure 4-7 were assigned values when submitted as a mitigation measure based on location and USACE levee design criteria. The seepage berm width, W_b, was set at 10H (where H is the levee height) for cost estimating purposes. Actual seepage berm widths depend largely on site specific geotechnical conditions; calculation of actual widths that would be needed was beyond the scope of this study. This template would be assigned in areas that were identified as having an underseepage deficiency along with the need for levee crest widening.

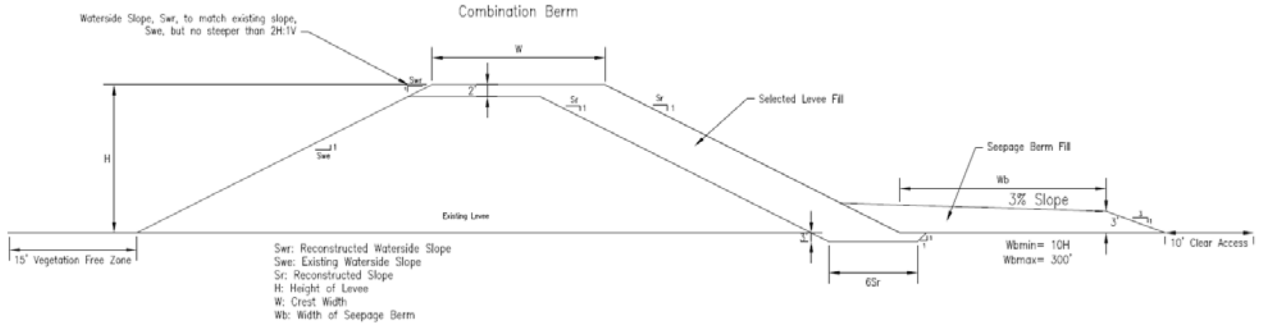


Figure 4-7: Template Option 6 – Combination Berm

Template Option 7, Levee Raise with Combination Berm, is similar to Template Option 6 (Combination Berm) but also includes components to raise the height of the levee to address height deficiency. This template was included as an alternative option to the Levee Raise with Cutoff Wall option, Template Option 4. The variables shown in Figure 4-8 were assigned values when submitted as a mitigation measure based on location and USACE levee design criteria. The seepage berm width, W_b, was set at 10H (where H is the levee height) for cost estimating purposes. Actual seepage berm widths depend largely on site specific geotechnical conditions; calculation of actual widths that would be needed was beyond the scope of this study. This template would only be assigned in areas with a height deficiency where there was also an underseepage deficiency. Template Option 6 would supersede this option if no height deficiency were present.

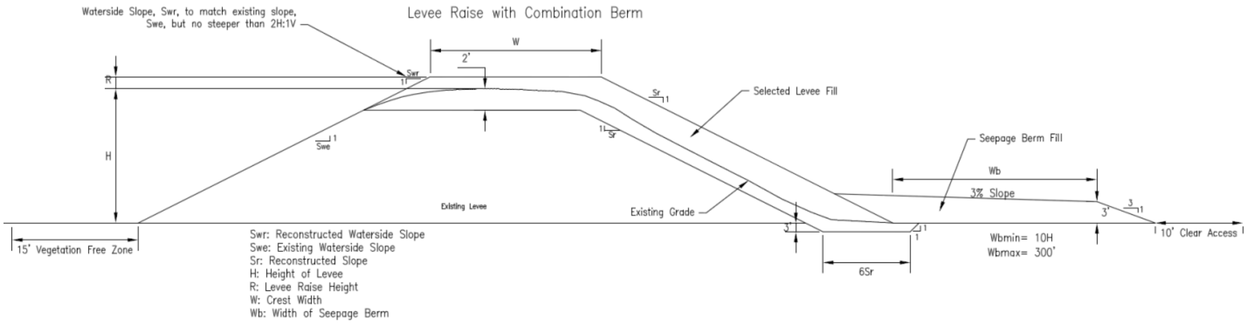


Figure 4-8: Template Option 7 – Levee Raise with Combination Berm

Template Option 8, New Levee, would be for areas where a new levee is proposed and no additional measures are needed to mitigate for underseepage. This template has the flexibility to accommodate varying levee heights and crest widths. The variables shown in Figure 4-9 were assigned values when submitted as a mitigation measure based on location and USACE levee design criteria.

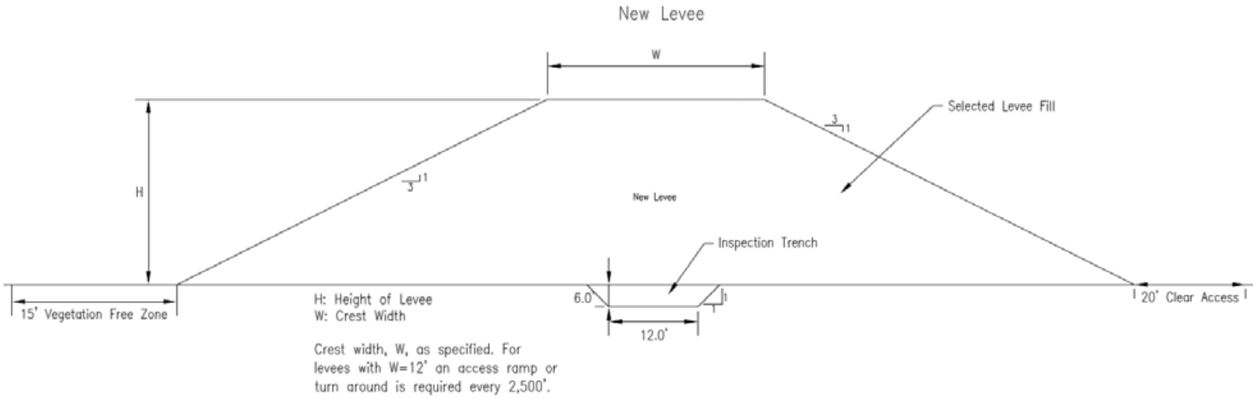


Figure 4-9: Template Option 8 – New Levee

Template Option 9, New Levee with Cutoff Wall, is a template for a new levee (i.e., at a location where no levee currently exists) but that also includes a cutoff wall to mitigate for underseepage. This template was included as an alternative option to the New Levee with Seepage Berm option, Template Option 10. This template has the flexibility to accommodate varying levee heights, crest widths, and depth of cutoff wall. The variables shown in Figure 4-10 were assigned values when submitted as a mitigation measure based on location and USACE levee design criteria.

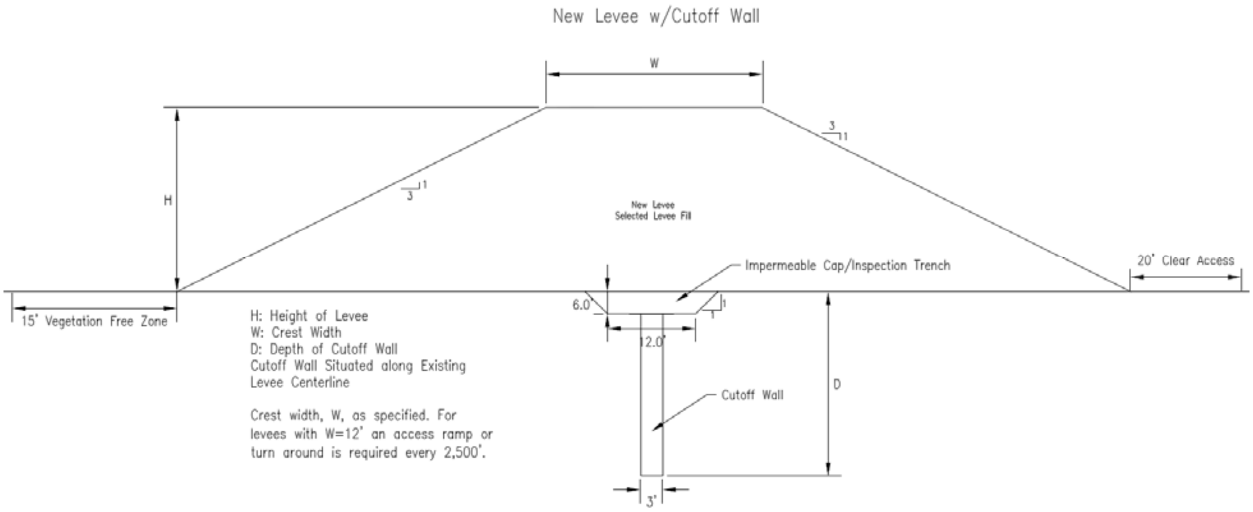


Figure 4-10: Template Option 9 – New Levee with Cutoff Wall

Template Option 10, New Levee with Seepage Berm, is a template for a new levee (i.e., at a location where no levee currently exists), but also includes a landside seepage berm to mitigate for underseepage. This template would be for new levee construction in areas with the potential for underseepage, where the underseepage potential would not be adequately mitigated by the standard levee width. This template has the flexibility to accommodate varying levee heights, crest widths, and seepage berm widths. The variables shown in Figure 4-11 were assigned values when submitted as a mitigation measure based on location and USACE levee design criteria. The seepage berm width, W_b, was set at 10H (where H is the levee height) for cost estimating purposes. Actual seepage berm widths depend largely on site specific geotechnical conditions; calculation of actual widths that would be needed was beyond the scope of this study.

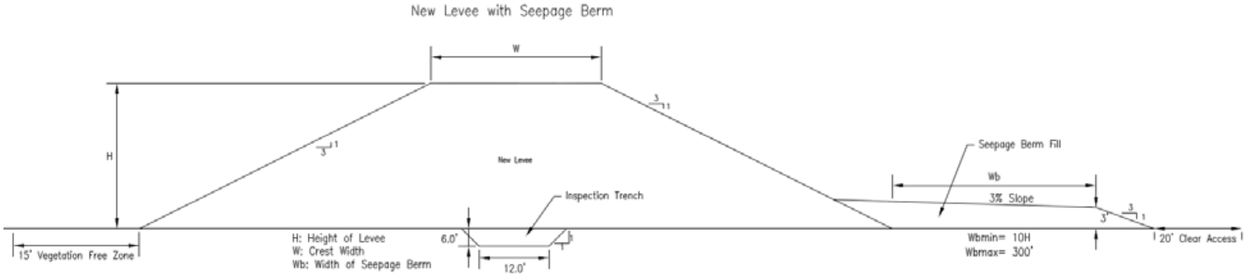


Figure 4-11: Template Option 10 – New Levee with Seepage Berm

Template Option 11, Seismic DSM (Levee Degrade) Seismic Remediation, is an option to remediate areas of special seismic concern, i.e., areas of levee within North Stockton that are frequently loaded (due to slough water surface elevations that are tidally influenced) and that are also subject to potentially significant deformations due to a seismic event. This template incorporates:

- a levee degrade to half its height
- a series of overlapping deep-soil-mixing columns installed at specified longitudinal and transverse spacing that extend just beyond the extents of the levee prism
- reconstructed levee using select levee fill

This template has the flexibility to accommodate varying levee heights, crest widths, and depth of ground improvement. This template provides secondary benefits by reducing pore pressures that could lead to internal erosion, and improved landside slope stability. The variables shown in Figure 4-12 were assigned values when submitted as a mitigation measure based on preliminary seismic analyses, engineering judgment, and USACE levee design criteria. This template would be assigned only in an area of special seismic concern, i.e., areas where the levees are frequently loaded (tidally) and also subject to potentially significant deformations due to a seismic event.

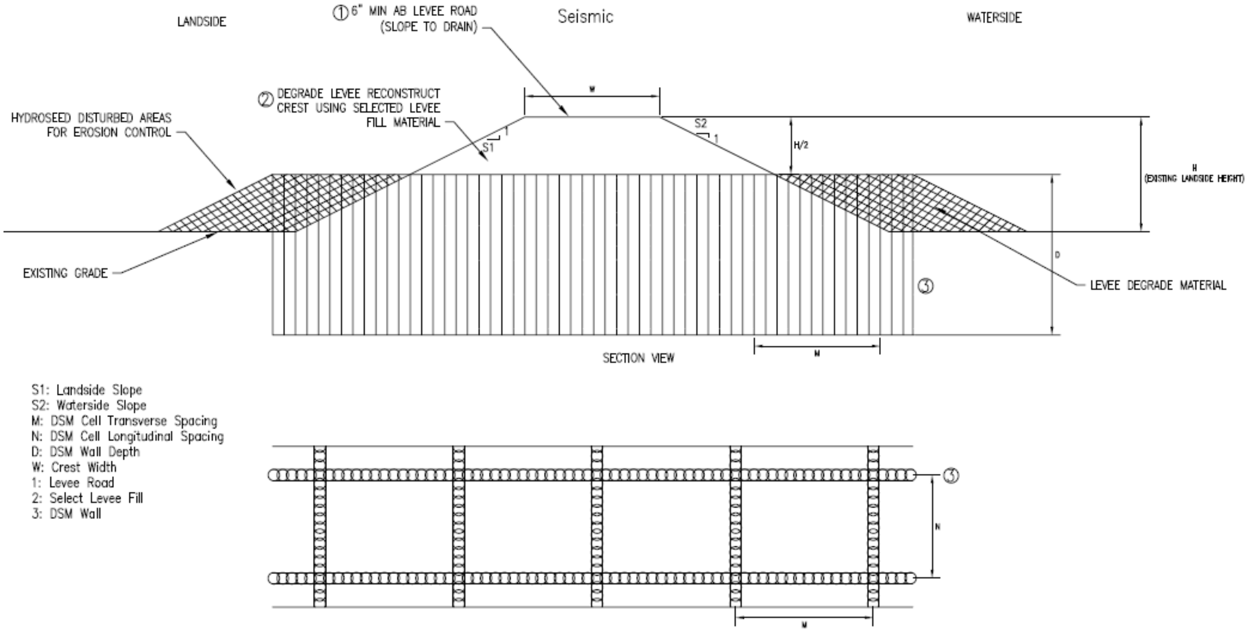


Figure 4-12: Template Option 11 – Seismic DSM (Degrade Levee) Seismic Remediation

4.3.4 Selection of Template Options for Mitigation Measures

As discussed in Section 4.3.1, template options were assigned to each reach considering two primary factors: (1) the intent of the Management Measure for the reach (e.g., strengthen existing levee, raise existing levee); and (2) the geotechnical potential failure modes that need to be mitigated for the reach. Also, to the extent possible, for each reach, two different options were assigned (typically a cutoff wall option and a seepage berm option) to allow for some optimization with respect to costs and impacts. Through this process, Management Measures and their mitigation options were assigned to more than 120 reaches.

Working through the Planning process to the Final Array of Alternatives has yielded six different alternatives. The approximate distribution of the selected template options within the Final Array of Alternatives ranges as follows:

- Template options for cutoff walls and seepage berms were chosen as mitigation between 70-80 percent and 8-10 percent of the time, respectively, to address through-seepage and underseepage.
- The template option for seismic was chosen to represent a smaller percentage of the reaches, roughly 2-4 percent of the time, to address areas with special seismic concerns.
- This template option for new levees was chosen to represent a smaller percentage of the reaches, roughly 6-8 percent of the time, to address areas where a levee did not currently exist.

4.4 WITH PROJECT PERFORMANCE CURVES

Consistent with the evolving Planning process and the implementation of Planning Modernization initiatives, with-project fragility curves were not developed for the LSJRFS. In an effort to develop with-project costs and benefits, the PDT decided that a with-project condition would be sufficiently approximated by a zero fragility assumption for water surface elevations prior-to-overtopping. This assumption would therefore flat-line the through-seepage, underseepage, slope stability, and judgment curves for water surface elevations below the levee crest elevation. Experience of performing analyses on with-project conditions in similar project areas and design configurations for seepage and stability mitigation has shown it to be reasonable to assume the mitigation measures assigned would successfully mitigate poor performing levees to produce such results. However, the judgment curve component of the fragility curve would not completely flatten with implementation of the template options, due to remaining potential for vegetation, encroachments, animal burrows, and/or erosion associated with many of the templates (levee design is not based on fragility, but rather USACE levee design criteria). Therefore, the assumption of the zero-fragility (i.e., flat-line) fragility curve may potentially overestimate with-project benefits and underestimate residual risk. This was recognized by the PDT and included as a Risk Register item. For further explanation of developing with-project fragility for the LSJRFS, refer to the Economics Summary in Appendix A.

5. CONCLUSIONS

This report presented the results of geotechnical analyses and feasibility level geotechnical recommendations to address technical deficiencies in the flood risk management system protecting the LSJRFS area. The recommended measures consist of a combination of structural measures to mitigate deficiencies in levee height, geometry, erosion, access, vegetation, seepage, and slope stability.

The results of the without project seepage and slope stability analyses for South Stockton indicated that the levees represented by index points LR-1, LR-2, and LR-3 in RD-17 did not meet minimum levee design criteria at various flood frequencies. Historical documentation indicates performance-related issues with seepage, slope instability, and erosion. The measures identified in this study to mitigate these performance issues, to create with-project conditions, typically included a cutoff wall and/or seepage berm.

The results of the without project seepage and slope stability analyses for Central Stockton indicated that the levees represented by index points FR-1 in RD-404, and SL-1 and SL-2 along Stockton Diverting Canal did not meet minimum levee design criteria at various flood frequencies. Historical documentation indicates performance-related issues with seepage and erosion along RD-404, erosion along the left bank of the Calaveras River with isolated areas of seepage, and erosion along the left bank of Stockton Diverting Canal. The measures identified in this study to mitigate these performance issues, to create with-project conditions, typically included a cutoff wall and/or seepage berm.

The results of the without project seepage and slope stability analyses for North Stockton indicated that the levees represented by index points CR-1/CR-2 and D-4 along the right bank of the Calaveras River, and index point D-BS along Delta Brookside, did not meet minimum levee design criteria at various flood frequencies. Historical documentation indicates performance-related issues with settlement, seepage, erosion, and animal burrowing activity along the Delta Brookside study area, and seepage and erosion along Delta Lincoln Village study area. The measures identified in this study to mitigate these performance issues, to create with-project conditions, typically included a cutoff wall and/or seepage berm.

The results of seismic and liquefaction evaluation indicated isolated areas throughout the study area that are capable of inducing significant deformation of the levees. Additionally, liquefaction analyses showed two areas within RD-17, and one area within RD-404, that contained zones of material that are susceptible to liquefaction when subjected to a 200-year seismic event. Most of these areas are unlikely to be capable of inducing flow failures and significant deformation of the levees. However, the Delta Brookside levees and the Deep Water Ship Channel levees, south of Delta Brookside, may also be susceptible to significant deformation due to a seismic event. Importantly, these levees are frequently loaded levees underlain by unconsolidated organic-rich silts, clays, peat, and mud deposits. As a result, seismically induced deformation may occur concurrently with a high water condition, which poses a greater risk than is typically the case for levees subject to possible seismic damage. Consequently, a special seismic mitigation measure was identified in this study to mitigate this performance issue to create a with-project condition in these areas. The seismic mitigation measure assumes full mitigation of all areas identified as a seismic concern. As this project proceeds into its design phase of work, there will be a potential to reduce the extents of the seismic mitigation with further analyses, to include a risk assessment to evaluate the likelihood of breach and flooding due to liquefaction or seismic deformation. Additional information will be gathered for a FLAC analysis to determine better estimates of deformation.

UPDATE 2017: Subsequent to completion of this study, the DWR performed additional site characterization and analysis of this area. Based on this new information it appears seismic ground improvements will not be needed under the alignment west of Lincoln Village (Segments FM_30_L, FM_40_L, and FM_60_L). Seepage mitigation in the form of a 50-feet deep cutoff wall will be required for these segments. Ground conditions for this portion of the project are not well characterized so seismic ground improvement is being added to the Cost and Schedule Risk Assessment (CSRA) risk register.

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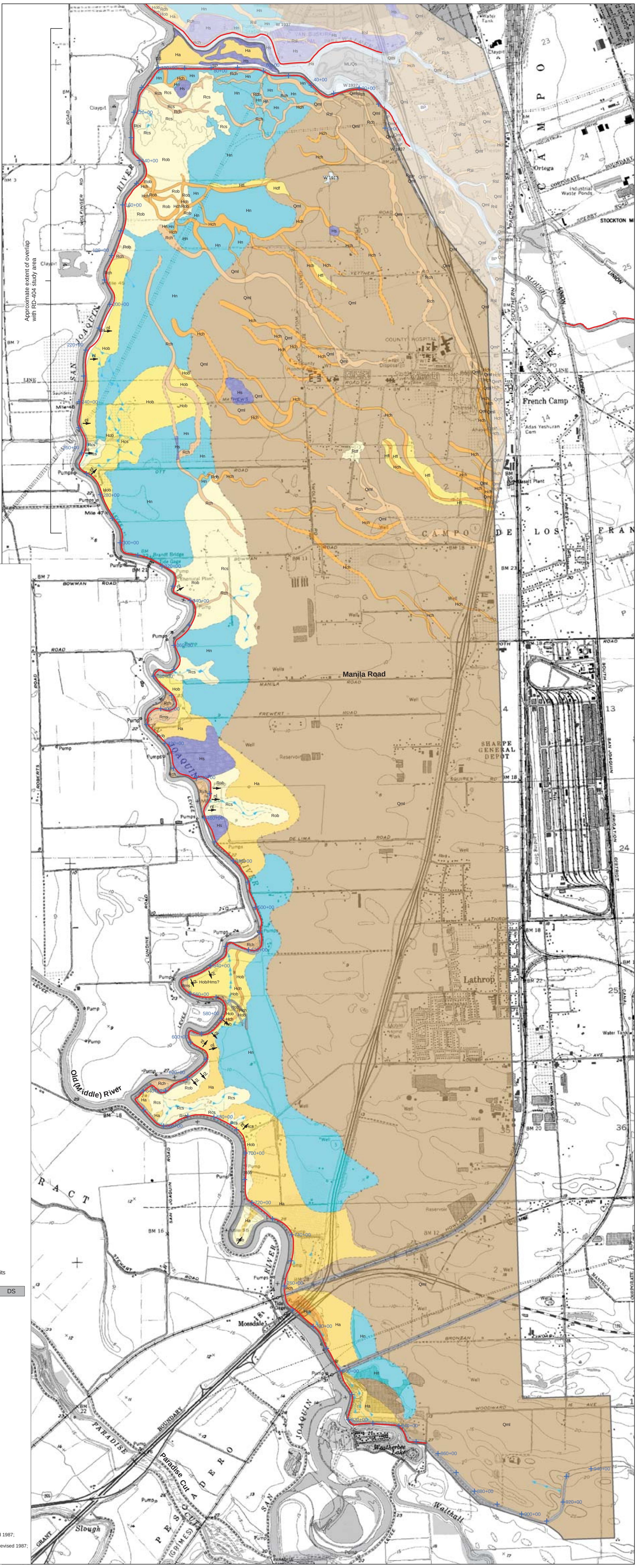
LOWER SAN JOAQUIN RIVER
FEASIBILITY STUDY

GEOTECHNICAL REPORT

ENCLOSURE E1
GEOMORPHOLOGY MAPS



This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on a modern U.S. Geological Survey 7.5' topographic base map.
Screened back semi-transparent mapping shown on this plate is from RD-404 study area, which is not assessed in this investigation.
For clarity, only the surficial geologic map units of this study appear in the explanation.
See accompanying report for complete descriptions of map units, process descriptions and methodology.

Explanation

——— – – –? ········	Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map, dashed contacts accurate to within about 250' on either side of the line.
►——►——►	Erosional channel, generally <100 ft in width; likely contains unsorted soil.
– · – · – · –	Swale; topographic lineament associated with meander scroll topography low.
———	Urban Project Levee
↘ nl	Natural levee; arrow indicates slope direction away from channel.
+ 860+00	Approximate RD-17 Levee stationing distance in feet.

W 1937	Water, circa 1937.
W 1913	Water, circa 1913.
BP	Borrow pit present in 1937.

Geologic Units

HISTORICAL	L	Levee (made of artificial fill), circa 1937.
	R	Road embankment (made of artificial fill), circa 1937.
	DS	Dredge spoils; material from dredging operations within channels.
	Rob	Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
	Rcs	Crevasse splay deposits; fine to coarse sand, with minor lenses of clay deposited from breaching of natural or artifical levees.
	Rdf	Distributary fan deposits; sand, silt and clay.
	Rch	Channel deposits; well sorted sands and fine gravels.
	Rms	Channel meander scroll deposits; sand, silt and clay from lateral channel migration.
	Rsl	Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
HOLOCENE	Hob/Hms?	Thin veneer of overbank deposits overlying probable channel meander scroll deposits.
	Hob	Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
	Hcs	Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
	Hdf	Distributary fan deposits; sand, silt and clay.
	Hfl	Fan channel levee deposits; relatively coarser (sandier and siltier) deposits accumulating next to alluvial fan channels.
	Hch	Channel deposits; sorted sands and silts; fining upward.
	Hms	Channel meander scroll deposits; sand, silt and clay from lateral channel migration.
	Ha	Alluvial deposits; undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.
	Hn	Basin deposits; fine sand, silt and clay, under cultivation in 1937.
	Hs	Marsh deposits; silt and clay, likely organic-rich; perennially or seasonally submerged on 1937 photography.
PLEISTOCENE	Qml	Modesto Formation; lower member; unconsolidated gravel, sand, silt, and clay; Alluvial fan deposits of the Stanislaus River.

Stratigraphic Correlation Chart

Time	Depositional Environment			
Epoch	Channel deposits	Floodplain and alluvial-fan deposits	Flood basin deposits	Cultural deposits
Historical	Rch Rms Rsl	Rcs Rdf Rob	Hn Hs	L R DS
Holocene	Hch Hms	Ha Hob Hcs Hfl Hdf		
Latest Pleistocene		Qml		

DWR URBAN LEVEE PROJECT
WLA WORK ORDER W02 STOCKTON

Surficial Geologic Map of the Eastern Side of the San Joaquin River, along RD-17 Levee System near Stockton and Lathrop, California

Fugro William Lettis & Associates, Inc.

Plate 1

2083_DWRLevees_RD17_Stockton_Plate.mxd

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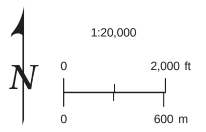


Map projection: NAD83 UTM Zone 10N

Topographic base USGS quadrangles:
Lathrop topographic quadrangle, published 1952, revised 1987;
map scale 1:24,000, five foot contour interval.
West Stockton topographic quadrangle published 1968, revised 1987;
map scale 1:24,000, five foot contour interval.

Plate 1 - Surficial Geologic Map of French Camp Slough and the Lower San Joaquin River along RD-404 Levee System, near Stockton, California

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below). See accompanying report for complete descriptions of map units, process descriptions and methodology.

Explanation

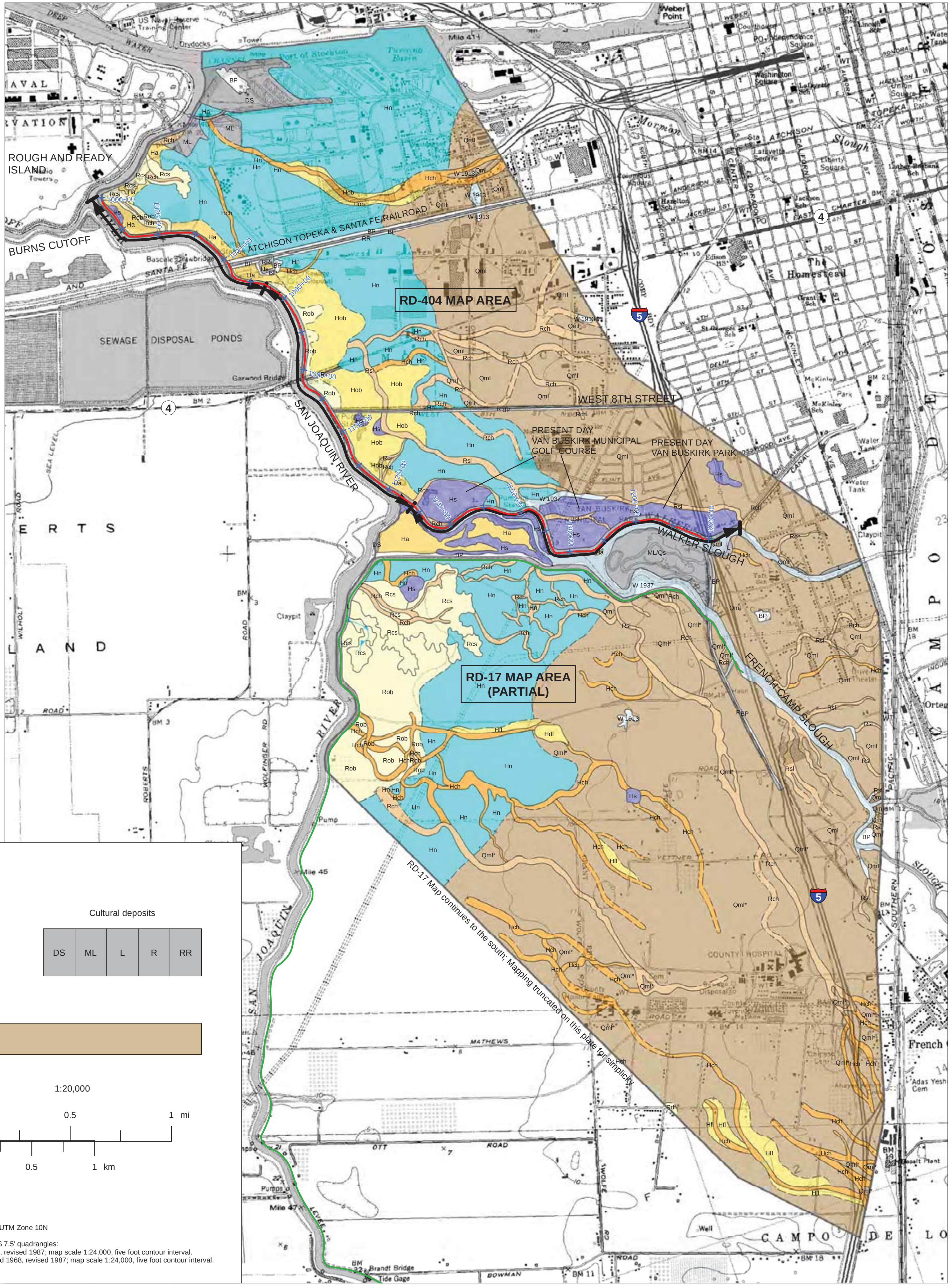
— — –? ········	Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts are accurate to within about 100 feet on either side of the line shown on the map, dashed contacts are accurate to within about 200 feet
►—►—►	Centerline of channel <30ft in width. Likely contains sorted sands and silts. Arrows indicate direction of flow.
|◄SJR-II►|	Geomorphic Reach described in text.
🟥	Urban Project Levee (RD-404 area)
🟩	Urban Project Levee (RD-17 area)
+ 1180+00	Approximate RD404 Levee stationing distance in feet (draft, 03/11/08 version).
W 1913	Water, circa 1913.
W 1937	Water, circa 1937.
BP	Borrow pit present in 1937.

Geologic Units

HISTORICAL	L	Levee (made of artificial fill), circa 1937.
	R	Road embankment (made of artificial fill), circa 1937.
	RR	Railroad embankment (made of artificial fill), circa 1937.
	DS	Dredge spoils; material from dredging operations within channels.
	ML	Made land; fill material of local and non-local sources: sand, silt, organics, garbage, etc.
	ML/Qs	Made land overlying marsh deposits.
	Rob	Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
	Rcs	Crevasse splay deposits; fine to coarse sand, with minor lenses of clay deposited from breaching of natural or artifical levees.
	Rdf	Distributary fan deposits; sand, silt and clay.
	Rch	Channel deposits; well sorted sand and trace gravel.
	Rsl	Slough deposits; sand, silt and clay, fining upward facies, low-energy channel deposits; tidally-influenced in RD-404.
HOLOCENE	Hob	Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
	Hdf	Distributary fan deposits; sand, silt and clay.
	Hch	Channel deposits; sorted sand and silt; fining upward.
	Ha	Alluvial deposits; undifferentiated; sand, silt, and minor lenses of gravel; under cultivation in 1937.
	Hn	Basin deposits; sand, silt and clay, dark yellow to dark yellowish brown, under cultivation in 1937.
	Hs	Marsh deposits; silt and clay, likely organic-rich; perennially or seasonally submerged on 1937 photography.
PLEISTOCENE	Qml	Modesto Formation; lower member; unconsolidated gravel, sand, silt, and clay. (Qml*) Asterisk denotes Modesto Formation of Stanislaus Alluvial Fan.

Stratigraphic Correlation Chart

Time	Depositional Environment													
Epoch	Channel deposits		Floodplain and alluvial-fan deposits				Basin deposits		Cultural deposits					
Historical	Rch	Rsl	Ha	Rob	Rcs	Rdf	Hn	Hs	DS	ML	L	R	RR
Holocene	Hch			Hob	Hdf								
Pleistocene	Qml												



1:20,000

0 0.5 1 mi

0 0.5 1 km

N

Map projection: NAD83 UTM Zone 10N

Topographic base USGS 7.5' quadrangles:
Lathrop, published 1952, revised 1987; map scale 1:24,000, five foot contour interval.
West Stockton, published 1968, revised 1987; map scale 1:24,000, five foot contour interval.

Surficial Geologic Map of French Camp Slough and the Lower San Joaquin River along RD-404 Levee System, near Stockton, California

FUGRO Fugro William Lettis & Associates, Inc. | Plate 1

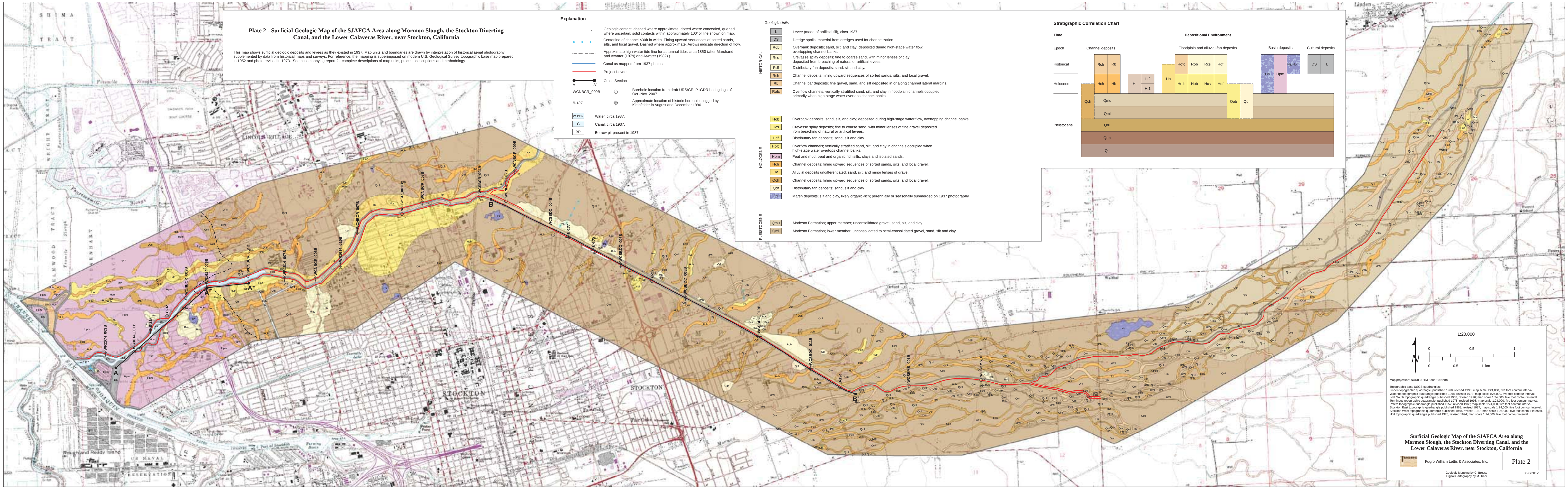
1965_RD404_Plate.mxd

Geologic Mapping by C. Brossy and J. Pearce
Digital Cartography by M. Ticci

12/14/2010

Plate 2 - Surficial Geologic Map of the SJAFCA Area along Mormon Slough, the Stockton Diverting Canal, and the Lower Calaveras River, near Stockton, California

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey topographic base map prepared in 1952 and photo revised in 1973. See accompanying report for complete descriptions of map units, process descriptions and methodology.



Explanation

	Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain; solid contacts within approximately 100' of line shown on map.
	Centerline of channel <30ft in width. Fining upward sequences of sorted sands, silts, and local gravel. Dashed where approximate. Arrows indicate direction of flow.
	Approximate high-water tide line for autumnal tides circa 1850 (after Marchand and Atwater (1979) and Atwater (1982).)
	Canal as mapped from 1937 photos.
	Project Levee
A A'	Cross Section
WCNBCR_009B ⌖	Borehole location from draft URS/GEI P1GDR boring logs of Oct.-Nov. 2007
B-137 ⌖	Approximate location of historic boreholes logged by Kleinfelder in August and December 1990
W 1937	Water, circa 1937.
C	Canal, circa 1937.
BP	Borrow pit present in 1937.

Geologic Units

HISTORICAL	L	Levee (made of artificial fill), circa 1937.
	DS	Dredge spoils; material from dredges used for channelization.
	Rob	Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
	Rcs	Crevasse splay deposits; fine to coarse sand, with minor lenses of clay deposited from breaching of natural or artifical levees.
	Rdf	Distributary fan deposits; sand, silt and clay.
	Rch	Channel deposits; fining upward sequences of sorted sands, silts, and local gravel.
	Rb	Channel bar deposits; fine gravel, sand, and silt deposited in or along channel lateral margins.
	Rofc	Overflow channels; vertically stratified sand, silt, and clay in floodplain channels occupied primarily when high-stage water overtops channel banks.
HOLOCENE	Hob	Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks.
	Hcs	Crevasse splay deposits; fine to coarse sand, with minor lenses of fine gravel deposited from breaching of natural or artifical levees.
	Hdf	Distributary fan deposits; sand, silt and clay.
	Hofc	Overflow channels; vertically stratified sand, silt, and clay in channels occupied when high-stage water overtops channel banks.
	Hpm	Peat and mud; peat and organic rich silts, clays and isolated sands.
	Hch	Channel deposits; fining upward sequences of sorted sands, silts, and local gravel.
	Ha	Alluvial deposits undifferentiated; sand, silt, and minor lenses of gravel.
	Qch	Channel deposits; fining upward sequences of sorted sands, silts, and local gravel.
	Qdf	Distributary fan deposits; sand, silt and clay.
	Qs	Marsh deposits; silt and clay, likely organic-rich; perennially or seasonally submerged on 1937 photography.
PLEISTOCENE	Qmu	Modesto Formation; upper member; unconsolidated gravel, sand, silt, and clay.
	Qml	Modesto Formation; lower member; unconsolidated to semi-consolidated gravel, sand, silt and clay.

1:20,000

0 0.5 1 mi

0 0.5 1 km

Map projection: NAD83 UTM Zone 10 North

Topographic base USGS quadrangles:
Linden topographic quadrangle, published 1968, revised 1993; map scale 1:24,000, five foot contour interval.
Waterloo topographic quadrangle published 1968, revised 1978; map scale 1:24,000, five foot contour interval.
Lodi South topographic quadrangle published 1968, revised 1976; map scale 1:24,000, five foot contour interval.
Terminous topographic quadrangle, published 1978, revised 1993; map scale 1:24,000, five foot contour interval.
Peters topographic quadrangle published 1952, revised 1968; map scale 1:24,000, five foot contour interval.
Stockton East topographic quadrangle published 1968, revised 1987; map scale 1:24,000, five foot contour interval.
Stockton West topographic quadrangle published 1968, revised 1987; map scale 1:24,000, five foot contour interval.
Holt topographic quadrangle published 1978, revised 1994; map scale 1:24,000, five foot contour interval.

Surficial Geologic Map of the SJAFCA Area along Mormon Slough, the Stockton Diverting Canal, and the Lower Calaveras River, near Stockton, California

Fugro William Lettis & Associates, Inc.

Plate 2

Geologic Mapping by C. Brossy
Digital Cartography by M. Ticci

3/28/2012

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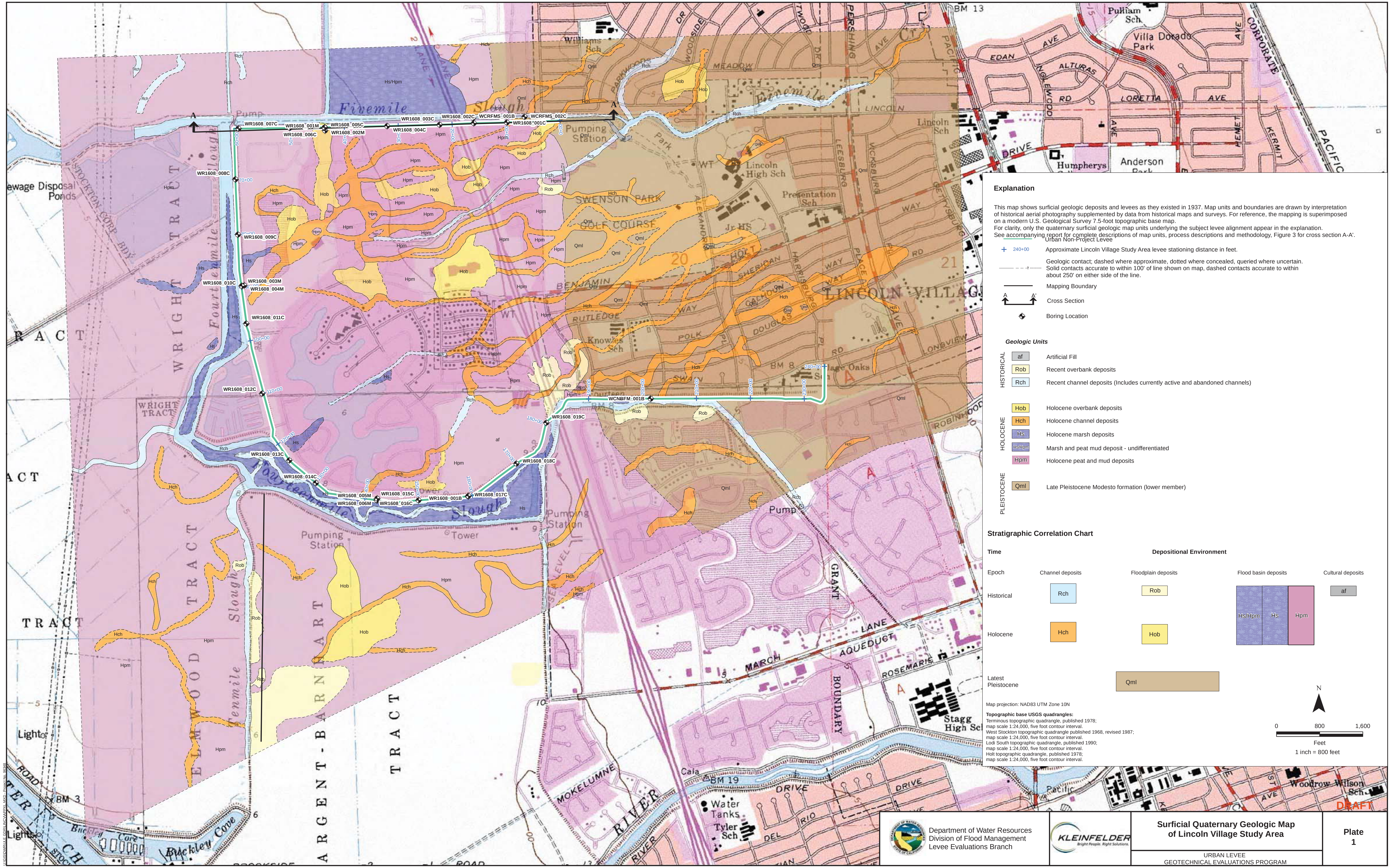


Explanation

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on a modern U.S. Geological Survey 7.5-foot topographic base map.
For clarity, only the quaternary surficial geologic map units underlying the subject levee alignment appear in the explanation.
See accompanying report for complete descriptions of map units, process descriptions and methodology, Figure 3 for cross section A-A'.

	Urban Non-Project Levee
+ 240+00	Approximate Lincoln Village Study Area levee stationing distance in feet.
— — -? ········	Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map, dashed contacts accurate to within about 250' on either side of the line.
	Mapping Boundary
A A'	Cross Section
⊕	Boring Location

Geologic Units

HISTORICAL	af	Artificial Fill
	Rob	Recent overbank deposits
	Rch	Recent channel deposits (Includes currently active and abandoned channels)
HOLOCENE	Hob	Holocene overbank deposits
	Hch	Holocene channel deposits
	Hs	Holocene marsh deposits
	Hs/Hpm	Marsh and peat mud deposit - undifferentiated
	Hpm	Holocene peat and mud deposits
PLEISTOCENE	Qml	Late Pleistocene Modesto formation (lower member)

Stratigraphic Correlation Chart

Time	Depositional Environment					
Epoch	Channel deposits	Floodplain deposits	Flood basin deposits			Cultural deposits
Historical	Rch	Rob	Hs/Hpm	Hs	Hpm	af
Holocene	Hch	Hob				
Latest Pleistocene		Qml				

Map projection: NAD83 UTM Zone 10N

Topographic base USGS quadrangles:
Terminous topographic quadrangle, published 1978;
map scale 1:24,000, five foot contour interval.
West Stockton topographic quadrangle published 1968, revised 1987;
map scale 1:24,000, five foot contour interval.
Lodi South topographic quadrangle, published 1990;
map scale 1:24,000, five foot contour interval.
Holt topographic quadrangle, published 1978;
map scale 1:24,000, five foot contour interval.

N
0 800 1,600
Feet
1 inch = 800 feet

DRAFT

Department of Water Resources
Division of Flood Management
Levee Evaluations Branch

KLEINFELDER
Bright People. Right Solutions.

Surficial Quaternary Geologic Map of Lincoln Village Study Area

URBAN LEVEE
GEOTECHNICAL EVALUATIONS PROGRAM

Plate
1

LOWER SAN JOAQUIN RIVER
FEASIBILITY STUDY

GEOTECHNICAL REPORT

ENCLOSURE E2
CALCULATION PACKAGE

LOWER SAN JOAQUIN RIVER
FEASIBILITY STUDY

WITHOUT PROJECT
STRENGTH PARAMETERS

LOWER SAN JOAQUIN RIVER
GEOTECHNICAL ANALYSIS
SJR - REACH LR-1
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_036B	1	Clay Levee	1.00E-06	4	2.50E-07	0.00284	0.00071	28	50	120
	2	Silt Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	28	0	120
	3	Clay Blanket	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120
	4	Silty Sand	1.00E-03	4	2.50E-04	2.83500	0.70875	32	0	125
	5	Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120
	6	Sand	5.00E-03	4	1.25E-03	14.17500	3.54375	32	0	125

LOWER SAN JOAQUIN RIVER
GEOTECHNICAL ANALYSIS
SJR - REACH LR-2
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_052B	1	Levee Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120
	2	Silty Sand Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	30	0	125
	3	Poorly Graded Sand wSilt	1.00E-04	4	2.50E-05	0.28350	0.07088	32	0	130
	4	Foundation Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120

LOWER SAN JOAQUIN RIVER
GEOTECHNICAL ANALYSIS
SJR - REACH LR-3
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_085B	1	Poorly Graded Sand wSilt	5.00E-03	4	1.25E-03	14.17500	3.54375	32	0	125
	2	Clayey Sand	5.00E-05	4	1.25E-05	0.14175	0.03544	30	50	125
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.17500	3.54375	32	0	125
	4	Sandy Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	28	140	120
	5	Silty Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	30	0	120
	6	Poorly Graded Sand wSilt	1.00E-02	4	2.50E-03	28.35000	7.08750	32	0	125
	7	Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120

LOWER SAN JOAQUIN RIVER
GEOTECHNICAL ANALYSIS
SJR - REACH LR-4
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_100C	1	Clayey Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	30	50	125
	2	Lean Clay Blanket	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120
	3	Poorly Graded Sand w/Silt	1.00E-03	4	2.50E-04	2.83500	0.70875	32	0	130
	4	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120

FRENCH CAMP SLOUGH
GEOTECHNICAL ANALYSIS
FRENCH CAMP - REACH FL-1
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_007B	1	Levee Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120
	2	Lean Clay Blanket	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120
	3	Foundation Silty Sand	5.00E-03	4	1.25E-03	14.17500	3.54375	32	0	125
	4	Foundation Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120

FRENCH CAMP SLOUGH
GEOTECHNICAL ANALYSIS
FRENCH CAMP - REACH FR-1
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0404_042B	1	Clay Levee	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120
	2	Silt Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	30	0	120
	3	Clayey Sand Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	28	50	125
	4	Silty Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	32	0	125
	5	Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.83500	0.70875	32	0	125
	7	Silt and Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120

STOCKTON DIVERTING CANAL
GEOTECHNICAL ANALYSIS
DIVERTING CANAL - REACH SL-1
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCSBDC_004B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	34	100	115
	2	Lean Clay Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	120
	3	Silty Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120
	4	Sandy Silt	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120
	5	Silty Sand (more permeable)	1.00E-03	4	2.50E-04	2.83500	0.70875	35	0	120
	6	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	120

STOCKTON DIVERTING CANAL
GEOTECHNICAL ANALYSIS
DIVERTING CANAL - REACH SL-2
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCSBDC_025C	1	Sandy Silt Levee	1.00E-04	4	2.50E-05	0.28350	0.07088	34	0	115
	2	Lean Clay/Silty Lean Clay Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115
	3	Lean Clay/Silty Lean Clay Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115
	4	Sand to Silty Sand	5.00E-04	4	1.25E-04	1.41750	0.35438	35	0	125
	5	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	115
	6	Sandy Silt	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120

CALAVERAS RIVER
GEOTECHNICAL ANALYSIS
CALAVERAS RIVER - REACH CL-1/CL-2
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCSBCR_004B	1	Silt Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	34	100	115
	2	Silt Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115
	3	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	120
	4	Sandy Silt Foundation	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120

CALAVERAS RIVER
GEOTECHNICAL ANALYSIS
CALAVERAS RIVER - REACH CR-1/CR-2
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCNBCR_010A	1	Lean Clay wSand Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	34	100	120
	2	Sandy Silt	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115
	3	Lean Clay wSand	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	120
	4	Pooly Graded Sand wSilt	2.10E-03	4	5.25E-04	5.95350	1.48838	35	0	120
	5	Silt	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115

CALAVERAS RIVER
GEOTECHNICAL ANALYSIS
CALAVERAS RIVER - REACH D-4
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCNBCR_003B	1	Sandy Silt Levee	1.00E-04	4	2.50E-05	0.28350	0.07088	31	0	110
	2	Lean Clay wSand to CH Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	34	100	110
	3	FAT Clay wSand Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	27	50	110
	4	Sandy Silt	1.00E-04	4	2.50E-05	0.28350	0.07088	31	0	115
	5	Pooly Graded Sand wSilt	6.40E-04	4	1.60E-04	1.81440	0.45360	32	0	120
	6	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	120

CALAVERAS RIVER
GEOTECHNICAL ANALYSIS
CALAVERAS RIVER - REACH D-5
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR1614_004B	1	Silt to Sandy Silt Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	31	0	110
	2	Lean Clay Levee	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	115
	3	Lean Clay Blanket	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	115
	4	Silty Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120
	5	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	115

SAN JOAQUIN RIVER
GEOTECHNICAL ANALYSIS
LSJ RIVER - DELTA FRONT BROOKSIDE REACH D-BS
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR2074_015C	1	Clay Levee	4.00E-06	4	1.00E-06	0.01134	0.00284	30	50	120
	2	Farm Levee	4.00E-06	4	1.00E-06	0.01134	0.00284	30	50	110
	3	Organic Soil	4.00E-06	4	1.00E-06	0.01134	0.00284	26	50	80
	4	Blanket	4.00E-06	4	1.00E-06	0.01134	0.00284	30	100	120
	5	Silty Sand	4.00E-04	4	1.00E-04	1.13400	0.28350	32	0	125
	6	Clay	4.00E-06	4	1.00E-06	0.01134	0.00284	30	100	120
	7	Poorly graded Sand w/silt	1.00E-03	4	2.50E-04	2.83500	0.70875	34	0	125
	8	Silt	4.00E-06	4	1.00E-06	0.01134	0.00284	32	0	120
	9	Silty Sand	4.00E-04	4	1.00E-04	1.13400	0.28350	32	0	125

SAN JOAQUIN RIVER
GEOTECHNICAL ANALYSIS
LSJ RIVER - DELTA FRONT LINCOLN VILLAGE REACH D-LV
ANALYSIS PARAMETERS SUMMARY

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR1608_001B	1	Clay Levee	4.00E-06	4	1.00E-06	0.01134	0.00284	27	50	120
	2	Organic Soil	1.00E-04	10	1.00E-05	0.28350	0.02835	28	25	80
	3	Blanket	4.00E-06	4	1.00E-06	0.01134	0.00284	28	50	120
	4	Silty Sand	4.00E-04	4	1.00E-04	1.13400	0.28350	32	0	125
	5	Poorly graded Sand w/silt	1.00E-03	4	2.50E-04	2.83500	0.70875	34	0	125
	6	Foundation Clay	4.00E-06	4	1.00E-06	0.01134	0.00284	30	100	120
	7	Deep Clay Layer	4.00E-06	4	1.00E-06	0.01134	0.00284	30	100	120

LOWER SAN JOAQUIN RIVER
FEASIBILITY STUDY

RESULTS OF WITHOUT PROJECT
SEEPAGE AND STABILITY ANALYSES

SEEPAGE/STABILITY ANALYSES LOWER SAN JOAQUIN RIVER REACH LR-1

STA. 1292+00

Water Level		USACE Pre-Project Conditions						Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe of Berm	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	
Crest	25.0	0.33	1.00	0.30	0.44	8.02	1.33	Seepage Complete 12/18/12 Stability Completed 12/18/12
Elev.	22.4	0.33	0.85	0.20	0.43	7.22	1.56	
200 yr	19.8	0.32	0.70	0.10	0.41	6.42	1.66	
Elev.	17.0	0.29	0.54	<0.1	0.37	1.10	1.83	

URS Results P1GER RD 17 December 2007

Water Level		Pre-Project Conditions						Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe of Berm		Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	
200 yr +3	22.80		0.90				1.90	URS data differs in material properties and absence of waterside Bathymetry and landside LIDAR data.
200 yr	19.80		0.80				2.10	
100 yr	18.90		0.80				2.00	

SEEPAGE/STABILITY ANALYSES LOWER SAN JOAQUIN RIVER REACH LR-2

STA. 1417+00

Water Level		USACE Pre-Project Conditions						Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe of Berm	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	
Crest	27.8	0.83	0.90	0.11	0.24	5.06	1.94	Seepage Complete 11/26/12 Stability Completed 12/06/12
Elev.	24.6	0.70	0.76	<0.1	0.19	4.44	2.20	
200 year	21.5	0.54	0.60	<0.1	0.14	2.12	2.48	
Elev.	17.0	0.28	0.33	<0.1	0.09	1.00	2.88	

URS Results P1GER RD 17 December 2007

Water Level		Pre-Project Conditions						Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe of Berm		Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	
200 yr +3	24.50		0.80				2.60	2007 URS report used method not used by Corps, Corps uses different range of WSE to create curve.
200 yr	21.50		0.60				2.90	
100 yr	20.30		0.50				2.90	

SEEPAGE/STABILITY ANALYSES LOWER SAN JOAQUIN RIVER REACH LR-3

STA. 1685+00

Water Level		USACE Pre-Project Conditions						Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe of Berm	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	
Crest	31.0	3.18	3.36	1.34	1.37	7.83	0.77	Seepage Complete 12/20/12 Stability Completed 12/21/12
Elev.	28.9	2.79	2.94	1.11	1.19	6.97	1.03	
200 year	26.9	2.39	2.52	0.89	1.00	0.00	1.20	
Elev.	24.0	1.83	1.94	0.57	0.73	0.00	1.35	

URS Results P1GER RD 17 December 2007

Water Level		Pre-Project Conditions						Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe of Berm	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	
200 yr +3	29.90			1.10			0.70	2007 URS report used method not used by Corps, Corps uses different range of WSE to create curve.
200 yr	26.90			0.90			1.20	
100 yr	23.80			0.60			1.40	

SEEPAGE/STABILITY ANALYSES LOWER SAN JOAQUIN RIVER REACH LR-4

STA. 1815+00

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Global Failure Surface FOS UTexas4	
Crest	33.9	0.47	0.22	0.59	5.87	1.63	Seepage Complete 12/09/12 Stability Completed 12/10/12
200 year	31.3	0.40	0.18	0.53	3.20	1.78	
Elev.	27.5	0.28	0.12	0.41	1.69	1.98	
Elev.	23.7	0.16	0.06	0.19	0.80	2.14	

URS Results P1GER Task Order 21 December 2007

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Failure Surface FOS	
-	-						The 2007 URS report did not perform analysis on this Station.
-	-						
-	-						

SEEPAGE/STABILITY ANALYSES FRENCH CAMP SLOUGH REACH FL-1

STA. 1049+00

Water Level		USACE Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Global Failure Surface FOS UTexas4	
Crest	21.4	0.44	0.33	0.38	1.40	2.28	Seepage Completed 11/19/12 Stability Completed 11/19/12
Elev.	18.6	0.33	0.26	0.32	0.64	2.41	
200 year	15.9	0.23	0.18	0.22	0.45	2.50	
Elev.	13.0	0.14	0.11	0.14	0.22	2.58	

URS Results P1GER Task Order 21 December 2007

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Failure Surface FOS	
200 yr +3	18.90		0.10			1.50	The 2007 URS report used method not used by Corps, Corps uses different range of WSE to create curve.
200 yr	15.90		0.10			2.00	
100 yr	15.30		0.10			2.00	

SEEPAGE/STABILITY ANALYSES FRENCH CAMP SLOUGH REACH FR-1

STA. 1164+20

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Global Failure Surface FOS UTexas4	
Crest	21.8	0.94	1.11	0.52	8.63	1.52	Seepage Complete 12/12/12 Stability Completed 12/12/12
Elev.	18.8	0.82	0.96	0.44	7.80	1.65	
200 year	15.9	0.69	0.81	0.35	1.89	1.76	
Elev.	12.9	0.56	0.65	0.24	0.94	1.88	

URS Results GER Volume 1, Appendix B (No date)

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Failure Surface FOS	
HTOL	-		1.07			1.71	Report was not available. Data was obtained from an electronic ULE file: \\crystal\Dirt\Levee Historical Information\RD 404\ULE
200 yr	15.90		1.00			1.80	
1955/1957	-		0.58			2.07	

SEEPAGE/STABILITY ANALYSES STOCKTON DIVERTING CANAL REACH SL-1

STA. 846+68

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Global Failure Surface FOS	Seepage Complete 8/27/12 Stability Completed 9/19/12
Crest	39.2	1.24	1.10	0.48	5.72	1.40	
Elev.	36.1	0.99	0.87	0.45	2.87	1.74	
Elev.	33.1	0.74	0.64	0.32	1.92	1.87	
200 year	30.2	0.48	0.41	0.29	1.44	2.01	

URS Results P1GER SJAFCA Calaveras July 2011

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Failure Surface FOS	Data was obtained from P1GER, P1GDR, AND SGDR
200 yr +3	33.22		0.68		2.78	1.76	
200 yr	30.22		0.43		1.90	1.95	
100 yr	29.91		0.40		1.60	1.97	

SEEPAGE/STABILITY ANALYSES STOCKTON DIVERTING CANAL REACH SL-2

STA. 976+00

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Global Failure Surface FOS	Seepage Complete 8/27/12 Stability Completed 9/19/12
Crest	44.6	1.04	0.99	0.47	4.57	1.68	
200 year	40.4	0.65	0.62	0.47	2.64	2.02	
Elev.	38.8	0.50	0.48	0.38	0.97	2.13	
Elev.	37.2	0.33	0.33	0.32	0.14	2.25	

URS Results P1GER SJAFCA Calaveras July 2011

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Failure Surface FOS	Data was obtained from P1GER, P1GDR, AND SGDR
200 yr +3	43.44		0.83		3.90	1.66	
200 yr	40.44		0.58		3.00	1.94	
100 yr	40.10		0.56		2.60	1.97	

SEEPAGE/STABILITY ANALYSES CALAVERAS RIVER REACH CL-1/CL-2

STA. 6757+00

Water Level		USACE Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Global Failure Surface FOS	
Crest	31.4	0.34	0.14	0.38	4.66	2.05	Seepage Completed 8/28/12 Stability Completed 9/6/12
Elev.	29.4	0.29	0.12	0.22	2.42	2.28	
Elev.	27.4	0.25	0.09	0.21	1.68	2.46	
200 year	25.5	0.13	0.05	0.13	0.00	2.71	

URS Results P1GER SJAFCA Calaveras July 2011

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Failure Surface FOS	
200 yr +3	28.51		0.12		2.60	2.35	Analyses Completed By URS
200 yr	25.51		<0.1		0.30	2.69	
100 yr	25.07		<0.1		0.30	2.72	

SEEPAGE/STABILITY ANALYSES CALAVERAS RIVER REACH CR-1/CR-2

STA. 3306+00

Water Level		USACE Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Global Failure Surface FOS	
Crest	29.7	0.97	1.57	0.22	1.85	2.91	Seepage Completed on 8/30/12 Stability Completed 9/6/12
Elev.	28.2	0.62	1.10	0.18	0.92	3.13	
200 yr	26.9	0.19	0.47	0.14	0.21	3.37	
Elev.	25.3	0.00	<0.1	0.00	0.00	3.73	

URS Results P1GER SJAFCA Calaveras July 2011

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Failure Surface FOS	URS Results from P1GER July 2011. Exit gradient results appear lower due to the fact URS used the same permeability for materials 1 & 2 and chose to take the gradient inbetween the two layers.
200 yr +3	29.88		0.67		2.20	2.87	
200 yr	26.88		0.20		0.40	3.29	
100 yr	26.45		0.20		0.20	3.41	

SEEPAGE/STABILITY ANALYSES CALAVERAS RIVER REACH D-4

STA. 3092+00

Water Level		USACE Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Global Failure Surface FOS	
Crest	18.8	1.33	1.21	0.48	9.92	0.95	Seepage Completed on 8/30/12 Stability Completed 9/6/12
Elev.	16.5	1.10	1.00	0.43	4.14	1.18	
200 year	14.2	0.87	0.79	0.41	2.83	1.57	
Elev.	11.8	0.63	0.57	0.35	1.65	1.89	

URS Results P1GER SJAFCA Calaveras July 2011

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Failure Surface FOS	
200 yr +3	17.16		0.79		8.80	1.10	URS Results from P1GER July 2011
200 yr	14.16		0.55		1.90	1.56	
100 yr	13.77		0.52		1.90	1.60	

SEEPAGE/STABILITY ANALYSES CALAVERAS RIVER REACH D-5

STA. 6535+00

Water Level		USACE Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Global Failure Surface FOS UTexas4	
Crest	17.5	0.53	0.23	0.33	6.76	1.86	Seepage Complete 8/27/12 Stability Completed 9/5/12
200 year	13.2	0.41	0.15	0.29	4.05	2.15	
Elev.	10.0	0.29	0.09	0.28	1.19	2.38	
Elev.	7.2	0.09	0.04	0.09	0.00	2.60	

URS Results P1GER SJAFCA Calaveras July 2011

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Failure Surface FOS	
200 yr +3	16.16		0.18		3.80	1.18	URS and Corps results for FOS are different. After some study of materials properties and cross-section obtained from URS, the FOS generated by UTexas4 appear correct.
200 yr	13.16		0.13		1.60	1.38	
100 yr	12.81		0.12		1.40	1.40	

SEEPAGE/STABILITY ANALYSES DELTA FRONT BROOKSIDE REACH D-BS

STA. 166+50

Water Level		USACE Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	
Crest	18.0	0.99	0.80	0.41	5.21	0.94	**USACE** **Seepage Complete 3/11/13** **Stability Completed 3/14/13**
Elev.	14.0	0.81	0.64	0.30	3.50	1.22	
Elev.	10.0	0.62	0.49	0.26	2.30	1.27	
Elev.	6.0	0.44	0.35	0.21	1.10	1.30	

NO RESULTS FROM A-E REPORTS

Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	**No analyses. Historic Kleinfelder data used to generate cross-section in USACE analysis. Material properites listed were modified based on discussions with Levee Safety.**
200 yr +3							
200 yr							
100 yr							

SEEPAGE/STABILITY ANALYSES DELTA FRONT LINCOLN VILLALGE REACH D-LV

STA. 162+50

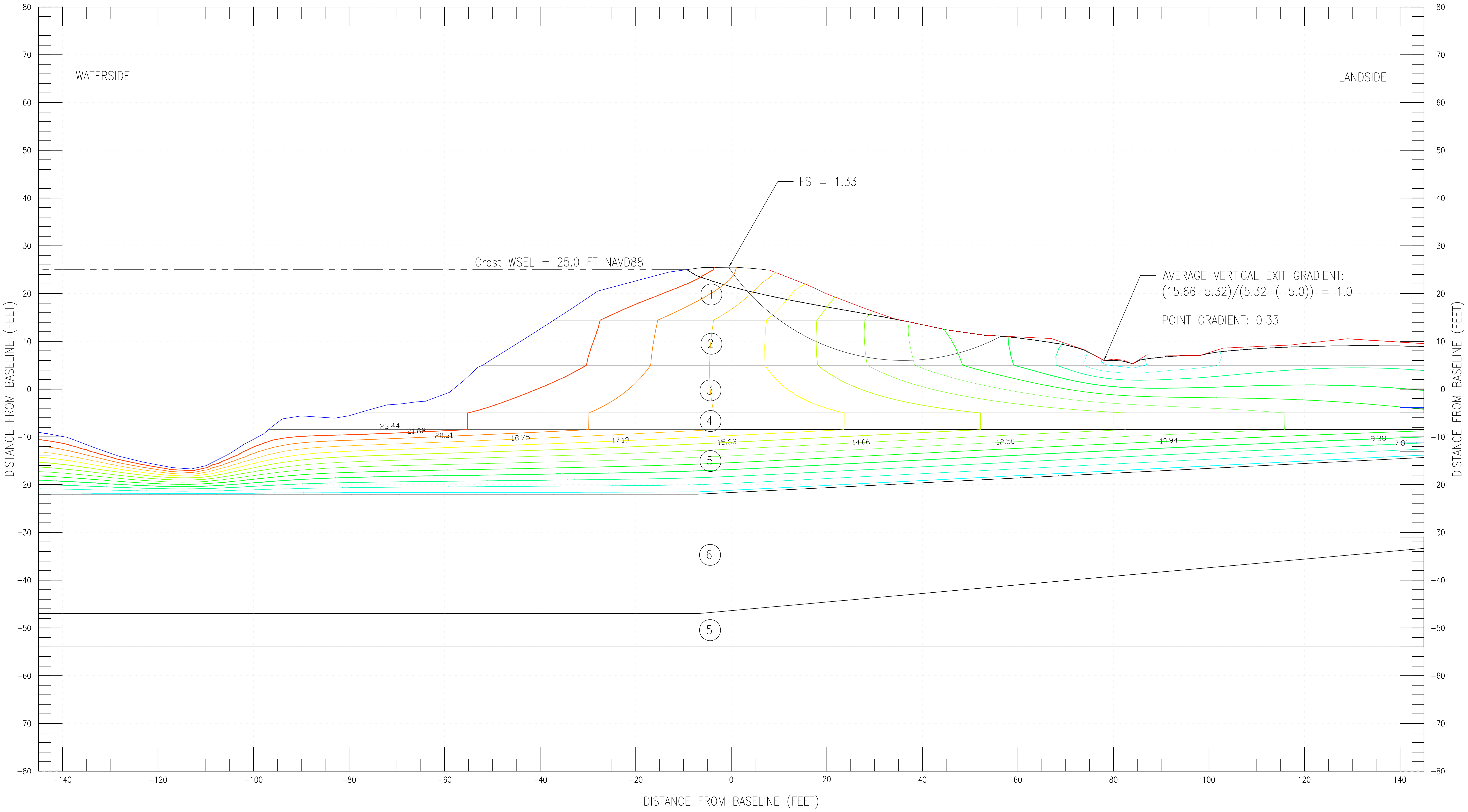
Water Level		USACE Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	
Crest	13.2	0.51	0.63	0.16	1.00	1.83	**USACE** **Seepage Complete 4/02/13** **Stability Completed 4/03/13**
Elev.	11.0	0.35	0.44	0.14	0.67	1.94	
Elev.	8.5	0.18	0.24	0.10	0.00	2.04	
Elev.	6.0	0.01	0.01	0.00	0.00	2.13	

NO RESULTS FROM A-E REPORTS

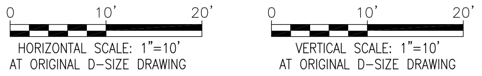
Water Level		Pre-Project Conditions					Notes
		Point Gradient at Toe	Average Vertical Exit Gradient at Toe	Horizontal Gradient	Breakout Above Landside Toe (ft)	Circular Failure Surface FOS UTexas4	**No analyses. Historic Kleinfelder data used to generate cross-section in USACE analysis. Material properites listed were modified based on discussions with Levee Safety.**
200 yr +3							
200 yr							
100 yr							

LOWER SAN JOAQUIN RIVER
FEASIBILITY STUDY

CROSS-SECTIONS WITH STRATIGRAPHY
HEAD CONTOURS AND
FAILURE SURFACE



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_036B	1	Clay Levee	1.00E-06	4	2.50E-07	0.00284	0.00071	28	50	120
	2	Silt Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	28	0	120
	3	Clay Blanket	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120
	4	Silty Sand	1.00E-03	4	2.50E-04	2.83500	0.70875	32	0	125
	5	Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120
	6	Sand	5.00E-03	4	1.25E-03	14.17500	3.54375	32	0	125



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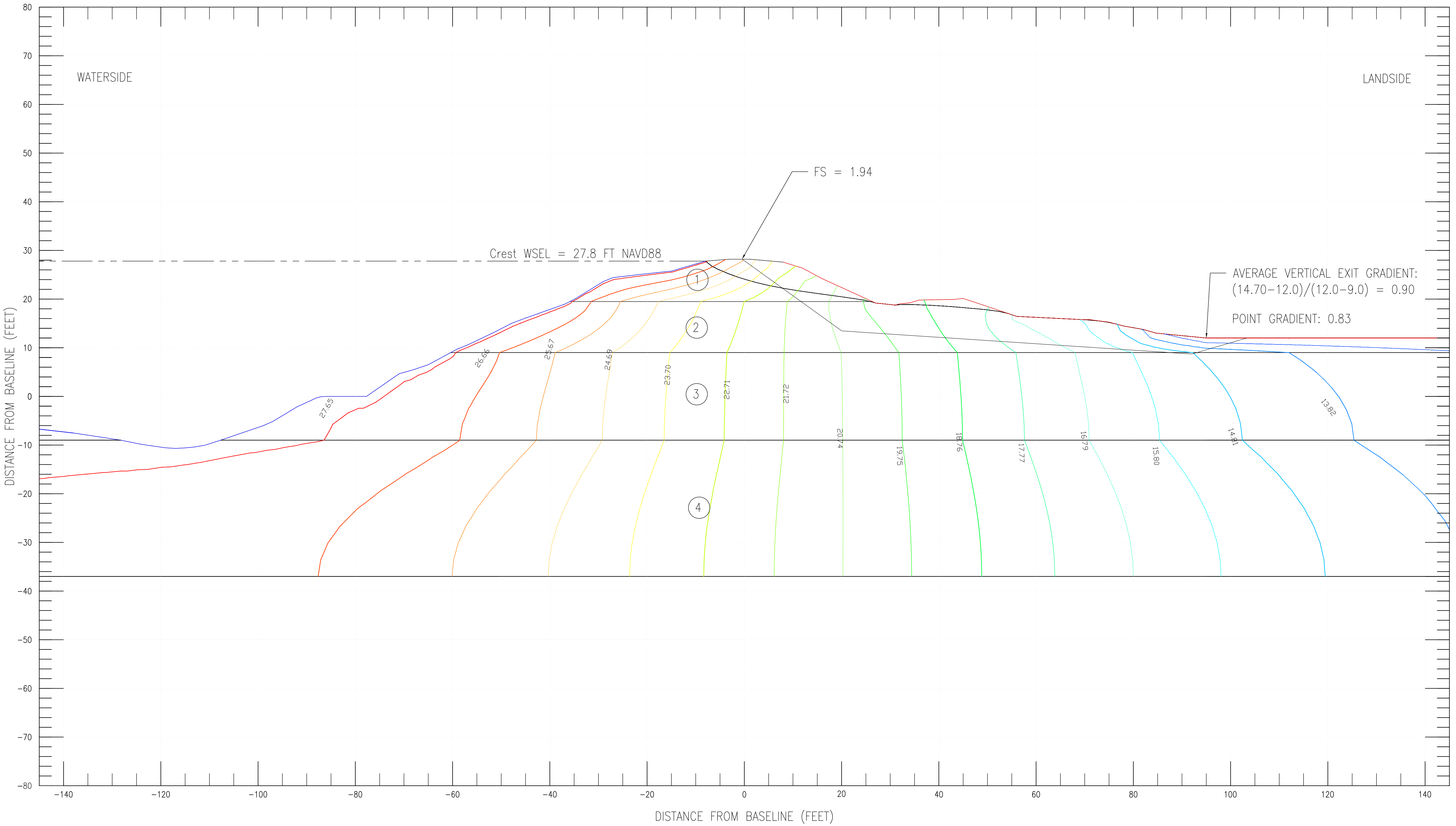
Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results

CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
SAN JOAQUIN RIVER RD−17 REACH LR−1 STA. 1292+00

DATE:	SCALE:	SHEET NO.
12 - August - 13	As Shown	1 of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 2:29:32pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\RD 17\ReacReach LR1 Sta 1292+00.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_0 52B	1	Levee Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120
	2	Silty Sand Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	30	0	125
	3	Poorly Graded Sand wSilt	1.00E-04	4	2.50E-05	0.28350	0.07088	32	0	130
	4	Foundation Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

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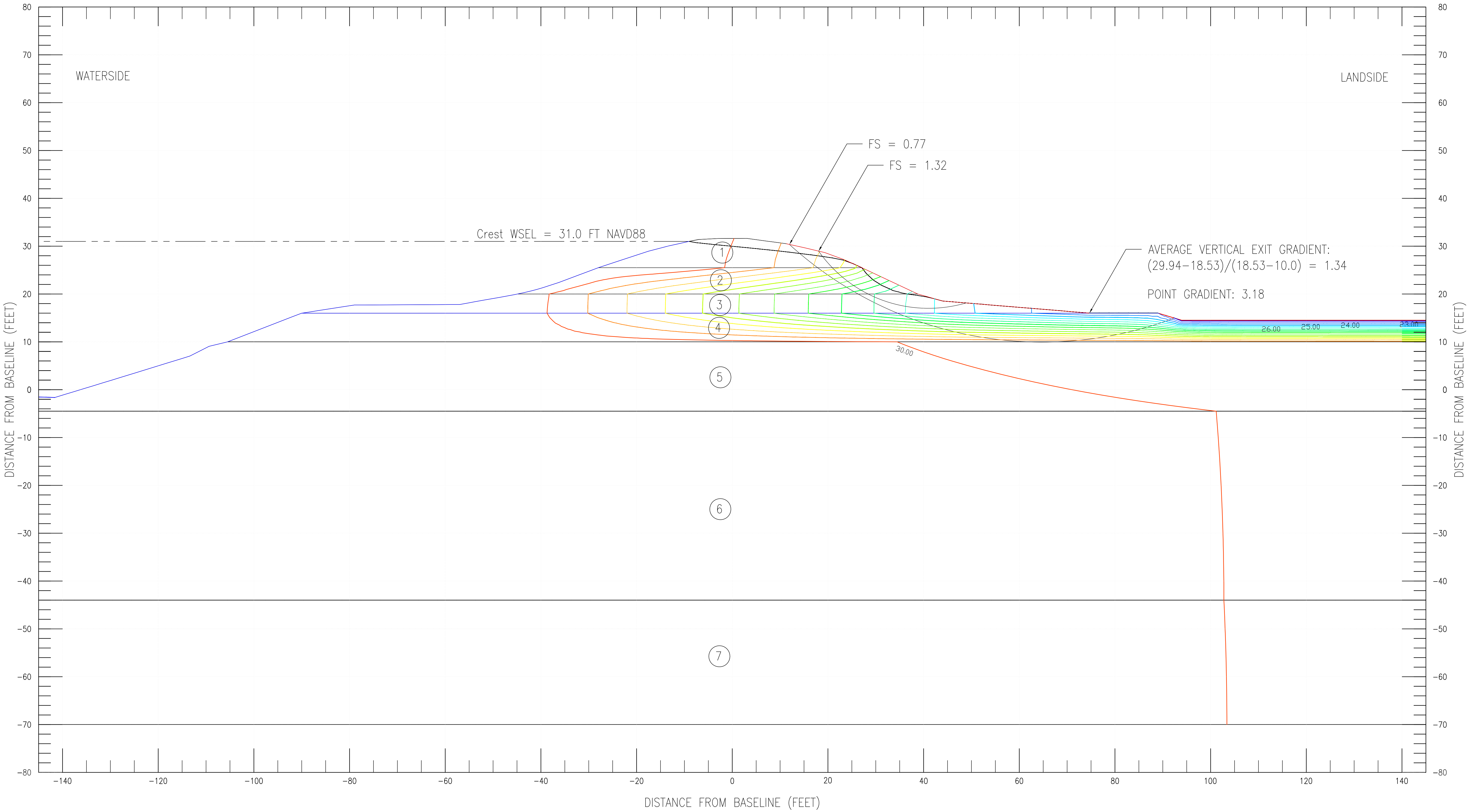
Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results

CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
SAN JOAQUIN RIVER RD−17 REACH LR−2 STA. 1417+00

DATE:	SCALE:	SHEET NO.
12 - August - 13	As Shown	2 of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 2:49:00pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\sj seepage stability plates\GMS\RD 17\ReacReach LR2 Sta. 1417+00.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_085B	1	Poorly Graded Sand wSilt	5.00E-03	4	1.25E-03	14.17500	3.54375	32	0	125
	2	Clayey Sand	5.00E-05	4	1.25E-05	0.14175	0.03544	30	50	125
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.17500	3.54375	32	0	125
	4	Sandy Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	28	140	120
	5	Silty Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	30	0	120
	6	Poorly Graded Sand wSilt	1.00E-02	4	2.50E-03	28.35000	7.08750	32	0	125
	7	Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

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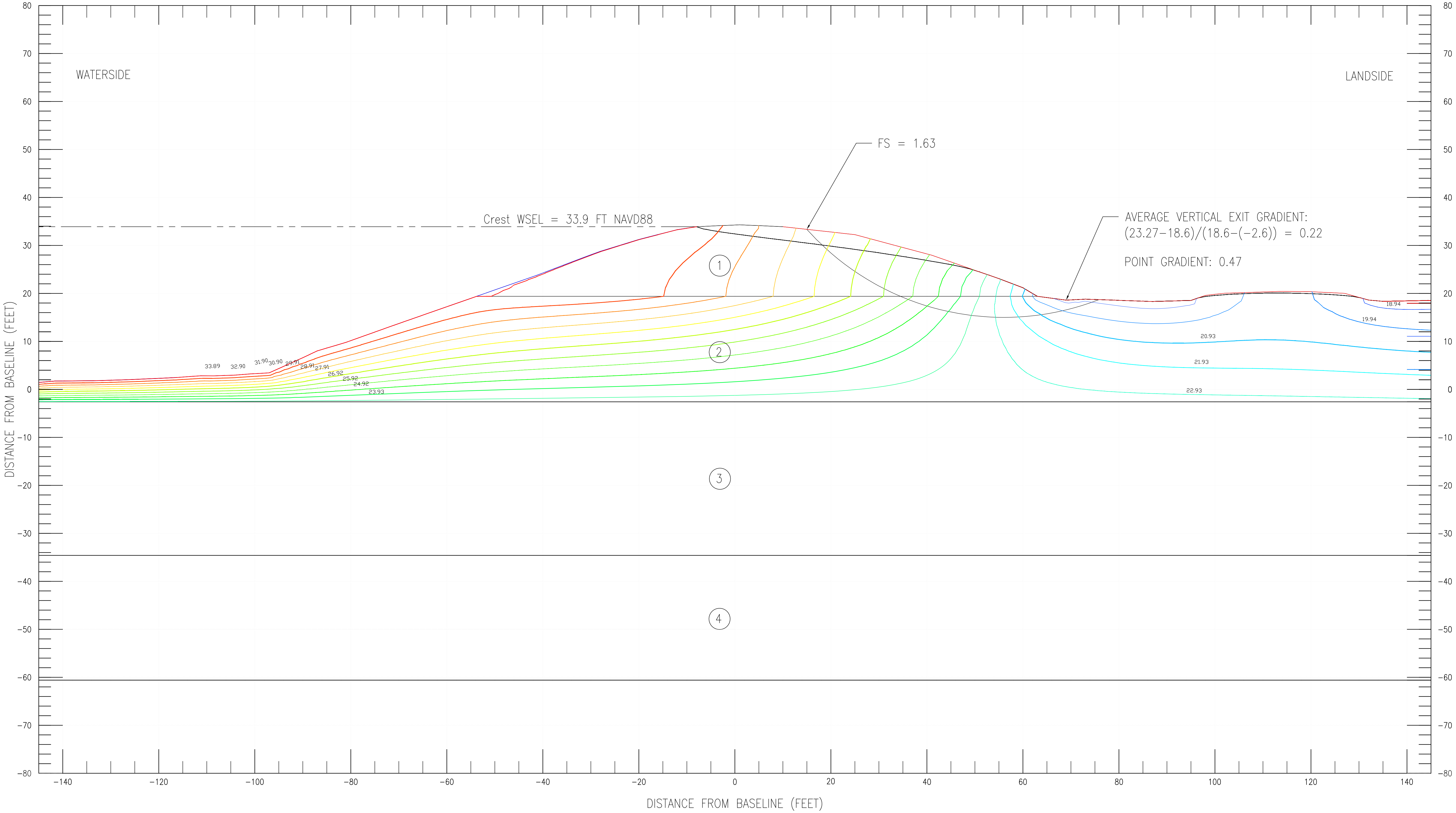
Seepage and Stability Results
CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
SAN JOAQUIN RIVER RD−17 REACH LR−3 STA. 1685+00

DATE: 12 - August - 13
SCALE: As Shown
SHEET NO. 3 of 14

PLOT BY: L2EDGGAJ - Aug 28, 2013 - 2:16:30pm
DRAWING: I:\CAD\CAD for Enclosures\GMS\RD 17\Reach LR3 Sta. 1685+00\Reach LR3 Sta. 1685+00.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_100C	1	Clayey Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	30	50	125
	2	Lean Clay Blanket	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120
	3	Poorly Graded Sand w/Silt	1.00E-03	4	2.50E-04	2.83500	0.70875	32	0	130
	4	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

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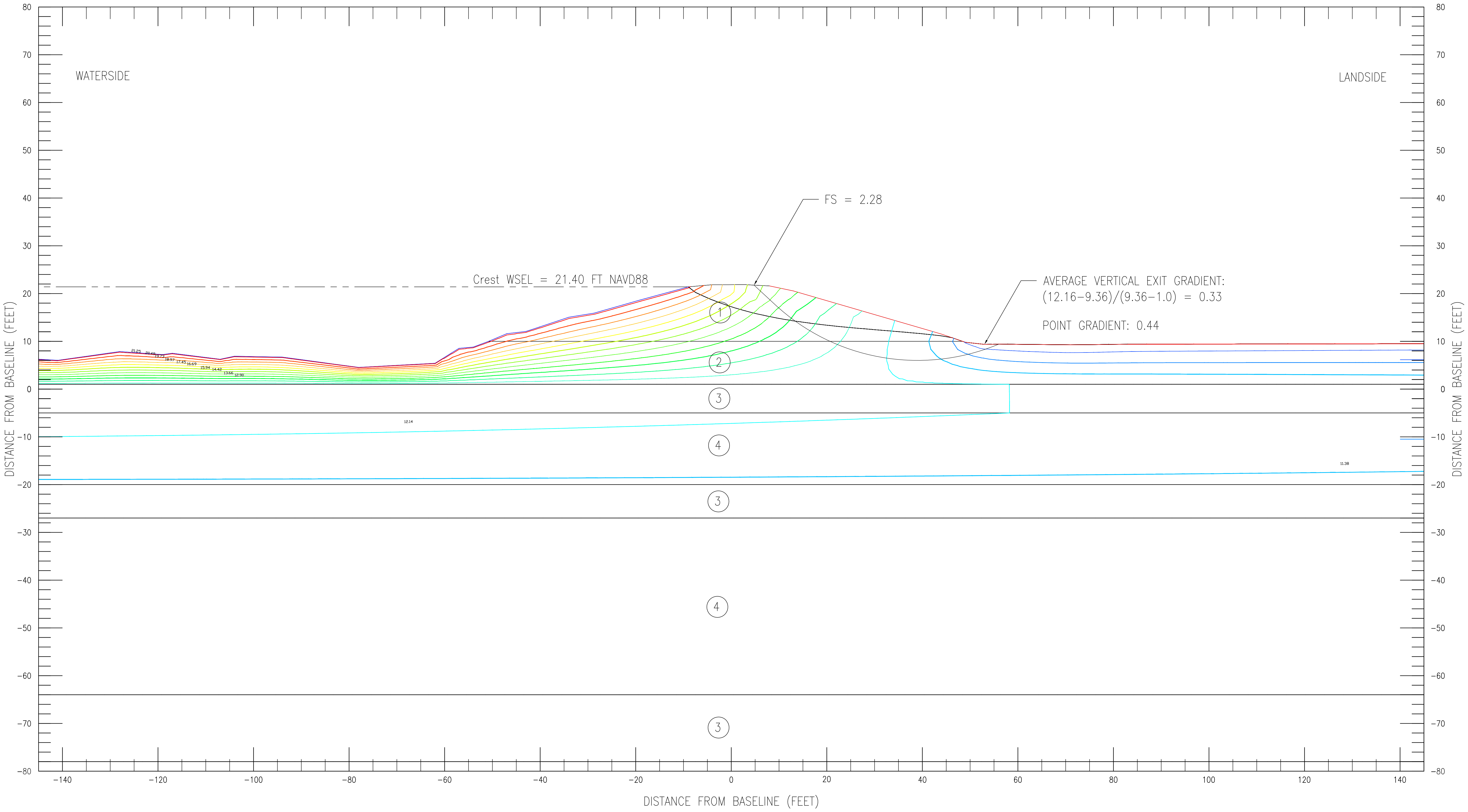
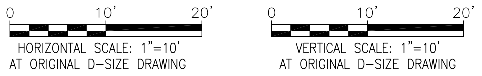
CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
SAN JOAQUIN RIVER RD−17 REACH LR−4 STA. 1815+00

DATE: 12 - August - 13
SCALE: As Shown
SHEET NO. 4 of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 3:24:59pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\RD 17\ReacReach LR4 Sta. 1815+00.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0017_007B	1	Levee Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120
	2	Lean Clay Blanket	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120
	3	Foundation Silty Sand	5.00E-03	4	1.25E-03	14.17500	3.54375	32	0	125
	4	Foundation Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120



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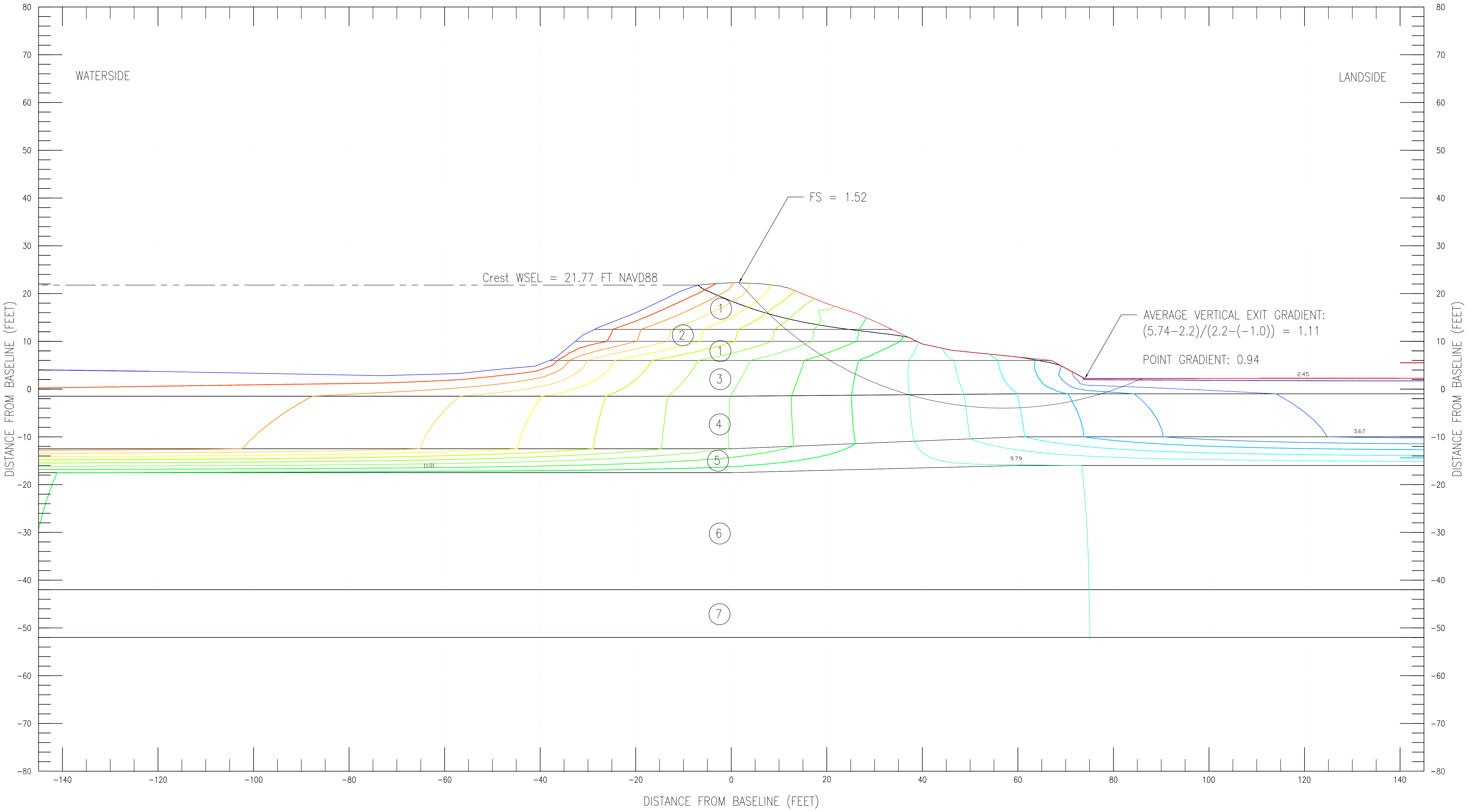
Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results

CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
FRENCH CAMP REACH FL–1 STA. 1049+00

DATE: 12 - August - 13
SCALE: As Shown
SHEET NO. 5 of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 4:47:12pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\French CamReach FL1 Sta. 1049+00.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR0404_042B	1	Clay Levee	1.00E-06	4	2.50E-07	0.00284	0.00071	28	100	120
	2	Silt Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	30	0	120
	3	Clayey Sand Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	28	50	125
	4	Silty Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	32	0	125
	5	Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.83500	0.70875	32	0	125
	7	Silt and Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	30	100	120

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

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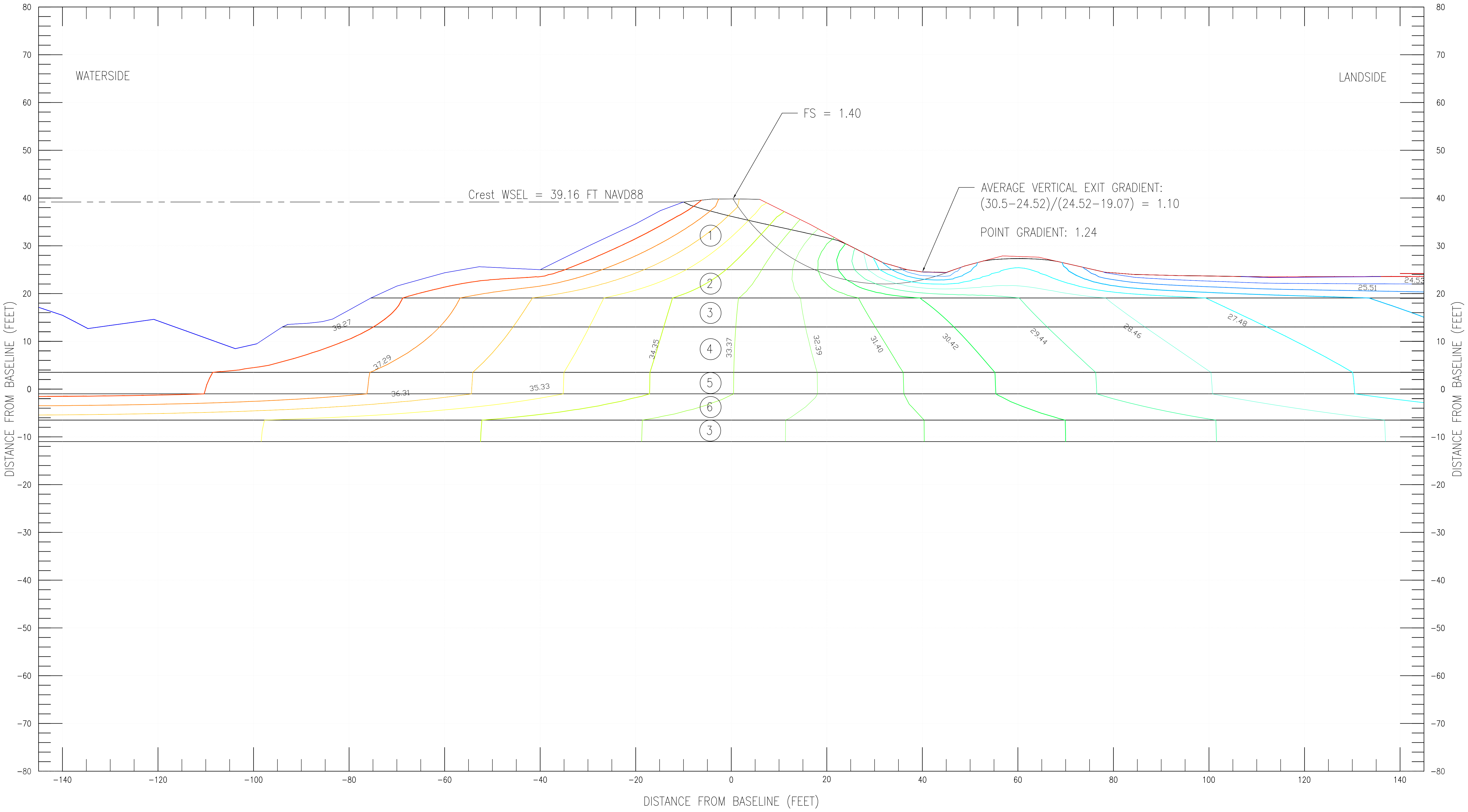
Seepage and Stability Results

CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
FRENCH CAMP REACH FR-1 STA. 1164+20

DATE: 12 - August - 13
SCALE: As Shown
SHEET NO. 6 of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 4:45:30pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\French CamReach FR1 Sta. 1164+20.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCSBDC_004B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	34	100	115
	2	Lean Clay Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	120
	3	Silty Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120
	4	Sandy Silt	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120
	5	Silty Sand (more permeable)	1.00E-03	4	2.50E-04	2.83500	0.70875	35	0	120
	6	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	120

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

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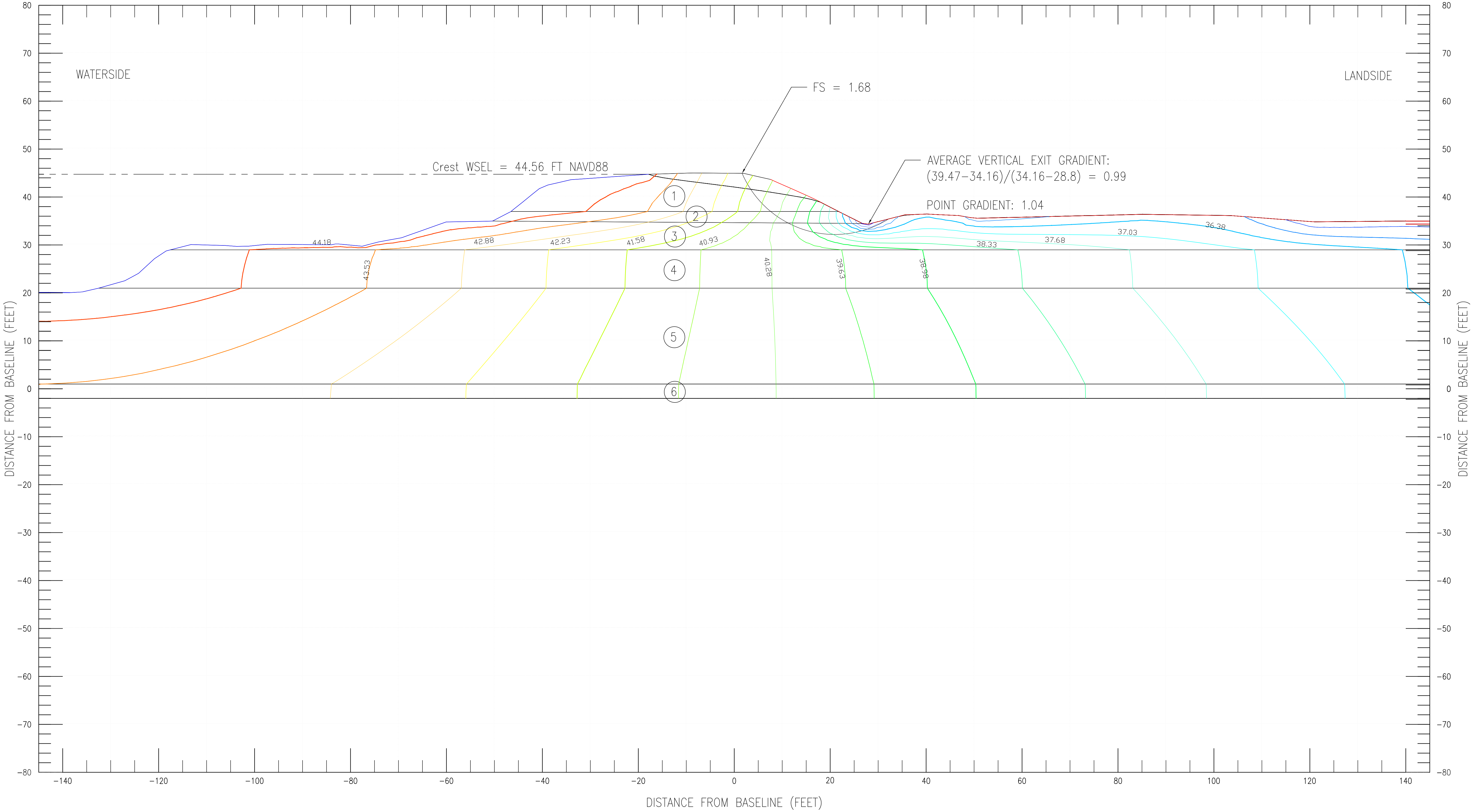
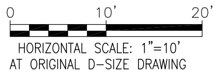
Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results
CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
STOCKTON DIVERTING CANAL REACH SL−1 STA. 846+68

DATE:	SCALE:	SHEET NO.
12 - August - 13	As Shown	7 of 14

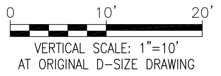
PLOT BY: L2EDGGAJ - Aug 21, 2013 - 4:02:35pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\Stockton DReach SL1 Sta. 846+68.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCSBDC_025C	1	Sandy Silt Levee	1.00E-04	4	2.50E-05	0.28350	0.07088	34	0	115
	2	Lean Clay/Silty Lean Clay Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115
	3	Lean Clay/Silty Lean Clay Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115
	4	Sand to Silty Sand	5.00E-04	4	1.25E-04	1.41750	0.35438	35	0	125
	5	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	115
	6	Sandy Silt	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120



HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D−SIZE DRAWING



VERTICAL SCALE: 1"=10'
AT ORIGINAL D−SIZE DRAWING

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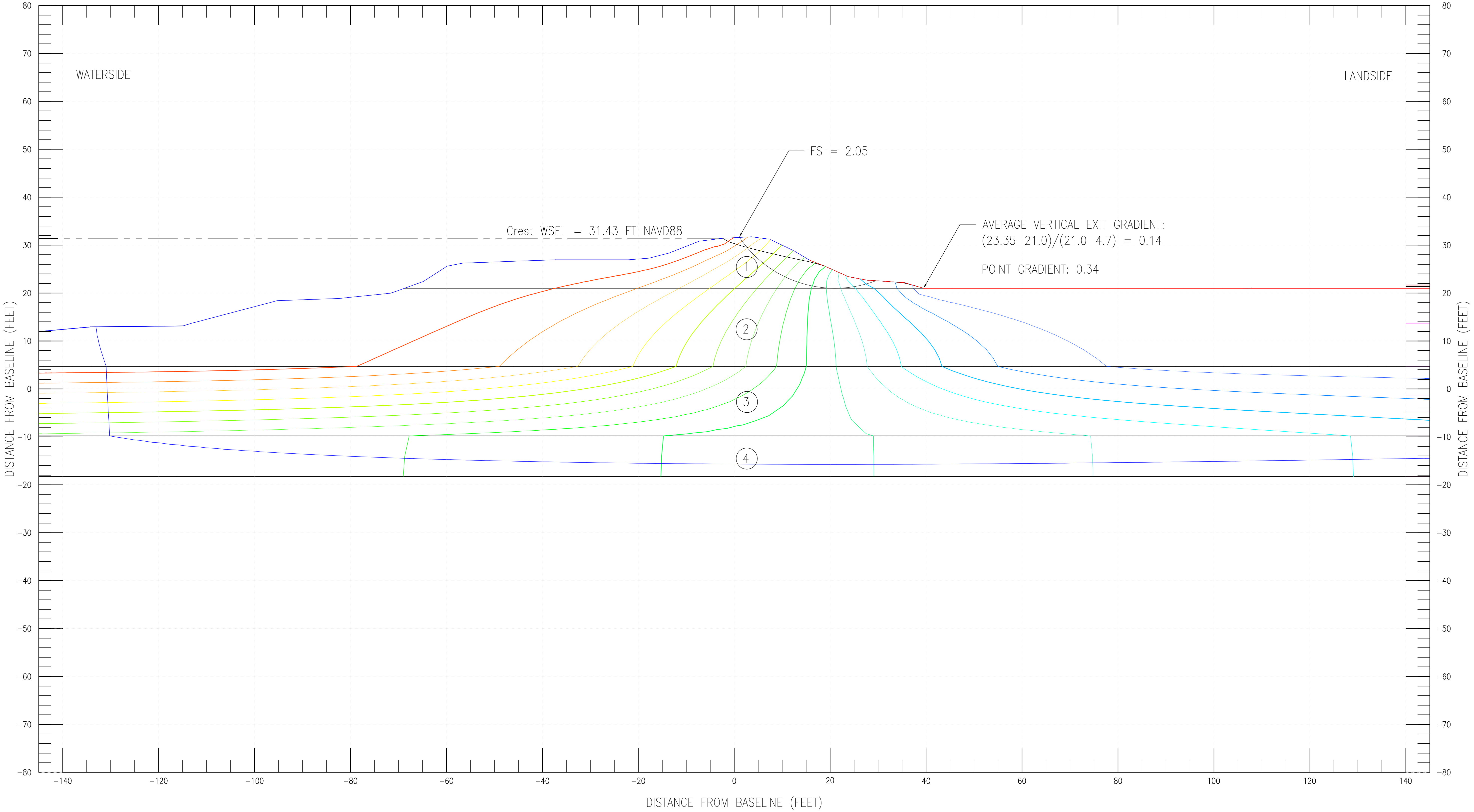
Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results

CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
STOCKTON DIVERTING CANAL REACH SL−2 STA. 976+00

DATE:	SCALE:	SHEET NO.
12 - August - 13	As Shown	8 of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 4:27:09pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\Stockton DReach SL2 Sta. 976+00.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCSBCR_ 004B	1	Silt Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	34	100	115
	2	Silt Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115
	3	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	120
	4	Sandy Silt Foundation	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

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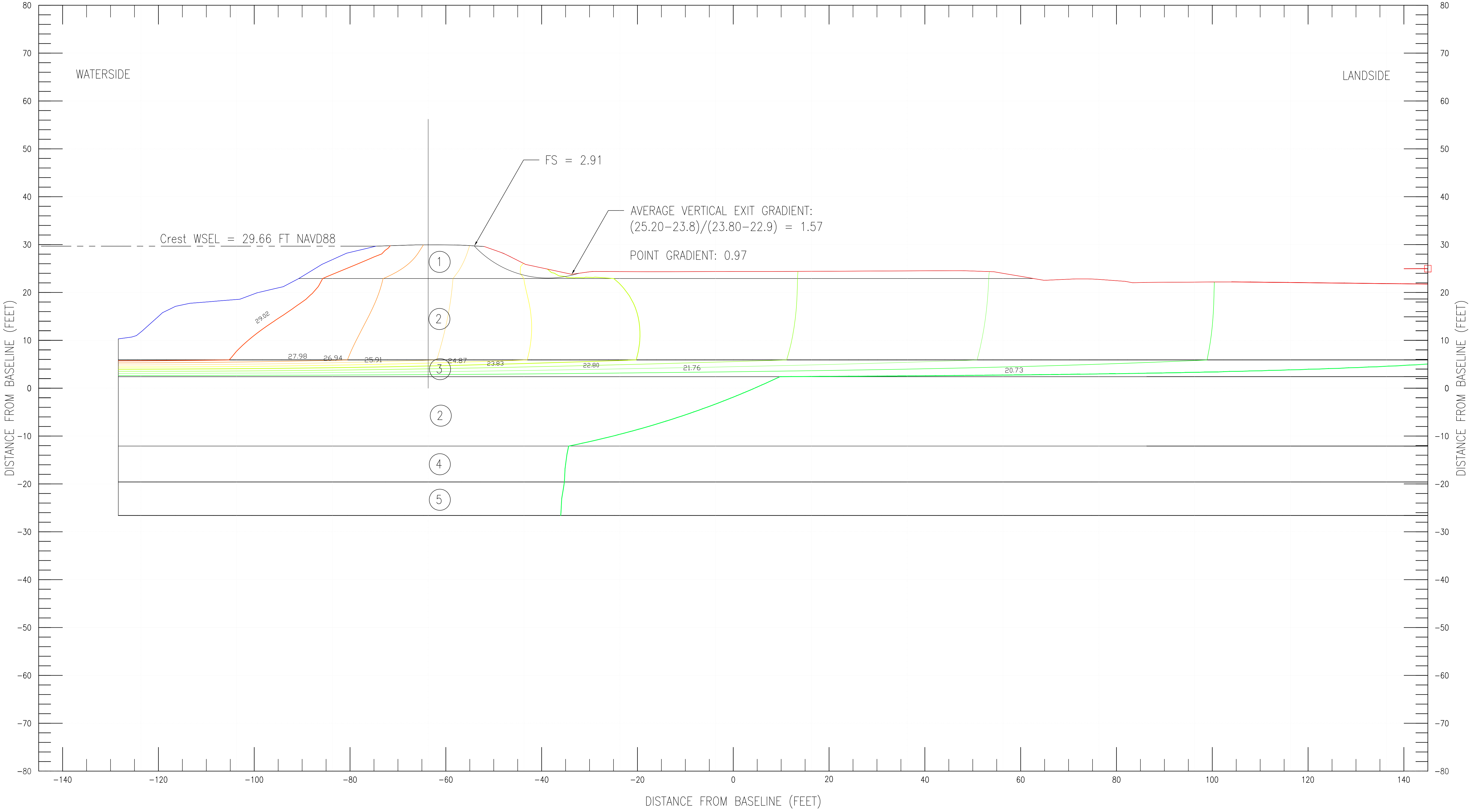
Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results

CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
CALAVERAS RIVER REACH CL–1/CL–2 STA. 6757+00

DATE: 12 - August - 13
SCALE: As Shown
SHEET NO. 9 of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 4:39:15pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\Calaveras Reach CL1 Sta. 6757+00.dwg



Crest WSEL = 29.66 FT NAVD88

FS = 2.91

AVERAGE VERTICAL EXIT GRADIENT:
(25.20−23.8)/(23.80−22.9) = 1.57

POINT GRADIENT: 0.97

Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCNBCR_010 A	1	Lean Clay wSand Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	34	100	120
	2	Sandy Silt	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115
	3	Lean Clay wSand	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	120
	4	Pooly Graded Sand wSilt	2.10E-03	4	5.25E-04	5.95350	1.48838	35	0	120
	5	Silt	1.00E-05	4	2.50E-06	0.02835	0.00709	31	150	115

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

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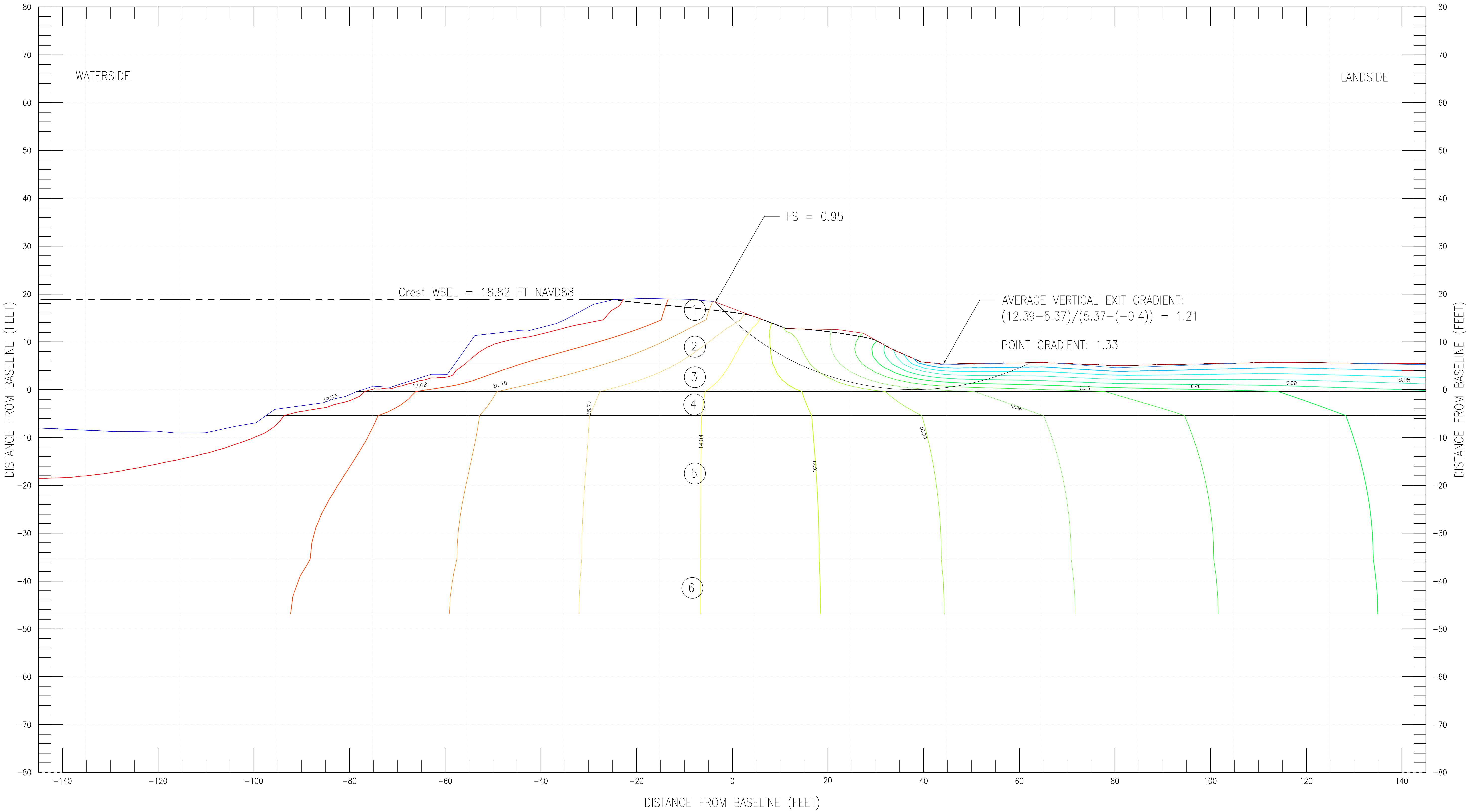
SACRAMENTO
CALIFORNIA

Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results
CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
CALAVERAS RIVER REACH CR−1/CR−2 STA. 3306+00

DATE: 12 - August - 13
SCALE: As Shown
SHEET NO. 10of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 4:40:58pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\Calaveras Reach CR1 Sta. 3306+00.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WCNBCR_003B	1	Sandy Silt Levee	1.00E-04	4	2.50E-05	0.28350	0.07088	31	0	110
	2	Lean Clay wSand to CH Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	34	100	110
	3	FAT Clay wSand Blanket	1.00E-05	4	2.50E-06	0.02835	0.00709	27	50	110
	4	Sandy Silt	1.00E-04	4	2.50E-05	0.28350	0.07088	31	0	115
	5	Pooly Graded Sand wSilt	6.40E-04	4	1.60E-04	1.81440	0.45360	32	0	120
	6	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	120

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

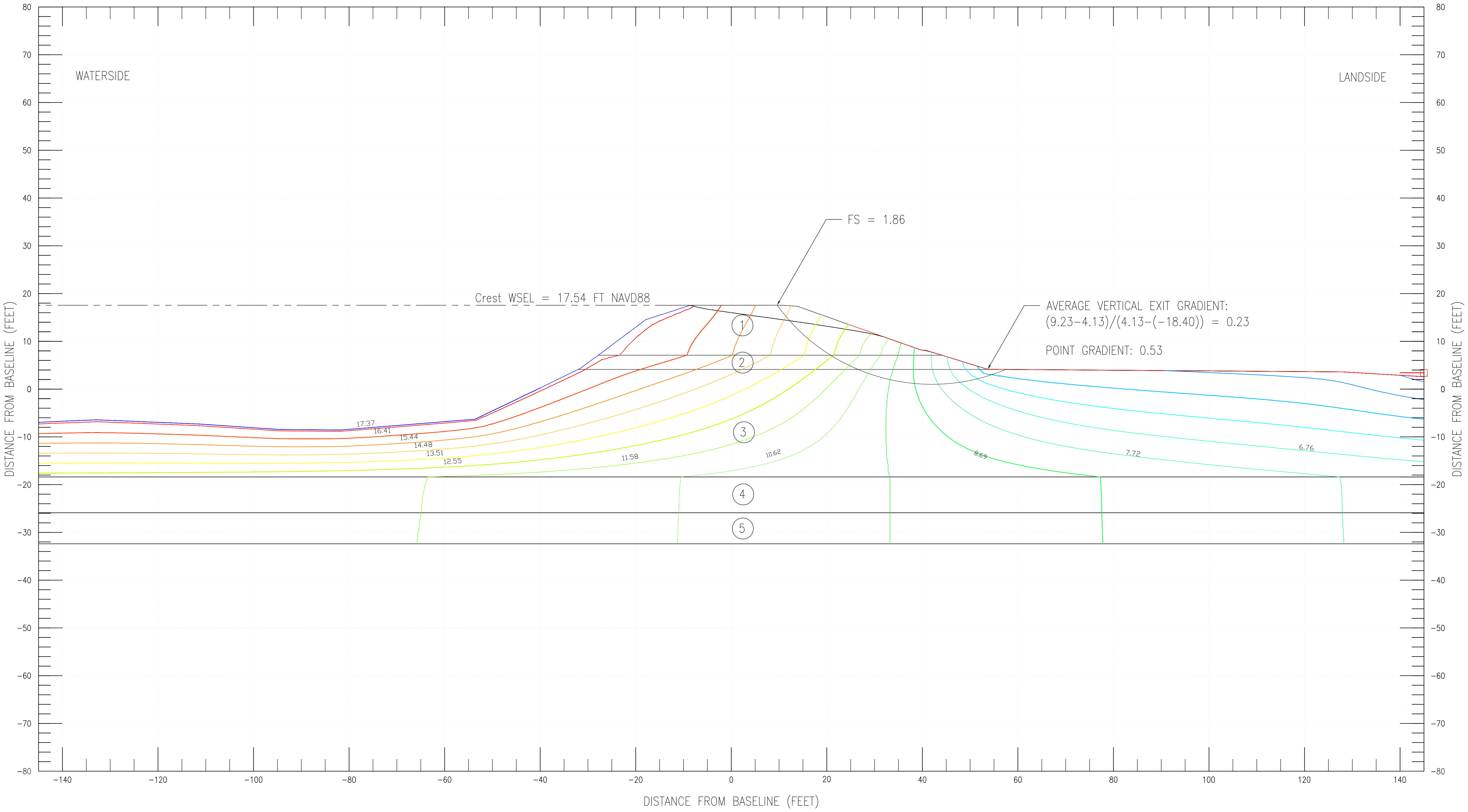
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO CALIFORNIA

Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results
CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
CALAVERAS RIVER REACH D−4 STA. 3092+00

DATE: 12 - August - 13
SCALE: As Shown
SHEET NO. 11of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 4:42:26pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\Calaveras Reach D4 Sta. 3092+00.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR1614_004B	1	Silt to Sandy Silt Levee	1.00E-05	4	2.50E-06	0.02835	0.00709	31	0	110
	2	Lean Clay Levee	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	115
	3	Lean Clay Blanket	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	115
	4	Silty Sand	1.00E-04	4	2.50E-05	0.28350	0.07088	35	0	120
	5	Lean Clay	1.00E-06	4	2.50E-07	0.00284	0.00071	31	150	115

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

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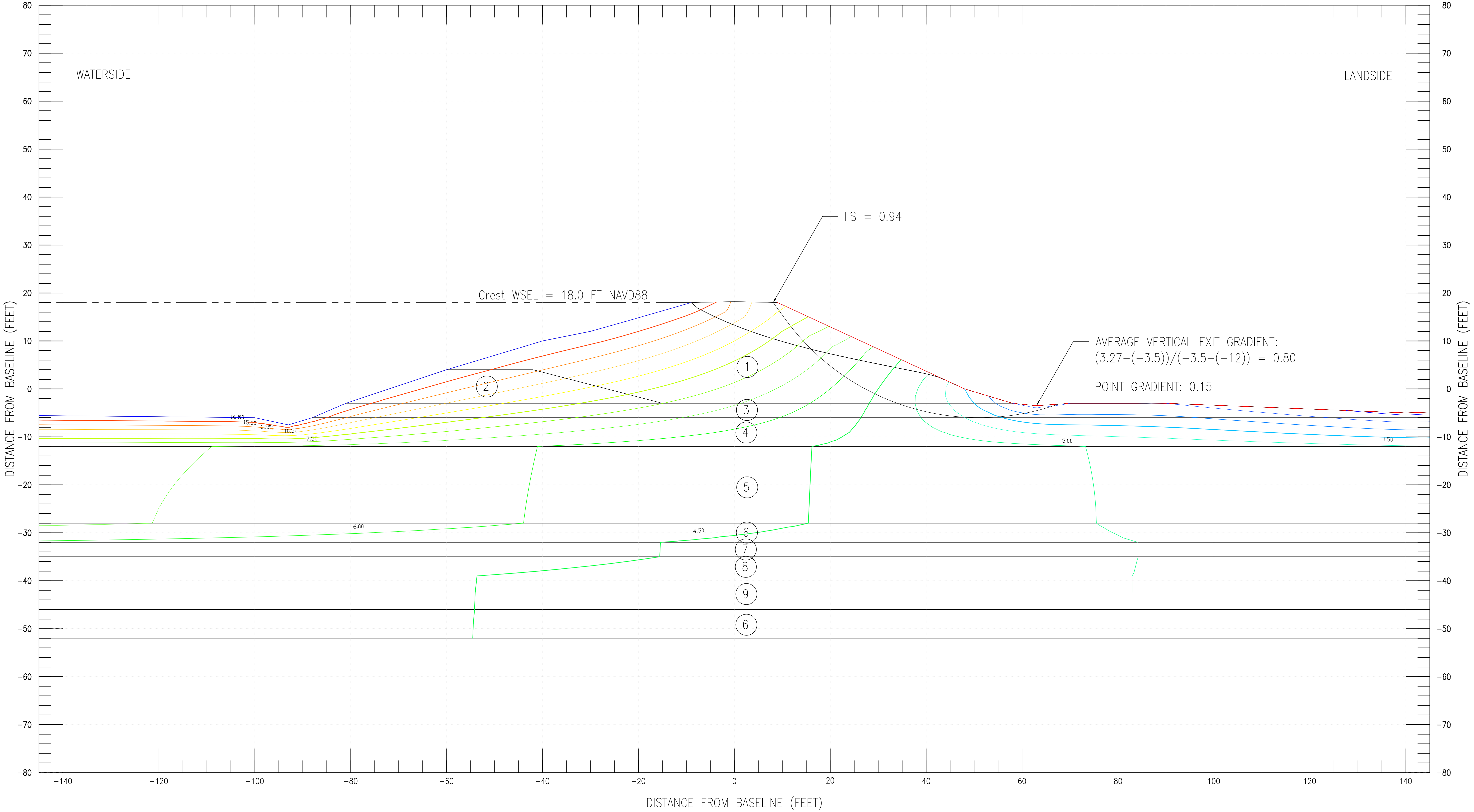
Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results
CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
CALAVERAS RIVER REACH D–5 STA. 6535+00

DATE:	SCALE:	SHEET NO.
12 - August - 13	As Shown	12of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 4:43:48pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\Calaveras Reach D5 Sta. 6535+00.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR2074_015C	1	Clay Levee	4.00E-06	4	1.00E-06	0.01134	0.00284	30	50	120
	2	Farm Levee	4.00E-06	4	1.00E-06	0.01134	0.00284	30	50	110
	3	Organic Soil	4.00E-06	4	1.00E-06	0.01134	0.00284	26	50	80
	4	Blanket	4.00E-06	4	1.00E-06	0.01134	0.00284	30	100	120
	5	Silty Sand	4.00E-04	4	1.00E-04	1.13400	0.28350	32	0	125
	6	Clay	4.00E-06	4	1.00E-06	0.01134	0.00284	30	100	120
	7	Poorly graded Sand w/silt	1.00E-03	4	2.50E-04	2.83500	0.70875	34	0	125
	8	Silt	4.00E-06	4	1.00E-06	0.01134	0.00284	32	0	120
	9	Silty Sand	4.00E-04	4	1.00E-04	1.13400	0.28350	32	0	125

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D-SIZE DRAWING

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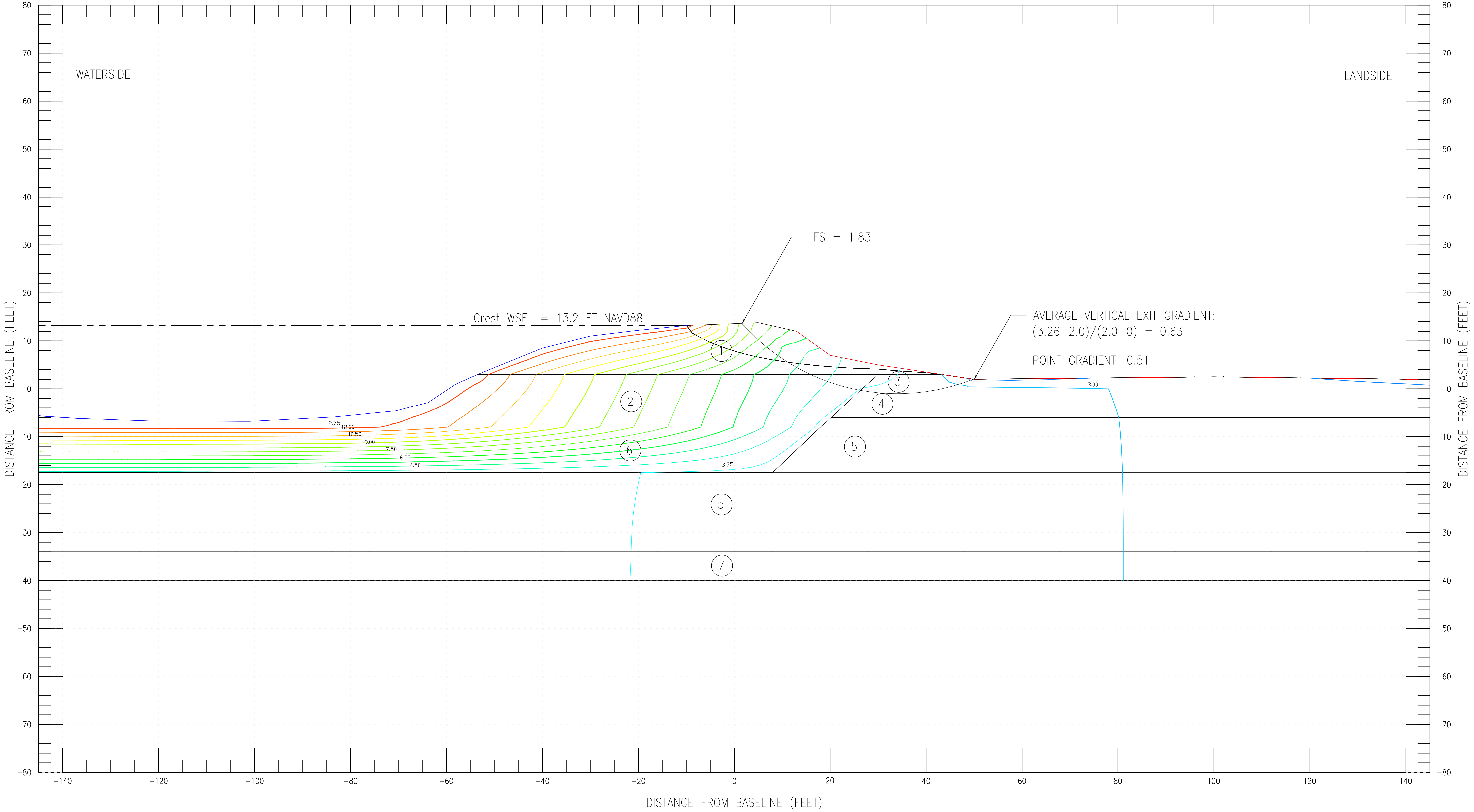
Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results
CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
DELTA BROOKSIDE REACH D-BS STA. 166+50

DATE:	SCALE:	SHEET NO.
12 - August - 13	As Shown	13of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 11:35:28am
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\Delta FronBrookside.dwg



Boring Number	Layer ID	Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WR1608_001B	1	Clay Levee	4.00E-06	4	1.00E-06	0.01134	0.00284	27	50	120
	2	Organic Soil	1.00E-04	10	1.00E-05	0.28350	0.02835	28	25	80
	3	Blanket	4.00E-06	4	1.00E-06	0.01134	0.00284	28	50	120
	4	Silty Sand	4.00E-04	4	1.00E-04	1.13400	0.28350	32	0	125
	5	Poorly graded Sand w/silt	1.00E-03	4	2.50E-04	2.83500	0.70875	34	0	125
	6	Foundation Clay	4.00E-06	4	1.00E-06	0.01134	0.00284	30	100	120
	7	Deep Clay Layer	4.00E-06	4	1.00E-06	0.01134	0.00284	30	100	120

0 10' 20'
HORIZONTAL SCALE: 1"=10'
AT ORIGINAL D–SIZE DRAWING

0 10' 20'
VERTICAL SCALE: 1"=10'
AT ORIGINAL D–SIZE DRAWING

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SACRAMENTO CALIFORNIA

Lower Jan Joaquin
Feasibility Study
Seepage and Stability Results
CREST WSE STEADY STATE SEEPAGE AND SLOPE STABILITY
DELTA LINCOLN VILLAGE REACH D–LV STA. 162+50

DATE:	SCALE:	SHEET NO.
12 - August - 13	As Shown	14of 14

PLOT BY: L2EDGGAJ - Aug 21, 2013 - 1:23:39pm
DRAWING: I:\draft-final geotechnical appendix\2 - enclosures\enclosure seepage stability results\lsj seepage stability plates\GMS\Delta FronLincolnVillage.dwg

LOWER SAN JOAQUIN RIVER
FEASIBILITY STUDY

GEOTECHNICAL REPORT

ENCLOSURE E3
RISK AND UNCERTAINTY ANALYSES

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: San Joaquin River
Basin and Reach: Index Point LR1

Levee Mile: 1292+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 25.00
L/S Toe Elev.: 12.42
W/S Toe Elev.: 11.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/18/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR0017_016C	16	13	6	41	46	40	28	16	288	57	CL	0.0007	SP-SM	14.18	20257	14838	8004	75668237	54
WR0017_017C	22					35					CL	0.0007	SP-SM	14.18	20257				
WR0017_020C	18					38					CL	0.0007	SP-SM	14.18	20257				
WR0017_021C	14					46					CL	0.0007	SP-SM	14.18	20257				
WR0017_025C	14					20					CL	0.0007	SM	2.8	4000				
WR0017_027C	12					28					CL	0.0007	SM	2.8	4000				
WR0017_029B	4					12					CL	0.0007	SP	14.18	20257				
WR0017_031C	12					8					CL	0.0007	SM	2.8	4000				
WR0017_034C	16					54					CL	0.0007	SM	14.18	20257				
WR0017_036B	10					5					CL	0.0007	SM	2.8	4000				
WR0017_041B	2					32					CL	0.0007	SP-SM	14.18	20257				
WR0017_039C	14					14					CL	0.0007	SP-SM	14.18	20257				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR0017_016C	CL	16	0.0007				16	SP-SM	40	14.18							14.18
WR0017_017C	CL	22	0.0007				22	SP-SM	35	14.18							14.18
WR0017_020C	CL	18	0.0007				18	SP-SM	38	14.18							14.18
WR0017_021C	CL	14	0.0007				14	SP-SM	46	14.18							14.18
WR0017_025C	CL	14	0.0007				14	SM	20	2.8							2.8
WR0017_027C	CL	12	0.0007				12	SM	28	2.8							2.8
WR0017_029B	CL	4	0.0007				4	SP	12	14.18							14.18
WR0017_031C	CL	12	0.0007				12	SM	8	2.8							2.8
WR0017_034C	CL	16	0.0007				16	SM	54	14.18							14.18
WR0017_036B	CL	10	0.0007				10	SM	5	2.8							2.8
WR0017_041B	CL	2	0.0007				2	SP-SM	32	14.18							14.18
WR0017_039C	CL	14	0.0007				14	SP-SM	14	14.18							14.18

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR1

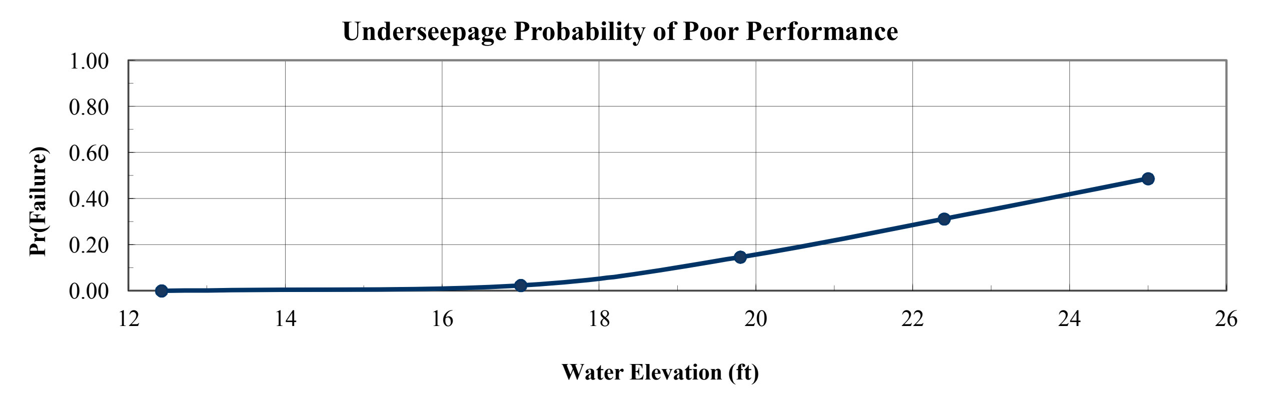
Levee Mile: 1292+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 25.00
L/S Toe Elev.: 12.42
W/S Toe Elev.: 11.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/18/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permaebility Ratio	14838	8004	54
Blanket Thickness (z)	13	6	46
Aquifer Thickness (d)	28	16	57

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	90	95	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	12.42	0.0000
Elev. 17.0	4.58	17.00	0.0234
200 yr	7.38	19.80	0.1465
Elev. 22.4	9.98	22.40	0.3121
Crest	12.58	25.00	0.4868

Crest	Rh
Head = 12.58	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	14838	13.00	28.00	89.96	2324.01	0.0112	11.65	0.90		
2	22842	13.00	28.00	89.97	2883.49	0.0091	11.82	0.91	0.000400	0.16
3	6834	13.00	28.00	89.90	1577.21	0.0159	11.26	0.87		
4	14838	19.00	28.00	89.97	2809.59	0.0094	11.80	0.62	0.250000	99.59
5	14838	7.00	28.00	89.92	1705.36	0.0148	11.35	1.62		
6	14838	13.00	44.00	89.97	2913.30	0.0142	11.83	0.91	0.000625	0.25
7	14838	13.00	12.00	89.90	1521.42	0.0070	11.22	0.86		
								Total	0.251025	100.00

E[I] = 0.900000
Var[I]= 0.251025
σ[I]= 0.501024
V(I) = 0.556693

E[ln I] = -0.240339
σ [ln I] = 0.519573

β =	-0.462569
F(z) =	0.513201
Pr(f) % =	48.679948

Ic= 0.80
ln(I crit) = -0.223144

Elev. 22.4	Rh
Head = 9.98	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	14838	13.00	28.00	89.96	2324.01	0.0112	9.24	0.71		
2	22842	13.00	28.00	89.97	2883.49	0.0091	9.38	0.72	0.000225	0.14
3	6834	13.00	28.00	89.90	1577.21	0.0159	8.93	0.69		
4	14838	19.00	28.00	89.97	2809.59	0.0094	9.36	0.49	0.160000	99.61
5	14838	7.00	28.00	89.92	1705.36	0.0148	9.00	1.29		
6	14838	13.00	44.00	89.97	2913.30	0.0142	9.38	0.72	0.000400	0.25
7	14838	13.00	12.00	89.90	1521.42	0.0070	8.90	0.68		
								Total	0.160625	100.00

E[I] = 0.710000
Var[I]= 0.160625
σ[I]= 0.400780
V(I) = 0.564480

E[ln I] = -0.480790
σ [ln I] = 0.525927

β =	-0.914176
F(z) =	0.687894
Pr(f) % =	31.210589

Ic= 0.80
ln(I crit) = -0.223144

200 yr	Rh
Head = 7.38	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	14838	13.00	28.00	89.96	2324.01	0.0112	6.84	0.53		
2	22842	13.00	28.00	89.97	2883.49	0.0091	6.94	0.53	0.000100	0.11
3	6834	13.00	28.00	89.90	1577.21	0.0159	6.61	0.51		
4	14838	19.00	28.00	89.97	2809.59	0.0094	6.92	0.36	0.087025	99.77
5	14838	7.00	28.00	89.92	1705.36	0.0148	6.66	0.95		
6	14838	13.00	44.00	89.97	2913.30	0.0142	6.94	0.53	0.000100	0.11
7	14838	13.00	12.00	89.90	1521.42	0.0070	6.58	0.51		
								Total	0.087225	100.00

E[I] = 0.530000
Var[I]= 0.087225
σ[I]= 0.295339
V(I) = 0.557243

E[ln I] = -0.770090
σ [ln I] = 0.520023

β =	-1.480877
F(z) =	0.853548
Pr(f) % =	14.645160

Ic= 0.80
ln(I crit) = -0.223144

Elev. 17.0	Rh
Head = 4.58	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	14838	13.00	28.00	89.96	2324.01	0.0112	4.24	0.33		
2	22842	13.00	28.00	89.97	2883.49	0.0091	4.30	0.33	0.000025	0.08
3	6834	13.00	28.00	89.90	1577.21	0.0159	4.10	0.32		
4	14838	19.00	28.00	89.97	2809.59	0.0094	4.30	0.23	0.032400	99.62
5	14838	7.00	28.00	89.92	1705.36	0.0148	4.13	0.59		
6	14838	13.00	44.00	89.97	2913.30	0.0142	4.31	0.33	0.000100	0.31
7	14838	13.00	12.00	89.90	1521.42	0.0070	4.08	0.31		
								Total	0.032525	100.00

E[I] = 0.330000
Var[I]= 0.032525
σ[I]= 0.180347
V(I) = 0.546506

E[ln I] = -1.239332
σ [ln I] = 0.511214

β =	-2.424294
F(z) =	0.976583
Pr(f) % =	2.341711

Ic= 0.80
ln(I crit) = -0.223144

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

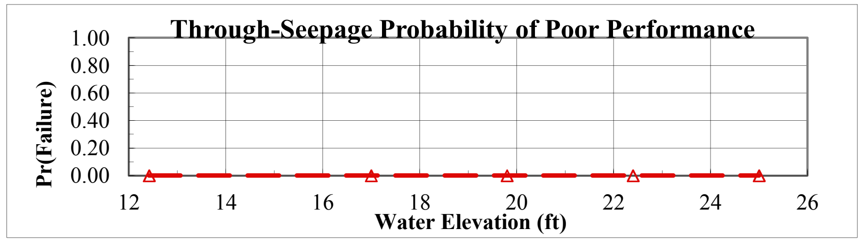
Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR1

Levee Mile: 1292+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 25.00
L/S Toe Elev.: 12.42
W/S Toe Elev.: 11.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/18/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	50	5.0	10.00
Initial Porosity (n)	0.4	0.04	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	12.42	0.0000
Elev. 17.0	4.58	17.00	0.000000
200 yr	7.38	19.80	0.000000
Elev. 22.4	9.98	22.40	0.000000
Crest	12.58	25.00	0.000000

Pr(f)=0
NO

Crest	**Head =**	12.58	**Horizontal Gradient (Ix) =**	0.440

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	50.00	0.40	1.00E-10	1140.21	2591.38		
2	45.00	0.40	1.00E-10	1026.19	2332.25	67152.701113	26.44
3	55.00	0.40	1.00E-10	1254.23	2850.52		
4	50.00	0.36	1.00E-10	1081.70	2458.40	16830.356890	6.63
5	50.00	0.44	1.00E-10	1195.86	2717.87		
6	50.00	0.40	7.00E-11	1362.81	3097.30	169950.936279	66.93
7	50.00	0.40	1.30E-10	1000.03	2272.79		
E[FS] =	2591.383822		E[ln FS] =	7.841389	Total	253933.994282	100.00
Var[FS]=	253933.994282						
σ[FS]=	503.918639		σ[ln FS]=	0.192658		β =	40.701152
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

200 yr	**Head =**	7.38	**Horizontal Gradient (Ix) =**	0.410

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	50.00	0.40	1.00E-10	1140.21	2781.00		
2	45.00	0.40	1.00E-10	1026.19	2502.90	77339.458272	26.44
3	55.00	0.40	1.00E-10	1254.23	3059.10		
4	50.00	0.36	1.00E-10	1081.70	2638.29	19383.444936	6.63
5	50.00	0.44	1.00E-10	1195.86	2916.73		
6	50.00	0.40	7.00E-11	1362.81	3323.93	195731.714835	66.93
7	50.00	0.40	1.30E-10	1000.03	2439.10		
E[FS] =	2780.997272		E[ln FS] =	7.912006	Total	292454.618043	100.00
Var[FS]=	292454.618043						
σ[FS]=	540.790734		σ[ln FS]=	0.192658		β =	41.067696
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Elev. 22.4	**Head =**	9.98	**Horizontal Gradient (Ix) =**	0.430

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	50.00	0.40	1.00E-10	1140.21	2651.65		
2	45.00	0.40	1.00E-10	1026.19	2386.48	70312.400949	26.44
3	55.00	0.40	1.00E-10	1254.23	2916.81		
4	50.00	0.36	1.00E-10	1081.70	2515.57	17622.266597	6.63
5	50.00	0.44	1.00E-10	1195.86	2781.07		
6	50.00	0.40	7.00E-11	1362.81	3169.33	177947.546045	66.93
7	50.00	0.40	1.30E-10	1000.03	2325.65		
E[FS] =	2651.648562		E[ln FS] =	7.864378	Total	265882.213591	100.00
Var[FS]=	265882.213591						
σ[FS]=	515.637677		σ[ln FS]=	0.192658		β =	40.820480
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Elev. 17.0	**Head =**	4.58	**Horizontal Gradient (Ix) =**	0.370

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	50.00	0.40	1.00E-10	1140.21	3081.65		
2	45.00	0.40	1.00E-10	1026.19	2773.48	94965.397630	26.44
3	55.00	0.40	1.00E-10	1254.23	3389.81		
4	50.00	0.36	1.00E-10	1081.70	2923.51	23801.001416	6.63
5	50.00	0.44	1.00E-10	1195.86	3232.06		
6	50.00	0.40	7.00E-11	1362.81	3683.27	240339.673219	66.93
7	50.00	0.40	1.30E-10	1000.03	2702.78		
E[FS] =	3081.645626		E[ln FS] =	8.014661	Total	359106.072265	100.00
Var[FS]=	359106.072265						
σ[FS]=	599.254597		σ[ln FS]=	0.192658		β =	41.600528
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

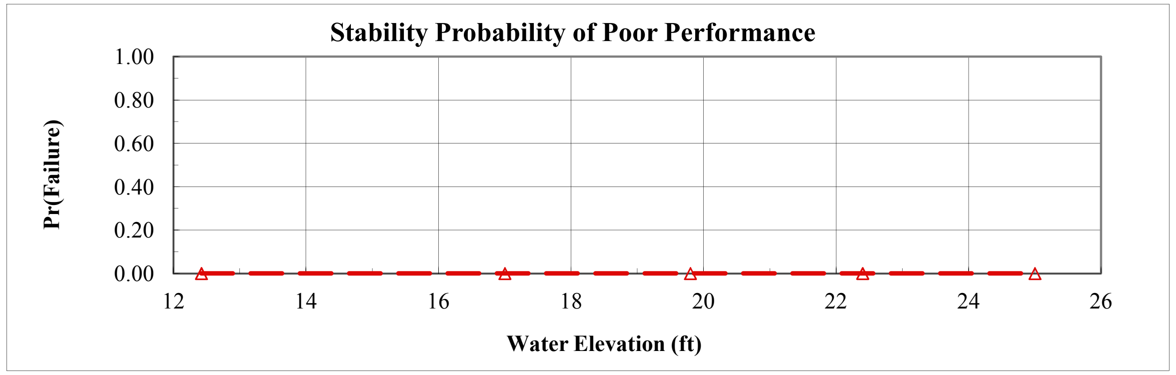
Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR1

Levee Mile: 1292+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 25.00
L/S Toe Elev.: 12.42
W/S Toe Elev.: 11.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/18/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	28	4	13.00
Levee Cohesion	50	20	40.00
Levee γ	120	8	7.00
Foundation Φ	30	4	13.00
Foundation Cohesion	100	40	40.00



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	12.42	0.0000
Elev. 17.0	4.58	17.00	0.000000
200 yr	7.38	19.80	0.000000
Elev. 22.4	9.98	22.40	0.000000
Crest	12.58	25.00	0.000000

Crest	**Head =**	12.58	**Pr(f)=0**	NO

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	50	120	30	100	1.33		
2	24	50	120	30	100	1.30	0.001024	50.28
3	32	50	120	30	100	1.36		
4	28	30	120	30	100	1.31	0.000380	18.67
5	28	70	120	30	100	1.35		
6	28	50	112	30	100	1.36	0.000240	11.80
7	28	50	128	30	100	1.32		
8	28	50	120	26	100	1.36	0.000196	9.62
9	28	50	120	34	100	1.33		
10	28	50	120	30	60	1.36	0.000196	9.62
11	28	50	120	30	140	1.33		

E[FS] = 1.329000
Var[FS]= 0.002037
σ[FS]= 0.045128
V(FS) = 0.033956
FS req'd = 1.00

E[ln FS] = 0.283851
σ[ln FS]= 0.033946
ln(FS req'd) = 0.000000

Total 0.002037 100.00

β = 8.361761
F(z) = 0.000000
Pr(f) % = 0.000000

Elev. 22.4	**Head =**	9.98	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	50	120	30	100	1.56		
2	24	50	120	30	100			
3	32	50	120	30	100			
4	28	30	120	30	100			
5	28	70	120	30	100			
6	28	50	112	30	100			
7	28	50	128	30	100			
8	28	50	120	26	100			
9	28	50	120	34	100			
10	28	50	120	30	60			
11	28	50	120	30	140			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

200 yr	**Head =**	7.38	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	50	120	30	100	1.66		
2	24	50	120	30	100			
3	32	50	120	30	100			
4	28	30	120	30	100			
5	28	70	120	30	100			
6	28	50	112	30	100			
7	28	50	128	30	100			
8	28	50	120	26	100			
9	28	50	120	34	100			
10	28	50	120	30	60			
11	28	50	120	30	140			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Elev. 17.0	**Head =**	4.58	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	50	120	30	100	1.83		
2	24	50	120	30	100			
3	32	50	120	30	100			
4	28	30	120	30	100			
5	28	70	120	30	100			
6	28	50	112	30	100			
7	28	50	128	30	100			
8	28	50	120	26	100			
9	28	50	120	34	100			
10	28	50	120	30	60			
11	28	50	120	30	140			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

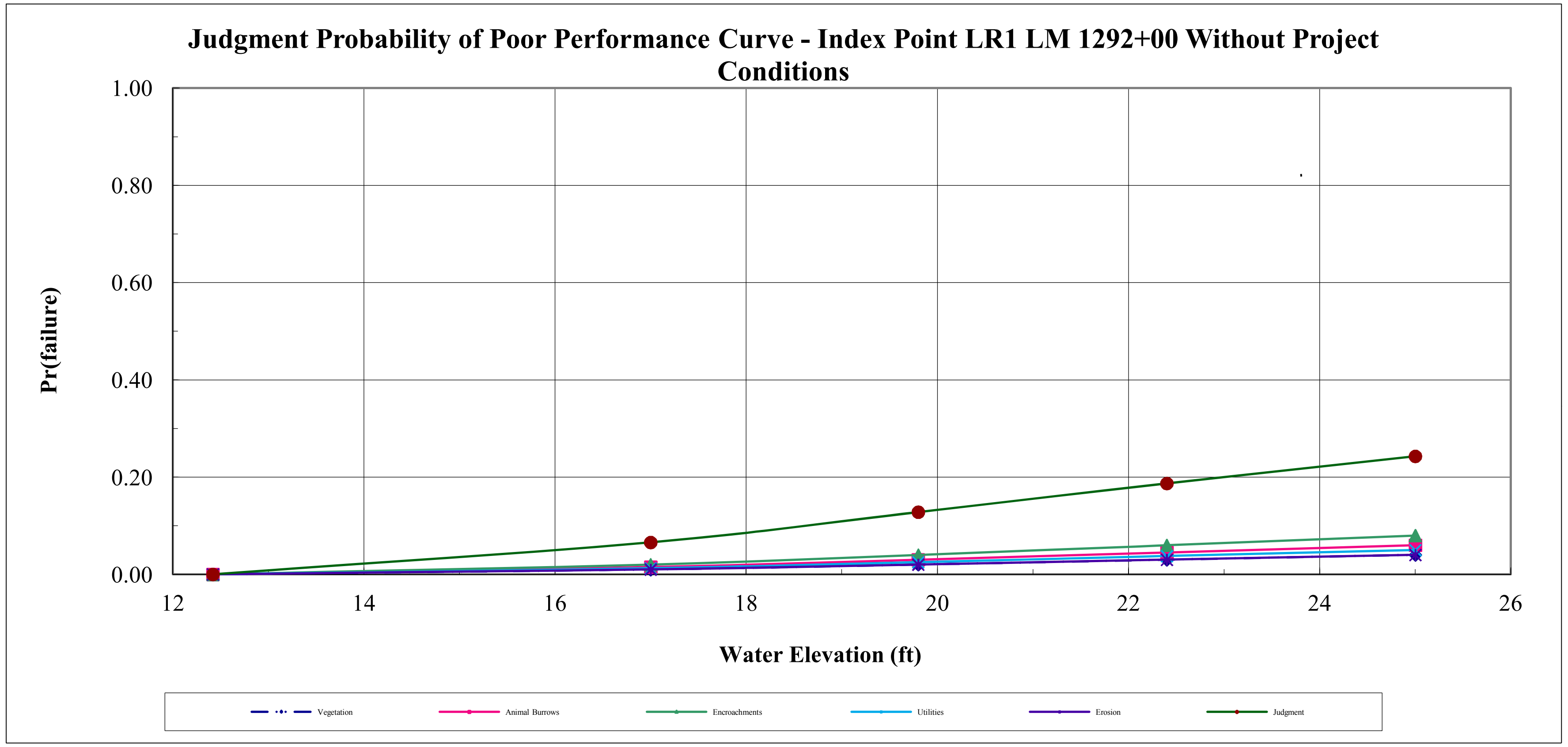
Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR1

Levee Mile: 1292+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 25.00
L/S Toe Elev.: 12.42
W/S Toe Elev.: 11.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. F
Date: 12/18/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
12.42	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
17.00	0.0100	0.9900	0.0150	0.9850	0.0200	0.9800	0.0125	0.9875	0.0100	0.9900	0.0657	0.9343
19.80	0.0200	0.9800	0.0300	0.9700	0.0400	0.9600	0.0250	0.9750	0.0200	0.9800	0.1280	0.8720
22.40	0.0300	0.9700	0.0450	0.9550	0.0600	0.9400	0.0375	0.9625	0.0300	0.9700	0.1870	0.8130
25.00	0.0400	0.9600	0.0600	0.9400	0.0800	0.9200	0.0500	0.9500	0.0400	0.9600	0.2429	0.7571



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

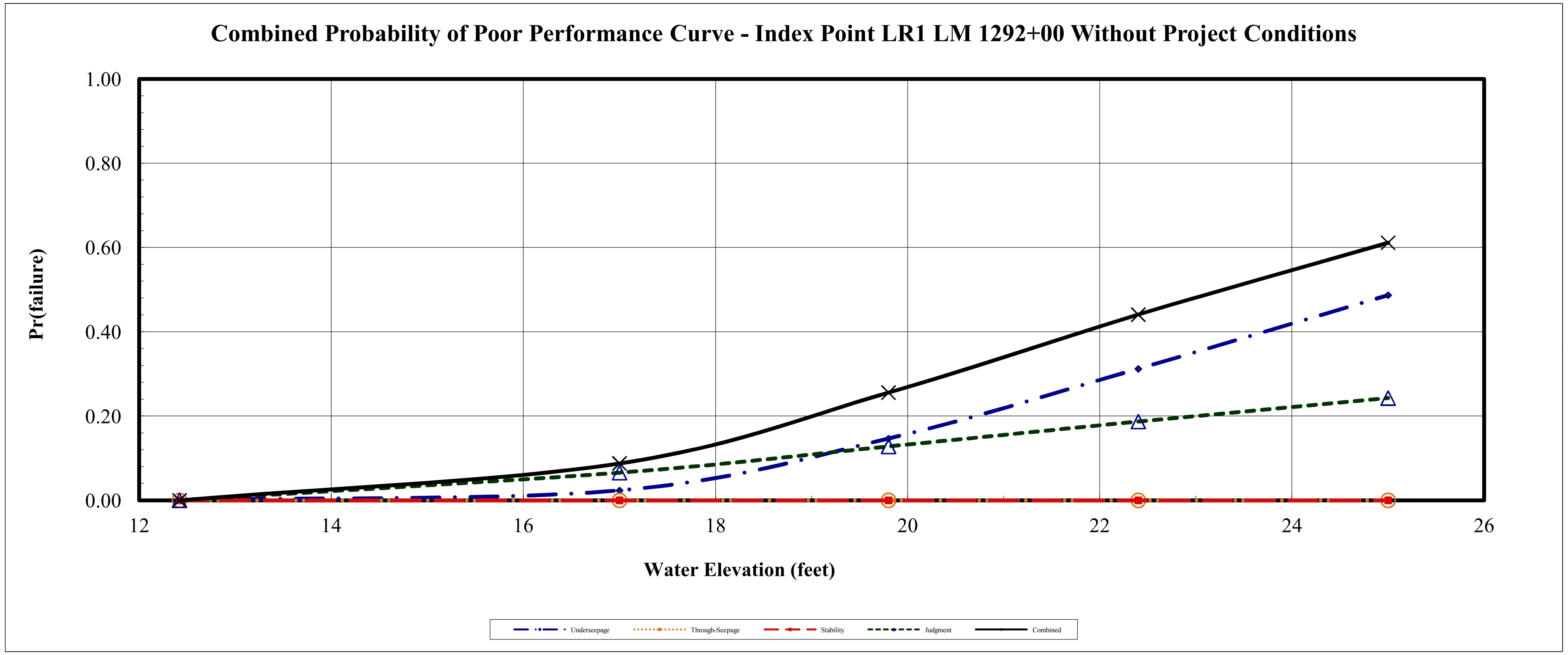
Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR1

Levee Mile: 1292+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 25.00
L/S Toe Elev.: 12.42
W/S Toe Elev.: 11.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Per
Date: 12/18/2012

Water Surface Elevation	**Underseepage**		**Through-Seepage**		**Stability**		**Judgment**		**Combined**	
	Pr(f)	**R**	**Pr(f)**	**R**	**Pr(f)**	**R**	**Pr(f)**	**R**	**Pr(f)**	**R**
12.42	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
17.00	0.0234	0.9766	0.0000	1.0000	0.0000	1.0000	0.0657	0.9343	0.0876	0.9124
19.80	0.1465	0.8535	0.0000	1.0000	0.0000	1.0000	0.1280	0.8720	0.2557	0.7443
22.40	0.3121	0.6879	0.0000	1.0000	0.0000	1.0000	0.1870	0.8130	0.4408	0.5592
25.00	0.4868	0.5132	0.0000	1.0000	0.0000	1.0000	0.2429	0.7571	0.6114	0.3886



Combined Probability of Poor Performance Curve - Index Point LR1 LM 1292+00 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Right Bank San Joaquin River
Basin and Reach: Index Point LR2

Levee Mile: STA 1417+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 27.80
L/S Toe Elev.: 12.00
W/S Toe Elev.: 12.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR0017_047B	10	7	4	20	57	28	18	7	95	39	CL	0.0007	SP-SM	0.28	400	126	170	25246	98
WR0017_049C	12					26					CL	0.0007	SP-SM	0.28	400				
WR0017_052B	8					10					SM	0.007	SP-SM	0.28	40				
WR0017_055C	6					12					SM	0.007	SP-SM	0.28	40				
WR0017_057B	4					20					SM	0.007	SM	0.028	4				
WR0017_063B	11					22					CL	0.0007	SM	0.028	40				
WR0017_064C	3					16					CL	0.0007	SM	0.028	40				
WR0017_065C	2					12					CL	0.0007	SM	0.028	40				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR0017_047B	CL	10	0.0007				10	SP-SM	28	0.28							0.28
WR0017_049C	CL	12	0.0007				12	SP-SM	26	0.28							0.28
WR0017_052B	SM	8	0.007				8	SP-SM	10	0.28							0.28
WR0017_055C	SM	6	0.007				6	SP-SM	12	0.28							0.28
WR0017_057B	SM	4	0.007				4	SM	20	0.028							0.028
WR0017_063B	CL	11	0.0007				11	SM	22	0.028							0.028
WR0017_064C	CL	3	0.0007				3	SM	16	0.028							0.028
WR0017_065C	CL	2	0.0007				2	SM	12	0.028							0.028

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR2

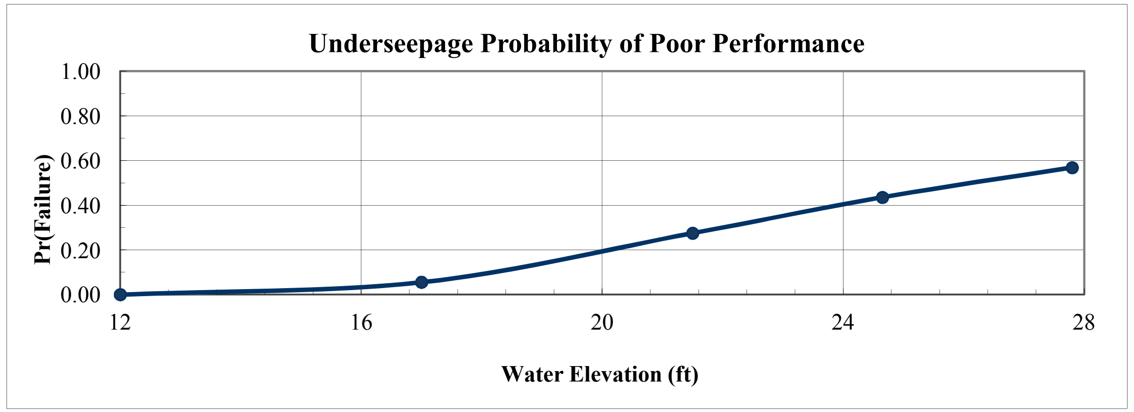
Levee Mile: STA 1417+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 27.80
L/S Toe Elev.: 12.00
W/S Toe Elev.: 12.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permeability Ratio	126	123	98
Blanket Thickness (z)	7	4	57
Aquifer Thickness (d)	18	7	39

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	75	62	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	12.00	0.0000
Elev. 17.0	5.00	17.00	0.0555
200 year	9.50	21.50	0.2749
Elev. 24.65	12.65	24.65	0.4353
Crest	15.80	27.80	0.5685

Crest	**Rh**
Head = 15.80	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	126	7.00	18.00	67.24	126.00	0.0705	7.80	1.11		
2	249	7.00	18.00	70.82	177.30	0.0580	9.03	1.29	0.193600	29.32
3	3	7.00	18.00	17.81	17.82	0.1844	2.88	0.41		
4	126	11.00	18.00	69.83	157.95	0.0621	8.61	0.78	0.455625	69.01
5	126	3.00	18.00	59.45	82.49	0.0883	6.39	2.13		
6	126	7.00	25.00	69.21	148.49	0.0894	8.39	1.20	0.011025	1.67
7	126	7.00	11.00	63.23	98.50	0.0492	6.96	0.99		
								Total	0.660250	100.00

E[I] = 1.110000
Var[I]= 0.660250
σ[I]= 0.812558
V(I) = 0.732034

E[ln I] = -0.110190
σ [ln I] = 0.655057
ln(I crit) = -0.223144

Ic= 0.80

β =	-0.168214
F(z) =	0.431548
Pr(f) % =	56.845171

Elev. 24.65	**Rh**
Head = 12.65	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	126	7.00	18.00	67.24	126.00	0.0705	6.24	0.89		
2	249	7.00	18.00	70.82	177.30	0.0580	7.23	1.03	0.122500	29.13
3	3	7.00	18.00	17.81	17.82	0.1844	2.31	0.33		
4	126	11.00	18.00	69.83	157.95	0.0621	6.90	0.63	0.291600	69.35
5	126	3.00	18.00	59.45	82.49	0.0883	5.12	1.71		
6	126	7.00	25.00	69.21	148.49	0.0894	6.72	0.96	0.006400	1.52
7	126	7.00	11.00	63.23	98.50	0.0492	5.57	0.80		
								Total	0.420500	100.00

E[I] = 0.890000
Var[I]= 0.420500
σ[I]= 0.648460
V(I) = 0.728606

E[ln I] = -0.329451
σ [ln I] = 0.652560
ln(I crit) = -0.223144

Ic= 0.80

β =	-0.504859
F(z) =	0.564705
Pr(f) % =	43.529528

200 year	**Rh**
Head = 9.50	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	126	7.00	18.00	67.24	126.00	0.0705	4.69	0.67		
2	249	7.00	18.00	70.82	177.30	0.0580	5.43	0.78	0.070225	29.52
3	3	7.00	18.00	17.81	17.82	0.1844	1.73	0.25		
4	126	11.00	18.00	69.83	157.95	0.0621	5.18	0.47	0.164025	68.96
5	126	3.00	18.00	59.45	82.49	0.0883	3.84	1.28		
6	126	7.00	25.00	69.21	148.49	0.0894	5.04	0.72	0.003600	1.51
7	126	7.00	11.00	63.23	98.50	0.0492	4.18	0.60		
								Total	0.237850	100.00

E[I] = 0.670000
Var[I]= 0.237850
σ[I]= 0.487699
V(I) = 0.727908

E[ln I] = -0.613063
σ [ln I] = 0.652051
ln(I crit) = -0.223144

Ic= 0.80

β =	-0.940207
F(z) =	0.725076
Pr(f) % =	27.492367

Elev. 17.0	**Rh**
Head = 5.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	126	7.00	18.00	67.24	126.00	0.0705	2.47	0.35		
2	249	7.00	18.00	70.82	177.30	0.0580	2.86	0.41	0.019600	30.19
3	3	7.00	18.00	17.81	17.82	0.1844	0.91	0.13		
4	126	11.00	18.00	69.83	157.95	0.0621	2.73	0.25	0.044100	67.92
5	126	3.00	18.00	59.45	82.49	0.0883	2.02	0.67		
6	126	7.00	25.00	69.21	148.49	0.0894	2.65	0.38	0.001225	1.89
7	126	7.00	11.00	63.23	98.50	0.0492	2.20	0.31		
								Total	0.064925	100.00

E[I] = 0.350000
Var[I]= 0.064925
σ[I]= 0.254804
V(I) = 0.728011

E[ln I] = -1.262456
σ [ln I] = 0.652126
ln(I crit) = -0.223144

Ic= 0.80

β =	-1.935909
F(z) =	0.944502
Pr(f) % =	5.549819

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR2

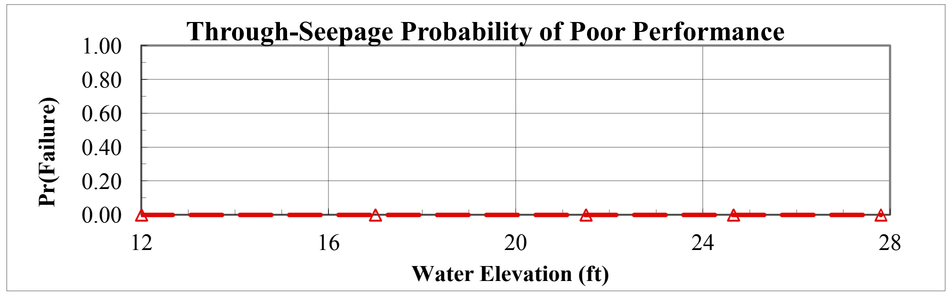
Levee Mile: STA 1417+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 27.80
L/S Toe Elev.: 12.00
W/S Toe Elev.: 12.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	5	0.5	10.00
Initial Porosity (n)	0.4	0.04	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
NO



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	12.00	0.0000
Elev. 17.0	5.00	17.00	0.000000
200 year	9.50	21.50	0.000000
Elev. 24.65	12.65	24.65	0.000000
Crest	15.80	27.80	0.000000

Crest **Head =** 15.80 **Horizontal Gradient (Ix) =** 0.240

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	475.09		
2	4.50	0.40	1.00E-10	102.62	427.58	2257.076899	26.44
3	5.50	0.40	1.00E-10	125.42	522.60		
4	5.00	0.36	1.00E-10	108.17	450.71	565.686995	6.63
5	5.00	0.44	1.00E-10	119.59	498.28		
6	5.00	0.40	7.00E-11	136.28	567.84	5712.239803	66.93
7	5.00	0.40	1.30E-10	100.00	416.68		

E[FS] = 475.087034
Var[FS]= 8535.003697
σ[FS]= 92.385084
V(FS) = 0.194459
FS req'd = 1.00

E[ln FS] = 6.144940
σ[ln FS]= 0.192658
ln(FS req'd) = 0.000000

Total 8535.003697 100.00

β = 31.895640
F(z) = 0.000000
Pr(f) % = 0.000000

Elev. 24.65 **Head =** 12.65 **Horizontal Gradient (Ix) =** 0.190

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	600.11		
2	4.50	0.40	1.00E-10	102.62	540.10	3601.319373	26.44
3	5.50	0.40	1.00E-10	125.42	660.12		
4	5.00	0.36	1.00E-10	108.17	569.31	902.591993	6.63
5	5.00	0.44	1.00E-10	119.59	629.40		
6	5.00	0.40	7.00E-11	136.28	717.27	9114.266278	66.93
7	5.00	0.40	1.30E-10	100.00	526.33		

E[FS] = 600.109938
Var[FS]= 13618.177643
σ[FS]= 116.696948
V(FS) = 0.194459
FS req'd = 1.00

E[ln FS] = 6.378554
σ[ln FS]= 0.192658
ln(FS req'd) = 0.000000

Total 13618.177643 100.00

β = 33.108231
F(z) = 0.000000
Pr(f) % = 0.000000

200 year **Head =** 9.50 **Horizontal Gradient (Ix) =** 0.140

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	814.43		
2	4.50	0.40	1.00E-10	102.62	732.99	6633.042314	26.44
3	5.50	0.40	1.00E-10	125.42	895.88		
4	5.00	0.36	1.00E-10	108.17	772.64	1662.427089	6.63
5	5.00	0.44	1.00E-10	119.59	854.19		
6	5.00	0.40	7.00E-11	136.28	973.44	16786.990441	66.93
7	5.00	0.40	1.30E-10	100.00	714.31		

E[FS] = 814.434915
Var[FS]= 25082.459843
σ[FS]= 158.374429
V(FS) = 0.194459
FS req'd = 1.00

E[ln FS] = 6.683936
σ[ln FS]= 0.192658
ln(FS req'd) = 0.000000

Total 25082.459843 100.00

β = 34.693331
F(z) = 0.000000
Pr(f) % = 0.000000

Elev. 17.0 **Head =** 5.00 **Horizontal Gradient (Ix) =** 0.090

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	1266.90		
2	4.50	0.40	1.00E-10	102.62	1140.21	16050.324612	26.44
3	5.50	0.40	1.00E-10	125.42	1393.59		
4	5.00	0.36	1.00E-10	108.17	1201.89	4022.663079	6.63
5	5.00	0.44	1.00E-10	119.59	1328.73		
6	5.00	0.40	7.00E-11	136.28	1514.23	40620.371930	66.93
7	5.00	0.40	1.30E-10	100.00	1111.14		

E[FS] = 1266.898757
Var[FS]= 60693.359621
σ[FS]= 246.360223
V(FS) = 0.194459
FS req'd = 1.00

E[ln FS] = 7.125769
σ[ln FS]= 0.192658
ln(FS req'd) = 0.000000

Total 60693.359621 100.00

β = 36.986687
F(z) = 0.000000
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

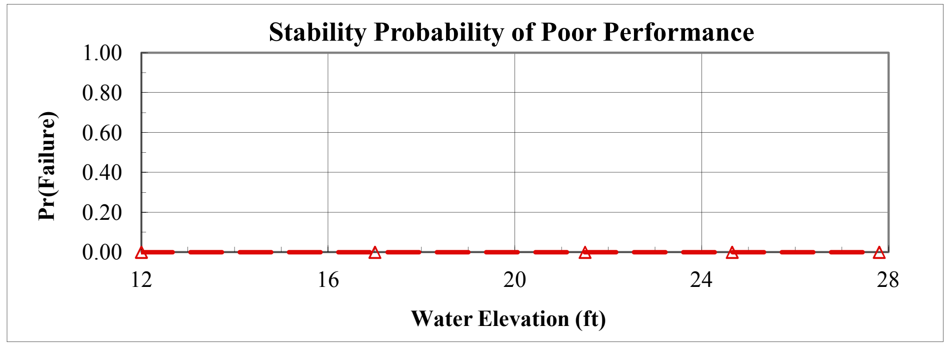
Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR2

Levee Mile: STA 1417+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 27.80
L/S Toe Elev.: 12.00
W/S Toe Elev.: 12.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	28	4	13.00
Levee Cohesion	100	40	40.00
Levee γ	120	8	7.00
Foundation Φ	30	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	12.00	0.0000
Elev. 17.0	5.00	17.00	0.000000
200 year	9.50	21.50	0.000000
Elev. 24.65	12.65	24.65	0.000000
Crest	15.80	27.80	0.000000

Crest	**Head =**	15.80	**Pr(f)=0**	NO

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	30	0	1.94		
2	24	100	120	30	0	1.90	0.001225	1.86
3	32	100	120	30	0	1.97		
4	28	60	120	30	0	1.89	0.002352	3.57
5	28	140	120	30	0	1.98		
6	28	100	112	30	0	1.97	0.001296	1.97
7	28	100	128	30	0	1.90		
8	28	100	120	26	0	1.70	0.061009	92.60
9	28	100	120	34	0	2.19		
10	28	100	120	30	0	1.94	0.000000	0.00
11	28	100	120	30	0	1.94		

E[FS] = 1.940000
Var[FS]= 0.065882
σ[FS]= 0.256675
V(FS) = 0.132307
FS req'd = 1.00

E[ln FS] = 0.654011
σ[ln FS]= 0.131733
ln(FS req'd) = 0.000000

Total 0.065882 100.00

β =	4.964660
F(z) =	0.000000
Pr(f) % =	0.000034

Elev. 24.65	**Head =**	12.65	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	30	0	2.20		
2	24	100	120	30	0			
3	32	100	120	30	0			
4	28	60	120	30	0			
5	28	140	120	30	0			
6	28	100	112	30	0			
7	28	100	128	30	0			
8	28	100	120	26	0			
9	28	100	120	34	0			
10	28	100	120	30	0			
11	28	100	120	30	0			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =	
F(z) =	
Pr(f) % =	0.000000

200 year	**Head =**	9.50	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	30	0	2.48		
2	24	100	120	30	0			
3	32	100	120	30	0			
4	28	60	120	30	0			
5	28	140	120	30	0			
6	28	100	112	30	0			
7	28	100	128	30	0			
8	28	100	120	26	0			
9	28	100	120	34	0			
10	28	100	120	30	0			
11	28	100	120	30	0			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =	
F(z) =	
Pr(f) % =	0.000000

Elev. 17.0	**Head =**	5.00	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	30	0	2.88		
2	24	100	120	30	0			
3	32	100	120	30	0			
4	28	60	120	30	0			
5	28	140	120	30	0			
6	28	100	112	30	0			
7	28	100	128	30	0			
8	28	100	120	26	0			
9	28	100	120	34	0			
10	28	100	120	30	0			
11	28	100	120	30	0			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

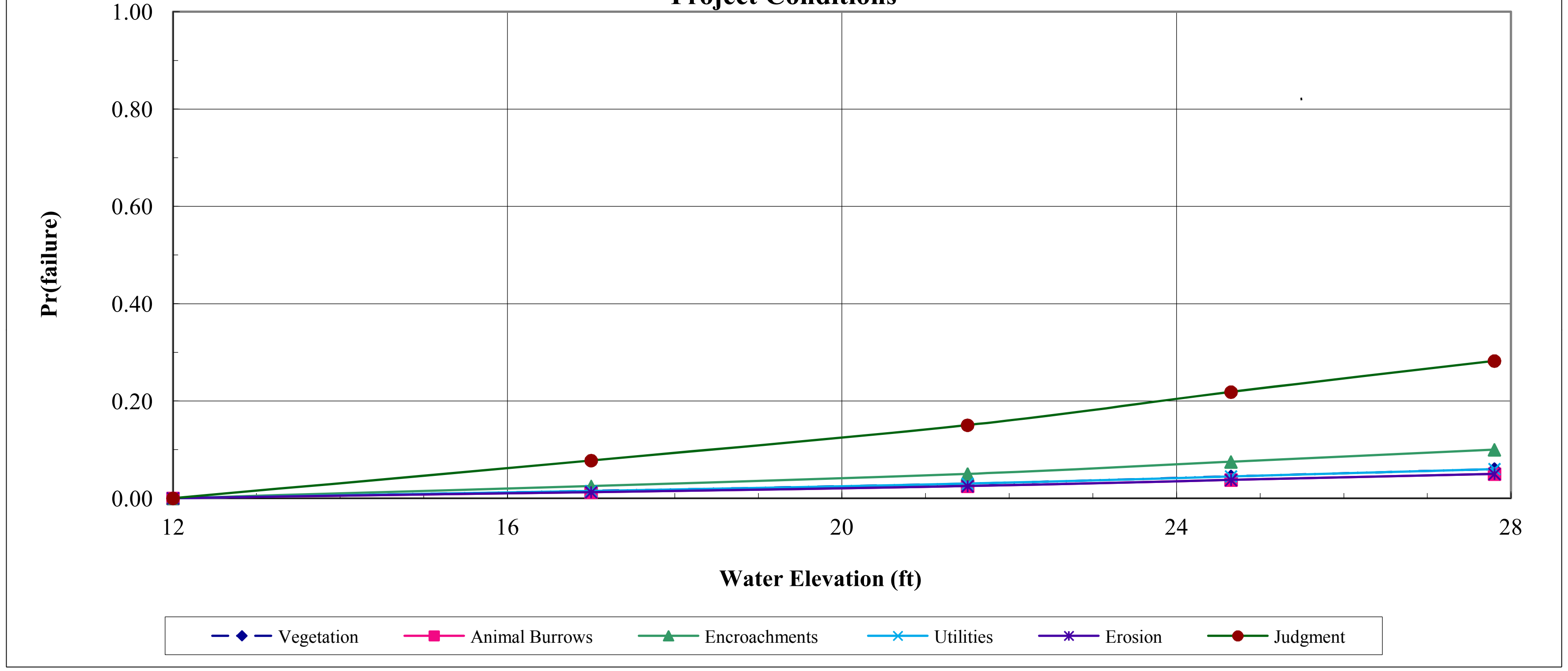
Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR2

Levee Mile: STA 1417+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 27.80
L/S Toe Elev.: 12.00
W/S Toe Elev.: 12.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
12.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
17.00	0.0150	0.9850	0.0125	0.9875	0.0250	0.9750	0.0150	0.9850	0.0125	0.9875	0.0775	0.9225
21.50	0.0300	0.9700	0.0250	0.9750	0.0500	0.9500	0.0300	0.9700	0.0250	0.9750	0.1503	0.8497
24.65	0.0450	0.9550	0.0375	0.9625	0.0750	0.9250	0.0450	0.9550	0.0375	0.9625	0.2185	0.7815
27.80	0.0600	0.9400	0.0500	0.9500	0.1000	0.9000	0.0600	0.9400	0.0500	0.9500	0.2823	0.7177


Judgment Probability of Poor Performance Curve - Index Point LR2 LM STA 1417+00 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

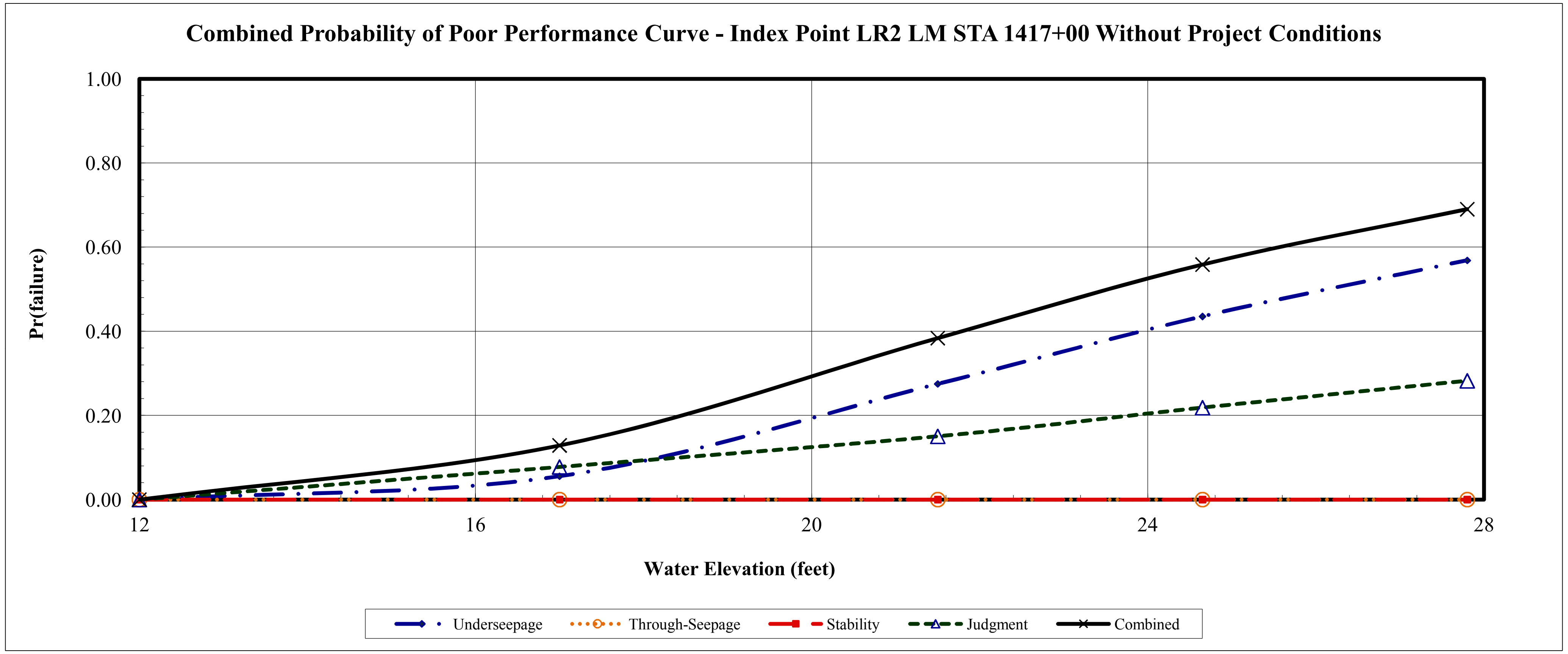
Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR2

Levee Mile: STA 1417+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 27.80
L/S Toe Elev.: 12.00
W/S Toe Elev.: 12.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
12.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
17.00	0.0555	0.9445	0.0000	1.0000	0.0000	1.0000	0.0775	0.9225	0.1287	0.8713
21.50	0.2749	0.7251	0.0000	1.0000	0.0000	1.0000	0.1503	0.8497	0.3839	0.6161
24.65	0.4353	0.5647	0.0000	1.0000	0.0000	1.0000	0.2185	0.7815	0.5587	0.4413
27.80	0.5685	0.4315	0.0000	1.0000	0.0000	1.0000	0.2823	0.7177	0.6903	0.3097


Combined Probability of Poor Performance Curve - Index Point LR2 LM STA 1417+00 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: San Joaquin River
Basin and Reach: Index Point LR3

Levee Mile: 1685+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 31.00
L/S Toe Elev.: 18.53
W/S Toe Elev.: 17.80

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/19/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR0017_067C	16	11	6	43	55	26	35	12	239	34	CL	0.0007	SM	0.28	400	6933	9800	90176000	98
WR0017_070C	18					24					CL	0.0007	SM	0.28	400				
WR0017_071C	8					45					CL	0.0007	SM	0.28	400				
WR0017_072C	16					52					CL	0.0007	SM	0.28	400				
WR0017_075C	18					18					CL	0.0007	SP	14	20000				
WR0017_076C	10					26					CL	0.0007	SP	14	20000				
WR0017_080B	3					42					CL	0.0007	SM	0.28	400				
WR0017_081C	10					40					CL	0.0007	SM	0.28	400				
WR0017_085B	4					40					CL	0.0007	SP-SM	14	20000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR0017_067C	CL	16	0.0007				16	SM	26	0.28							0.28
WR0017_069B	ML	6	0.035				6	SP-SM	16	14							14
WR0017_070C	CL	18	0.0007				18	SM	24	0.28							0.28
WR0017_071C	CL	8	0.0007				8	SM	45	0.28							0.28
WR0017_072C	CL	16	0.0007				16	SM	52	0.28							0.28
WR0017_075C	CL	18	0.0007				18	SP	18	14							14
WR0017_076C	CL	10	0.0007				10	SP	26	14							14
WR0017_080B	CL	3	0.0007				3	SM	42	0.28							0.28
WR0017_081C	CL	10	0.0007				10	SM	40	0.28							0.28
WR0017_085B	CL	4	0.0007				4	SP-SM	40	14							14

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR3

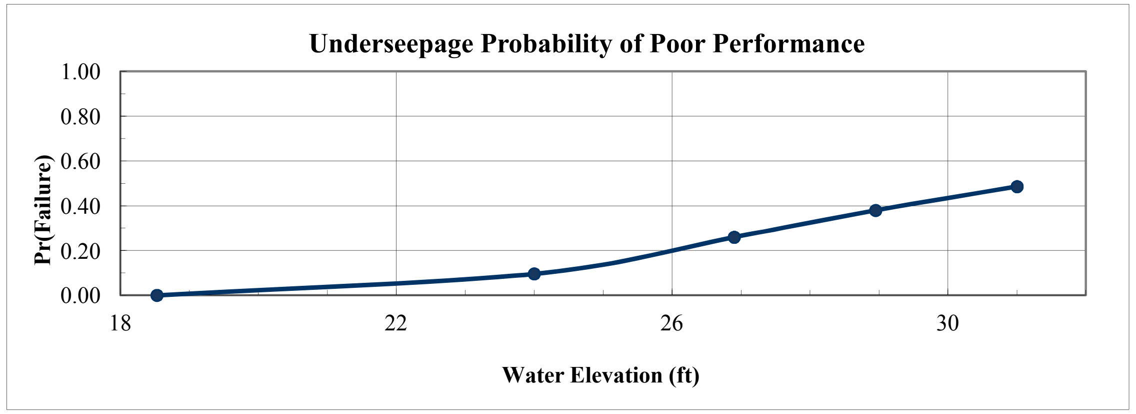
Levee Mile: 1685+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 31.00
L/S Toe Elev.: 18.53
W/S Toe Elev.: 17.80

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/19/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permaebility Ratio	6933	6794	98
Blanket Thickness (z)	11	6	55
Aquifer Thickness (d)	35	12	34

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	190	90	∞	112



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	18.53	0.0000
Elev.	5.47	24.00	0.0961
Elev.	8.37	26.90	0.2596
Elev.	10.42	28.95	0.3790
Crest	12.47	31.00	0.4857

Crest	Rh
Head = 12.47	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	6933	11.00	35.00	189.15	1633.77	0.0183	10.65	0.97		
2	13727	11.00	35.00	189.57	2298.92	0.0136	11.12	1.01	0.052900	10.39
3	139	11.00	35.00	156.27	231.05	0.0733	6.04	0.55		
4	6933	17.00	35.00	189.45	2031.04	0.0151	10.96	0.64	0.455625	89.49
5	6933	5.00	35.00	188.14	1101.49	0.0254	9.96	1.99		
6	6933	11.00	47.00	189.36	1893.24	0.0216	10.87	0.99	0.000625	0.12
7	6933	11.00	23.00	188.71	1324.41	0.0143	10.30	0.94		
								Total	0.509150	100.00

E[I] = 0.970000
Var[I]= 0.509150
σ[I]= 0.713547
V(I) = 0.735616

E[ln I] = -0.246717
σ [ln I] = 0.657660

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.375144
F(z) =	0.514297
Pr(f) % =	48.570294

Elev.	Rh
Head = 10.42	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	6933	11.00	35.00	189.15	1633.77	0.0183	8.90	0.81		
2	13727	11.00	35.00	189.57	2298.92	0.0136	9.29	0.84	0.036100	10.30
3	139	11.00	35.00	156.27	231.05	0.0733	5.04	0.46		
4	6933	17.00	35.00	189.45	2031.04	0.0151	9.16	0.54	0.313600	89.52
5	6933	5.00	35.00	188.14	1101.49	0.0254	8.32	1.66		
6	6933	11.00	47.00	189.36	1893.24	0.0216	9.08	0.83	0.000625	0.18
7	6933	11.00	23.00	188.71	1324.41	0.0143	8.61	0.78		
								Total	0.350325	100.00

E[I] = 0.810000
Var[I]= 0.350325
σ[I]= 0.591883
V(I) = 0.730719

E[ln I] = -0.424644
σ [ln I] = 0.654100

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.649204
F(z) =	0.620981
Pr(f) % =	37.901906

Elev.	Rh
Head = 8.37	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	6933	11.00	35.00	189.15	1633.77	0.0183	7.15	0.65		
2	13727	11.00	35.00	189.57	2298.92	0.0136	7.46	0.68	0.024025	10.39
3	139	11.00	35.00	156.27	231.05	0.0733	4.05	0.37		
4	6933	17.00	35.00	189.45	2031.04	0.0151	7.36	0.43	0.207025	89.51
5	6933	5.00	35.00	188.14	1101.49	0.0254	6.68	1.34		
6	6933	11.00	47.00	189.36	1893.24	0.0216	7.29	0.66	0.000225	0.10
7	6933	11.00	23.00	188.71	1324.41	0.0143	6.91	0.63		
								Total	0.231275	100.00

E[I] = 0.650000
Var[I]= 0.231275
σ[I]= 0.480911
V(I) = 0.739862

E[ln I] = -0.649070
σ [ln I] = 0.660737

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.982342
F(z) =	0.740414
Pr(f) % =	25.958586

Elev.	Rh
Head = 5.47	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	6933	11.00	35.00	189.15	1633.77	0.0183	4.67	0.42		
2	13727	11.00	35.00	189.57	2298.92	0.0136	4.88	0.44	0.010000	10.30
3	139	11.00	35.00	156.27	231.05	0.0733	2.65	0.24		
4	6933	17.00	35.00	189.45	2031.04	0.0151	4.81	0.28	0.087025	89.60
5	6933	5.00	35.00	188.14	1101.49	0.0254	4.37	0.87		
6	6933	11.00	47.00	189.36	1893.24	0.0216	4.77	0.43	0.000100	0.10
7	6933	11.00	23.00	188.71	1324.41	0.0143	4.52	0.41		
								Total	0.097125	100.00

E[I] = 0.420000
Var[I]= 0.097125
σ[I]= 0.311649
V(I) = 0.742021

E[ln I] = -1.086820
σ [ln I] = 0.662298

Ic= 0.80
ln(I crit) = -0.223144

β =	-1.640983
F(z) =	0.903893
Pr(f) % =	9.610659

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR3

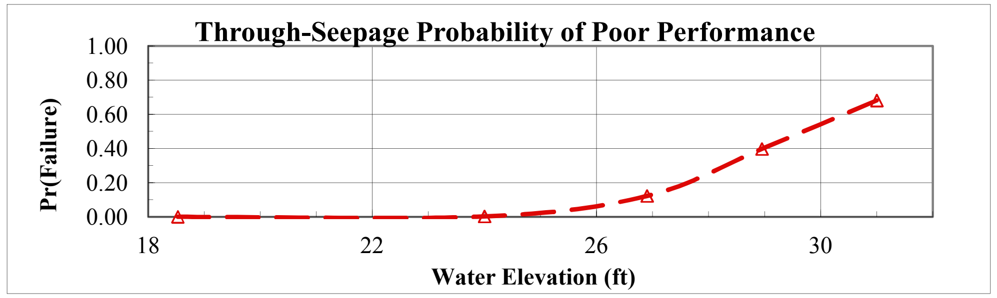
Levee Mile: 1685+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 31.00
L/S Toe Elev.: 18.53
W/S Toe Elev.: 17.80

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/19/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	2	0.2	10.00
Initial Porosity (n)	0.25	0.03	10.00
Initial Permeability (Ko)	8.00E-08	2.40E-08	30.00

Pr(f)=0
NO



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	18.53	0.0000
Elev.	5.47	24.00	0.002576
Elev.	8.37	26.90	0.122242
Elev.	10.42	28.95	0.397071
Crest	12.47	31.00	0.680891

Crest	**Head =**	12.47	**Horizontal Gradient (Ix) =**	1.370

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	2.00	0.25	8.00E-08	1.27	0.93		
2	1.80	0.25	8.00E-08	1.15	0.84	0.008658	26.44
3	2.20	0.25	8.00E-08	1.40	1.02		
4	2.00	0.23	8.00E-08	1.21	0.88	0.002170	6.63
5	2.00	0.28	8.00E-08	1.34	0.98		
6	2.00	0.25	5.60E-08	1.52	1.11	0.021913	66.93
7	2.00	0.25	1.04E-07	1.12	0.82		

E[FS] = 0.930505
E[ln FS] = -0.090586
Total 0.032741 100.00
Var[FS]= 0.032741
σ[FS]= 0.180945
σ[ln FS]= 0.192658
β = -0.470191
V(FS) = 0.194459
F(z) = 0.680891
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 68.089086

Elev.	**Head =**	8.37	**Horizontal Gradient (Ix) =**	1.000

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	2.00	0.25	8.00E-08	1.27	1.27		
2	1.80	0.25	8.00E-08	1.15	1.15	0.016251	26.44
3	2.20	0.25	8.00E-08	1.40	1.40		
4	2.00	0.23	8.00E-08	1.21	1.21	0.004073	6.63
5	2.00	0.28	8.00E-08	1.34	1.34		
6	2.00	0.25	5.60E-08	1.52	1.52	0.041128	66.93
7	2.00	0.25	1.04E-07	1.12	1.12		

E[FS] = 1.274792
E[ln FS] = 0.224225
Total 0.061452 100.00
Var[FS]= 0.061452
σ[FS]= 0.247895
σ[ln FS]= 0.192658
β = 1.163851
V(FS) = 0.194459
F(z) = 0.122242
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 12.224225

Elev.	**Head =**	10.42	**Horizontal Gradient (Ix) =**	1.190

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	2.00	0.25	8.00E-08	1.27	1.07		
2	1.80	0.25	8.00E-08	1.15	0.96	0.011476	26.44
3	2.20	0.25	8.00E-08	1.40	1.18		
4	2.00	0.23	8.00E-08	1.21	1.02	0.002876	6.63
5	2.00	0.28	8.00E-08	1.34	1.12		
6	2.00	0.25	5.60E-08	1.52	1.28	0.029043	66.93
7	2.00	0.25	1.04E-07	1.12	0.94		

E[FS] = 1.071254
E[ln FS] = 0.050271
Total 0.043395 100.00
Var[FS]= 0.043395
σ[FS]= 0.208315
σ[ln FS]= 0.192658
β = 0.260937
V(FS) = 0.194459
F(z) = 0.397071
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 39.707066

Elev.	**Head =**	5.47	**Horizontal Gradient (Ix) =**	0.730

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	2.00	0.25	8.00E-08	1.27	1.75		
2	1.80	0.25	8.00E-08	1.15	1.57	0.030495	26.44
3	2.20	0.25	8.00E-08	1.40	1.92		
4	2.00	0.23	8.00E-08	1.21	1.66	0.007643	6.63
5	2.00	0.28	8.00E-08	1.34	1.83		
6	2.00	0.25	5.60E-08	1.52	2.09	0.077178	66.93
7	2.00	0.25	1.04E-07	1.12	1.53		

E[FS] = 1.746291
E[ln FS] = 0.538936
Total 0.115316 100.00
Var[FS]= 0.115316
σ[FS]= 0.339582
σ[ln FS]= 0.192658
β = 2.797374
V(FS) = 0.194459
F(z) = 0.002576
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 0.257599

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

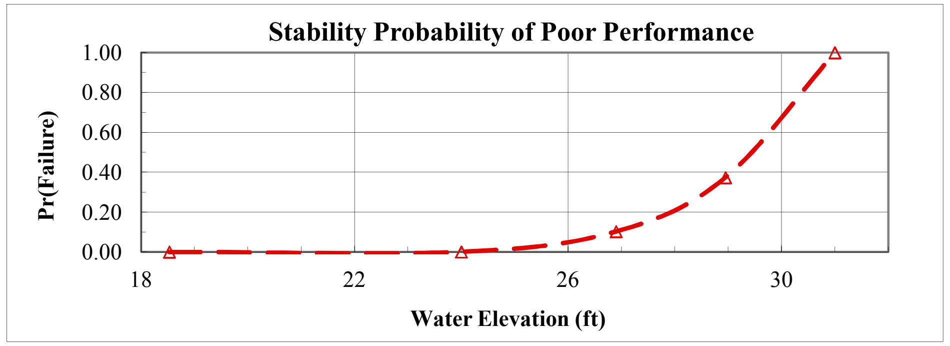
Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR3

Levee Mile: 1685+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 31.00
L/S Toe Elev.: 18.53
W/S Toe Elev.: 17.80

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/19/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	30	4	13.00
Levee Cohesion	50	20	40.00
Levee γ	125	9	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	100	40	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	18.53	0.0000
Elev.	5.47	24.00	0.000272
Elev.	8.37	26.90	0.102531
Elev.	10.42	28.95	0.372477
Crest	12.47	31.00	0.999333

Crest	**Head =**	12.47	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	125	28	100	0.77		
2	26	50	125	28	100	0.73	0.002162	53.37
3	34	50	125	28	100	0.82		
4	30	30	125	28	100	0.73	0.000992	24.49
5	30	70	125	28	100	0.80		
6	30	50	116	28	100	0.76	0.000121	2.99
7	30	50	134	28	100	0.78		
8	30	50	125	24	100	0.76	0.000100	2.47
9	30	50	125	32	100	0.78		
10	30	50	125	28	60	0.74	0.000676	16.69
11	30	50	125	28	140	0.79		

E[FS] = 0.770000 E[ln FS] = -0.264770 Total 0.004052 100.00
Var[FS]= 0.004052
σ[FS]= 0.063651 σ[ln FS]= 0.082523 **β =** -3.208419
V(FS) = 0.082664 **F(z) =** 0.999333
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 99.933267

Elev.	**Head =**	10.42	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	125	28	100	1.03		
2	26	50	125	28	100	0.98	0.004900	70.47
3	34	50	125	28	100	1.12		
4	30	30	125	28	100	1.01	0.000441	6.34
5	30	70	125	28	100	1.05		
6	30	50	116	28	100	1.06	0.000081	1.16
7	30	50	134	28	100	1.04		
8	30	50	125	24	100	1.01	0.000306	4.40
9	30	50	125	32	100	1.05		
10	30	50	125	28	60	0.99	0.001225	17.62
11	30	50	125	28	140	1.06		

E[FS] = 1.030000 E[ln FS] = 0.026292 Total 0.006953 100.00
Var[FS]= 0.006953
σ[FS]= 0.083386 σ[ln FS]= 0.080825 **β =** 0.325300
V(FS) = 0.080957 **F(z) =** 0.372477
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 37.247706

Elev.	**Head =**	8.37	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	125	28	100	1.20		
2	26	50	125	28	100	1.12	0.007310	26.99
3	34	50	125	28	100	1.29		
4	30	30	125	28	100	1.16	0.001122	4.14
5	30	70	125	28	100	1.23		
6	30	50	116	28	100	1.19	0.000004	0.01
7	30	50	134	28	100	1.20		
8	30	50	125	24	100	1.20	0.000020	0.07
9	30	50	125	32	100	1.19		
10	30	50	125	28	60	0.93	0.018632	68.78
11	30	50	125	28	140	1.21		

E[FS] = 1.200000 E[ln FS] = 0.173003 Total 0.027089 100.00
Var[FS]= 0.027089
σ[FS]= 0.164587 σ[ln FS]= 0.136518 **β =** 1.267258
V(FS) = 0.137156 **F(z) =** 0.102531
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 10.253149

Elev.	**Head =**	5.47	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	125	28	100	1.35		
2	26	50	125	28	100	1.30	0.002916	21.69
3	34	50	125	28	100	1.40		
4	30	30	125	28	100	1.30	0.001600	11.90
5	30	70	125	28	100	1.38		
6	30	50	116	28	100	1.35	0.000016	0.12
7	30	50	134	28	100	1.34		
8	30	50	125	24	100	1.32	0.000900	6.70
9	30	50	125	32	100	1.38		
10	30	50	125	28	60	1.31	0.008010	59.59
11	30	50	125	28	140	1.49		

E[FS] = 1.350000 E[ln FS] = 0.296430 Total 0.013442 100.00
Var[FS]= 0.013442
σ[FS]= 0.115941 σ[ln FS]= 0.085724 **β =** 3.457950
V(FS) = 0.085882 **F(z) =** 0.000272
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.027215

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

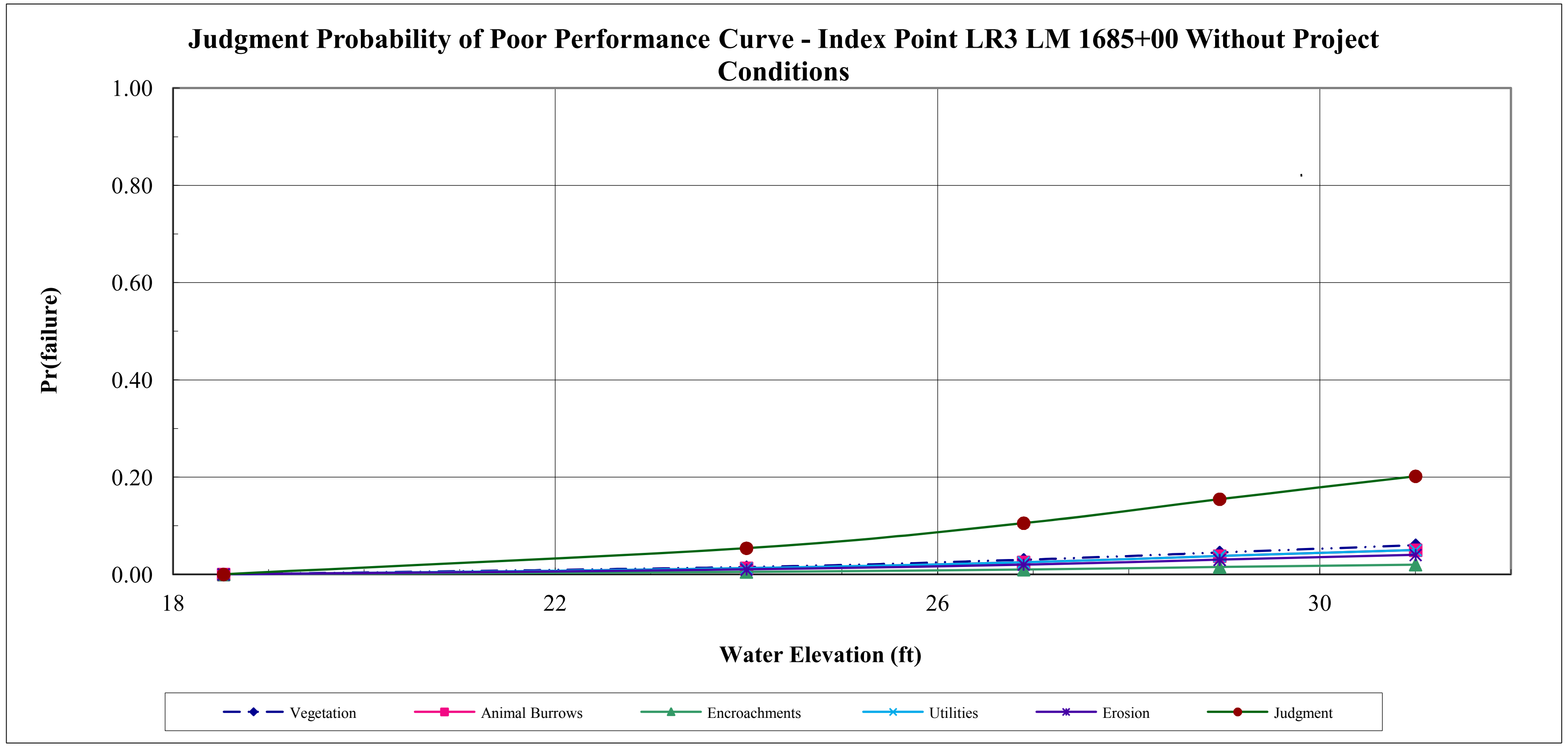
Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR3

Levee Mile: 1685+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 31.00
L/S Toe Elev.: 18.53
W/S Toe Elev.: 17.80

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/19/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
18.53	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
24.00	0.0150	0.9850	0.0125	0.9875	0.0050	0.9950	0.0125	0.9875	0.0100	0.9900	0.0538	0.9462
26.90	0.0300	0.9700	0.0250	0.9750	0.0100	0.9900	0.0250	0.9750	0.0200	0.9800	0.1054	0.8946
28.95	0.0450	0.9550	0.0375	0.9625	0.0150	0.9850	0.0375	0.9625	0.0300	0.9700	0.1547	0.8453
31.00	0.0600	0.9400	0.0500	0.9500	0.0200	0.9800	0.0500	0.9500	0.0400	0.9600	0.2019	0.7981


Judgment Probability of Poor Performance Curve - Index Point LR3 LM 1685+00 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

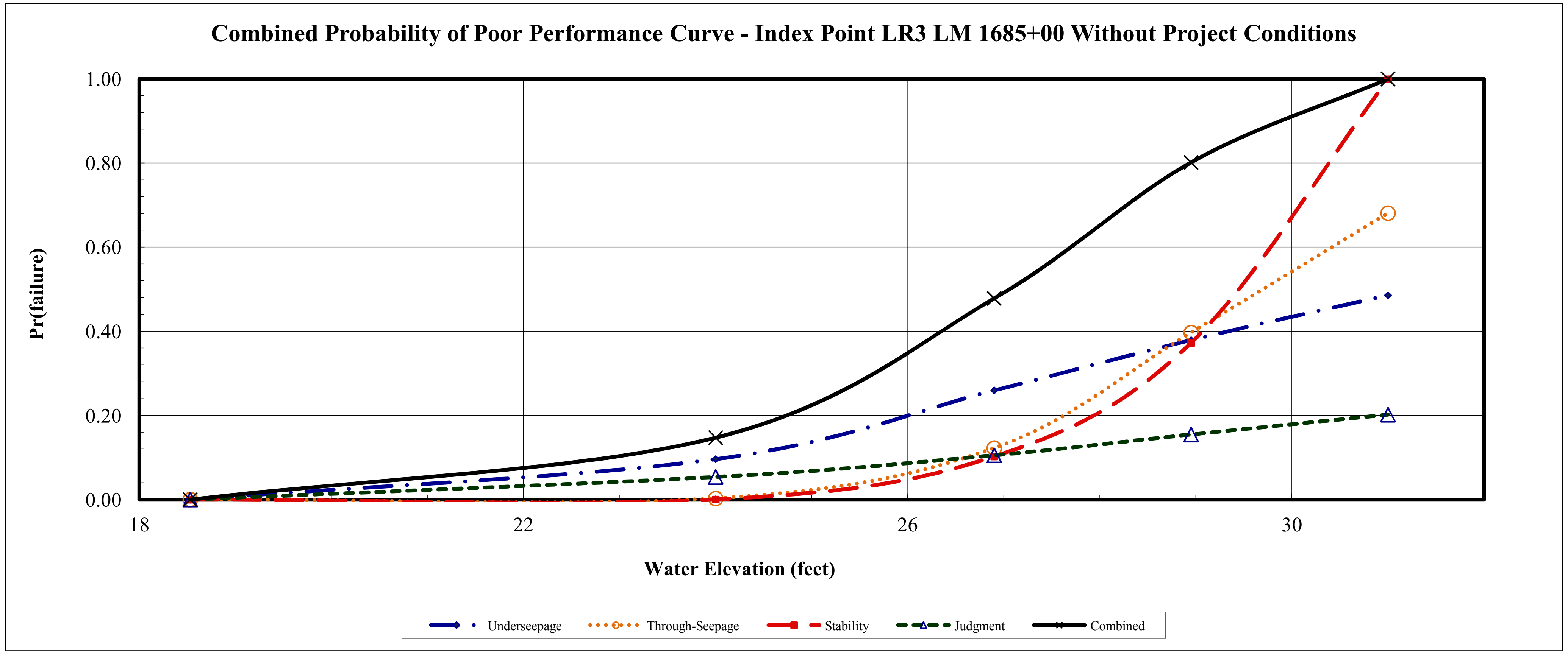
Project: Lower San Joaquin
Study Area: San Joaquin River
River Section: Index Point LR3

Levee Mile: 1685+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 31.00
L/S Toe Elev.: 18.53
W/S Toe Elev.: 17.80

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 12/19/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
18.53	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
24.00	0.0961	0.9039	0.0026	0.9974	0.0003	0.9997	0.0538	0.9462	0.1472	0.8528
26.90	0.2596	0.7404	0.1222	0.8778	0.1025	0.8975	0.1054	0.8946	0.4782	0.5218
28.95	0.3790	0.6210	0.3971	0.6029	0.3725	0.6275	0.1547	0.8453	0.8014	0.1986
31.00	0.4857	0.5143	0.6809	0.3191	0.9993	0.0007	0.2019	0.7981	0.9999	0.0001



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Right Bank San Joaquin River
Basin and Reach: Index Point LR4

Levee Mile: STA 1815+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 33.90
L/S Toe Elev.: 18.60
W/S Toe Elev.: 19.40

Analysis By: G. Johnson
Checked By: M. Perlea 12/13/2012
Date: 12/13/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR0017_098C	28	23	3	154	13	20	33	8	324	24	CL	0.007	SP-SM	14	2000	3200	1095	3377778	34
WR0017_099C	20					38					CL	0.007	SP-SM	14	2000				
WR0017_100C	22					32					CL	0.0007	SP-SM	2.8	4000				
WR0017_101C	24					38					CL	0.0007	SP-SM	2.8	4000				
WR0017_103C	22					36					CL	0.0007	SP-SM	2.8	4000				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR0017_098C	CL	28	0.007				28	SP-SM	20	14							14
WR0017_099C	CL	20	0.007				20	SP-SM	38	14							14
WR0017_100C	CL	22	0.0007				22	SP-SM	32	2.8							2.8
WR0017_101C	CL	24	0.0007				24	SP-SM	38	2.8							2.8
WR0017_103C	CL	22	0.0007				22	SP-SM	36	2.8							2.8

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR4

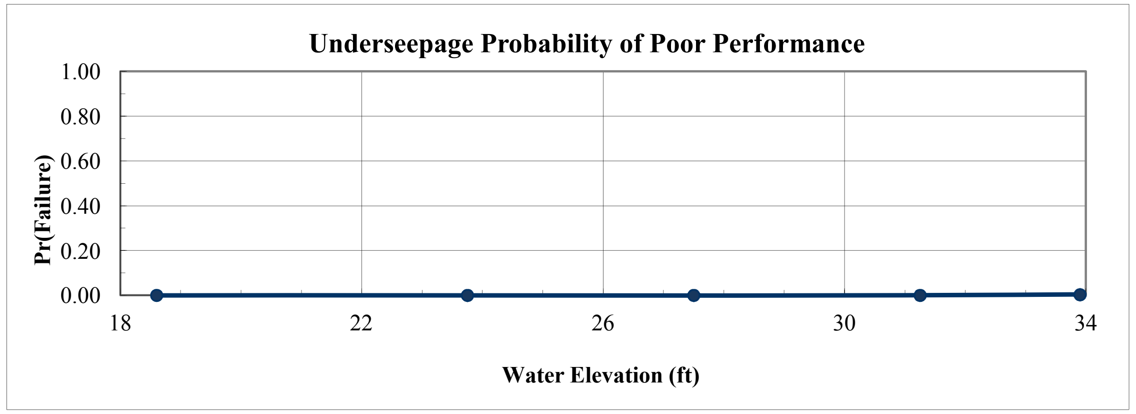
Levee Mile: STA 1815+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 33.90
L/S Toe Elev.: 18.60
W/S Toe Elev.: 19.40

Analysis By: G. Johnson
Checked By: M. Perlea 12/13/2012
Date: 12/13/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	3200	1095	34
Blanket Thickness (z)	23	3	13
Aquifer Thickness (d)	33	8	24

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	153	110	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	18.60	0.0000
Elev. 23.75	5.15	23.75	0.0000
Elev. 27.5	8.90	27.50	0.0000
200 yr.	12.65	31.25	0.0000
Crest	15.30	33.90	0.0030

Crest	Rh
Head = 15.30	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	3200	23.00	33.00	152.51	1558.46	0.0181	13.09	0.57		
2	4295	23.00	33.00	152.63	1805.52	0.0160	13.36	0.58	0.000225	4.31
3	2105	23.00	33.00	152.26	1264.00	0.0216	12.67	0.55		
4	3200	26.00	33.00	152.57	1656.99	0.0172	13.21	0.51	0.004900	93.78
5	3200	20.00	33.00	152.44	1453.27	0.0192	12.96	0.65		
6	3200	23.00	41.00	152.61	1737.12	0.0205	13.29	0.58	0.000100	1.91
7	3200	23.00	25.00	152.35	1356.47	0.0154	12.82	0.56		
								Total	0.005225	100.00

E[I] = 0.570000
Var[I]= 0.005225
σ[I]= 0.072284
V(I) = 0.126814
E[ln I] = -0.570096
σ [ln I] = 0.126309
Ic= 0.80
ln(I crit) = -0.223144

β =	-4.513507
F(z) =	0.996992
Pr(f) % =	0.300847

200 yr.	Rh
Head = 12.65	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	3200	23.00	33.00	152.51	1558.46	0.0181	10.83	0.47		
2	4295	23.00	33.00	152.63	1805.52	0.0160	11.04	0.48	0.000100	2.63
3	2105	23.00	33.00	152.26	1264.00	0.0216	10.48	0.46		
4	3200	26.00	33.00	152.57	1656.99	0.0172	10.92	0.42	0.003600	94.74
5	3200	20.00	33.00	152.44	1453.27	0.0192	10.72	0.54		
6	3200	23.00	41.00	152.61	1737.12	0.0205	10.99	0.48	0.000100	2.63
7	3200	23.00	25.00	152.35	1356.47	0.0154	10.60	0.46		
								Total	0.003800	100.00

E[I] = 0.470000
Var[I]= 0.003800
σ[I]= 0.061644
V(I) = 0.131158
E[ln I] = -0.763551
σ [ln I] = 0.130599
Ic= 0.80
ln(I crit) = -0.223144

β =	-5.846532
F(z) =	0.999982
Pr(f) % =	0.001752

Elev. 27.5	Rh
Head = 8.90	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	3200	23.00	33.00	152.51	1558.46	0.0181	7.62	0.33		
2	4295	23.00	33.00	152.63	1805.52	0.0160	7.77	0.34	0.000100	5.56
3	2105	23.00	33.00	152.26	1264.00	0.0216	7.37	0.32		
4	3200	26.00	33.00	152.57	1656.99	0.0172	7.68	0.30	0.001600	88.89
5	3200	20.00	33.00	152.44	1453.27	0.0192	7.54	0.38		
6	3200	23.00	41.00	152.61	1737.12	0.0205	7.73	0.34	0.000100	5.56
7	3200	23.00	25.00	152.35	1356.47	0.0154	7.46	0.32		
								Total	0.001800	100.00

E[I] = 0.330000
Var[I]= 0.001800
σ[I]= 0.042426
V(I) = 0.128565
E[ln I] = -1.116860
σ [ln I] = 0.128038
Ic= 0.80
ln(I crit) = -0.223144

β =	-8.722854
F(z) =	1.000000
Pr(f) % =	0.000000

Elev. 23.75	Rh
Head = 5.15	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	3200	23.00	33.00	152.51	1558.46	0.0181	4.41	0.19		
2	4295	23.00	33.00	152.63	1805.52	0.0160	4.50	0.20	0.000025	3.85
3	2105	23.00	33.00	152.26	1264.00	0.0216	4.27	0.19		
4	3200	26.00	33.00	152.57	1656.99	0.0172	4.45	0.17	0.000625	96.15
5	3200	20.00	33.00	152.44	1453.27	0.0192	4.36	0.22		
6	3200	23.00	41.00	152.61	1737.12	0.0205	4.47	0.19	0.000000	0.00
7	3200	23.00	25.00	152.35	1356.47	0.0154	4.32	0.19		
								Total	0.000650	100.00

E[I] = 0.190000
Var[I]= 0.000650
σ[I]= 0.025495
V(I) = 0.134185
E[ln I] = -1.669654
σ [ln I] = 0.133587
Ic= 0.80
ln(I crit) = -0.223144

β =	-12.498670
F(z) =	1.000000
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR4

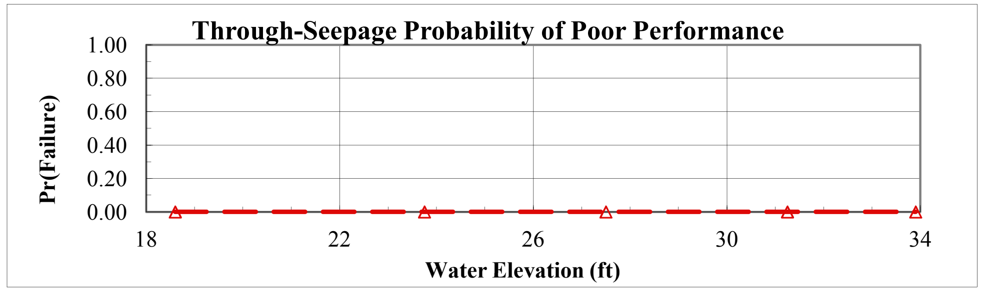
Levee Mile: STA 1815+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 33.90
L/S Toe Elev.: 18.60
W/S Toe Elev.: 19.40

Analysis By: G. Johnson
Checked By: M. Perlea 12/13/2012
Date: 12/13/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	5	0.5	10.00
Initial Porosity (n)	0.5	0.05	10.00
Initial Permeability (Ko)	1.00E-08	3.00E-09	30.00

Pr(f)=0
NO


Through-Seepage Probability of Poor Performance

Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	18.60	0.0000
Elev. 23.75	5.15	23.75	0.000000
Elev. 27.5	8.90	27.50	0.000000
200 yr.	12.65	31.25	0.000000
Crest	15.30	33.90	0.000000

Crest	**Head =**	15.30	**Horizontal Gradient (Ix) =**	0.590

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.50	1.00E-08	12.75	21.61		
2	4.50	0.50	1.00E-08	11.47	19.45	4.668473	26.44
3	5.50	0.50	1.00E-08	14.02	23.77		
4	5.00	0.45	1.00E-08	12.09	20.50	1.170051	6.63
5	5.00	0.55	1.00E-08	13.37	22.66		
6	5.00	0.50	7.00E-09	15.24	25.82	11.815032	66.93
7	5.00	0.50	1.30E-08	11.18	18.95		
E[FS] =	21.606649		E[ln FS] =	3.054443	Total	17.653555	100.00
Var[FS]=	17.653555						
σ[FS]=	4.201613		σ[ln FS]=	0.192658		β =	15.854249
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

200 yr.	**Head =**	12.65	**Horizontal Gradient (Ix) =**	0.530

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.50	1.00E-08	12.75	24.05		
2	4.50	0.50	1.00E-08	11.47	21.65	5.785316	26.44
3	5.50	0.50	1.00E-08	14.02	26.46		
4	5.00	0.45	1.00E-08	12.09	22.82	1.449963	6.63
5	5.00	0.55	1.00E-08	13.37	25.23		
6	5.00	0.50	7.00E-09	15.24	28.75	14.641554	66.93
7	5.00	0.50	1.30E-08	11.18	21.10		
E[FS] =	24.052685		E[ln FS] =	3.161688	Total	21.876834	100.00
Var[FS]=	21.876834						
σ[FS]=	4.677268		σ[ln FS]=	0.192658		β =	16.410913
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Elev. 27.5	**Head =**	8.90	**Horizontal Gradient (Ix) =**	0.410

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.50	1.00E-08	12.75	31.09		
2	4.50	0.50	1.00E-08	11.47	27.98	9.667432	26.44
3	5.50	0.50	1.00E-08	14.02	34.20		
4	5.00	0.45	1.00E-08	12.09	29.50	2.422931	6.63
5	5.00	0.55	1.00E-08	13.37	32.61		
6	5.00	0.50	7.00E-09	15.24	37.16	24.466464	66.93
7	5.00	0.50	1.30E-08	11.18	27.27		
E[FS] =	31.092495		E[ln FS] =	3.418408	Total	36.556827	100.00
Var[FS]=	36.556827						
σ[FS]=	6.046224		σ[ln FS]=	0.192658		β =	17.743431
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Elev. 23.75	**Head =**	5.15	**Horizontal Gradient (Ix) =**	0.190

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.50	1.00E-08	12.75	67.09		
2	4.50	0.50	1.00E-08	11.47	60.38	45.016492	26.44
3	5.50	0.50	1.00E-08	14.02	73.80		
4	5.00	0.45	1.00E-08	12.09	63.65	11.282400	6.63
5	5.00	0.55	1.00E-08	13.37	70.37		
6	5.00	0.50	7.00E-09	15.24	80.19	113.928328	66.93
7	5.00	0.50	1.30E-08	11.18	58.85		
E[FS] =	67.094331		E[ln FS] =	4.187541	Total	170.227221	100.00
Var[FS]=	170.227221						
σ[FS]=	13.047115		σ[ln FS]=	0.192658		β =	21.735658
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

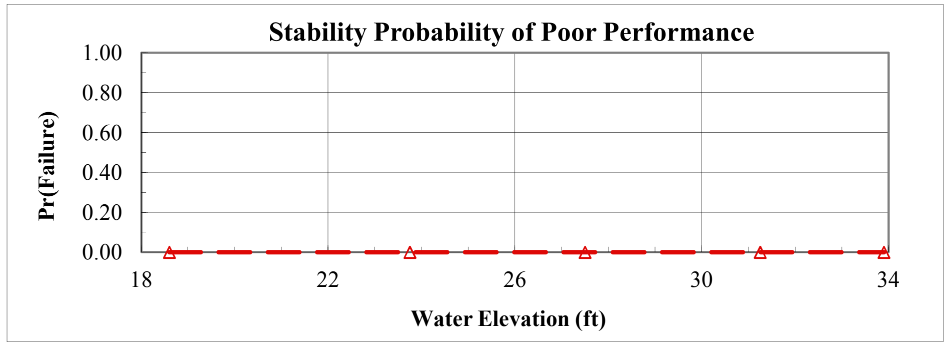
Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR4

Levee Mile: STA 1815+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 33.90
L/S Toe Elev.: 18.60
W/S Toe Elev.: 19.40

Analysis By: G. Johnson
Checked By: M. Perlea 12/13/2012
Date: 12/13/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	30	4	13.00
Levee Cohesion	50	20	40.00
Levee γ	125	9	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	100	40	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	18.60	0.0000
Elev. 23.75	5.15	23.75	0.000000
Elev. 27.5	8.90	27.50	0.000000
200 yr.	12.65	31.25	0.000000
Crest	15.30	33.90	0.000090

Crest	**Head =**	15.30	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	125	28	100	1.63		
2	26	50	125	28	100	1.57	0.003906	8.87
3	34	50	125	28	100	1.70		
4	30	30	125	28	100	1.60	0.001056	2.40
5	30	70	125	28	100	1.66		
6	30	50	116	28	100	1.65	0.000144	0.33
7	30	50	134	28	100	1.62		
8	30	50	125	24	100	1.50	0.018496	41.99
9	30	50	125	32	100	1.77		
10	30	50	125	28	60	1.49	0.020449	46.42
11	30	50	125	28	140	1.77		

E[FS] = 1.630000 E[ln FS] = 0.480358 Total 0.044052 100.00
Var[FS]= 0.044052
σ[FS]= 0.209884 σ[ln FS]= 0.128235 **β =** 3.745934
V(FS) = 0.128763 **F(z) =** 0.000090
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.008986

200 yr.	**Head =**	12.65	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	125	28	100	1.78		
2	26	50	125	28	100			
3	34	50	125	28	100			
4	30	30	125	28	100			
5	30	70	125	28	100			
6	30	50	116	28	100			
7	30	50	134	28	100			
8	30	50	125	24	100			
9	30	50	125	32	100			
10	30	50	125	28	60			
11	30	50	125	28	140			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]= **β =**
V(FS) = **F(z) =**
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

Elev. 27.5	**Head =**	8.90	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	125	28	100	1.98		
2	26	50	125	28	100			
3	34	50	125	28	100			
4	30	30	125	28	100			
5	30	70	125	28	100			
6	30	50	116	28	100			
7	30	50	134	28	100			
8	30	50	125	24	100			
9	30	50	125	32	100			
10	30	50	125	28	60			
11	30	50	125	28	140			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]= **β =**
V(FS) = **F(z) =**
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

Elev. 23.75	**Head =**	5.15	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	125	28	100	2.14		
2	26	50	125	28	100			
3	34	50	125	28	100			
4	30	30	125	28	100			
5	30	70	125	28	100			
6	30	50	116	28	100			
7	30	50	134	28	100			
8	30	50	125	24	100			
9	30	50	125	32	100			
10	30	50	125	28	60			
11	30	50	125	28	140			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]= **β =**
V(FS) = **F(z) =**
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

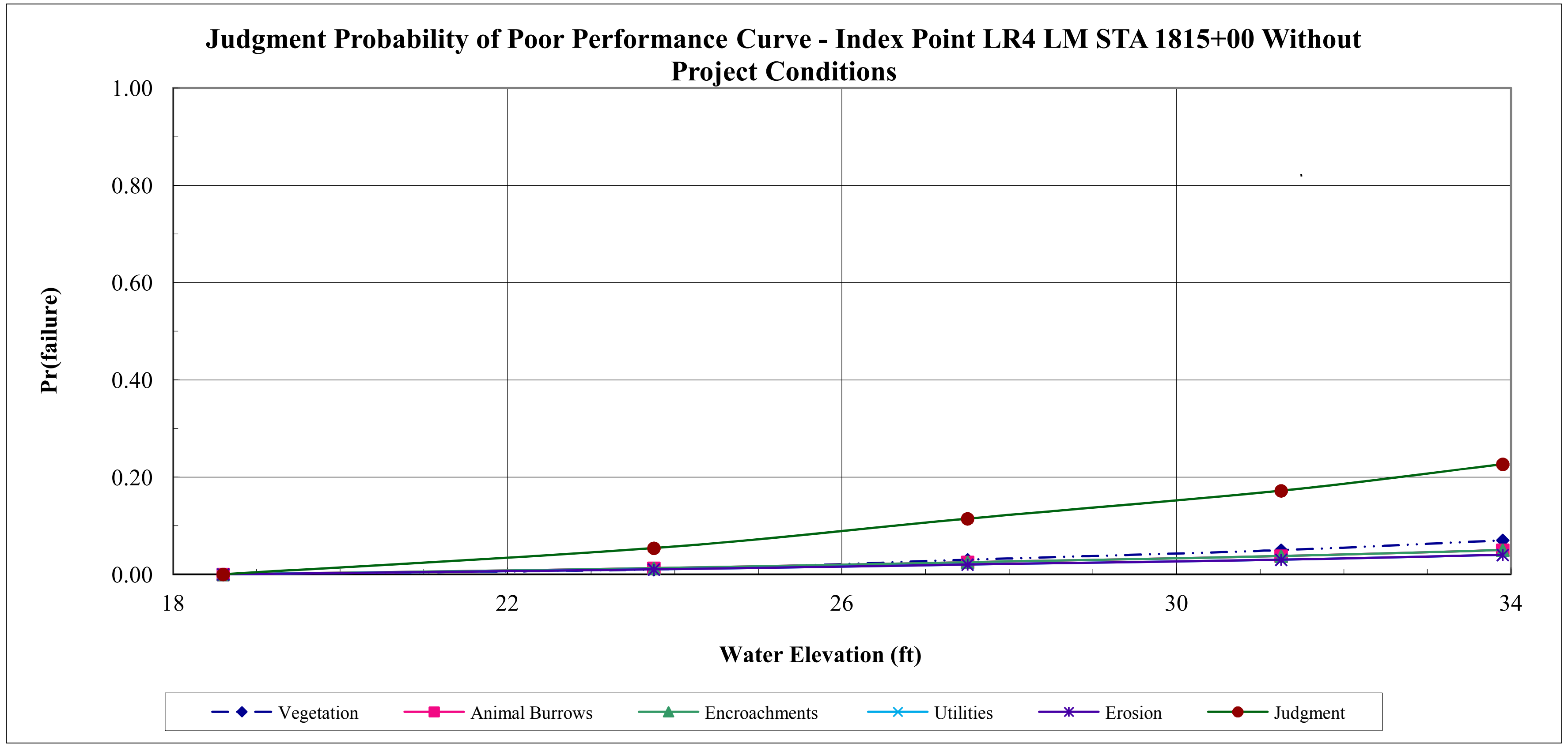
Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR4

Levee Mile: STA 1815+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 33.90
L/S Toe Elev.: 18.60
W/S Toe Elev.: 19.40

Analysis By: G. Johnson
Checked By: M. Perlea 12/13/2012
Date: 12/13/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
18.60	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
23.75	0.0100	0.9900	0.0125	0.9875	0.0125	0.9875	0.0100	0.9900	0.0100	0.9900	0.0538	0.9462
27.50	0.0300	0.9700	0.0250	0.9750	0.0250	0.9750	0.0200	0.9800	0.0200	0.9800	0.1144	0.8856
31.25	0.0500	0.9500	0.0375	0.9625	0.0375	0.9625	0.0300	0.9700	0.0300	0.9700	0.1719	0.8281
33.90	0.0700	0.9300	0.0500	0.9500	0.0500	0.9500	0.0400	0.9600	0.0400	0.9600	0.2265	0.7735



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

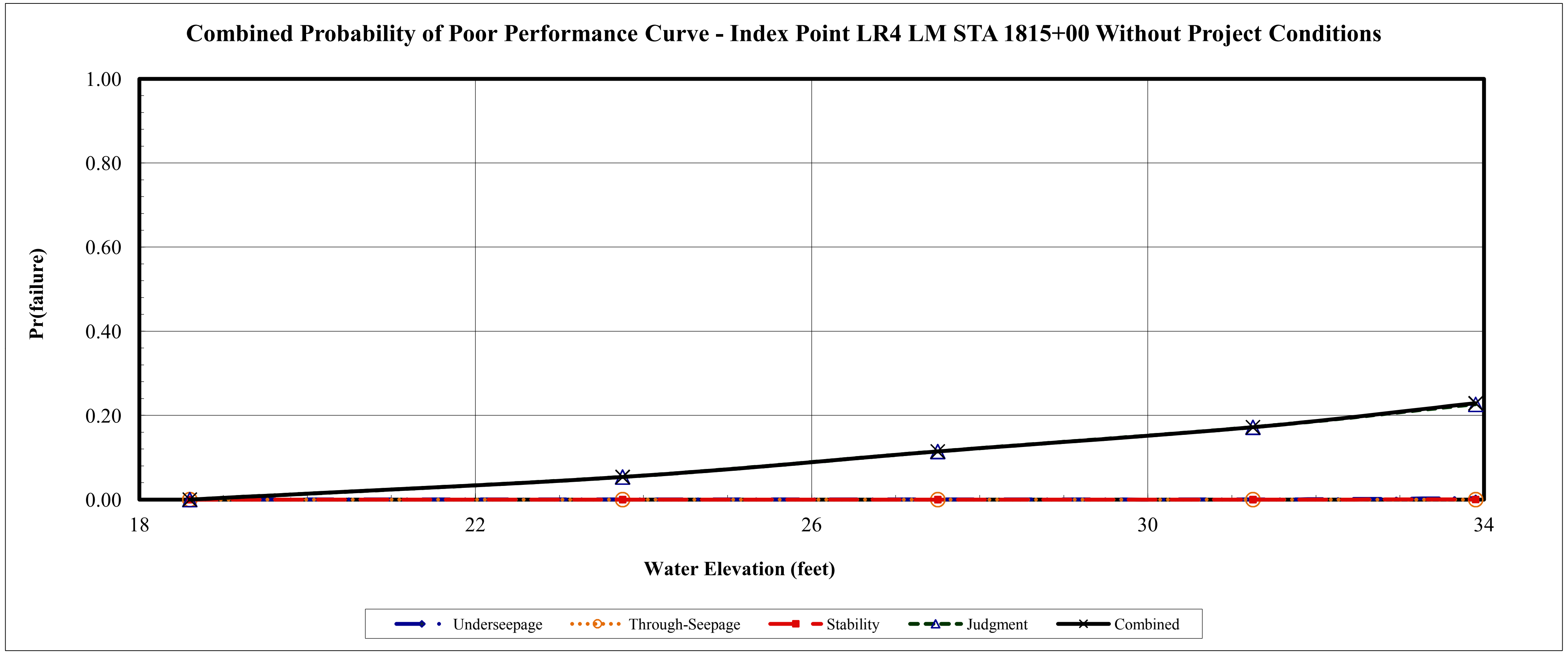
Project: Lower San Joaquin
Study Area: Right Bank San Joaquin River
River Section: Index Point LR4

Levee Mile: STA 1815+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 33.90
L/S Toe Elev.: 18.60
W/S Toe Elev.: 19.40

Analysis By: G. Johnson
Checked By: M. Perlea 12/13/2012
Date: 12/13/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
18.60	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
23.75	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0538	0.9462	0.0538	0.9462
27.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1144	0.8856	0.1144	0.8856
31.25	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1719	0.8281	0.1719	0.8281
33.90	0.0030	0.9970	0.0000	1.0000	0.0001	0.9999	0.2265	0.7735	0.2289	0.7711



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Left Bank French Camp Slough
Basin and Reach: Index Point FL1

Levee Mile: STA 1049+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 21.40
L/S Toe Elev.: 9.36
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR0017_004C	10	10	1	29	10	6	9	6	35	67	CL	0.0007	SC	0.28	400	400	0	44444	0
WR0017_005C	8					4					CL	0.0007	SC	0.28	400				
WR0017_007B	10					6					CL	0.0007	SC	0.28	400				
WR0017_010C	10					10					CL	0.0007	SC	0.28	400				
WR0017_011C	12					18					CL	0.0007	SC	0.28	400				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR0017_004C	CL	10	0.0007				10	SC	6	0.28							0.28
WR0017_005C	CL	8	0.0007				8	SC	4	0.28							0.28
WR0017_007B	CL	10	0.0007				10	SC	6	0.28							0.28
WR0017_010C	CL	10	0.0007				10	SC	10	0.28							0.28
WR0017_011C	CL	12	0.0007				12	SC	18	0.28							0.28

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Left Bank French Camp Slough
River Section: Index Point FL1

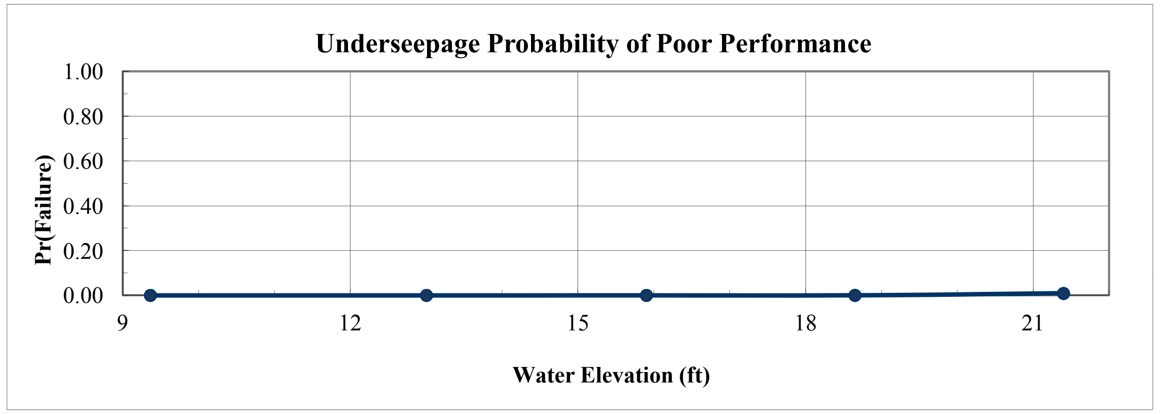
Levee Mile: STA 1049+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 21.40
L/S Toe Elev.: 9.36
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permeability Ratio	400	0	0
Blanket Thickness (z)	10	1	10
Aquifer Thickness (d)	9	6	67

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	175	103	∞	112



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	9.36	0.0000
Elev. 13.0	3.64	13.00	0.0000
200 year	6.54	15.90	0.0000
Elev. 18.65	9.29	18.65	0.0000
Crest	12.04	21.40	0.0087

Crest		**Rh**
Head =	12.04	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	400	10.00	9.00	137.94	189.74	0.0209	5.30	0.53		
2	400	10.00	9.00	137.94	189.74	0.0209	5.30	0.53	0.000000	0.00
3	400	10.00	9.00	137.94	189.74	0.0209	5.30	0.53		
4	400	11.00	9.00	140.52	199.00	0.0203	5.41	0.49	0.002025	21.89
5	400	9.00	9.00	134.94	180.00	0.0215	5.19	0.58		
6	400	10.00	15.00	150.26	244.95	0.0301	5.92	0.59	0.007225	78.11
7	400	10.00	3.00	100.92	109.54	0.0096	4.21	0.42		
								Total	0.009250	100.00

E[I] = 0.530000
Var[I]= 0.009250
σ[I]= 0.096177
V(I) = 0.181466
Ic= 0.80

E[ln I] = -0.651078
σ [ln I] = 0.179998
ln(I crit) = -0.223144

β = -3.617139
F(z) = 0.991283
Pr(f) % = 0.871666

Elev. 18.65		**Rh**
Head =	9.29	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	400	10.00	9.00	137.94	189.74	0.0209	4.09	0.41		
2	400	10.00	9.00	137.94	189.74	0.0209	4.09	0.41	0.000000	0.00
3	400	10.00	9.00	137.94	189.74	0.0209	4.09	0.41		
4	400	11.00	9.00	140.52	199.00	0.0203	4.18	0.38	0.000900	17.56
5	400	9.00	9.00	134.94	180.00	0.0215	4.00	0.44		
6	400	10.00	15.00	150.26	244.95	0.0301	4.57	0.46	0.004225	82.44
7	400	10.00	3.00	100.92	109.54	0.0096	3.25	0.33		
								Total	0.005125	100.00

E[I] = 0.410000
Var[I]= 0.005125
σ[I]= 0.071589
V(I) = 0.174608
Ic= 0.80

E[ln I] = -0.906614
σ [ln I] = 0.173298
ln(I crit) = -0.223144

β = -5.231525
F(z) = 0.999960
Pr(f) % = 0.004008

200 year		**Rh**
Head =	6.54	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	400	10.00	9.00	137.94	189.74	0.0209	2.88	0.29		
2	400	10.00	9.00	137.94	189.74	0.0209	2.88	0.29	0.000000	0.00
3	400	10.00	9.00	137.94	189.74	0.0209	2.88	0.29		
4	400	11.00	9.00	140.52	199.00	0.0203	2.94	0.27	0.000400	16.49
5	400	9.00	9.00	134.94	180.00	0.0215	2.82	0.31		
6	400	10.00	15.00	150.26	244.95	0.0301	3.22	0.32	0.002025	83.51
7	400	10.00	3.00	100.92	109.54	0.0096	2.29	0.23		
								Total	0.002425	100.00

E[I] = 0.290000
Var[I]= 0.002425
σ[I]= 0.049244
V(I) = 0.169808
Ic= 0.80

E[ln I] = -1.252088
σ [ln I] = 0.168603
ln(I crit) = -0.223144

β = -7.426268
F(z) = 1.000000
Pr(f) % = 0.000000

Elev. 13.0		**Rh**
Head =	3.64	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	400	10.00	9.00	137.94	189.74	0.0209	1.60	0.16		
2	400	10.00	9.00	137.94	189.74	0.0209	1.60	0.16	0.000000	0.00
3	400	10.00	9.00	137.94	189.74	0.0209	1.60	0.16		
4	400	11.00	9.00	140.52	199.00	0.0203	1.64	0.15	0.000100	13.79
5	400	9.00	9.00	134.94	180.00	0.0215	1.57	0.17		
6	400	10.00	15.00	150.26	244.95	0.0301	1.79	0.18	0.000625	86.21
7	400	10.00	3.00	100.92	109.54	0.0096	1.27	0.13		
								Total	0.000725	100.00

E[I] = 0.160000
Var[I]= 0.000725
σ[I]= 0.026926
V(I) = 0.168286
Ic= 0.80

E[ln I] = -1.846545
σ [ln I] = 0.167113
ln(I crit) = -0.223144

β = -11.049687
F(z) = 1.000000
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Left Bank French Camp Slough
River Section: Index Point FL1

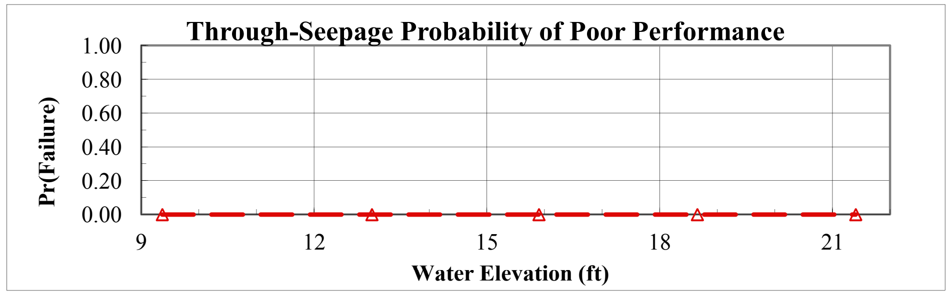
Levee Mile: STA 1049+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 21.40
L/S Toe Elev.: 9.36
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	5	0.5	10.00
Initial Porosity (n)	0.4	0.04	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
NO



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	9.36	0.0000
Elev. 13.0	3.64	13.00	0.000000
200 year	6.54	15.90	0.000000
Elev. 18.65	9.29	18.65	0.000000
Crest	12.04	21.40	0.000000

Crest | **Head =** 12.04 | **Horizontal Gradient (Ix) =** 0.380

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	300.05		
2	4.50	0.40	1.00E-10	102.62	270.05	900.329843	26.44
3	5.50	0.40	1.00E-10	125.42	330.06		
4	5.00	0.36	1.00E-10	108.17	284.66	225.647998	6.63
5	5.00	0.44	1.00E-10	119.59	314.70		
6	5.00	0.40	7.00E-11	136.28	358.63	2278.566570	66.93
7	5.00	0.40	1.30E-10	100.00	263.17		

E[FS] = 300.054969 E[ln FS] = 5.685407 Total 3404.544411 100.00
Var[FS]= 3404.544411
σ[FS]= 58.348474 σ[ln FS]= 0.192658 β = 29.510413
V(FS) = 0.194459 F(z) = 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

200 year | **Head =** 6.54 | **Horizontal Gradient (Ix) =** 0.220

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	518.28		
2	4.50	0.40	1.00E-10	102.62	466.45	2686.108045	26.44
3	5.50	0.40	1.00E-10	125.42	570.10		
4	5.00	0.36	1.00E-10	108.17	491.68	673.214276	6.63
5	5.00	0.44	1.00E-10	119.59	543.57		
6	5.00	0.40	7.00E-11	136.28	619.46	6798.037451	66.93
7	5.00	0.40	1.30E-10	100.00	454.56		

E[FS] = 518.276764 E[ln FS] = 6.231951 Total 10157.359771 100.00
Var[FS]= 10157.359771
σ[FS]= 100.783728 σ[ln FS]= 0.192658 β = 32.347277
V(FS) = 0.194459 F(z) = 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

Elev. 18.65 | **Head =** 9.29 | **Horizontal Gradient (Ix) =** 0.320

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	356.32		
2	4.50	0.40	1.00E-10	102.62	320.68	1269.605755	26.44
3	5.50	0.40	1.00E-10	125.42	391.95		
4	5.00	0.36	1.00E-10	108.17	338.03	318.198935	6.63
5	5.00	0.44	1.00E-10	119.59	373.71		
6	5.00	0.40	7.00E-11	136.28	425.88	3213.134889	66.93
7	5.00	0.40	1.30E-10	100.00	312.51		

E[FS] = 356.315275 E[ln FS] = 5.857257 Total 4800.939579 100.00
Var[FS]= 4800.939579
σ[FS]= 69.288813 σ[ln FS]= 0.192658 β = 30.402411
V(FS) = 0.194459 F(z) = 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

Elev. 13.0 | **Head =** 3.64 | **Horizontal Gradient (Ix) =** 0.140

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	814.43		
2	4.50	0.40	1.00E-10	102.62	732.99	6633.042314	26.44
3	5.50	0.40	1.00E-10	125.42	895.88		
4	5.00	0.36	1.00E-10	108.17	772.64	1662.427089	6.63
5	5.00	0.44	1.00E-10	119.59	854.19		
6	5.00	0.40	7.00E-11	136.28	973.44	16786.990441	66.93
7	5.00	0.40	1.30E-10	100.00	714.31		

E[FS] = 814.434915 E[ln FS] = 6.683936 Total 25082.459843 100.00
Var[FS]= 25082.459843
σ[FS]= 158.374429 σ[ln FS]= 0.192658 β = 34.693331
V(FS) = 0.194459 F(z) = 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

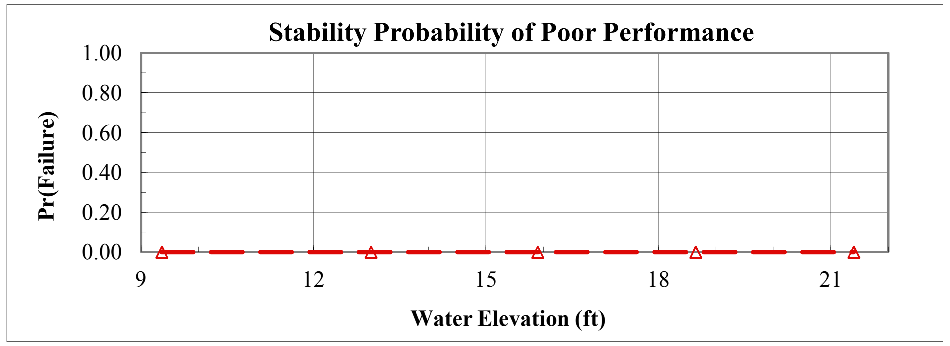
Project: Lower San Joaquin
Study Area: Left Bank French Camp Slough
River Section: Index Point FL1

Levee Mile: STA 1049+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 21.40
L/S Toe Elev.: 9.36
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	28	4	13.00
Levee Cohesion	100	40	40.00
Levee γ	120	8	7.00
Foundation Φ	30	4	13.00
Foundation Cohesion	100	40	40.00



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	9.36	0.0000
Elev. 13.0	3.64	13.00	0.000000
200 year	6.54	15.90	0.000000
Elev. 18.65	9.29	18.65	0.000000
Crest	12.04	21.40	0.000000

Crest	**Head =**	12.04	**Pr(f)=0**	NO

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	30	100	2.28		
2	24	100	120	30	100	2.20	0.005852	6.83
3	32	100	120	30	100	2.35		
4	28	60	120	30	100	2.21	0.004356	5.09
5	28	140	120	30	100	2.34		
6	28	100	112	30	100	2.32	0.001722	2.01
7	28	100	128	30	100	2.24		
8	28	100	120	26	100	2.09	0.036290	42.36
9	28	100	120	34	100	2.47		
10	28	100	120	30	60	2.07	0.037442	43.71
11	28	100	120	30	140	2.46		

E[FS] = 2.280000
Var[FS]= 0.085663
σ[FS]= 0.292682
V(FS) = 0.128369
FS req'd = 1.00

E[ln FS] = 0.816003
σ[ln FS]= 0.127845
ln(FS req'd) = 0.000000

Total 0.085663 100.00

β =	6.382739
F(z) =	0.000000
Pr(f) % =	0.000000

Elev. 18.65	**Head =**	9.29	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	30	100	2.41		
2	24	100	120	30	100			
3	32	100	120	30	100			
4	28	60	120	30	100			
5	28	140	120	30	100			
6	28	100	112	30	100			
7	28	100	128	30	100			
8	28	100	120	26	100			
9	28	100	120	34	100			
10	28	100	120	30	60			
11	28	100	120	30	140			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =	
F(z) =	
Pr(f) % =	0.000000

200 year	**Head =**	6.54	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	30	100	2.50		
2	24	100	120	30	100			
3	32	100	120	30	100			
4	28	60	120	30	100			
5	28	140	120	30	100			
6	28	100	112	30	100			
7	28	100	128	30	100			
8	28	100	120	26	100			
9	28	100	120	34	100			
10	28	100	120	30	60			
11	28	100	120	30	140			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =	
F(z) =	
Pr(f) % =	0.000000

Elev. 13.0	**Head =**	3.64	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	30	100	2.58		
2	24	100	120	30	100			
3	32	100	120	30	100			
4	28	60	120	30	100			
5	28	140	120	30	100			
6	28	100	112	30	100			
7	28	100	128	30	100			
8	28	100	120	26	100			
9	28	100	120	34	100			
10	28	100	120	30	60			
11	28	100	120	30	140			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

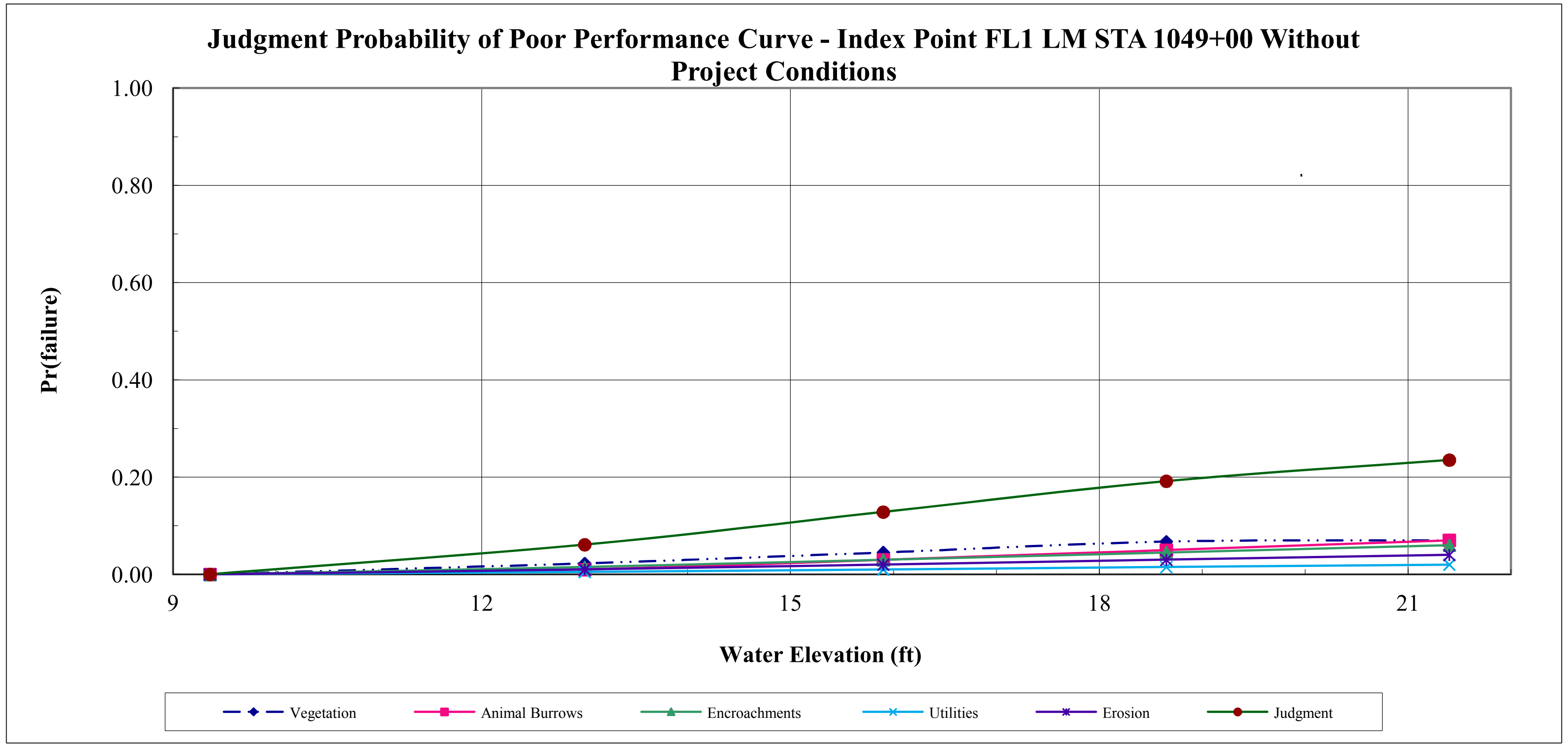
Total

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project: Lower San Joaquin
Study Area: Left Bank French Camp Slough
River Section: Index Point FL1
Levee Mile: STA 1049+00
River Mile: XX.XX
Analysis Case: Without Project Conditions
Crest Elev.: 21.40
L/S Toe Elev.: 9.36
W/S Toe Elev.: 10.00
Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
9.36	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
13.00	0.0225	0.9775	0.0100	0.9900	0.0150	0.9850	0.0050	0.9950	0.0100	0.9900	0.0610	0.9390
15.90	0.0450	0.9550	0.0300	0.9700	0.0300	0.9700	0.0100	0.9900	0.0200	0.9800	0.1282	0.8718
18.65	0.0675	0.9325	0.0500	0.9500	0.0450	0.9550	0.0150	0.9850	0.0300	0.9700	0.1917	0.8083
21.40	0.0700	0.9300	0.0700	0.9300	0.0600	0.9400	0.0200	0.9800	0.0400	0.9600	0.2351	0.7649


Judgment Probability of Poor Performance Curve - Index Point FL1 LM STA 1049+00 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

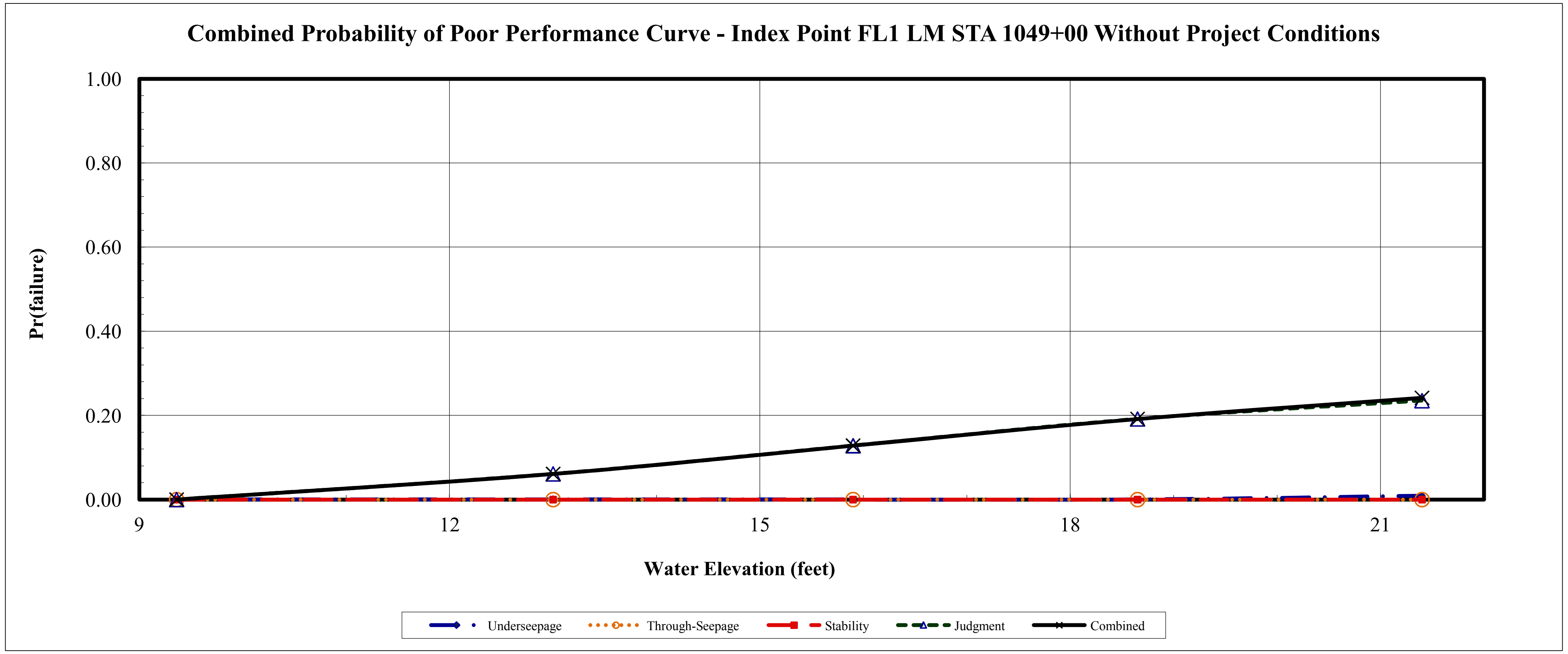
Project: Lower San Joaquin
Study Area: Left Bank French Camp Slough
River Section: Index Point FL1

Levee Mile: STA 1049+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 21.40
L/S Toe Elev.: 9.36
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/03/2012
Date: 11/28/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
9.36	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
13.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0610	0.9390	0.0610	0.9390
15.90	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1282	0.8718	0.1282	0.8718
18.65	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1917	0.8083	0.1917	0.8083
21.40	0.0087	0.9913	0.0000	1.0000	0.0000	1.0000	0.2351	0.7649	0.2418	0.7582



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Right Bank French Camp Slough
Basin and Reach: Index Point FR1

Levee Mile: STA 1164+20
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 21.77
L/S Toe Elev.: 8.14
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/12/2012
Date: 12/10/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR0404_075C	7	7	2	13	29	10	8	2	19	25	SC	0.007	SM	0.28	40	367	800	391556	98
WR0404_042B	3.5					9					SC	0.007	SM	0.28	40				
WR0404_041B	9					9.5					ML	0.007	SP-SM	14	2000				
1-CPT-43	6.5					5					ML	0.007	SM	0.28	40				
WR0404_043C	8					6.5					CL	0.0007	ML	0.028	40				
WR0404_046B	5					7					CL	0.0007	ML	0.028	40				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR0404_075C	SC	7	0.007				7	SM	10	0.28							0.28
WR0404_042B	SC	3.5	0.007				3.5	SM	9	0.28							0.28
WR0404_041B	ML	9	0.007				9	SP-SM	9.5	14							14
1-CPT-43	ML	6.5	0.007				6.5	SM	5	0.28							0.28
WR0404_043C	CL	8	0.0007				8	ML	6.5	0.028							0.028
WR0404_046B	CL	5	0.0007				5	ML	7	0.028							0.028

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Right Bank French Camp Slough
River Section: Index Point FR1

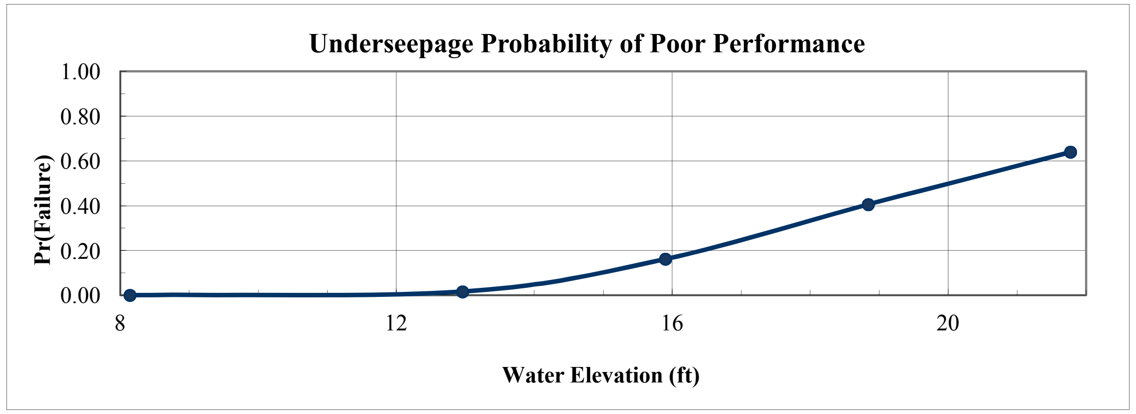
Levee Mile: STA 1164+20
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 21.77
L/S Toe Elev.: 8.14
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/12/2012
Date: 12/10/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permaebility Ratio	367	360	98
Blanket Thickness (z)	7	2	29
Aquifer Thickness (d)	20	2	25

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	150	78	∞	112



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	8.14	0.0000
E.ev. 12.96	4.82	12.96	0.0157
200 yr	7.76	15.90	0.1615
Elev. 18.84	10.70	18.84	0.4054
Crest	13.63	21.77	0.6396

Crest	**Rh**
Head = 13.63	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	367	7.00	20.00	131.36	226.67	0.0459	7.09	1.01		
2	727	7.00	20.00	139.84	318.96	0.0373	8.10	1.16	0.129600	68.20
3	7	7.00	20.00	32.05	32.06	0.1407	3.07	0.44		
4	367	9.00	20.00	135.01	257.02	0.0426	7.45	0.83	0.060025	31.59
5	367	5.00	20.00	125.37	191.57	0.0506	6.61	1.32		
6	367	7.00	22.00	132.82	237.74	0.0490	7.22	1.03	0.000400	0.21
7	367	7.00	18.00	129.63	215.04	0.0426	6.93	0.99		
								Total	0.190025	100.00

E[I] = 1.010000
Var[I]= 0.190025
σ[I]= 0.435919
V(I) = 0.431603

E[ln I] = -0.075461
σ [ln I] = 0.413307

β =	-0.182579
F(z) =	0.360427
Pr(f) % =	63.957331

Ic= 0.80

ln(I crit) = -0.223144

Elev. 18.84	**Rh**
Head = 10.70	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	367	7.00	20.00	131.36	226.67	0.0459	5.56	0.79		
2	727	7.00	20.00	139.84	318.96	0.0373	6.36	0.91	0.081225	67.98
3	7	7.00	20.00	32.05	32.06	0.1407	2.41	0.34		
4	367	9.00	20.00	135.01	257.02	0.0426	5.85	0.65	0.038025	31.83
5	367	5.00	20.00	125.37	191.57	0.0506	5.19	1.04		
6	367	7.00	22.00	132.82	237.74	0.0490	5.67	0.81	0.000225	0.19
7	367	7.00	18.00	129.63	215.04	0.0426	5.44	0.78		
								Total	0.119475	100.00

E[I] = 0.790000
Var[I]= 0.119475
σ[I]= 0.345652
V(I) = 0.437534

E[ln I] = -0.323302
σ [ln I] = 0.418520

β =	-0.772488
F(z) =	0.594569
Pr(f) % =	40.543051

Ic= 0.80

ln(I crit) = -0.223144

200 yr	**Rh**
Head = 7.76	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	367	7.00	20.00	131.36	226.67	0.0459	4.03	0.58		
2	727	7.00	20.00	139.84	318.96	0.0373	4.61	0.66	0.042025	67.95
3	7	7.00	20.00	32.05	32.06	0.1407	1.75	0.25		
4	367	9.00	20.00	135.01	257.02	0.0426	4.24	0.47	0.019600	31.69
5	367	5.00	20.00	125.37	191.57	0.0506	3.76	0.75		
6	367	7.00	22.00	132.82	237.74	0.0490	4.11	0.59	0.000225	0.36
7	367	7.00	18.00	129.63	215.04	0.0426	3.95	0.56		
								Total	0.061850	100.00

E[I] = 0.580000
Var[I]= 0.061850
σ[I]= 0.248697
V(I) = 0.428787

E[ln I] = -0.629117
σ [ln I] = 0.410827

β =	-1.531341
F(z) =	0.838469
Pr(f) % =	16.153113

Ic= 0.80

ln(I crit) = -0.223144

E.ev. 12.96	**Rh**
Head = 4.82	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	367	7.00	20.00	131.36	226.67	0.0459	2.51	0.36		
2	727	7.00	20.00	139.84	318.96	0.0373	2.86	0.41	0.015625	65.79
3	7	7.00	20.00	32.05	32.06	0.1407	1.09	0.16		
4	367	9.00	20.00	135.01	257.02	0.0426	2.64	0.29	0.008100	34.11
5	367	5.00	20.00	125.37	191.57	0.0506	2.34	0.47		
6	367	7.00	22.00	132.82	237.74	0.0490	2.55	0.36	0.000025	0.11
7	367	7.00	18.00	129.63	215.04	0.0426	2.45	0.35		
								Total	0.023750	100.00

E[I] = 0.360000
Var[I]= 0.023750
σ[I]= 0.154110
V(I) = 0.428084

E[ln I] = -1.105786
σ [ln I] = 0.410207

β =	-2.695676
F(z) =	0.984289
Pr(f) % =	1.571054

Ic= 0.80

ln(I crit) = -0.223144

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

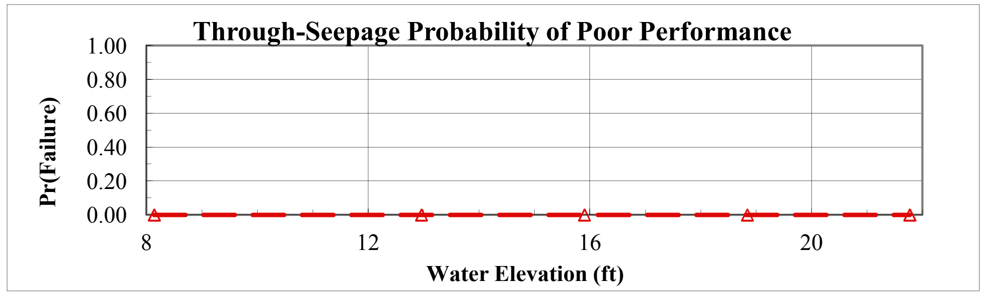
Project: Lower San Joaquin
Study Area: Right Bank French Camp Slough
River Section: Index Point FR1

Levee Mile: STA 1164+20
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 21.77
L/S Toe Elev.: 8.14
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/12/2012
Date: 12/10/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	5	0.5	10.00
Initial Porosity (n)	0.4	0.04	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	8.14	0.0000
E.ev. 12.96	4.82	12.96	0.000000
200 yr	7.76	15.90	0.000000
Elev. 18.84	10.70	18.84	0.000000
Crest	13.63	21.77	0.000000

Pr(f)=0
NO

Crest	**Head =**	13.63	**Horizontal Gradient (Ix) =**	0.520

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	219.27		
2	4.50	0.40	1.00E-10	102.62	197.34	480.797446	26.44
3	5.50	0.40	1.00E-10	125.42	241.20		
4	5.00	0.36	1.00E-10	108.17	208.02	120.501372	6.63
5	5.00	0.44	1.00E-10	119.59	229.97		
6	5.00	0.40	7.00E-11	136.28	262.08	1216.808479	66.93
7	5.00	0.40	1.30E-10	100.00	192.31		

E[FS] = 219.270939
Var[FS]= 1818.107296
σ[FS]= 42.639269
V(FS) = 0.194459
FS req'd = 1.00

E[ln FS] = 5.371750
σ[ln FS]= 0.192658
ln(FS req'd) = 0.000000

Total 1818.107296 100.00

β = 27.882356
F(z) = 0.000000
Pr(f) % = 0.000000

Elev. 18.84	**Head =**	10.70	**Horizontal Gradient (Ix) =**	0.440

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	259.14		
2	4.50	0.40	1.00E-10	102.62	233.22	671.527011	26.44
3	5.50	0.40	1.00E-10	125.42	285.05		
4	5.00	0.36	1.00E-10	108.17	245.84	168.303569	6.63
5	5.00	0.44	1.00E-10	119.59	271.79		
6	5.00	0.40	7.00E-11	136.28	309.73	1699.509363	66.93
7	5.00	0.40	1.30E-10	100.00	227.28		

E[FS] = 259.138382
Var[FS]= 2539.339943
σ[FS]= 50.391864
V(FS) = 0.194459
FS req'd = 1.00

E[ln FS] = 5.538804
σ[ln FS]= 0.192658
ln(FS req'd) = 0.000000

Total 2539.339943 100.00

β = 28.749460
F(z) = 0.000000
Pr(f) % = 0.000000

200 yr	**Head =**	7.76	**Horizontal Gradient (Ix) =**	0.350

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	325.77		
2	4.50	0.40	1.00E-10	102.62	293.20	1061.286770	26.44
3	5.50	0.40	1.00E-10	125.42	358.35		
4	5.00	0.36	1.00E-10	108.17	309.06	265.988334	6.63
5	5.00	0.44	1.00E-10	119.59	341.67		
6	5.00	0.40	7.00E-11	136.28	389.37	2685.918471	66.93
7	5.00	0.40	1.30E-10	100.00	285.72		

E[FS] = 325.773966
Var[FS]= 4013.193575
σ[FS]= 63.349772
V(FS) = 0.194459
FS req'd = 1.00

E[ln FS] = 5.767645
σ[ln FS]= 0.192658
ln(FS req'd) = 0.000000

Total 4013.193575 100.00

β = 29.937274
F(z) = 0.000000
Pr(f) % = 0.000000

E.ev. 12.96	**Head =**	4.82	**Horizontal Gradient (Ix) =**	0.240

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	5.00	0.40	1.00E-10	114.02	475.09		
2	4.50	0.40	1.00E-10	102.62	427.58	2257.076899	26.44
3	5.50	0.40	1.00E-10	125.42	522.60		
4	5.00	0.36	1.00E-10	108.17	450.71	565.686995	6.63
5	5.00	0.44	1.00E-10	119.59	498.28		
6	5.00	0.40	7.00E-11	136.28	567.84	5712.239803	66.93
7	5.00	0.40	1.30E-10	100.00	416.68		

E[FS] = 475.087034
Var[FS]= 8535.003697
σ[FS]= 92.385084
V(FS) = 0.194459
FS req'd = 1.00

E[ln FS] = 6.144940
σ[ln FS]= 0.192658
ln(FS req'd) = 0.000000

Total 8535.003697 100.00

β = 31.895640
F(z) = 0.000000
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

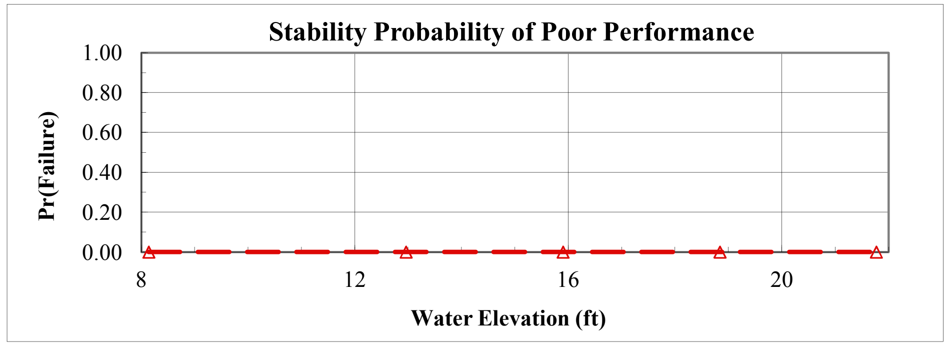
Project: Lower San Joaquin
Study Area: Right Bank French Camp Slough
River Section: Index Point FR1

Levee Mile: STA 1164+20
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 21.77
L/S Toe Elev.: 8.14
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/12/2012
Date: 12/10/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	28	4	13.00
Levee Cohesion	100	40	40.00
Levee γ	120	8	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	50	20	40.00



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	8.14	0.0000
E.ev. 12.96	4.82	12.96	0.000000
200 yr	7.76	15.90	0.000000
Elev. 18.84	10.70	18.84	0.000000
Crest	13.63	21.77	0.000000

Crest	**Head =**	13.63	**Pr(f)=0**	NO

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	28	50	1.52		
2	24	100	120	28	50	1.46	0.002209	24.29
3	32	100	120	28	50	1.56		
4	28	60	120	28	50	1.49	0.000729	8.02
5	28	140	120	28	50	1.54		
6	28	100	112	28	50	1.52	0.000081	0.89
7	28	100	128	28	50	1.50		
8	28	100	120	24	50	1.44	0.005476	60.21
9	28	100	120	32	50	1.59		
10	28	100	120	28	30	1.49	0.000600	6.60
11	28	100	120	28	70	1.54		

E[FS] = 1.520000
E[ln FS] = 0.416746
Total 0.009095 100.00
Var[FS]= 0.009095
σ[FS]= 0.095369
σ[ln FS]= 0.062681
V(FS) = 0.062743
FS req'd = 1.00
ln(FS req'd) = 0.000000

β =	6.648663
F(z) =	0.000000
Pr(f) % =	0.000000

Elev. 18.84	**Head =**	10.70	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	28	50	1.65		
2	24	100	120	28	50			
3	32	100	120	28	50			
4	28	60	120	28	50			
5	28	140	120	28	50			
6	28	100	112	28	50			
7	28	100	128	28	50			
8	28	100	120	24	50			
9	28	100	120	32	50			
10	28	100	120	28	30			
11	28	100	120	28	70			

E[FS] =
E[ln FS] =
Total
Var[FS]=
σ[FS]=
σ[ln FS]=
V(FS) =
FS req'd = 1.00
ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

200 yr	**Head =**	7.76	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	28	50	1.76		
2	24	100	120	28	50			
3	32	100	120	28	50			
4	28	60	120	28	50			
5	28	140	120	28	50			
6	28	100	112	28	50			
7	28	100	128	28	50			
8	28	100	120	24	50			
9	28	100	120	32	50			
10	28	100	120	28	30			
11	28	100	120	28	70			

E[FS] =
E[ln FS] =
Total
Var[FS]=
σ[FS]=
σ[ln FS]=
V(FS) =
FS req'd = 1.00
ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

E.ev. 12.96	**Head =**	4.82	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	28	100	120	28	50	1.88		
2	24	100	120	28	50			
3	32	100	120	28	50			
4	28	60	120	28	50			
5	28	140	120	28	50			
6	28	100	112	28	50			
7	28	100	128	28	50			
8	28	100	120	24	50			
9	28	100	120	32	50			
10	28	100	120	28	30			
11	28	100	120	28	70			

E[FS] =
E[ln FS] =
Total
Var[FS]=
σ[FS]=
σ[ln FS]=
V(FS) =
FS req'd = 1.00
ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

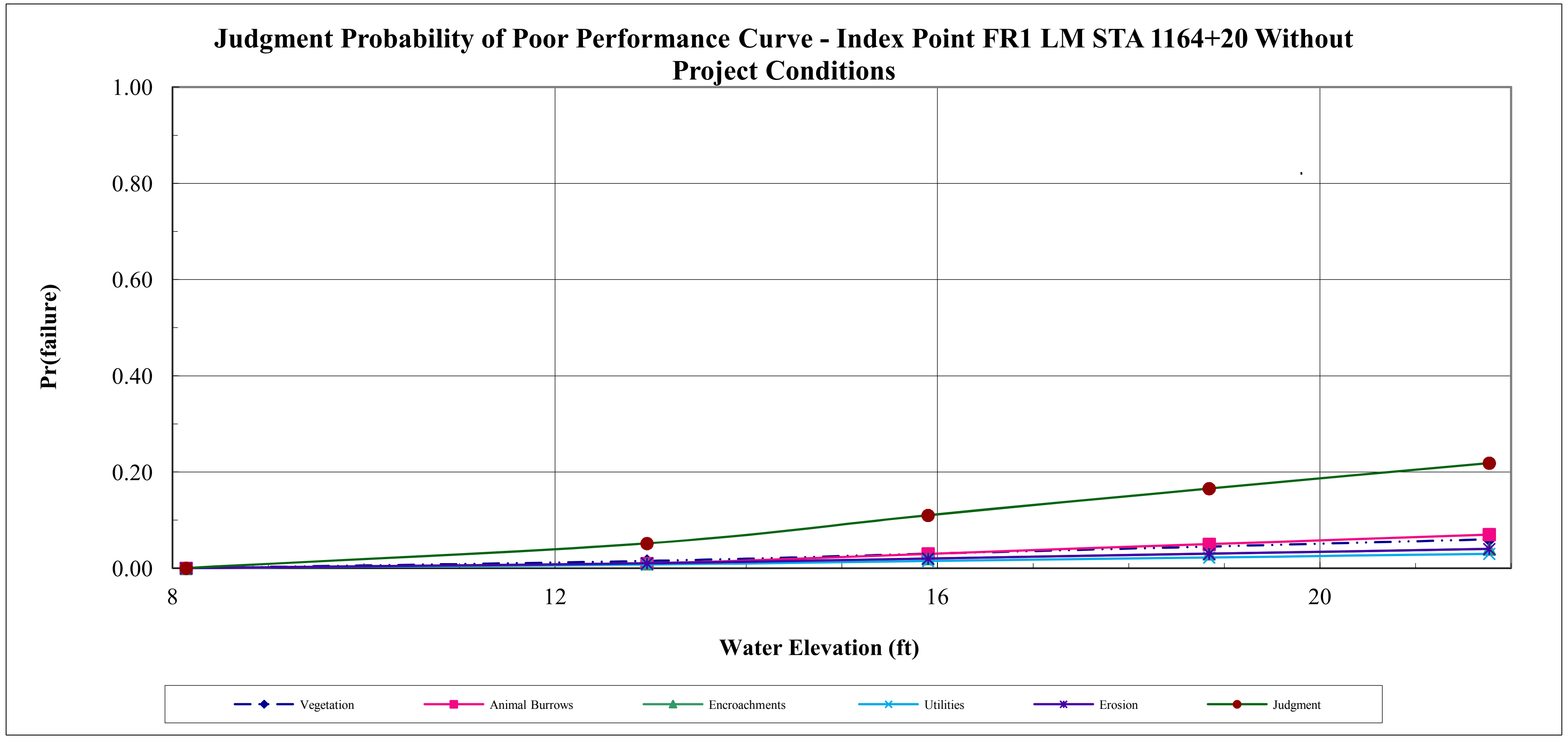
Project: Lower San Joaquin
Study Area: Right Bank French Camp Slough
River Section: Index Point FR1

Levee Mile: STA 1164+20
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 21.77
L/S Toe Elev.: 8.14
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/12/2012
Date: 12/10/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
8.14	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
12.96	0.0150	0.9850	0.0100	0.9900	0.0100	0.9900	0.0075	0.9925	0.0100	0.9900	0.0514	0.9486
15.90	0.0300	0.9700	0.0300	0.9700	0.0200	0.9800	0.0150	0.9850	0.0200	0.9800	0.1099	0.8901
18.84	0.0450	0.9550	0.0500	0.9500	0.0300	0.9700	0.0225	0.9775	0.0300	0.9700	0.1656	0.8344
21.77	0.0600	0.9400	0.0700	0.9300	0.0400	0.9600	0.0300	0.9700	0.0400	0.9600	0.2185	0.7815


Judgment Probability of Poor Performance Curve - Index Point FR1 LM STA 1164+20 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

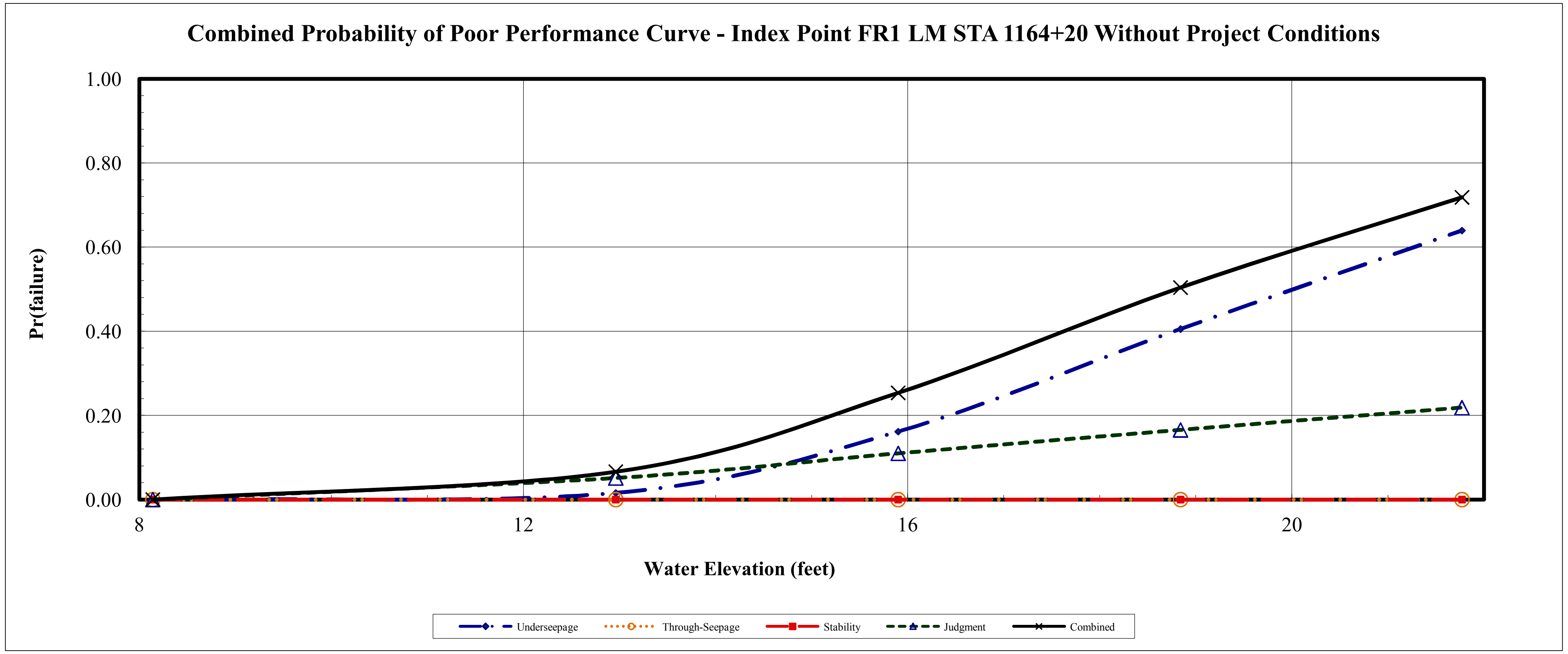
Project: Lower San Joaquin
Study Area: Right Bank French Camp Slough
River Section: Index Point FR1

Levee Mile: STA 1164+20
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 21.77
L/S Toe Elev.: 8.14
W/S Toe Elev.: 10.00

Analysis By: G. Johnson
Checked By: M. Perlea 12/12/2012
Date: 12/10/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
8.14	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
12.96	0.0157	0.9843	0.0000	1.0000	0.0000	1.0000	0.0514	0.9486	0.0663	0.9337
15.90	0.1615	0.8385	0.0000	1.0000	0.0000	1.0000	0.1099	0.8901	0.2537	0.7463
18.84	0.4054	0.5946	0.0000	1.0000	0.0000	1.0000	0.1656	0.8344	0.5039	0.4961
21.77	0.6396	0.3604	0.0000	1.0000	0.0000	1.0000	0.2185	0.7815	0.7183	0.2817



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Left Bank Stockton Diverting Canal
Basin and Reach: Index Point SL-1
Coordinates: State Plane (ft), N 2183207, E 6340943

Levee Mile: STA 846+68
River Mile: XX.XX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 39.16
L/S Toe Elev.: 25.00
W/S Toe Elev.: 25.00

Analysis By: J. Hogan
Checked By: M. Perlea, G. Johnson
Date: 9/27/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WCSBDC_001B	9	10	5	38	50	6	17	11	152	65	CL/ML	0.007	SM	0.28	40	194	192	33493	98
WCSBDC_002B	6					38					CL	0.007	SP-SM	2.8	400				
WCSBDC_003B	16.7					8					CH/ML	0.007	SM	0.28	40				
WCSBDC_004B	6					20					CL	0.007	SM	0.28	40				
WCSBDC_008C	10.8					12					CL/ML	0.007	SP-SM	2.8	400				
WCSBDC_009C	6.4					11					CL/ML	0.007	SP-SM	2.8	400				
WCSBDC_005B	16					24					CL	0.007	ML	0.28	40				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCSBDC_001B	CL	5	0.007	ML	4	0.007	9	SM	6	0.28							0.28
WCSBDC_002B	CL	6	0.007				6	SP-SM	38	2.8							2.8
WCSBDC_003B	CH	16	0.007	ML	7	0.07	16.7	SM	8	0.28							0.28
WCSBDC_004B	CL	6	0.007				6	SM	20	0.28							0.28
WCSBDC_008C	CL	8	0.007	ML	28	0.07	10.8	SP-SM	12	2.8							2.8
WCSBDC_009C	CL	4	0.007	ML	24	0.07	6.4	SP-SM	11	2.8							2.8
WCSBDC_005B	CL	16	0.007				16	ML	24	0.28							0.28

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-1
Coordinates: State Plane (ft), N 2183207, E 6340943

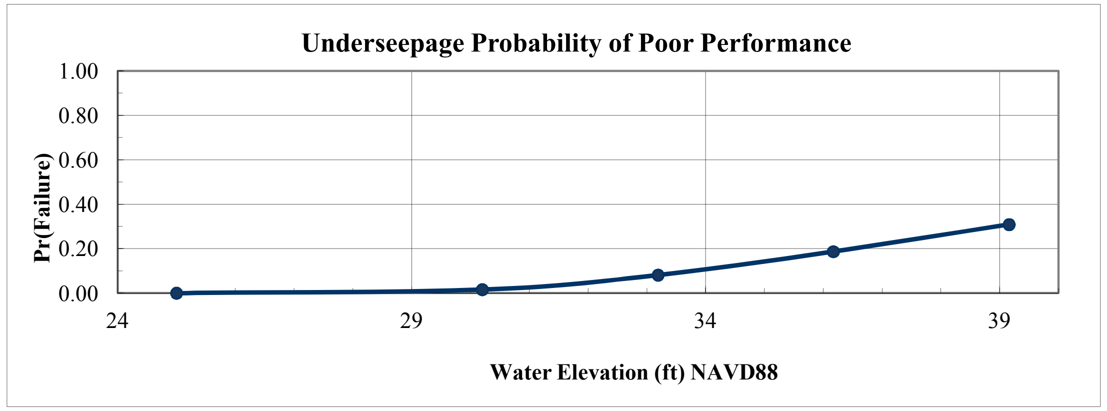
Levee Mile: STA 846+68
River Mile: XX.XX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 39.16
L/S Toe Elev.: 25.00
W/S Toe Elev.: 25.00

Analysis By: J. Hogan
Checked By: M. Perlea, G. Johnson
Date: 9/27/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permaebility Ratio	194	192	98
Blanket Thickness (z)	10	5	50
Aquifer Thickness (d)	17	11	65

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	115	77	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	25.00	0.0000
200yr	5.20	30.20	0.0160
200yr + 3ft	8.19	33.19	0.0813
Crest-3ft	11.17	36.17	0.1869
Crest	14.16	39.16	0.3087

Crest		Rh
Head =	14.16	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	194	10.00	17.00	101.75	181.60	0.0472	7.14	0.71		
2	386	10.00	17.00	107.85	256.16	0.0385	8.22	0.82	0.087025	39.27
3	2	10.00	17.00	18.44	18.44	0.1493	2.29	0.23		
4	194	15.00	17.00	105.74	222.42	0.0420	7.77	0.52	0.122500	55.27
5	194	5.00	17.00	91.70	128.41	0.0572	6.12	1.22		
6	194	10.00	28.00	106.49	233.07	0.0672	7.92	0.79	0.012100	5.46
7	194	10.00	6.00	85.01	107.89	0.0222	5.66	0.57		
								Total	0.221625	100.00

E[I] = 0.710000
Var[I]= 0.221625
σ[I]= 0.470771
V(I) = 0.663057

E[ln I] = -0.524689
σ [ln I] = 0.603653

β =	-0.869190
F(z) =	0.691298
Pr(f) % =	30.870162

Ic= 0.80
ln(I crit) = -0.223144

Crest-3ft		Rh
Head =	11.17	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	194	10.00	17.00	101.75	181.60	0.0472	5.63	0.56		
2	386	10.00	17.00	107.85	256.16	0.0385	6.49	0.65	0.055225	38.97
3	2	10.00	17.00	18.44	18.44	0.1493	1.81	0.18		
4	194	15.00	17.00	105.74	222.42	0.0420	6.13	0.41	0.078400	55.32
5	194	5.00	17.00	91.70	128.41	0.0572	4.83	0.97		
6	194	10.00	28.00	106.49	233.07	0.0672	6.25	0.63	0.008100	5.72
7	194	10.00	6.00	85.01	107.89	0.0222	4.47	0.45		
								Total	0.141725	100.00

E[I] = 0.560000
Var[I]= 0.141725
σ[I]= 0.376464
V(I) = 0.672257

E[ln I] = -0.766265
σ [ln I] = 0.610650

β =	-1.254836
F(z) =	0.813110
Pr(f) % =	18.688985

Ic= 0.80
ln(I crit) = -0.223144

200yr + 3ft		Rh
Head =	8.19	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	194	10.00	17.00	101.75	181.60	0.0472	4.13	0.41		
2	386	10.00	17.00	107.85	256.16	0.0385	4.76	0.48	0.030625	39.84
3	2	10.00	17.00	18.44	18.44	0.1493	1.33	0.13		
4	194	15.00	17.00	105.74	222.42	0.0420	4.50	0.30	0.042025	54.67
5	194	5.00	17.00	91.70	128.41	0.0572	3.54	0.71		
6	194	10.00	28.00	106.49	233.07	0.0672	4.58	0.46	0.004225	5.50
7	194	10.00	6.00	85.01	107.89	0.0222	3.27	0.33		
								Total	0.076875	100.00

E[I] = 0.410000
Var[I]= 0.076875
σ[I]= 0.277263
V(I) = 0.676252

E[ln I] = -1.079897
σ [ln I] = 0.613675

β =	-1.759721
F(z) =	0.918658
Pr(f) % =	8.134187

Ic= 0.80
ln(I crit) = -0.223144

200yr		Rh
Head =	5.20	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	194	10.00	17.00	101.75	181.60	0.0472	2.62	0.26		
2	386	10.00	17.00	107.85	256.16	0.0385	3.02	0.30	0.012100	39.54
3	2	10.00	17.00	18.44	18.44	0.1493	0.84	0.08		
4	194	15.00	17.00	105.74	222.42	0.0420	2.85	0.19	0.016900	55.23
5	194	5.00	17.00	91.70	128.41	0.0572	2.25	0.45		
6	194	10.00	28.00	106.49	233.07	0.0672	2.91	0.29	0.001600	5.23
7	194	10.00	6.00	85.01	107.89	0.0222	2.08	0.21		
								Total	0.030600	100.00

E[I] = 0.260000
Var[I]= 0.030600
σ[I]= 0.174929
V(I) = 0.672802

E[ln I] = -1.533773
σ [ln I] = 0.611063

β =	-2.510007
F(z) =	0.984017
Pr(f) % =	1.598306

Ic= 0.80
ln(I crit) = -0.223144

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-1
Coordinates: State Plane (ft), N 2183207, E 6340943

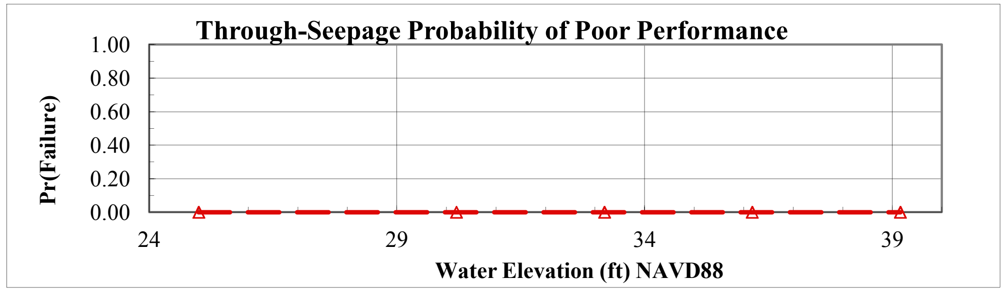
Levee Mile: STA 846+68
River Mile: XX.XX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 39.16
L/S Toe Elev.: 25.00
W/S Toe Elev.: 25.00

Analysis By: J. Hogan
Checked By: M. Perlea, G. Johnson
Date: 9/27/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	50	5.0	10.00
Initial Porosity (n)	0.7	0.07	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	25.00	0.0000
200yr	5.20	30.20	0.000000
200yr + 3ft	8.19	33.19	0.000000
Crest-3ft	11.17	36.17	0.000000
Crest	14.16	39.16	0.000000

Crest **Head =** 14.16 **Horizontal Gradient (Ix) =** 0.480

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	50.00	0.70	1.00E-10	1508.35	3142.41		
2	45.00	0.70	1.00E-10	1357.52	2828.16	98747.114311	26.44
3	55.00	0.70	1.00E-10	1659.19	3456.65		
4	50.00	0.63	1.00E-10	1430.95	2981.15	24748.806051	6.63
5	50.00	0.77	1.00E-10	1581.98	3295.78		
6	50.00	0.70	7.00E-11	1802.83	3755.89	249910.491369	66.93
7	50.00	0.70	1.30E-10	1322.91	2756.07		

E[FS] =	3142.405358	E[ln FS] =	8.034185	Total	373406.411731	100.00
Var[FS]=	373406.411731					
σ[FS]=	611.069891	σ[ln FS]=	0.192658	β =	41.701873
V(FS) =	0.194459			F(z) =	0.000000
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Crest-3ft **Head =** 11.17 **Horizontal Gradient (Ix) =** 0.450

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	50.00	0.70	1.00E-10	1508.35	3351.90		
2	45.00	0.70	1.00E-10	1357.52	3016.71	112352.272282	26.44
3	55.00	0.70	1.00E-10	1659.19	3687.09		
4	50.00	0.63	1.00E-10	1430.95	3179.89	28158.641551	6.63
5	50.00	0.77	1.00E-10	1581.98	3515.50		
6	50.00	0.70	7.00E-11	1802.83	4006.29	284342.603513	66.93
7	50.00	0.70	1.30E-10	1322.91	2939.81		

E[FS] =	3351.899048	E[ln FS] =	8.098724	Total	424853.517347	100.00
Var[FS]=	424853.517347					
σ[FS]=	651.807884	σ[ln FS]=	0.192658	β =	42.036863	
V(FS) =	0.194459			F(z) =	0.000000	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000	

200yr + 3ft **Head =** 8.19 **Horizontal Gradient (Ix) =** 0.320

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	50.00	0.70	1.00E-10	1508.35	4713.61		
2	45.00	0.70	1.00E-10	1357.52	4242.25	222181.007199	26.44
3	55.00	0.70	1.00E-10	1659.19	5184.97		
4	50.00	0.63	1.00E-10	1430.95	4471.72	55684.813615	6.63
5	50.00	0.77	1.00E-10	1581.98	4943.67		
6	50.00	0.70	7.00E-11	1802.83	5633.84	562298.605580	66.93
7	50.00	0.70	1.30E-10	1322.91	4134.11		

E[FS] =	4713.608036	E[ln FS] =	8.439650	Total	840164.426394	100.00
Var[FS]=	840164.426394					
σ[FS]=	916.604837	σ[ln FS]=	0.192658	β =	43.806461	
V(FS) =	0.194459			F(z) =	0.000000	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000	

200yr **Head =** 5.20 **Horizontal Gradient (Ix) =** 0.290

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	50.00	0.70	1.00E-10	1508.35	5201.22		
2	45.00	0.70	1.00E-10	1357.52	4681.10	270527.171667	26.44
3	55.00	0.70	1.00E-10	1659.19	5721.34		
4	50.00	0.63	1.00E-10	1430.95	4934.31	67801.723117	6.63
5	50.00	0.77	1.00E-10	1581.98	5455.09		
6	50.00	0.70	7.00E-11	1802.83	6216.65	684653.712383	66.93
7	50.00	0.70	1.30E-10	1322.91	4561.77		

E[FS] =	5201.222661	E[ln FS] =	8.538091	Total	1022982.607167	100.00
Var[FS]=	1022982.607167					
σ[FS]=	1011.426027	σ[ln FS]=	0.192658	β =	44.317420	
V(FS) =	0.194459			F(z) =	0.000000	
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000	

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

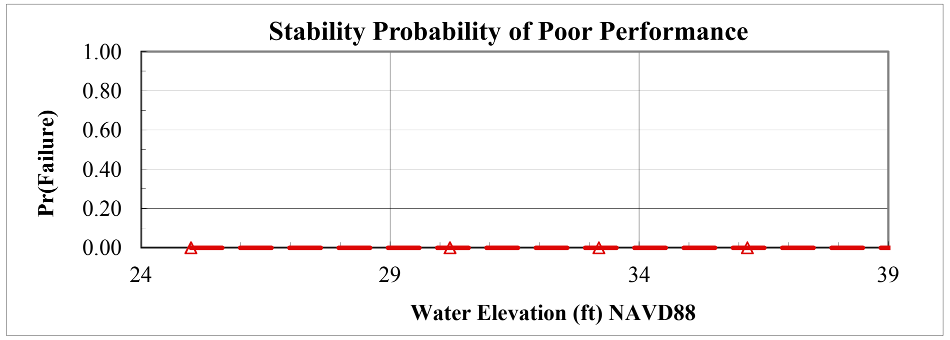
Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-1
Coordinates: State Plane (ft), N 2183207, E 6340943

Levee Mile: STA 846+68
River Mile: XX.XX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 39.16
L/S Toe Elev.: 25.00
W/S Toe Elev.: 25.00

Analysis By: J. Hogan
Checked By: M. Perlea, G. Johnson
Date: 9/27/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	34	4	13.00
Levee Cohesion	100	40	40.00
Levee γ	115	8	7.00
Foundation Φ	31	4	13.00
Foundation Cohesion	150	60	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	25.00	0.0000
200yr	5.20	30.20	0.000000
200yr + 3ft	8.19	33.19	0.000000
Crest-3ft	11.17	36.17	0.000000
Crest	14.16	39.16	0.000000

Crest	Head =	14.16	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	115	31	150	1.40		
2	30	100	115	31	150	1.32	0.002401	52.46
3	38	100	115	31	150	1.41		
4	34	60	115	31	150	1.39	0.000030	0.66
5	34	140	115	31	150	1.40		
6	34	100	107	31	150	1.40	0.000529	11.56
7	34	100	123	31	150	1.35		
8	34	100	115	27	150	1.34	0.001560	34.09
9	34	100	115	35	150	1.42		
10	34	100	115	31	90	1.39	0.000056	1.23
11	34	100	115	31	210	1.41		

E[FS] = 1.397000
E[ln FS] = 0.333156
Total 0.004577 100.00
Var[FS]= 0.004577
σ[FS]= 0.067652
σ[ln FS]= 0.048398
β = 6.883664
V(FS) = 0.048426
F(z) = 0.000000
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 0.000000

Crest-3ft	Head =	11.17	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	115	31	150	1.13		
2	30	100	115	31	150	1.02	0.008372	28.40
3	38	100	115	31	150	1.21		
4	34	60	115	31	150	1.08	0.004225	14.33
5	34	140	115	31	150	1.21		
6	34	100	107	31	150	1.13	0.002704	9.17
7	34	100	123	31	150	1.23		
8	34	100	115	27	150	1.10	0.008556	29.02
9	34	100	115	35	150	1.28		
10	34	100	115	31	90	1.08	0.005625	19.08
11	34	100	115	31	210	1.23		

E[FS] =
E[ln FS] =
Total 0.029483 100.00
Var[FS]= 0.029483
σ[FS]= 0.171705
σ[ln FS]=
β =
V(FS) =
F(z) =
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 0.000000

200yr + 3ft	Head =	8.19	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	115	31	150	1.27		
2	30	100	115	31	150	1.12	0.012769	79.39
3	38	100	115	31	150	1.34		
4	34	60	115	31	150	1.19	0.001156	7.19
5	34	140	115	31	150	1.26		
6	34	100	107	31	150	1.22	0.000016	0.10
7	34	100	123	31	150	1.23		
8	34	100	115	27	150	1.20	0.001722	10.71
9	34	100	115	35	150	1.29		
10	34	100	115	31	90	1.21	0.000420	2.61
11	34	100	115	31	210	1.25		

E[FS] =
E[ln FS] =
Total 0.016084 100.00
Var[FS]= 0.016084
σ[FS]= 0.126821
σ[ln FS]=
β =
V(FS) =
F(z) =
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 0.000000

200yr	Head =	5.20	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	115	31	150	1.30		
2	30	100	115	31	150			
3	38	100	115	31	150			
4	34	60	115	31	150			
5	34	140	115	31	150			
6	34	100	107	31	150			
7	34	100	123	31	150			
8	34	100	115	27	150			
9	34	100	115	35	150			
10	34	100	115	31	90			
11	34	100	115	31	210			

E[FS] =
E[ln FS] =
Total
Var[FS]=
σ[FS]=
σ[ln FS]=
β =
V(FS) =
F(z) =
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

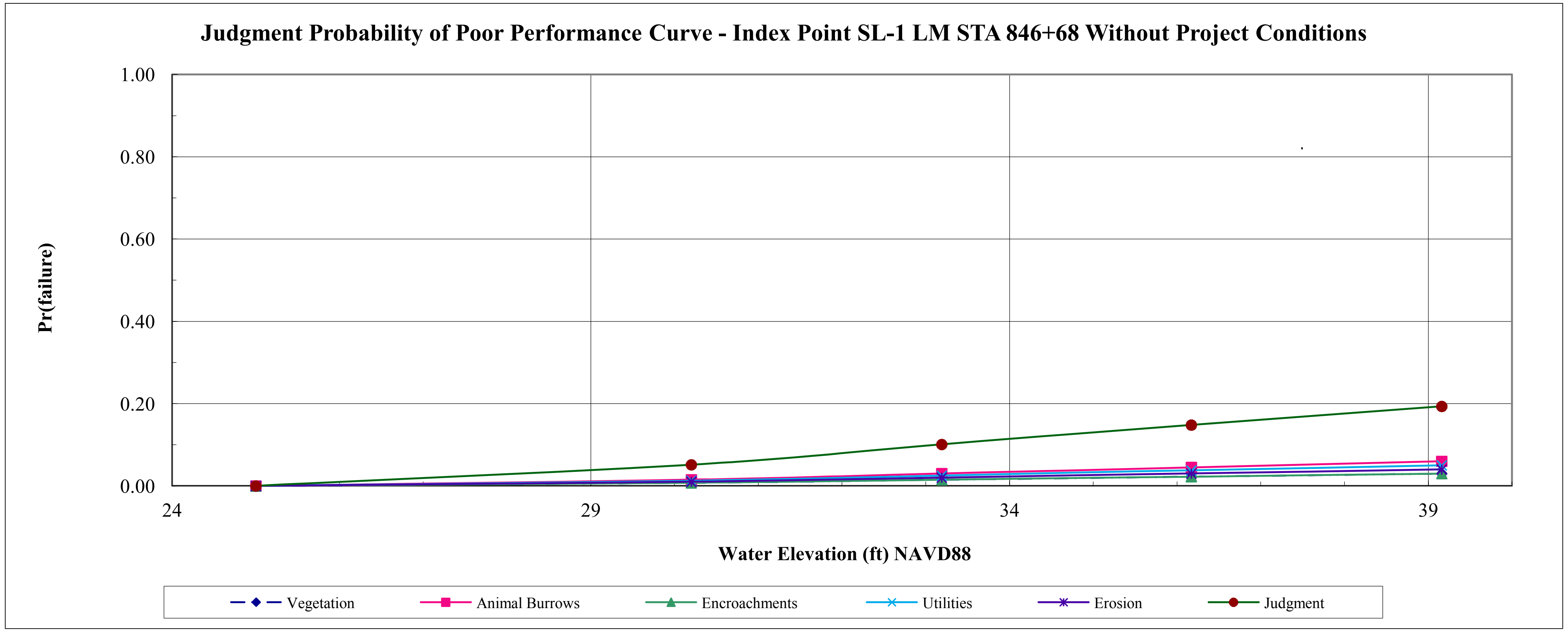
Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-1
Coordinates: State Plane (ft), N 2183207, E 6340943

Levee Mile: STA 846+68
River Mile: XX.XX
Analysis Case: Without Project Conditions

Datum: NAVD 88
Crest Elev.: 39.16
L/S Toe Elev.: 25.00
W/S Toe Elev.: 25.00

Analysis By: J. Hogan
Checked By: M. Perlea, G. John
Date: 9/27/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
25.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
30.20	0.0075	0.9925	0.0150	0.9850	0.0075	0.9925	0.0125	0.9875	0.0100	0.9900	0.0514	0.9486
33.19	0.0150	0.9850	0.0300	0.9700	0.0150	0.9850	0.0250	0.9750	0.0200	0.9800	0.1008	0.8992
36.17	0.0225	0.9775	0.0450	0.9550	0.0225	0.9775	0.0375	0.9625	0.0300	0.9700	0.1481	0.8519
39.16	0.0300	0.9700	0.0600	0.9400	0.0300	0.9700	0.0500	0.9500	0.0400	0.9600	0.1934	0.8066



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

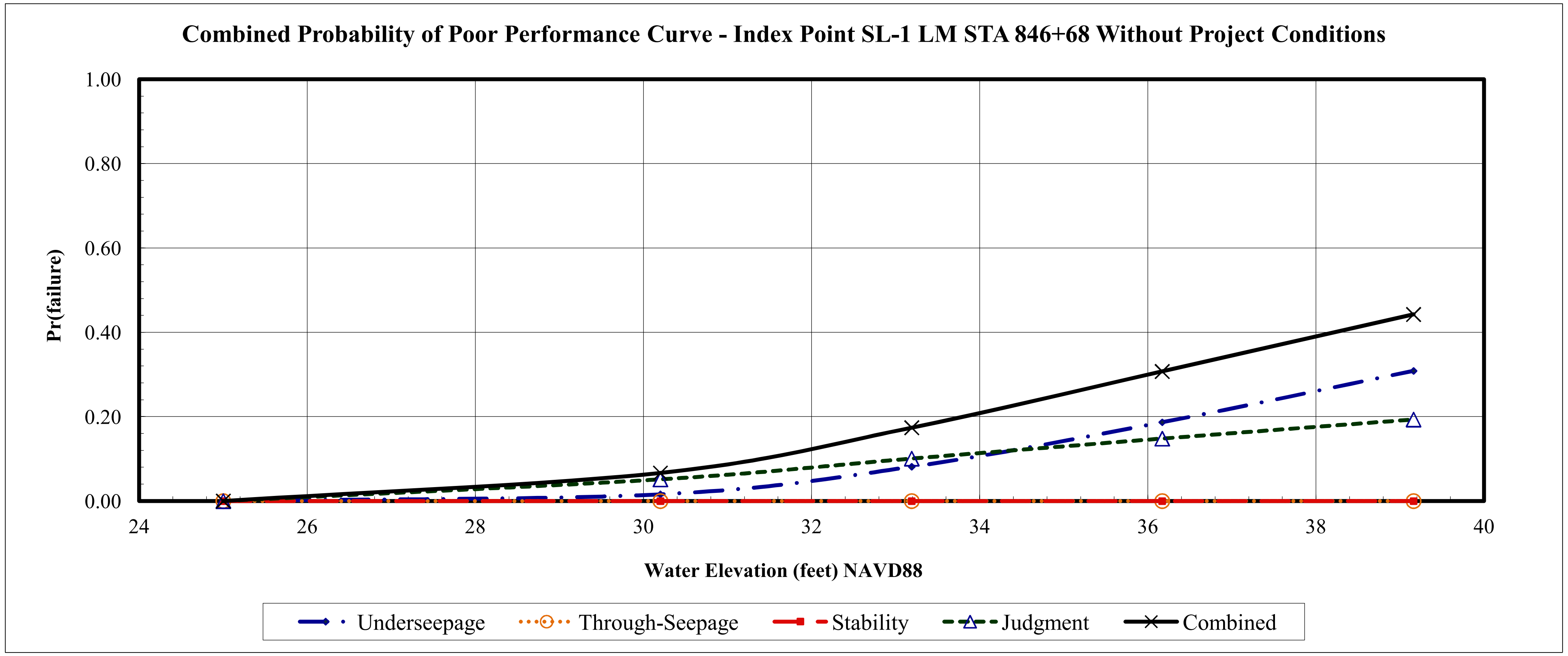
Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-1
Coordinates: State Plane (ft), N 2183207, E 6340943

Levee Mile: STA 846+68
River Mile: XX.XX
Analysis Case: Without Project Conditions

Datum: NAVD 88
Crest Elev.: 39.16
L/S Toe Elev.: 25.00
W/S Toe Elev.: 25.00

Analysis By: J. Hogan
Checked By: M. Perlea, G. Joh
Date: 9/27/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
25.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
30.20	0.0160	0.9840	0.0000	1.0000	0.0000	1.0000	0.0514	0.9486	0.0666	0.9334
33.19	0.0813	0.9187	0.0000	1.0000	0.0000	1.0000	0.1008	0.8992	0.1739	0.8261
36.17	0.1869	0.8131	0.0000	1.0000	0.0000	1.0000	0.1481	0.8519	0.3073	0.6927
39.16	0.3087	0.6913	0.0000	1.0000	0.0000	1.0000	0.1934	0.8066	0.4424	0.5576


Combined Probability of Poor Performance Curve - Index Point SL-1 LM STA 846+68 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Left Bank Stockton Diverting Canal
Basin and Reach: Index Point SL-2
Coordinates: State Plane (ft), N 2176913, E 6352470

Levee Mile: STA 976+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 44.56
L/S Toe Elev.: 34.30
W/S Toe Elev.: 34.79

Analysis By: J. Hogan
Checked By: M. Perlea, G. Johnson
Date: 9/27/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WCSBDC_007B	6	7	2	15	29	16	10	6	48	60	CL	0.007	SM	1.4	200	267	103	24889	39
WCSBDC_008B	10					19					CL	0.007	SP-SM	2.8	400				
WCSBDC_009B	4.6					3					CL/ML	0.007	SM	1.4	200				
WCSBDC_011B	5					4					CL	0.007	SM	1.4	200				
WCSBDC_012B	8					8					CL	0.0007	SC	0.28	400				
WCSBDC_025C	8					8					CL	0.007	SM	1.4	200				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCSBDC_007B	CL	6	0.007				6	SM	16	1.4							1.4
WCSBDC_008B	CL	10	0.007				10	SP-SM	19	2.8							2.8
WCSBDC_009B	CL	4	0.007	ML	6	0.07	4.6	SM	3	1.4							1.4
WCSBDC_011B	CL	5	0.007				5	SM	4	1.4							1.4
WCSBDC_012B	CL	8	0.0007				8	SC	8	0.28							0.28
WCSBDC_025C	CL	8	0.007				8	SM	8	1.4							1.4

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-2
Coordinates: State Plane (ft), N 2176913, E 6352470

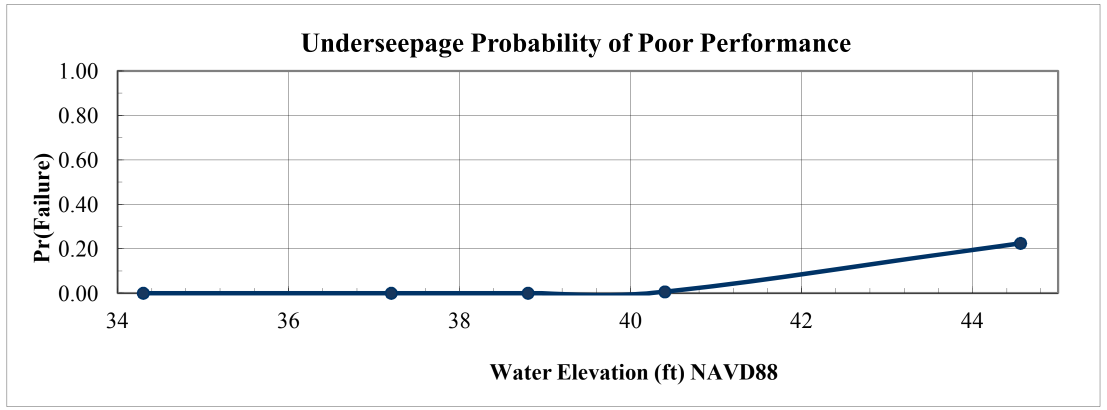
Levee Mile: STA 976+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 44.56
L/S Toe Elev.: 34.30
W/S Toe Elev.: 34.79

Analysis By: J. Hogan
Checked By: M. Perlea, G. Johnson
Date: 9/27/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	267	103	39
Blanket Thickness (z)	7	2	29
Aquifer Thickness (d)	10	6	60

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	97	77	∞	112


Underseepage Probability of Poor Performance

Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	34.30	0.0000
200yr	2.90	37.20	0.0000
200yr + 3ft	4.50	38.80	0.0002
Crest-3ft	6.10	40.40	0.0062
Crest	10.26	44.56	0.2245

Crest		Rh
Head =	10.26	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	267	7.00	10.00	83.45	136.71	0.0337	4.72	0.67		
2	370	7.00	10.00	86.74	160.93	0.0308	5.09	0.73	0.004225	10.76
3	164	7.00	10.00	77.02	107.14	0.0383	4.21	0.60		
4	267	9.00	10.00	86.05	155.02	0.0314	5.00	0.56	0.024025	61.17
5	267	5.00	10.00	79.21	115.54	0.0368	4.36	0.87		
6	267	7.00	16.00	87.96	172.93	0.0474	5.25	0.75	0.011025	28.07
7	267	7.00	4.00	69.88	86.46	0.0171	3.80	0.54		
								Total	0.039275	100.00

E[I] = 0.670000
Var[I]= 0.039275
σ[I]= 0.198179
V(I) = 0.295790

E[ln I] = -0.442414

σ [ln I] = 0.289610

β =	-1.527623
F(z) =	0.775513
Pr(f) % =	22.448734

Ic=	0.80

ln(I crit) = -0.223144

Crest-3ft		Rh
Head =	6.10	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	267	7.00	10.00	83.45	136.71	0.0337	2.81	0.40		
2	370	7.00	10.00	86.74	160.93	0.0308	3.02	0.43	0.001225	8.46
3	164	7.00	10.00	77.02	107.14	0.0383	2.50	0.36		
4	267	9.00	10.00	86.05	155.02	0.0314	2.97	0.33	0.009025	62.35
5	267	5.00	10.00	79.21	115.54	0.0368	2.59	0.52		
6	267	7.00	16.00	87.96	172.93	0.0474	3.12	0.45	0.004225	29.19
7	267	7.00	4.00	69.88	86.46	0.0171	2.26	0.32		
								Total	0.014475	100.00

E[I] = 0.400000
Var[I]= 0.014475
σ[I]= 0.120312
V(I) = 0.300780

E[ln I] = -0.959595

σ [ln I] = 0.294292

β =	-3.260691
F(z) =	0.993833
Pr(f) % =	0.616682

Ic=	0.80

ln(I crit) = -0.223144

200yr + 3ft		Rh
Head =	4.50	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	267	7.00	10.00	83.45	136.71	0.0337	2.07	0.30		
2	370	7.00	10.00	86.74	160.93	0.0308	2.23	0.32	0.000900	11.50
3	164	7.00	10.00	77.02	107.14	0.0383	1.85	0.26		
4	267	9.00	10.00	86.05	155.02	0.0314	2.19	0.24	0.004900	62.62
5	267	5.00	10.00	79.21	115.54	0.0368	1.91	0.38		
6	267	7.00	16.00	87.96	172.93	0.0474	2.30	0.33	0.002025	25.88
7	267	7.00	4.00	69.88	86.46	0.0171	1.67	0.24		
								Total	0.007825	100.00

E[I] = 0.300000
Var[I]= 0.007825
σ[I]= 0.088459
V(I) = 0.294863

E[ln I] = -1.245658

σ [ln I] = 0.288739

β =	-4.314124
F(z) =	0.999801
Pr(f) % =	0.019908

Ic=	0.80

ln(I crit) = -0.223144

200yr		Rh
Head =	2.90	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	267	7.00	10.00	83.45	136.71	0.0337	1.33	0.19		
2	370	7.00	10.00	86.74	160.93	0.0308	1.44	0.21	0.000400	12.03
3	164	7.00	10.00	77.02	107.14	0.0383	1.19	0.17		
4	267	9.00	10.00	86.05	155.02	0.0314	1.41	0.16	0.002025	60.90
5	267	5.00	10.00	79.21	115.54	0.0368	1.23	0.25		
6	267	7.00	16.00	87.96	172.93	0.0474	1.48	0.21	0.000900	27.07
7	267	7.00	4.00	69.88	86.46	0.0171	1.07	0.15		
								Total	0.003325	100.00

E[I] = 0.190000
Var[I]= 0.003325
σ[I]= 0.057663
V(I) = 0.303488

E[ln I] = -1.704785

σ [ln I] = 0.296829

β =	-5.743329
F(z) =	1.000000
Pr(f) % =	0.000030

Ic=	0.80

ln(I crit) = -0.223144

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-2
Coordinates: State Plane (ft), N 2176913, E 6352470

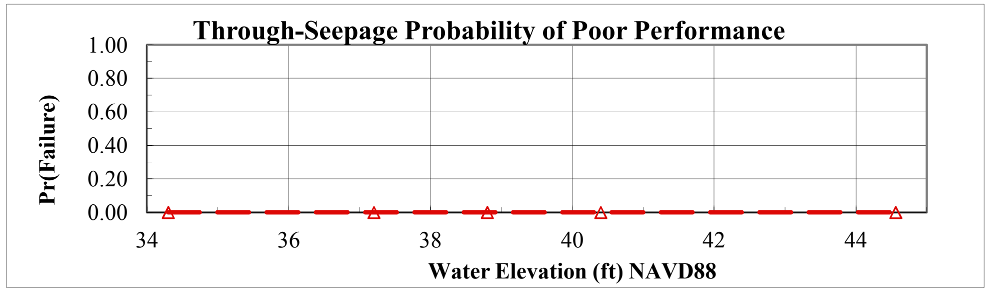
Levee Mile: STA 976+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 44.56
L/S Toe Elev.: 34.30
W/S Toe Elev.: 34.79

Analysis By: J. Hogan
Checked By: M. Perlea, G. Johnson
Date: 9/27/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	50	5.0	10.00
Initial Porosity (n)	0.35	0.04	10.00
Initial Permeability (Ko)	5.00E-10	1.50E-10	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	34.30	0.0000
200yr	2.90	37.20	0.000000
200yr + 3ft	4.50	38.80	0.000000
Crest-3ft	6.10	40.40	0.000000
Crest	10.26	44.56	0.000000

Crest	Head =	10.26	Horizontal Gradient (Ix) =	0.470

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	50.00	0.35	5.00E-10	476.98	1014.86		
2	45.00	0.35	5.00E-10	429.29	913.37	10299.382135	26.44
3	55.00	0.35	5.00E-10	524.68	1116.34		
4	50.00	0.32	5.00E-10	452.51	962.78	2581.315036	6.63
5	50.00	0.39	5.00E-10	500.26	1064.39		
6	50.00	0.35	3.50E-10	570.10	1212.99	26065.811323	66.93
7	50.00	0.35	6.50E-10	418.34	890.09		

E[FS] = 1014.858716 E[ln FS] = 6.903946 Total 38946.508494 100.00
Var[FS]= 38946.508494
σ[FS]= 197.348698 σ[ln FS]= 0.192658 β = 35.835305
V(FS) = 0.194459 F(z) = 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 Pr(f) % = 0.000000

Crest-3ft	Head =	6.10	Horizontal Gradient (Ix) =	0.470

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	50.00	0.35	5.00E-10	476.98	1014.86		
2	45.00	0.35	5.00E-10	429.29	913.37	10299.382135	26.44
3	55.00	0.35	5.00E-10	524.68	1116.34		
4	50.00	0.32	5.00E-10	452.51	962.78	2581.315036	6.63
5	50.00	0.39	5.00E-10	500.26	1064.39		
6	50.00	0.35	3.50E-10	570.10	1212.99	26065.811323	66.93
7	50.00	0.35	6.50E-10	418.34	890.09		

E[FS] = 1014.858716 E[ln FS] = 6.903946 Total 38946.508494 100.00
Var[FS]= 38946.508494
σ[FS]= 197.348698 σ[ln FS]= 0.192658 β = 35.835305
V(FS) = 0.194459 F(z) = 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 Pr(f) % = 0.000000

200yr + 3ft	Head =	4.50	Horizontal Gradient (Ix) =	0.380

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	50.00	0.35	5.00E-10	476.98	1255.22		
2	45.00	0.35	5.00E-10	429.29	1129.70	15755.772256	26.44
3	55.00	0.35	5.00E-10	524.68	1380.74		
4	50.00	0.32	5.00E-10	452.51	1190.81	3948.839968	6.63
5	50.00	0.39	5.00E-10	500.26	1316.49		
6	50.00	0.35	3.50E-10	570.10	1500.27	39874.914966	66.93
7	50.00	0.35	6.50E-10	418.34	1100.90		

E[FS] = 1255.219991 E[ln FS] = 7.116508 Total 59579.527190 100.00
Var[FS]= 59579.527190
σ[FS]= 244.089179 σ[ln FS]= 0.192658 β = 36.938617
V(FS) = 0.194459 F(z) = 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 Pr(f) % = 0.000000

200yr	Head =	2.90	Horizontal Gradient (Ix) =	0.320

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	50.00	0.35	5.00E-10	476.98	1490.57		
2	45.00	0.35	5.00E-10	429.29	1341.52	22218.100720	26.44
3	55.00	0.35	5.00E-10	524.68	1639.63		
4	50.00	0.32	5.00E-10	452.51	1414.08	5568.481361	6.63
5	50.00	0.39	5.00E-10	500.26	1563.33		
6	50.00	0.35	3.50E-10	570.10	1781.58	56229.860558	66.93
7	50.00	0.35	6.50E-10	418.34	1307.32		

E[FS] = 1490.573739 E[ln FS] = 7.288358 Total 84016.442639 100.00
Var[FS]= 84016.442639
σ[FS]= 289.855900 σ[ln FS]= 0.192658 β = 37.830615
V(FS) = 0.194459 F(z) = 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

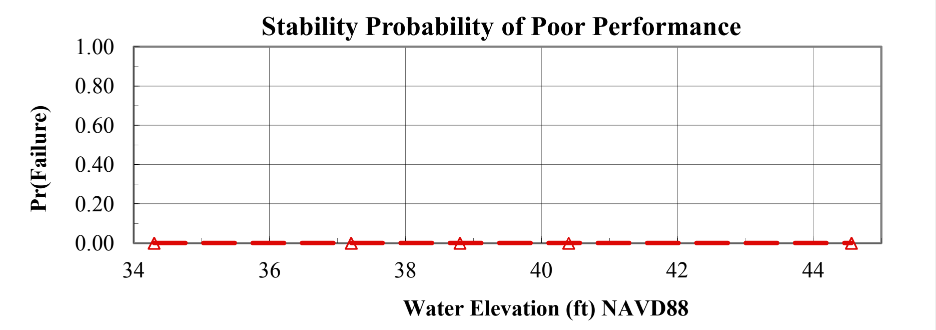
Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-2
Coordinates: State Plane (ft), N 2176913, E 6352470

Levee Mile: STA 976+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 44.56
L/S Toe Elev.: 34.30
W/S Toe Elev.: 34.79

Analysis By: J. Hogan
Checked By: M. Perlea, G. Johnson
Date: 9/27/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	31	4	13.00
Levee Cohesion	150	60	40.00
Levee γ	115	8	7.00
Foundation Φ	31	4	13.00
Foundation Cohesion	150	60	40.00


Stability Probability of Poor Performance

Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	34.30	0.0000
200yr	2.90	37.20	0.000000
200yr + 3ft	4.50	38.80	0.000000
Crest-3ft	6.10	40.40	0.000000
Crest	10.26	44.56	0.000000

Crest	**Head =**	10.26	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	31	150	115	31	150	1.68		
2	27	150	115	31	150	1.66	0.000576	4.05
3	35	150	115	31	150	1.71		
4	31	90	115	31	150	1.68	0.000009	0.06
5	31	210	115	31	150	1.69		
6	31	150	107	31	150	1.67	0.000256	1.80
7	31	150	123	31	150	1.70		
8	31	150	115	27	150	1.55	0.013225	93.07
9	31	150	115	35	150	1.78		
10	31	150	115	31	90	1.67	0.000144	1.01
11	31	150	115	31	210	1.69		

E[FS] = 1.682000 E[ln FS] = 0.517478 Total 0.014210 100.00
Var[FS]= 0.014210
σ[FS]= 0.119206 σ[ln FS]= 0.070783
V(FS) = 0.070871
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	7.310809
F(z) =	0.000000
Pr(f) % =	0.000000

Crest-3ft	**Head =**	6.10	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	31	150	115	31	150	1.13		
2	27	150	115	31	150	1.02	0.008372	28.40
3	35	150	115	31	150	1.21		
4	31	90	115	31	150	1.08	0.004225	14.33
5	31	210	115	31	150	1.21		
6	31	150	107	31	150	1.13	0.002704	9.17
7	31	150	123	31	150	1.23		
8	31	150	115	27	150	1.10	0.008556	29.02
9	31	150	115	35	150	1.28		
10	31	150	115	31	90	1.08	0.005625	19.08
11	31	150	115	31	210	1.23		

E[FS] = E[ln FS] = Total 0.029483 100.00
Var[FS]= 0.029483
σ[FS]= 0.171705 σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

200yr + 3ft	**Head =**	4.50	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	31	150	115	31	150	1.27		
2	27	150	115	31	150	1.12	0.012769	79.39
3	35	150	115	31	150	1.34		
4	31	90	115	31	150	1.19	0.001156	7.19
5	31	210	115	31	150	1.26		
6	31	150	107	31	150	1.22	0.000016	0.10
7	31	150	123	31	150	1.23		
8	31	150	115	27	150	1.20	0.001722	10.71
9	31	150	115	35	150	1.29		
10	31	150	115	31	90	1.21	0.000420	2.61
11	31	150	115	31	210	1.25		

E[FS] = E[ln FS] = Total 0.016084 100.00
Var[FS]= 0.016084
σ[FS]= 0.126821 σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

200yr	**Head =**	2.90	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	31	150	115	31	150	1.30		
2	27	150	115	31	150			
3	35	150	115	31	150			
4	31	90	115	31	150			
5	31	210	115	31	150			
6	31	150	107	31	150			
7	31	150	123	31	150			
8	31	150	115	27	150			
9	31	150	115	35	150			
10	31	150	115	31	90			
11	31	150	115	31	210			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

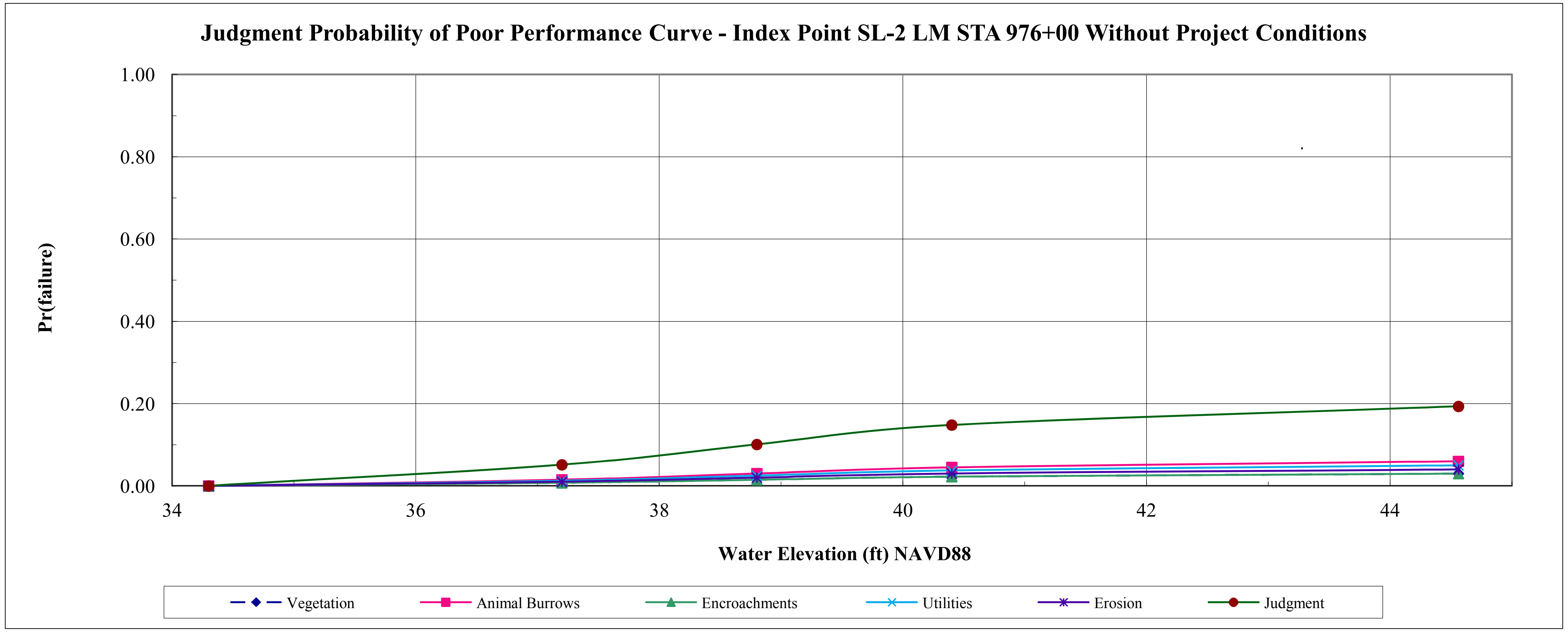
Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-2
Coordinates: State Plane (ft), N 2176913, E 6352470

Levee Mile: STA 976+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Datum: NAVD 88
Crest Elev.: 44.56
L/S Toe Elev.: 34.30
W/S Toe Elev.: 34.79

Analysis By: J. Hogan
Checked By: M. Perlea, G. John
Date: 9/27/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
34.30	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
37.20	0.0075	0.9925	0.0150	0.9850	0.0075	0.9925	0.0125	0.9875	0.0100	0.9900	0.0514	0.9486
38.80	0.0150	0.9850	0.0300	0.9700	0.0150	0.9850	0.0250	0.9750	0.0200	0.9800	0.1008	0.8992
40.40	0.0225	0.9775	0.0450	0.9550	0.0225	0.9775	0.0375	0.9625	0.0300	0.9700	0.1481	0.8519
44.56	0.0300	0.9700	0.0600	0.9400	0.0300	0.9700	0.0500	0.9500	0.0400	0.9600	0.1934	0.8066



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

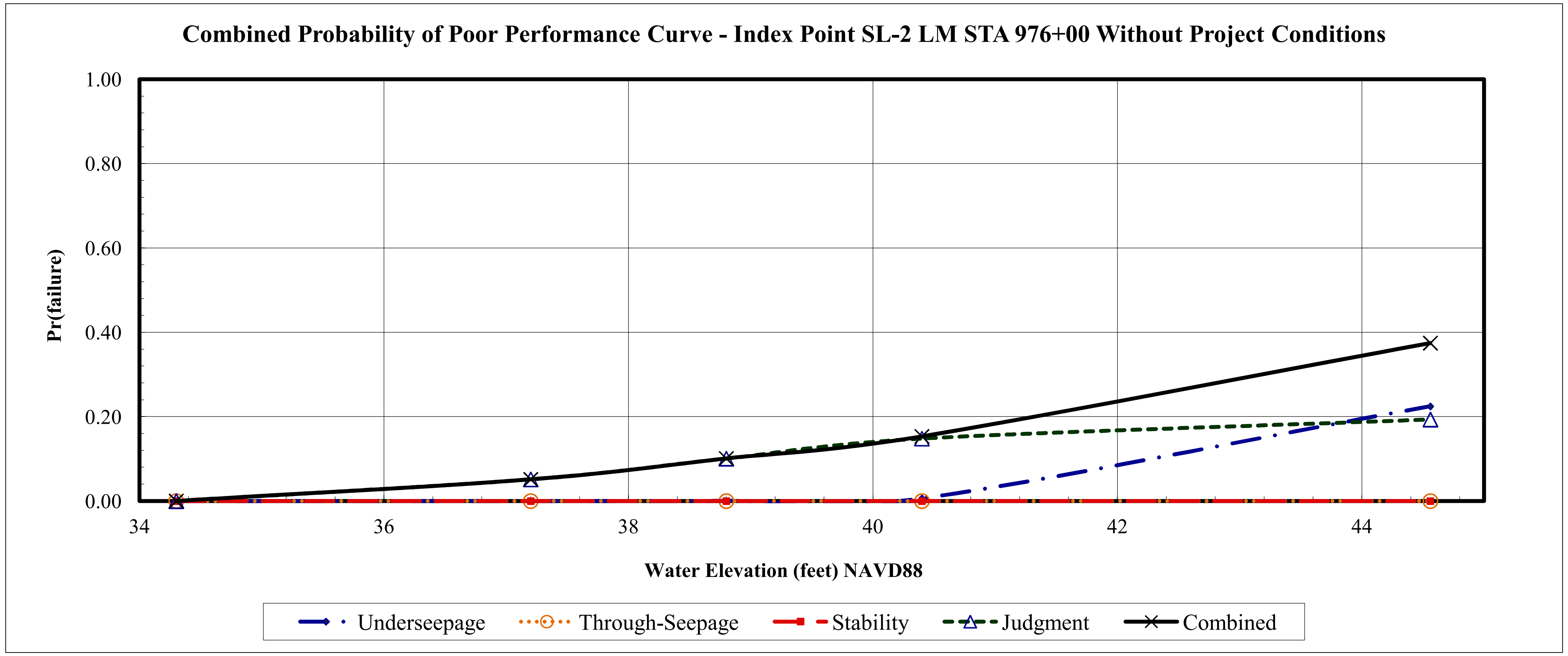
Project: Lower San Joaquin
Study Area: Left Bank Stockton Diverting Canal
River Section: Index Point SL-2
Coordinates: State Plane (ft), N 2176913, E 6352470

Levee Mile: STA 976+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Datum: NAVD 88
Crest Elev.: 44.56
L/S Toe Elev.: 34.30
W/S Toe Elev.: 34.79

Analysis By: J. Hogan
Checked By: M. Perlea, G. Joh
Date: 9/27/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
34.30	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
37.20	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0514	0.9486	0.0514	0.9486
38.80	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.1008	0.8992	0.1009	0.8991
40.40	0.0062	0.9938	0.0000	1.0000	0.0000	1.0000	0.1481	0.8519	0.1533	0.8467
44.56	0.2245	0.7755	0.0000	1.0000	0.0000	1.0000	0.1934	0.8066	0.3745	0.6255



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Left Bank Calaveras River
Basin and Reach: CL1

Levee Mile: STA 6757+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 31.43
L/S Toe Elev.: 21.00
W/S Toe Elev.: 26.94

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/24/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR1614_014C	11	19	8	119	42	7	15	11	137	73	ML	0.07	SM	2.8	40	40	0	373	0
WCSBCR_001B	10					6.5					CL	0.007	ML	0.28	40				
WCSBCR_003B	29					26					ML	0.07	SP-SM	2.8	40				
WCSBCR_003A	26					24					ML	0.07	SP-SM	2.8	40				
WCSBCR_006C	20					30					ML	0.07	SP-SM	2.8	40				
WCSBCR_008C	13					5					ML	0.07	SP-SM	2.8	40				
WCSBCR_004B	22					4					ML	0.007	OH	0.28	40				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR1614_014C	ML	11	0.07				11	SM	7	2.8							2.8
WCSBCR_001B	CL	10	0.007				10	ML	6.5	0.28							0.28
WCSBCR_003B	ML	29	0.07				29	SP-SM	26	2.8							2.8
WCSBCR_003A	ML	26	0.07				26	SP-SM	24	2.8							2.8
WCSBCR_006C	ML	20	0.07				20	SP-SM	30	2.8							2.8
WCSBCR_008C	ML	13	0.07				13	SP-SM	5	2.8							2.8
WCSBCR_004B	ML	22	0.007				22	OH	4	0.28							0.28

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: CL1

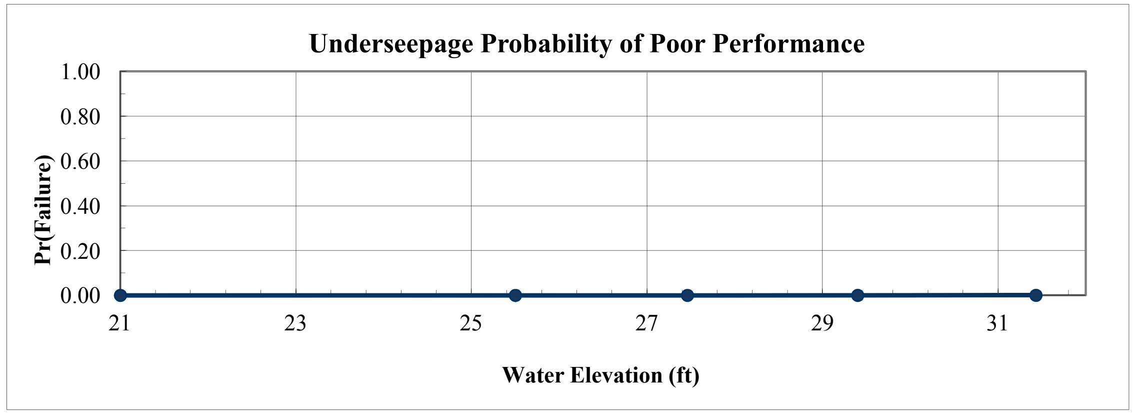
Levee Mile: STA 6757+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 31.43
L/S Toe Elev.: 21.00
W/S Toe Elev.: 26.94

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/24/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permaebility Ratio	40	0	0
Blanket Thickness (z)	19	8	42
Aquifer Thickness (d)	15	11	73

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	158	61	∞	112



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	21.00	0.0000
200yr	4.50	25.50	0.0000
200yr+2ft	6.46	27.46	0.0000
Crest-2ft	8.40	29.40	0.0001
Crest	10.43	31.43	0.0004

Crest	**Rh**
Head = 10.43	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	40	19.00	15.00	96.25	106.77	0.0568	4.22	0.22		
2	40	19.00	15.00	96.25	106.77	0.0568	4.22	0.22	0.000000	0.00
3	40	19.00	15.00	96.25	106.77	0.0568	4.22	0.22		
4	40	27.00	15.00	107.66	127.28	0.0507	4.49	0.17	0.008100	90.00
5	40	11.00	15.00	77.98	81.24	0.0681	3.85	0.35		
6	40	19.00	26.00	113.71	140.57	0.0825	4.65	0.24	0.000900	10.00
7	40	19.00	4.00	54.78	55.14	0.0234	3.36	0.18		
								Total	0.009000	100.00

E[I] = 0.220000
Var[I]= 0.009000
σ[I]= 0.094868
V(I) = 0.431220

E[ln I] = -1.599400
σ [ln I] = 0.412970
ln(I crit) = -0.223144

Ic=	0.80

β =	-3.872917
F(z) =	0.999570
Pr(f) % =	0.043022

Crest-2ft	**Rh**
Head = 8.40	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	40	19.00	15.00	96.25	106.77	0.0568	3.40	0.18		
2	40	19.00	15.00	96.25	106.77	0.0568	3.40	0.18	0.000000	0.00
3	40	19.00	15.00	96.25	106.77	0.0568	3.40	0.18		
4	40	27.00	15.00	107.66	127.28	0.0507	3.61	0.13	0.005625	86.21
5	40	11.00	15.00	77.98	81.24	0.0681	3.10	0.28		
6	40	19.00	26.00	113.71	140.57	0.0825	3.75	0.20	0.000900	13.79
7	40	19.00	4.00	54.78	55.14	0.0234	2.71	0.14		
								Total	0.006525	100.00

E[I] = 0.180000
Var[I]= 0.006525
σ[I]= 0.080777
V(I) = 0.448764

E[ln I] = -1.806538
σ [ln I] = 0.428344
ln(I crit) = -0.223144

Ic=	0.80

β =	-4.217496
F(z) =	0.999891
Pr(f) % =	0.010927

200yr+2ft	**Rh**
Head = 6.46	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	40	19.00	15.00	96.25	106.77	0.0568	2.61	0.14		
2	40	19.00	15.00	96.25	106.77	0.0568	2.61	0.14	0.000000	0.00
3	40	19.00	15.00	96.25	106.77	0.0568	2.61	0.14		
4	40	27.00	15.00	107.66	127.28	0.0507	2.78	0.10	0.003600	90.00
5	40	11.00	15.00	77.98	81.24	0.0681	2.38	0.22		
6	40	19.00	26.00	113.71	140.57	0.0825	2.88	0.15	0.000400	10.00
7	40	19.00	4.00	54.78	55.14	0.0234	2.08	0.11		
								Total	0.004000	100.00

E[I] = 0.140000
Var[I]= 0.004000
σ[I]= 0.063246
V(I) = 0.451754

E[ln I] = -2.058971
σ [ln I] = 0.430949
ln(I crit) = -0.223144

Ic=	0.80

β =	-4.777760
F(z) =	0.999990
Pr(f) % =	0.001022

200yr	**Rh**
Head = 4.50	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	40	19.00	15.00	96.25	106.77	0.0568	1.82	0.10		
2	40	19.00	15.00	96.25	106.77	0.0568	1.82	0.10	0.000000	0.00
3	40	19.00	15.00	96.25	106.77	0.0568	1.82	0.10		
4	40	27.00	15.00	107.66	127.28	0.0507	1.94	0.07	0.001600	87.67
5	40	11.00	15.00	77.98	81.24	0.0681	1.66	0.15		
6	40	19.00	26.00	113.71	140.57	0.0825	2.01	0.11	0.000225	12.33
7	40	19.00	4.00	54.78	55.14	0.0234	1.45	0.08		
								Total	0.001825	100.00

E[I] = 0.100000
Var[I]= 0.001825
σ[I]= 0.042720
V(I) = 0.427200

E[ln I] = -2.386401
σ [ln I] = 0.409427
ln(I crit) = -0.223144

Ic=	0.80

β =	-5.828628
F(z) =	1.000000
Pr(f) % =	0.000006

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: CL1

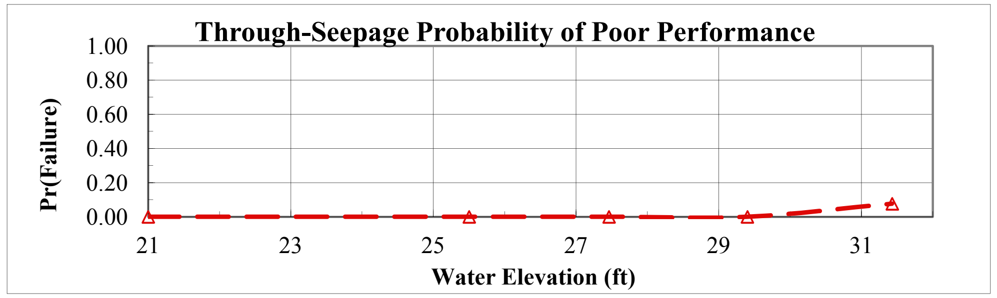
Levee Mile: STA 6757+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 31.43
L/S Toe Elev.: 21.00
W/S Toe Elev.: 26.94

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/24/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	3.2	0.3	10.00
Initial Porosity (n)	0.39	0.04	10.00
Initial Permeability (Ko)	2.00E-06	6.00E-07	30.00

Pr(f)=0
NO



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	21.00	0.0000
200yr	4.50	25.50	0.000000
200yr+2ft	6.46	27.46	0.000003
Crest-2ft	8.40	29.40	0.000010
Crest	10.43	31.43	0.076943

Crest	**Head =**	10.43	**Horizontal Gradient (Ix) =**	0.380

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	3.20	0.39	2.00E-06	0.51	1.34		
2	2.88	0.39	2.00E-06	0.46	1.21	0.017978	26.44
3	3.52	0.39	2.00E-06	0.56	1.47		
4	3.20	0.35	2.00E-06	0.48	1.27	0.004506	6.63
5	3.20	0.43	2.00E-06	0.53	1.41		
6	3.20	0.39	1.40E-06	0.61	1.60	0.045498	66.93
7	3.20	0.39	2.60E-06	0.45	1.18		
E[FS] =	1.340813		E[ln FS] =	0.274717	Total	0.067982	100.00
Var[FS]=	0.067982						
σ[FS]=	0.260733		σ[ln FS]=	0.192658		**β =**	1.425936
V(FS) =	0.194459					**F(z) =**	0.076943
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	7.694347

Crest-2ft	**Head =**	8.40	**Horizontal Gradient (Ix) =**	0.220

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	3.20	0.39	2.00E-06	0.51	2.32		
2	2.88	0.39	2.00E-06	0.46	2.08	0.053636	26.44
3	3.52	0.39	2.00E-06	0.56	2.55		
4	3.20	0.35	2.00E-06	0.48	2.20	0.013443	6.63
5	3.20	0.43	2.00E-06	0.53	2.43		
6	3.20	0.39	1.40E-06	0.61	2.77	0.135743	66.93
7	3.20	0.39	2.60E-06	0.45	2.03		
E[FS] =	2.315949		E[ln FS] =	0.821261	Total	0.202822	100.00
Var[FS]=	0.202822						
σ[FS]=	0.450358		σ[ln FS]=	0.192658		**β =**	4.262800
V(FS) =	0.194459					**F(z) =**	0.000010
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.001009

200yr+2ft	**Head =**	6.46	**Horizontal Gradient (Ix) =**	0.210

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	3.20	0.39	2.00E-06	0.51	2.43		
2	2.88	0.39	2.00E-06	0.46	2.18	0.058866	26.44
3	3.52	0.39	2.00E-06	0.56	2.67		
4	3.20	0.35	2.00E-06	0.48	2.30	0.014753	6.63
5	3.20	0.43	2.00E-06	0.53	2.54		
6	3.20	0.39	1.40E-06	0.61	2.90	0.148979	66.93
7	3.20	0.39	2.60E-06	0.45	2.13		
E[FS] =	2.426232		E[ln FS] =	0.867781	Total	0.222598	100.00
Var[FS]=	0.222598						
σ[FS]=	0.471803		σ[ln FS]=	0.192658		**β =**	4.504265
V(FS) =	0.194459					**F(z) =**	0.000003
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000333

200yr	**Head =**	4.50	**Horizontal Gradient (Ix) =**	0.130

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	3.20	0.39	2.00E-06	0.51	3.92		
2	2.88	0.39	2.00E-06	0.46	3.53	0.153609	26.44
3	3.52	0.39	2.00E-06	0.56	4.31		
4	3.20	0.35	2.00E-06	0.48	3.72	0.038499	6.63
5	3.20	0.43	2.00E-06	0.53	4.11		
6	3.20	0.39	1.40E-06	0.61	4.68	0.388756	66.93
7	3.20	0.39	2.60E-06	0.45	3.44		
E[FS] =	3.919299		E[ln FS] =	1.347354	Total	0.580863	100.00
Var[FS]=	0.580863						
σ[FS]=	0.762144		σ[ln FS]=	0.192658		**β =**	6.993515
V(FS) =	0.194459					**F(z) =**	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

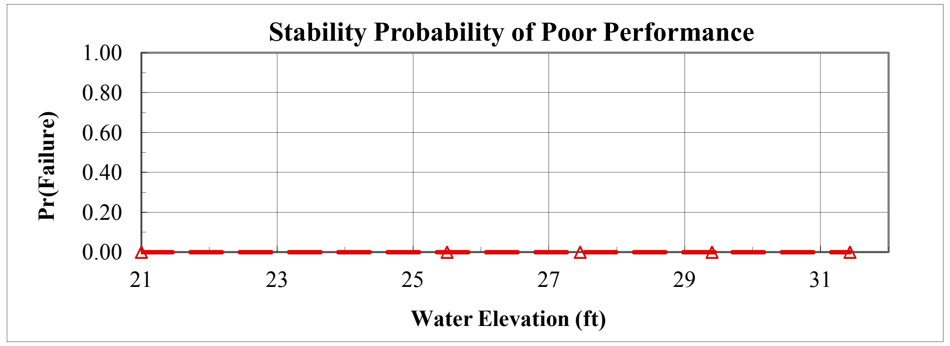
Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: CL1

Levee Mile: STA 6757+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 31.43
L/S Toe Elev.: 21.00
W/S Toe Elev.: 26.94

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/24/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	34	4	13.00
Levee Cohesion	100	40	40.00
Levee γ	115	8	7.00
Foundation Φ	31	4	13.00
Foundation Cohesion	150	60	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	21.00	0.0000
200yr	4.50	25.50	0.000000
200yr+2ft	6.46	27.46	0.000000
Crest-2ft	8.40	29.40	0.000000
Crest	10.43	31.43	0.000109

Crest **Head =** 10.43 **Pr(f)=0** NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	115	31	150	2.05		
2	30	100	115	31	150	1.88	0.039800	25.96
3	38	100	115	31	150	2.28		
4	34	60	115	31	150	1.70	0.109230	71.25
5	34	140	115	31	150	2.36		
6	34	100	107	31	150	2.05	0.000009	0.01
7	34	100	123	31	150	2.05		
8	34	100	115	27	150	2.10	0.000552	0.36
9	34	100	115	35	150	2.05		
10	34	100	115	31	90	1.93	0.003721	2.43
11	34	100	115	31	210	2.05		

E[FS] = 2.050000　E[ln FS] = 0.699924　Total 0.153313 100.00
Var[FS]= 0.153313
σ[FS]= 0.391552　σ[ln FS]= 0.189292　**β =** 3.697580
V(FS) = 0.191001　**F(z) =** 0.000109
FS req'd = 1.00　ln(FS req'd) = 0.000000　**Pr(f) % =** 0.010883

Crest-2ft **Head =** 8.40 **Pr(f)=0** YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	115	31	150	2.28		
2	30	100	115	31	150			
3	38	100	115	31	150			
4	34	60	115	31	150			
5	34	140	115	31	150			
6	34	100	107	31	150			
7	34	100	123	31	150			
8	34	100	115	27	150			
9	34	100	115	35	150			
10	34	100	115	31	90			
11	34	100	115	31	210			

E[FS] =　E[ln FS] =　Total
Var[FS]=
σ[FS]=　σ[ln FS]=　**β =**
V(FS) =　**F(z) =**
FS req'd = 1.00　ln(FS req'd) = 0.000000　**Pr(f) % =** 0.000000

200yr+2ft **Head =** 6.46 **Pr(f)=0** YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	115	31	150	2.46		
2	30	100	115	31	150			
3	38	100	115	31	150			
4	34	60	115	31	150			
5	34	140	115	31	150			
6	34	100	107	31	150			
7	34	100	123	31	150			
8	34	100	115	27	150			
9	34	100	115	35	150			
10	34	100	115	31	90			
11	34	100	115	31	210			

E[FS] =　E[ln FS] =　Total
Var[FS]=
σ[FS]=　σ[ln FS]=　**β =**
V(FS) =　**F(z) =**
FS req'd = 1.00　ln(FS req'd) = 0.000000　**Pr(f) % =** 0.000000

200yr **Head =** 4.50 **Pr(f)=0** YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	115	31	150	2.71		
2	30	100	115	31	150			
3	38	100	115	31	150			
4	34	60	115	31	150			
5	34	140	115	31	150			
6	34	100	107	31	150			
7	34	100	123	31	150			
8	34	100	115	27	150			
9	34	100	115	35	150			
10	34	100	115	31	90			
11	34	100	115	31	210			

E[FS] =　E[ln FS] =　Total
Var[FS]=
σ[FS]=　σ[ln FS]=　**β =**
V(FS) =　**F(z) =**
FS req'd = 1.00　ln(FS req'd) = 0.000000　**Pr(f) % =** 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

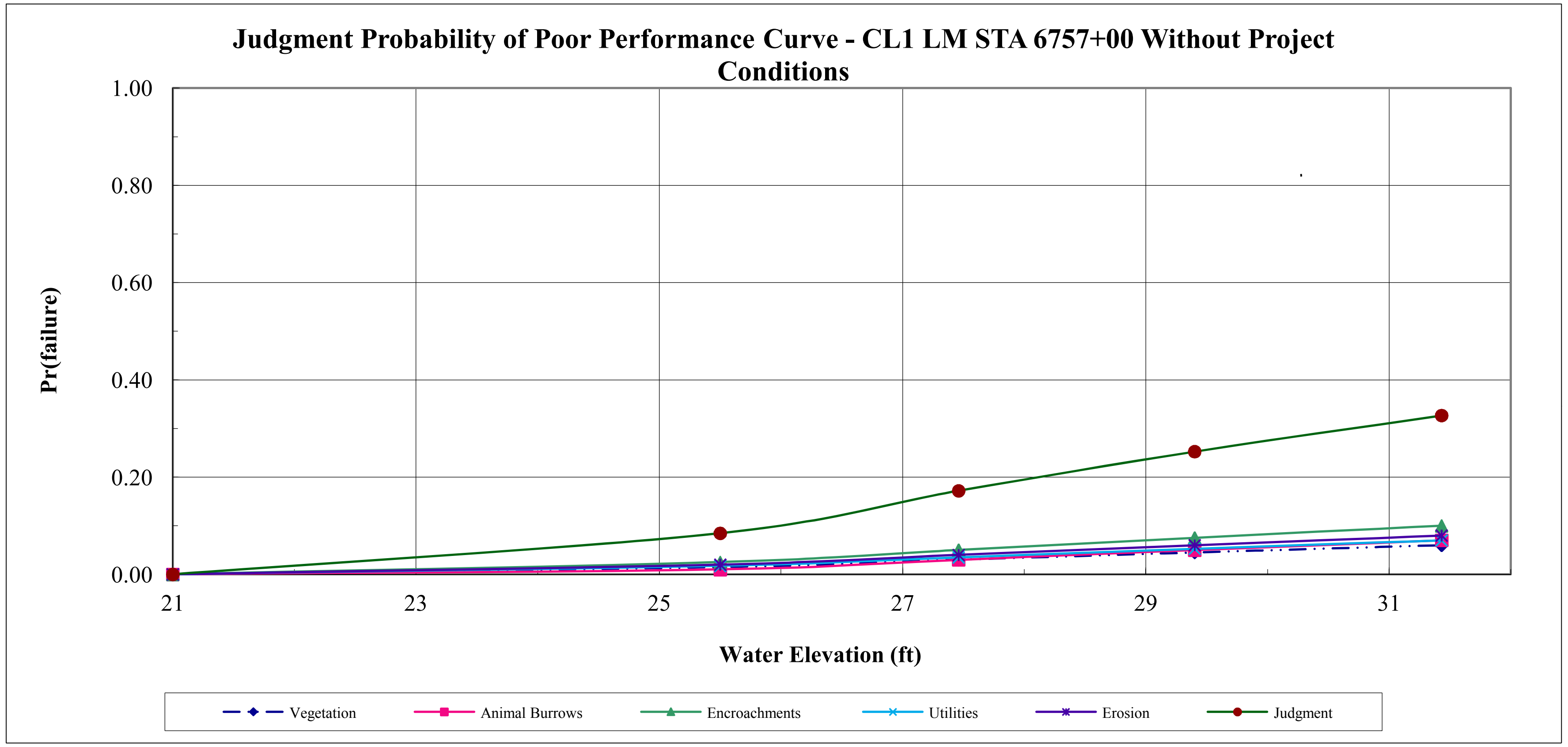
Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: CL1

Levee Mile: STA 6757+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 31.43
L/S Toe Elev.: 21.00
W/S Toe Elev.: 26.94

Analysis By: G. Johnson
Checked By: M. Perlea, J. F
Date: 9/24/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
21.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
25.50	0.0150	0.9850	0.0100	0.9900	0.0250	0.9750	0.0175	0.9825	0.0200	0.9800	0.0845	0.9155
27.46	0.0300	0.9700	0.0300	0.9700	0.0500	0.9500	0.0350	0.9650	0.0400	0.9600	0.1719	0.8281
29.40	0.0450	0.9550	0.0500	0.9500	0.0750	0.9250	0.0525	0.9475	0.0600	0.9400	0.2526	0.7474
31.43	0.0600	0.9400	0.0700	0.9300	0.1000	0.9000	0.0700	0.9300	0.0800	0.9200	0.3268	0.6732



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

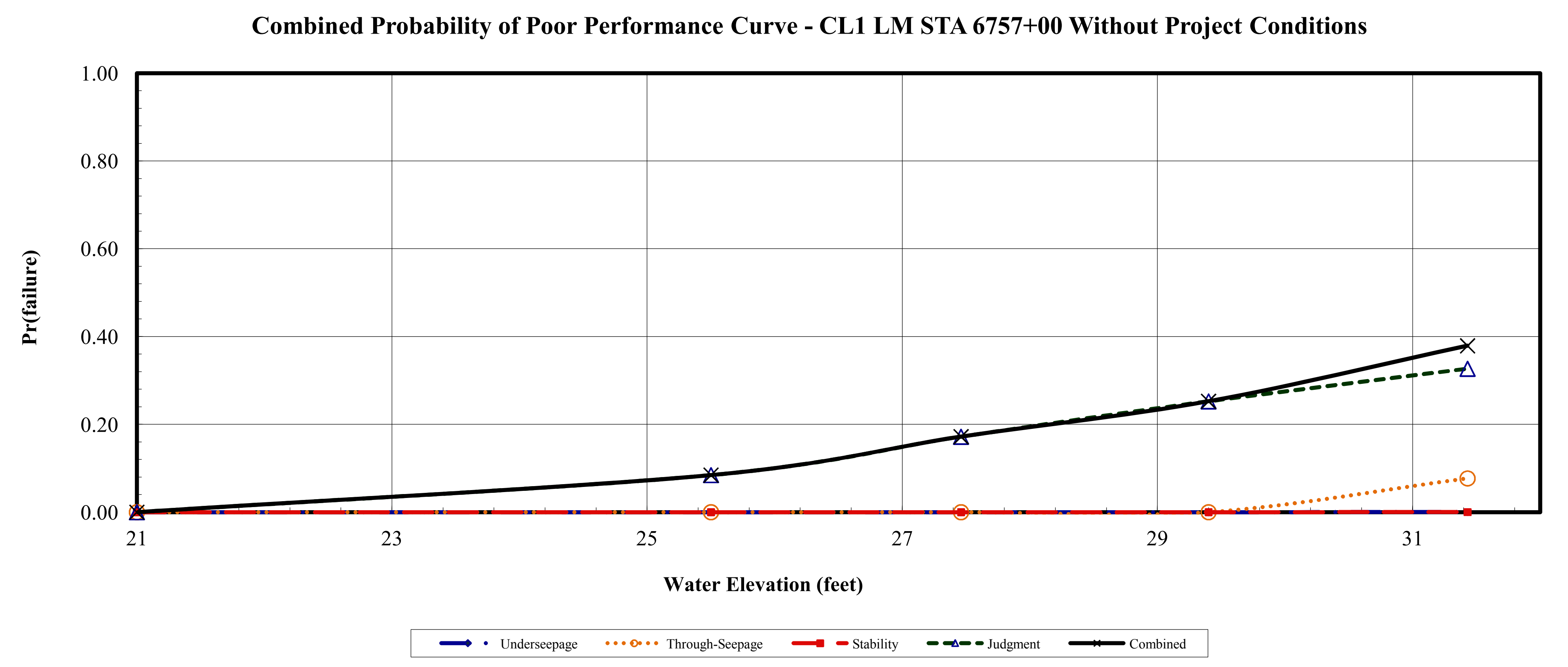
Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: CL1

Levee Mile: STA 6757+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 31.43
L/S Toe Elev.: 21.00
W/S Toe Elev.: 26.94

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hog
Date: 9/24/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
21.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
25.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0845	0.9155	0.0845	0.9155
27.46	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1719	0.8281	0.1719	0.8281
29.40	0.0001	0.9999	0.0000	1.0000	0.0000	1.0000	0.2526	0.7474	0.2527	0.7473
31.43	0.0004	0.9996	0.0769	0.9231	0.0001	0.9999	0.3268	0.6732	0.3790	0.6210



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Right Bank Calaveras River
Basin and Reach: Index Point CR1

Levee Mile: STA 3306+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 29.66
L/S Toe Elev.: 23.80
W/S Toe Elev.: 22.90

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/28/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WCNBCR_006A	8	5	2	8	40	26	14	8	86	57	CL	0.007	ML	1.4	200	200	0	11111	0
WCNBCR_007B	4					12					CL	0.007	ML	1.4	200				
WCNBCR_013C	4					14					CL	0.007	ML	1.4	200				
WCNBCR_008B	5					4					CL	0.007	ML	1.4	200				
WCNBCR_010A	2					16					CL	0.007	ML	1.4	200				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCNBCR_006A	CL	8	0.007				8	ML	26	1.4							1.4
WCNBCR_007B	CL	4	0.007				4	ML	12	1.4							1.4
WCNBCR_013C	CL	4	0.007				4	ML	14	1.4							1.4
WCNBCR_008B	CL	5	0.007				5	ML	4	1.4							1.4
WCNBCR_010A	CL	2	0.007				2	ML	16	1.4							1.4

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point CR1

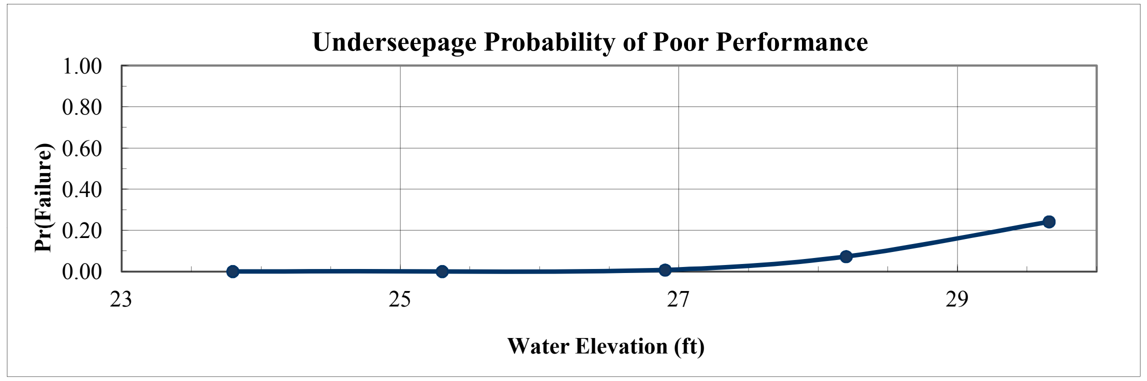
Levee Mile: STA 3306+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 29.66
L/S Toe Elev.: 23.80
W/S Toe Elev.: 22.90

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permeability Ratio	200	0	0
Blanket Thickness (z)	5	2	40
Aquifer Thickness (d)	14	8	57

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	37	56	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	23.80	0.0000
Elev. 25.3	1.50	25.30	0.0000
200 yr	3.10	26.90	0.0074
Elev. 28.2	4.40	28.20	0.0727
Crest	5.86	29.66	0.2418

Crest		Rh
Head =	5.86	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	200	5.00	14.00	35.84	118.32	0.0666	3.30	0.66		
2	200	5.00	14.00	35.84	118.32	0.0666	3.30	0.66	0.000000	0.00
3	200	5.00	14.00	35.84	118.32	0.0666	3.30	0.66		
4	200	7.00	14.00	36.16	140.00	0.0603	3.53	0.50	0.057600	87.67
5	200	3.00	14.00	35.11	91.65	0.0766	2.94	0.98		
6	200	5.00	22.00	36.25	148.32	0.0914	3.61	0.72	0.008100	12.33
7	200	5.00	6.00	34.42	77.46	0.0357	2.70	0.54		
								Total	0.065700	100.00

E[I] = 0.660000
E[ln I] = -0.485756
Var[I]= 0.065700
σ[I]= 0.256320
σ [ln I] = 0.374807
V(I) = 0.388364
β = -1.296015
F(z) = 0.758242
Ic= 0.80
ln(I crit) = -0.223144
Pr(f) % = 24.175783

Elev. 28.2		Rh
Head =	4.40	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	200	5.00	14.00	35.84	118.32	0.0666	2.48	0.50		
2	200	5.00	14.00	35.84	118.32	0.0666	2.48	0.50	0.000000	0.00
3	200	5.00	14.00	35.84	118.32	0.0666	2.48	0.50		
4	200	7.00	14.00	36.16	140.00	0.0603	2.66	0.38	0.032400	88.46
5	200	3.00	14.00	35.11	91.65	0.0766	2.21	0.74		
6	200	5.00	22.00	36.25	148.32	0.0914	2.72	0.54	0.004225	11.54
7	200	5.00	6.00	34.42	77.46	0.0357	2.03	0.41		
								Total	0.036625	100.00

E[I] = 0.500000
E[ln I] = -0.761504
Var[I]= 0.036625
σ[I]= 0.191377
σ [ln I] = 0.369748
V(I) = 0.382753
β = -2.059520
F(z) = 0.927306
Ic= 0.80
ln(I crit) = -0.223144
Pr(f) % = 7.269370

200 yr		Rh
Head =	3.10	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	200	5.00	14.00	35.84	118.32	0.0666	1.75	0.35		
2	200	5.00	14.00	35.84	118.32	0.0666	1.75	0.35	0.000000	0.00
3	200	5.00	14.00	35.84	118.32	0.0666	1.75	0.35		
4	200	7.00	14.00	36.16	140.00	0.0603	1.87	0.27	0.015625	88.53
5	200	3.00	14.00	35.11	91.65	0.0766	1.56	0.52		
6	200	5.00	22.00	36.25	148.32	0.0914	1.91	0.38	0.002025	11.47
7	200	5.00	6.00	34.42	77.46	0.0357	1.43	0.29		
								Total	0.017650	100.00

E[I] = 0.350000
E[ln I] = -1.117123
Var[I]= 0.017650
σ[I]= 0.132853
σ [ln I] = 0.366882
V(I) = 0.379581
β = -3.044913
F(z) = 0.992589
Ic= 0.80
ln(I crit) = -0.223144
Pr(f) % = 0.741105

Elev. 25.3		Rh
Head =	1.50	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	200	5.00	14.00	35.84	118.32	0.0666	0.85	0.17		
2	200	5.00	14.00	35.84	118.32	0.0666	0.85	0.17	0.000000	0.00
3	200	5.00	14.00	35.84	118.32	0.0666	0.85	0.17		
4	200	7.00	14.00	36.16	140.00	0.0603	0.91	0.13	0.003600	85.21
5	200	3.00	14.00	35.11	91.65	0.0766	0.75	0.25		
6	200	5.00	22.00	36.25	148.32	0.0914	0.93	0.19	0.000625	14.79
7	200	5.00	6.00	34.42	77.46	0.0357	0.69	0.14		
								Total	0.004225	100.00

E[I] = 0.170000
E[ln I] = -1.840180
Var[I]= 0.004225
σ[I]= 0.065000
σ [ln I] = 0.369387
V(I) = 0.382353
β = -4.981715
F(z) = 0.999994
Ic= 0.80
ln(I crit) = -0.223144
Pr(f) % = 0.000600

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point CR1

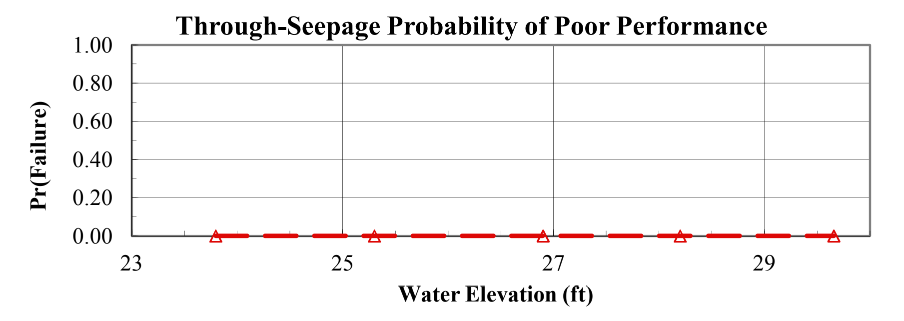
Levee Mile: STA 3306+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 29.66
L/S Toe Elev.: 23.80
W/S Toe Elev.: 22.90

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	8	0.8	10.00
Initial Porosity (n)	50	5.00	10.00
Initial Permeability (Ko)	2.80E-08	8.40E-09	30.00

Pr(f)=0
NO



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	23.80	0.0000
Elev. 25.3	1.50	25.30	0.000000
200 yr	3.10	26.90	0.000000
Elev. 28.2	4.40	28.20	0.000000
Crest	5.86	29.66	0.000000

Crest **Head =** 5.86 **Horizontal Gradient (Ix) =** 0.220

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	8.00	50.00	2.80E-08	121.89	554.06		
2	7.20	50.00	2.80E-08	109.70	498.66	3069.837765	26.44
3	8.80	50.00	2.80E-08	134.08	609.47		
4	8.00	45.00	2.80E-08	115.64	525.63	769.387744	6.63
5	8.00	55.00	2.80E-08	127.84	581.10		
6	8.00	50.00	1.96E-08	145.69	662.23	7769.185658	66.93
7	8.00	50.00	3.64E-08	106.91	485.94		

E[FS] = 554.061167 E[ln FS] = 6.298717 Total 11608.411167 100.00
Var[FS]= 11608.411167
σ[FS]= 107.742337 σ[ln FS]= 0.192658 **β =** 32.693828
V(FS) = 0.194459 **F(z) =** 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

Elev. 28.2 **Head =** 4.40 **Horizontal Gradient (Ix) =** 0.180

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	8.00	50.00	2.80E-08	121.89	677.19		
2	7.20	50.00	2.80E-08	109.70	609.47	4585.807032	26.44
3	8.80	50.00	2.80E-08	134.08	744.90		
4	8.00	45.00	2.80E-08	115.64	642.43	1149.332308	6.63
5	8.00	55.00	2.80E-08	127.84	710.24		
6	8.00	50.00	1.96E-08	145.69	809.39	11605.820552	66.93
7	8.00	50.00	3.64E-08	106.91	593.93		

E[FS] = 677.185870 E[ln FS] = 6.499387 Total 17340.959892 100.00
Var[FS]= 17340.959892
σ[FS]= 131.685078 σ[ln FS]= 0.192658 **β =** 33.735420
V(FS) = 0.194459 **F(z) =** 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

200 yr **Head =** 3.10 **Horizontal Gradient (Ix) =** 0.140

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	8.00	50.00	2.80E-08	121.89	870.67		
2	7.20	50.00	2.80E-08	109.70	783.60	7580.619787	26.44
3	8.80	50.00	2.80E-08	134.08	957.73		
4	8.00	45.00	2.80E-08	115.64	825.99	1899.916673	6.63
5	8.00	55.00	2.80E-08	127.84	913.16		
6	8.00	50.00	1.96E-08	145.69	1040.65	19185.131932	66.93
7	8.00	50.00	3.64E-08	106.91	763.63		

E[FS] = 870.667548 E[ln FS] = 6.750702 Total 28665.668392 100.00
Var[FS]= 28665.668392
σ[FS]= 169.309387 σ[ln FS]= 0.192658 **β =** 35.039882
V(FS) = 0.194459 **F(z) =** 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

Elev. 25.3 **Head =** 1.50 **Horizontal Gradient (Ix) =** 0.010

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	8.00	50.00	2.80E-08	121.89	12189.35		
2	7.20	50.00	2.80E-08	109.70	10970.41	1485801.478345	26.44
3	8.80	50.00	2.80E-08	134.08	13408.28		
4	8.00	45.00	2.80E-08	115.64	11563.83	372383.667864	6.63
5	8.00	55.00	2.80E-08	127.84	12784.29		
6	8.00	50.00	1.96E-08	145.69	14569.05	3760285.858706	66.93
7	8.00	50.00	3.64E-08	106.91	10690.76		

E[FS] = 12189.345669 E[ln FS] = 9.389759 Total 5618471.004916 100.00
Var[FS]= 5618471.004916
σ[FS]= 2370.331412 σ[ln FS]= 0.192658 **β =** 48.738051
V(FS) = 0.194459 **F(z) =** 0.000000
FS req'd = 1.00 ln(FS req'd) = 0.000000 **Pr(f) % =** 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

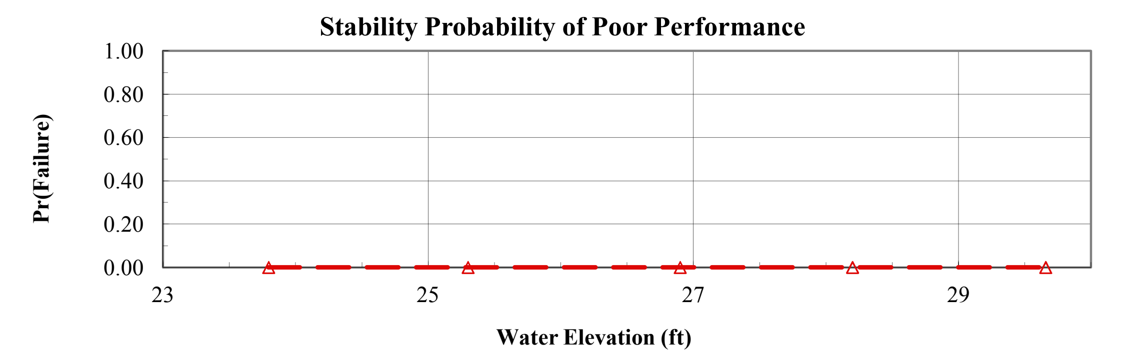
Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point CR1

Levee Mile: STA 3306+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 29.66
L/S Toe Elev.: 23.80
W/S Toe Elev.: 22.90

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	34	4	13.00
Levee Cohesion	100	40	40.00
Levee γ	120	8	7.00
Foundation Φ	31	4	13.00
Foundation Cohesion	150	60	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	23.80	0.0000
Elev. 25.3	1.50	25.30	0.000000
200 yr	3.10	26.90	0.000000
Elev. 28.2	4.40	28.20	0.000000
Crest	5.86	29.66	0.000000

Crest	**Head =**	5.86	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	120	31	150	2.91		
2	30	100	120	31	150	2.67	0.022052	8.22
3	38	100	120	31	150	2.97		
4	34	60	120	31	150	2.31	0.189660	70.73
5	34	140	120	31	150	3.18		
6	34	100	112	31	150	2.82	0.000225	0.08
7	34	100	128	31	150	2.85		
8	34	100	120	27	150	2.71	0.008464	3.16
9	34	100	120	35	150	2.89		
10	34	100	120	31	90	2.45	0.047742	17.80
11	34	100	120	31	210	2.89		

E[FS] = 2.910000
Var[FS]= 0.268144
σ[FS]= 0.517826
V(FS) = 0.177947
FS req'd = 1.00

E[ln FS] = 1.052566
σ[ln FS]= 0.176562
ln(FS req'd) = 0.000000

Total 0.268144 100.00

β = 5.961451
F(z) = 0.000000
Pr(f) % = 0.000000

200 yr	**Head =**	3.10	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	120	31	150	3.37		
2	30	100	120	31	150			
3	38	100	120	31	150			
4	34	60	120	31	150			
5	34	140	120	31	150			
6	34	100	112	31	150			
7	34	100	128	31	150			
8	34	100	120	27	150			
9	34	100	120	35	150			
10	34	100	120	31	90			
11	34	100	120	31	210			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Elev. 28.2	**Head =**	4.40	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	120	31	150	3.13		
2	30	100	120	31	150			
3	38	100	120	31	150			
4	34	60	120	31	150			
5	34	140	120	31	150			
6	34	100	112	31	150			
7	34	100	128	31	150			
8	34	100	120	27	150			
9	34	100	120	35	150			
10	34	100	120	31	90			
11	34	100	120	31	210			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Elev. 25.3	**Head =**	1.50	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	120	31	150	3.73		
2	30	100	120	31	150			
3	38	100	120	31	150			
4	34	60	120	31	150			
5	34	140	120	31	150			
6	34	100	112	31	150			
7	34	100	128	31	150			
8	34	100	120	27	150			
9	34	100	120	35	150			
10	34	100	120	31	90			
11	34	100	120	31	210			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

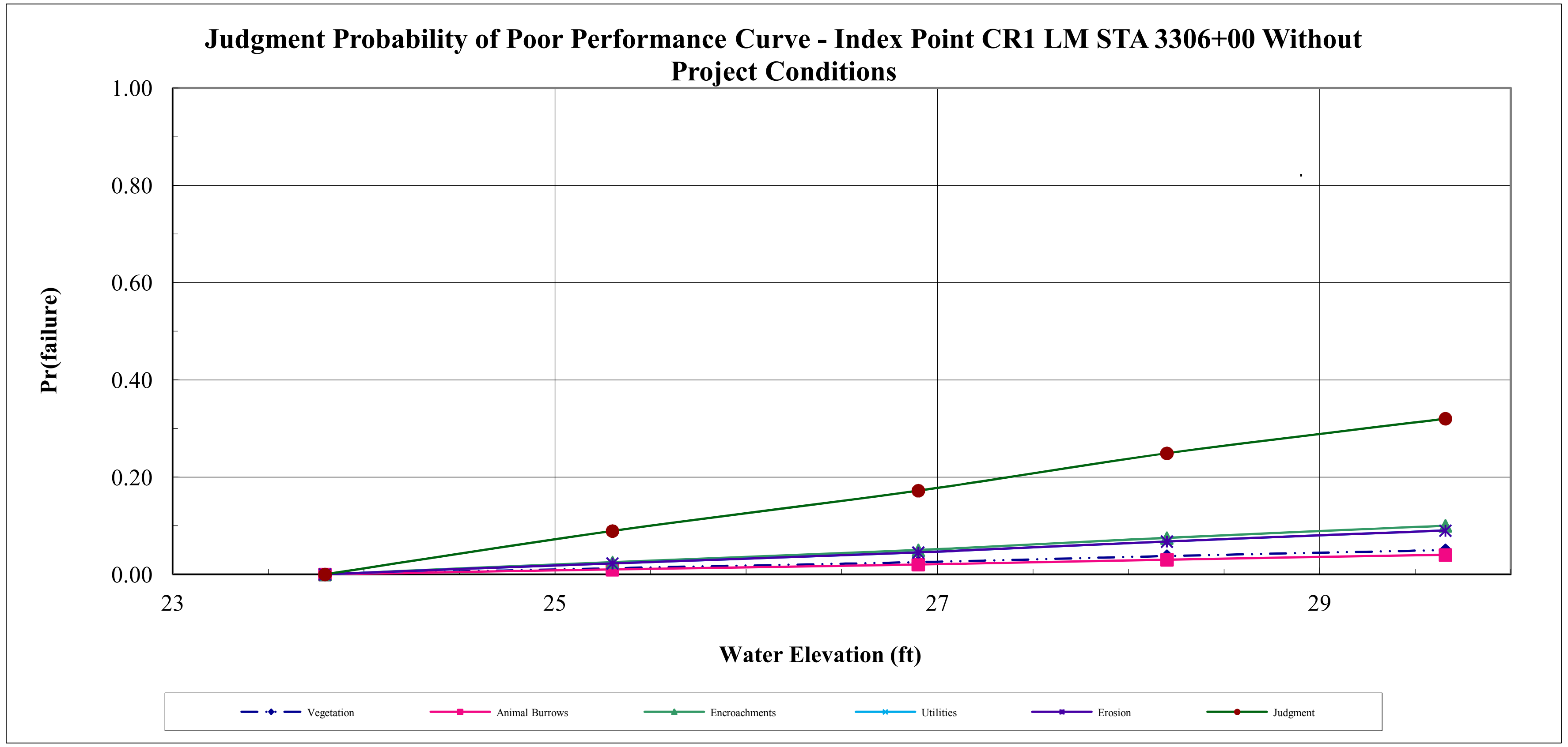
Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point CR1

Levee Mile: STA 3306+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 29.66
L/S Toe Elev.: 23.80
W/S Toe Elev.: 22.90

Analysis By: G. Johnson
Checked By: M. Perlea, J. F
Date: 9/28/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
23.80	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
25.30	0.0125	0.9875	0.0100	0.9900	0.0250	0.9750	0.0225	0.9775	0.0225	0.9775	0.0892	0.9108
26.90	0.0250	0.9750	0.0200	0.9800	0.0500	0.9500	0.0450	0.9550	0.0450	0.9550	0.1721	0.8279
28.20	0.0375	0.9625	0.0300	0.9700	0.0750	0.9250	0.0675	0.9325	0.0675	0.9325	0.2490	0.7510
29.66	0.0500	0.9500	0.0400	0.9600	0.1000	0.9000	0.0900	0.9100	0.0900	0.9100	0.3203	0.6797



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

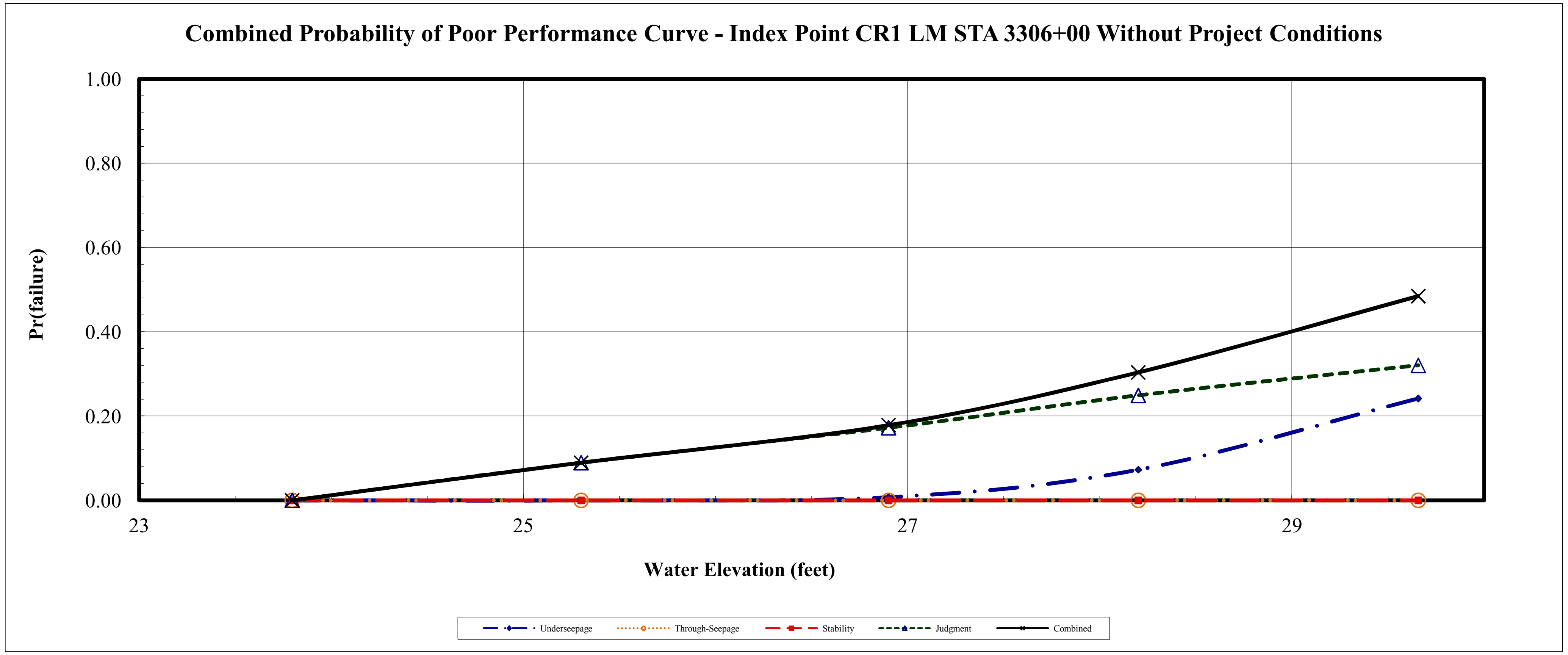
Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point CR1

Levee Mile: STA 3306+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 29.66
L/S Toe Elev.: 23.80
W/S Toe Elev.: 22.90

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hog
Date: 9/28/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
23.80	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
25.30	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0892	0.9108	0.0892	0.9108
26.90	0.0074	0.9926	0.0000	1.0000	0.0000	1.0000	0.1721	0.8279	0.1783	0.8217
28.20	0.0727	0.9273	0.0000	1.0000	0.0000	1.0000	0.2490	0.7510	0.3036	0.6964
29.66	0.2418	0.7582	0.0000	1.0000	0.0000	1.0000	0.3203	0.6797	0.4846	0.5154



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Right Bank Calaveras River
Basin and Reach: Index Point D4

Levee Mile: STA 3092+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 18.82
L/S Toe Elev.: 5.37
W/S Toe Elev.: 3.18

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/25/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR2074_001B	12	15	7	81	47	33	30	2	158	7	CL/ML	0.0007	SP-SM	19.6	28000	3804	9777	76919955	98
WR2074_002B	19					28					CL/ML	0.007	SP-SM	2.8	400				
WR2074_003B	28					28					CL	0.007	SP-SM	2.8	400				
WR2074_004B	7					28					CL	0.007	SP-SM	2.8	400				
WR2074_005B	18					32					CL/ML	0.007	SP-SM	2.8	400				
WCNBCR_003B	8.5					30					CH/ML	0.007	SP-SM	1.8	257				
WCNBCR_004B	8.3					27					CL/ML	0.007	SP-SM	2	286				
WCNBCR_005B	19					30					CL/ML	0.007	SP-SM	2	286				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR2074_001B	CL	11	0.0007	ML	10	0.007	12	SP-SM	33	19.6							19.6
WR2074_002B	CL	18	0.007	ML	10	0.07	19	SP-SM	28	2.8							2.8
WR2074_003B	CL	28	0.007				28	SP-SM	28	2.8							2.8
WR2074_004B	CL	7	0.007				7	SP-SM	28	2.8							2.8
WR2074_005B	CL/ML	18	0.007				18	SP-SM	32	2.8							2.8
WCNBCR_003B	CH	8	0.007	ML	5	0.07	8.5	SP-SM	30	1.8							1.8
WCNBCR_004B	CL	8	0.007	ML	3	0.07	8.3	SP-SM	27	2							2
WCNBCR_005B	CL	18	0.007	ML	10	0.07	19	SP-SM	30	2							2

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point D4

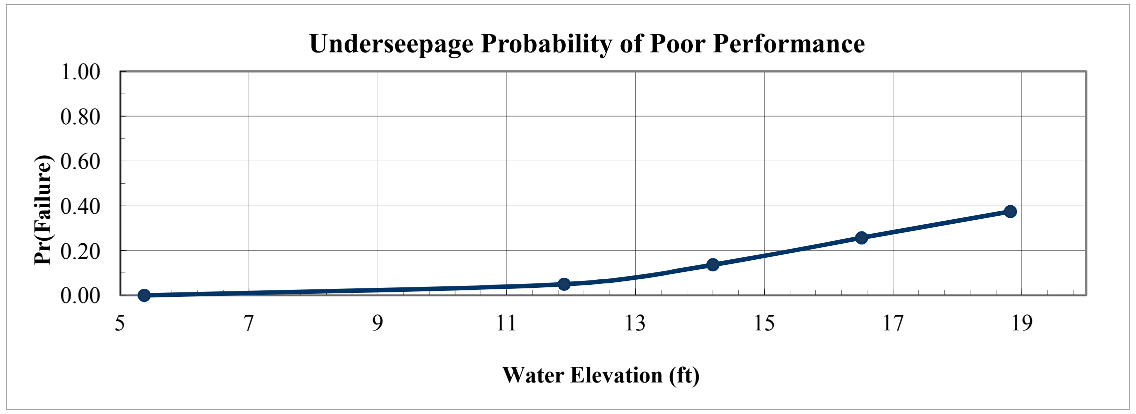
Levee Mile: STA 3092+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 18.82
L/S Toe Elev.: 5.37
W/S Toe Elev.: 3.18

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/25/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	3804	3728	98
Blanket Thickness (z)	15	7	47
Aquifer Thickness (d)	30	2	7

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	86	103	∞	112


Underseepage Probability of Poor Performance

Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	5.37	0.0000
Elev. 11.89	6.52	11.89	0.0500
200 yr	8.83	14.20	0.1369
Elev. 16.51	11.14	16.51	0.2570
Crest	13.45	18.82	0.3744

Crest		Rh
Head =	13.45	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	3804	15.00	30.00	85.88	1308.36	0.0200	11.75	0.78		
2	7532	15.00	30.00	85.94	1841.02	0.0148	12.20	0.81	0.032400	15.21
3	76	15.00	30.00	80.30	185.03	0.0814	6.76	0.45		
4	3804	22.00	30.00	85.92	1584.50	0.0169	12.02	0.55	0.180625	84.78
5	3804	8.00	30.00	85.77	955.49	0.0262	11.23	1.40		
6	3804	15.00	32.00	85.88	1351.27	0.0208	11.80	0.79	0.000025	0.01
7	3804	15.00	28.00	85.87	1263.99	0.0193	11.70	0.78		
								Total	0.213050	100.00

E[I] = 0.780000
Var[I]= 0.213050
σ[I]= 0.461573
V(I) = 0.591761

E[ln I] = -0.398581
σ [ln I] = 0.547940
ln(I crit) = -0.223144

Ic=	0.80

β =	-0.727416
F(z) =	0.625582
Pr(f) % =	37.441763

Elev. 16.51		Rh
Head =	11.14	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	3804	15.00	30.00	85.88	1308.36	0.0200	9.73	0.65		
2	7532	15.00	30.00	85.94	1841.02	0.0148	10.10	0.67	0.022500	15.15
3	76	15.00	30.00	80.30	185.03	0.0814	5.60	0.37		
4	3804	22.00	30.00	85.92	1584.50	0.0169	9.95	0.45	0.126025	84.85
5	3804	8.00	30.00	85.77	955.49	0.0262	9.30	1.16		
6	3804	15.00	32.00	85.88	1351.27	0.0208	9.77	0.65	0.000000	0.00
7	3804	15.00	28.00	85.87	1263.99	0.0193	9.69	0.65		
								Total	0.148525	100.00

E[I] = 0.650000
Var[I]= 0.148525
σ[I]= 0.385389
V(I) = 0.592907

E[ln I] = -0.581405
σ [ln I] = 0.548857
ln(I crit) = -0.223144

Ic=	0.80

β =	-1.059302
F(z) =	0.743038
Pr(f) % =	25.696167

200 yr		Rh
Head =	8.83	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	3804	15.00	30.00	85.88	1308.36	0.0200	7.72	0.51		
2	7532	15.00	30.00	85.94	1841.02	0.0148	8.01	0.53	0.013225	14.43
3	76	15.00	30.00	80.30	185.03	0.0814	4.44	0.30		
4	3804	22.00	30.00	85.92	1584.50	0.0169	7.89	0.36	0.078400	85.54
5	3804	8.00	30.00	85.77	955.49	0.0262	7.37	0.92		
6	3804	15.00	32.00	85.88	1351.27	0.0208	7.75	0.52	0.000025	0.03
7	3804	15.00	28.00	85.87	1263.99	0.0193	7.68	0.51		
								Total	0.091650	100.00

E[I] = 0.510000
Var[I]= 0.091650
σ[I]= 0.302738
V(I) = 0.593603

E[ln I] = -0.824272
σ [ln I] = 0.549413
ln(I crit) = -0.223144

Ic=	0.80

β =	-1.500278
F(z) =	0.863051
Pr(f) % =	13.694933

Elev. 11.89		Rh
Head =	6.52	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	3804	15.00	30.00	85.88	1308.36	0.0200	5.70	0.38		
2	7532	15.00	30.00	85.94	1841.02	0.0148	5.91	0.39	0.007225	14.67
3	76	15.00	30.00	80.30	185.03	0.0814	3.28	0.22		
4	3804	22.00	30.00	85.92	1584.50	0.0169	5.83	0.27	0.042025	85.33
5	3804	8.00	30.00	85.77	955.49	0.0262	5.44	0.68		
6	3804	15.00	32.00	85.88	1351.27	0.0208	5.72	0.38	0.000000	0.00
7	3804	15.00	28.00	85.87	1263.99	0.0193	5.67	0.38		
								Total	0.049250	100.00

E[I] = 0.380000
Var[I]= 0.049250
σ[I]= 0.221923
V(I) = 0.584009

E[ln I] = -1.114317
σ [ln I] = 0.541724
ln(I crit) = -0.223144

Ic=	0.80

β =	-2.056981
F(z) =	0.950022
Pr(f) % =	4.997793

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

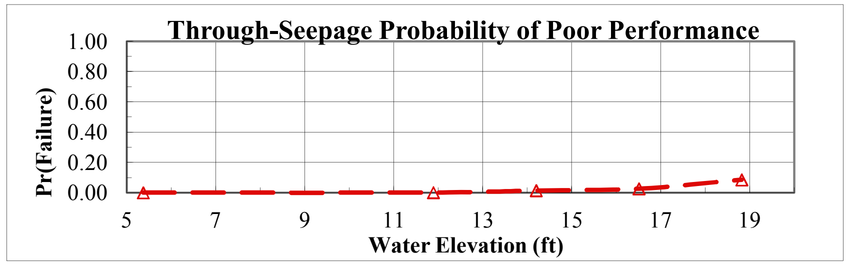
Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point D4

Levee Mile: STA 3092+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 18.82
L/S Toe Elev.: 5.37
W/S Toe Elev.: 3.18

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/25/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	4	0.4	10.00
Initial Porosity (n)	0.39	0.04	10.00
Initial Permeability (Ko)	2.00E-06	6.00E-07	30.00



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	5.37	0.0000
Elev. 11.89	6.52	11.89	0.001302
200 yr	8.83	14.20	0.014271
Elev. 16.51	11.14	16.51	0.026035
Crest	13.45	18.82	0.085097

Pr(f)=0
NO

Crest	**Head =**	13.45	**Horizontal Gradient (Ix) =**	0.480

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	4.00	0.39	2.00E-06	0.64	1.33		
2	3.60	0.39	2.00E-06	0.57	1.19	0.017605	26.44
3	4.40	0.39	2.00E-06	0.70	1.46		
4	4.00	0.35	2.00E-06	0.60	1.26	0.004412	6.63
5	4.00	0.43	2.00E-06	0.67	1.39		
6	4.00	0.39	1.40E-06	0.76	1.59	0.044555	66.93
7	4.00	0.39	2.60E-06	0.56	1.16		
E[FS] =	1.326846		E[ln FS] =	0.264246	Total	0.066573	100.00
Var[FS]=	0.066573						
σ[FS]=	0.258017		σ[ln FS]=	0.192658		**β =**	1.371584
V(FS) =	0.194459					**F(z) =**	0.085097
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	8.509653

Elev. 16.51	**Head =**	11.14	**Horizontal Gradient (Ix) =**	0.430

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	4.00	0.39	2.00E-06	0.64	1.48		
2	3.60	0.39	2.00E-06	0.57	1.33	0.021937	26.44
3	4.40	0.39	2.00E-06	0.70	1.63		
4	4.00	0.35	2.00E-06	0.60	1.41	0.005498	6.63
5	4.00	0.43	2.00E-06	0.67	1.55		
6	4.00	0.39	1.40E-06	0.76	1.77	0.055520	66.93
7	4.00	0.39	2.60E-06	0.56	1.30		
E[FS] =	1.481130		E[ln FS] =	0.374247	Total	0.082955	100.00
Var[FS]=	0.082955						
σ[FS]=	0.288020		σ[ln FS]=	0.192658		**β =**	1.942549
V(FS) =	0.194459					**F(z) =**	0.026035
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	2.603532

200 yr	**Head =**	8.83	**Horizontal Gradient (Ix) =**	0.410

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	4.00	0.39	2.00E-06	0.64	1.55		
2	3.60	0.39	2.00E-06	0.57	1.40	0.024130	26.44
3	4.40	0.39	2.00E-06	0.70	1.71		
4	4.00	0.35	2.00E-06	0.60	1.47	0.006048	6.63
5	4.00	0.43	2.00E-06	0.67	1.63		
6	4.00	0.39	1.40E-06	0.76	1.86	0.061068	66.93
7	4.00	0.39	2.60E-06	0.56	1.36		
E[FS] =	1.553381		E[ln FS] =	0.421875	Total	0.091246	100.00
Var[FS]=	0.091246						
σ[FS]=	0.302069		σ[ln FS]=	0.192658		**β =**	2.189765
V(FS) =	0.194459					**F(z) =**	0.014271
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	1.427063

Elev. 11.89	**Head =**	6.52	**Horizontal Gradient (Ix) =**	0.350

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	4.00	0.39	2.00E-06	0.64	1.82		
2	3.60	0.39	2.00E-06	0.57	1.64	0.033112	26.44
3	4.40	0.39	2.00E-06	0.70	2.00		
4	4.00	0.35	2.00E-06	0.60	1.73	0.008299	6.63
5	4.00	0.43	2.00E-06	0.67	1.91		
6	4.00	0.39	1.40E-06	0.76	2.17	0.083801	66.93
7	4.00	0.39	2.60E-06	0.56	1.60		
E[FS] =	1.819674		E[ln FS] =	0.580099	Total	0.125212	100.00
Var[FS]=	0.125212						
σ[FS]=	0.353853		σ[ln FS]=	0.192658		**β =**	3.011036
V(FS) =	0.194459					**F(z) =**	0.001302
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.130179

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

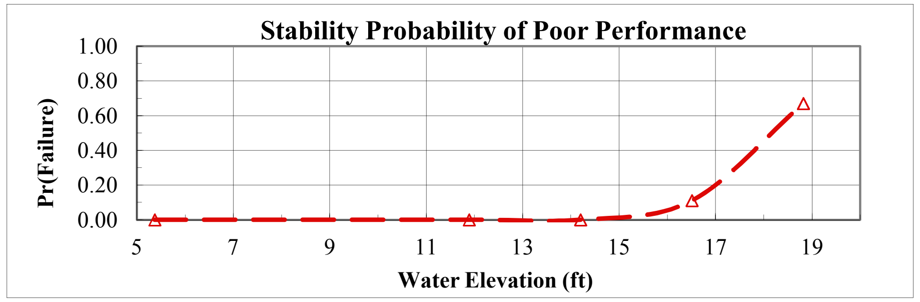
Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point D4

Levee Mile: STA 3092+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 18.82
L/S Toe Elev.: 5.37
W/S Toe Elev.: 3.18

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/25/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	34	4	13.00
Levee Cohesion	100	40	40.00
Levee γ	110	8	7.00
Foundation Φ	27	4	13.00
Foundation Cohesion	50	20	40.00


Stability Probability of Poor Performance

Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	5.37	0.0000
Elev. 11.89	6.52	11.89	0.000000
200 yr	8.83	14.20	0.000044
Elev. 16.51	11.14	16.51	0.110781
Crest	13.45	18.82	0.669813

Crest	**Head =**	13.45	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	110	27	50	0.95		
2	30	100	110	27	50	0.93	0.000380	2.17
3	38	100	110	27	50	0.97		
4	34	60	110	27	50	0.87	0.005550	31.71
5	34	140	110	27	50	1.02		
6	34	100	102	27	50	0.90	0.001764	10.08
7	34	100	118	27	50	0.98		
8	34	100	110	23	50	0.87	0.005776	33.00
9	34	100	110	31	50	1.03		
10	34	100	110	27	30	0.88	0.004032	23.04
11	34	100	110	27	70	1.01		

E[FS] = 0.950000
Var[FS]= 0.017503
σ[FS]= 0.132298
V(FS) = 0.139261
FS req'd = 1.00

E[ln FS] = -0.060897
σ[ln FS]= 0.138593
ln(FS req'd) = 0.000000

Total 0.017503 100.00

β = -0.439397
F(z) = 0.669813
Pr(f) % = 66.981308

Elev. 16.51	**Head =**	11.14	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	110	27	50	1.18		
2	30	100	110	27	50	1.15	0.001024	4.41
3	38	100	110	27	50	1.22		
4	34	60	110	27	50	1.11	0.004761	20.49
5	34	140	110	27	50	1.25		
6	34	100	102	27	50	1.15	0.001764	7.59
7	34	100	118	27	50	1.24		
8	34	100	110	23	50	1.08	0.010712	46.11
9	34	100	110	31	50	1.29		
10	34	100	110	27	30	1.11	0.004970	21.39
11	34	100	110	27	70	1.25		

E[FS] = 1.180000
Var[FS]= 0.023232
σ[FS]= 0.152419
V(FS) = 0.129169
FS req'd = 1.00

E[ln FS] = 0.157241
σ[ln FS]= 0.128635
ln(FS req'd) = 0.000000

Total 0.023232 100.00

β = 1.222386
F(z) = 0.110781
Pr(f) % = 11.078091

200 yr	**Head =**	8.83	**Pr(f)=0**	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	110	27	50	1.57		
2	30	100	110	27	50	1.52	0.002704	8.49
3	38	100	110	27	50	1.62		
4	34	60	110	27	50	1.53	0.002401	7.54
5	34	140	110	27	50	1.63		
6	34	100	102	27	50	1.56	0.000156	0.49
7	34	100	118	27	50	1.58		
8	34	100	110	23	50	1.43	0.018225	57.21
9	34	100	110	31	50	1.70		
10	34	100	110	27	30	1.49	0.008372	26.28
11	34	100	110	27	70	1.67		

E[FS] = 1.570000
Var[FS]= 0.031859
σ[FS]= 0.178489
V(FS) = 0.113688
FS req'd = 1.00

E[ln FS] = 0.444655
σ[ln FS]= 0.113323
ln(FS req'd) = 0.000000

Total 0.031859 100.00

β = 3.923788
F(z) = 0.000044
Pr(f) % = 0.004358

Elev. 11.89	**Head =**	6.52	**Pr(f)=0**	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	100	110	27	50	1.89		
2	30	100	110	27	50			
3	38	100	110	27	50			
4	34	60	110	27	50			
5	34	140	110	27	50			
6	34	100	102	27	50			
7	34	100	118	27	50			
8	34	100	110	23	50			
9	34	100	110	31	50			
10	34	100	110	27	30			
11	34	100	110	27	70			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

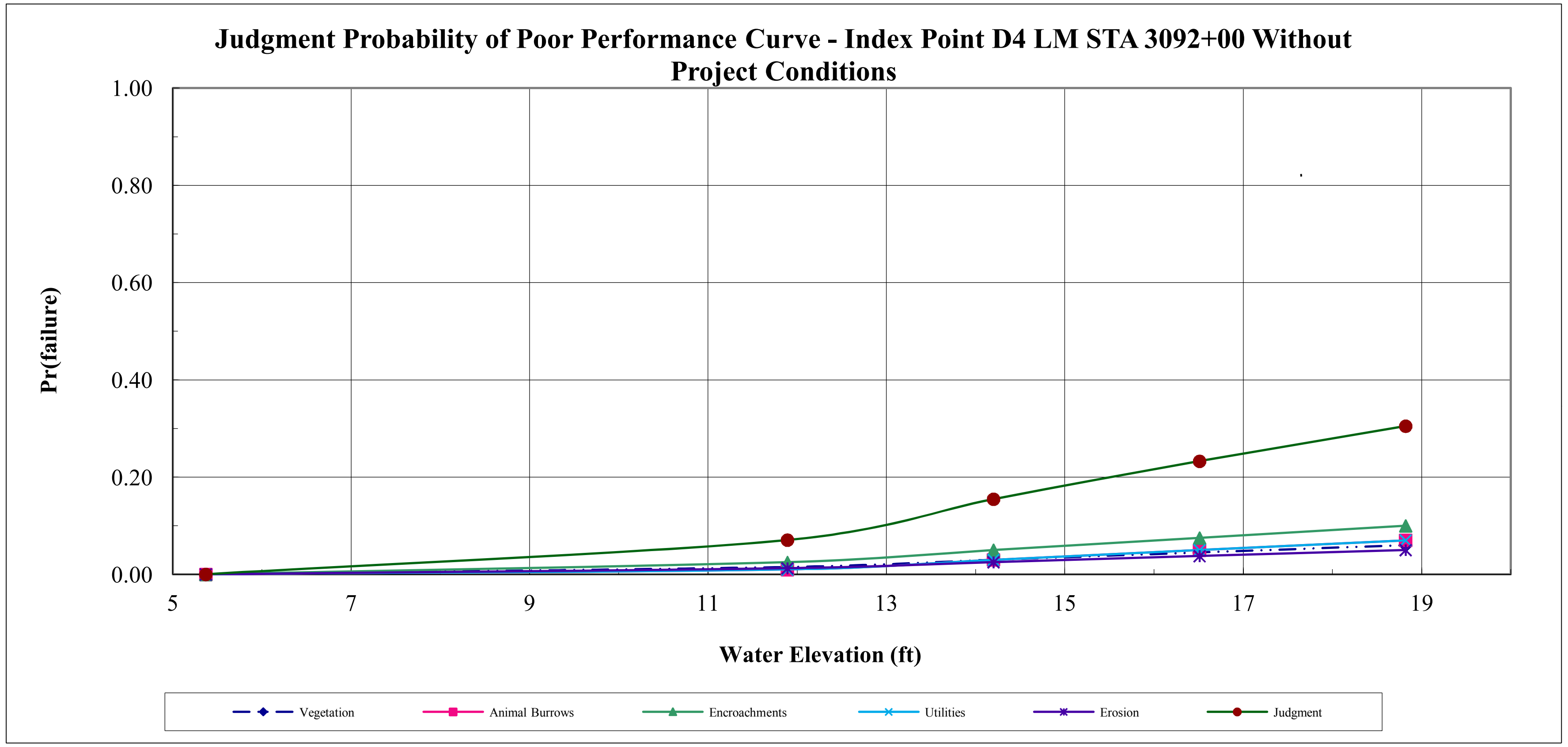
Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point D4

Levee Mile: STA 3092+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 18.82
L/S Toe Elev.: 5.37
W/S Toe Elev.: 3.18

Analysis By: G. Johnson
Checked By: M. Perlea, J. F
Date: 9/25/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
5.37	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
11.89	0.0150	0.9850	0.0100	0.9900	0.0250	0.9750	0.0100	0.9900	0.0125	0.9875	0.0705	0.9295
14.20	0.0300	0.9700	0.0300	0.9700	0.0500	0.9500	0.0300	0.9700	0.0250	0.9750	0.1546	0.8454
16.51	0.0450	0.9550	0.0500	0.9500	0.0750	0.9250	0.0500	0.9500	0.0375	0.9625	0.2327	0.7673
18.82	0.0600	0.9400	0.0700	0.9300	0.1000	0.9000	0.0700	0.9300	0.0500	0.9500	0.3049	0.6951



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

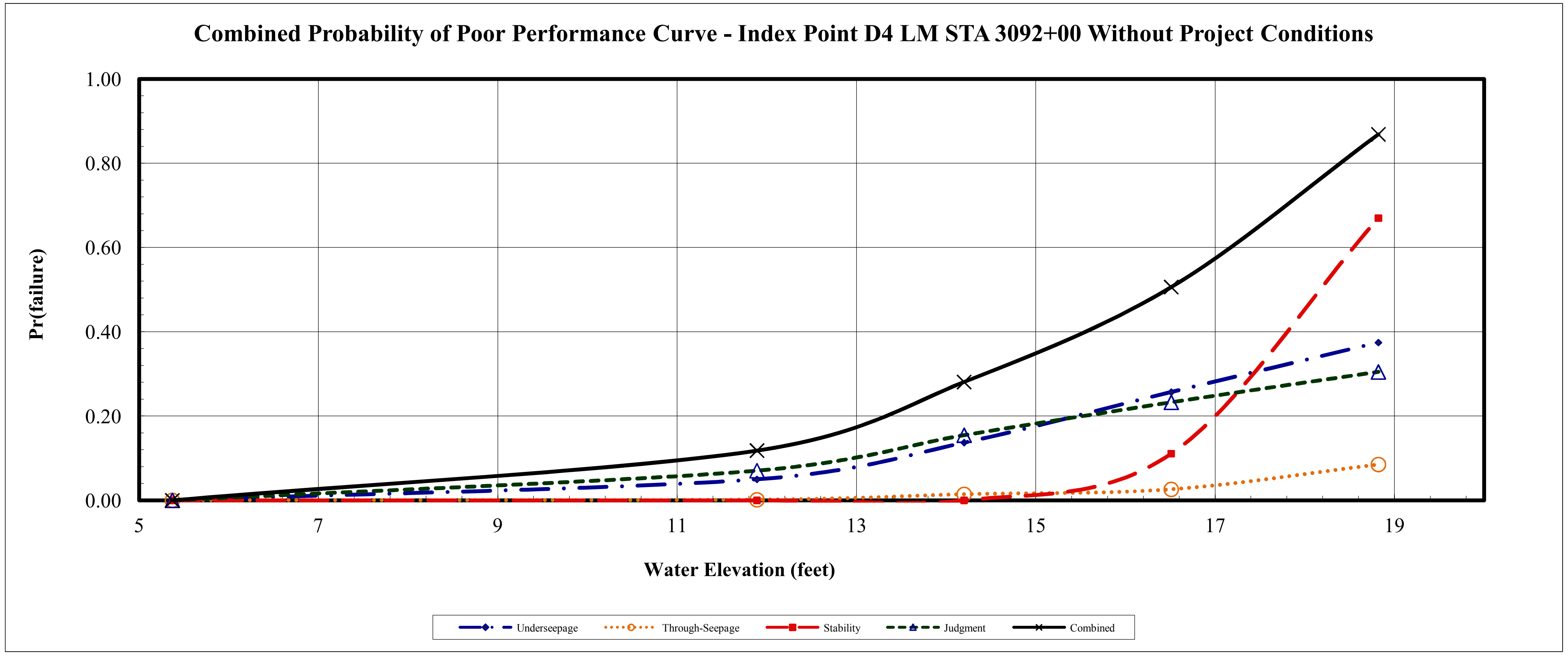
Project: Lower San Joaquin
Study Area: Right Bank Calaveras River
River Section: Index Point D4

Levee Mile: STA 3092+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 18.82
L/S Toe Elev.: 5.37
W/S Toe Elev.: 3.18

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hog
Date: 9/25/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
5.37	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
11.89	0.0500	0.9500	0.0013	0.9987	0.0000	1.0000	0.0705	0.9295	0.1181	0.8819
14.20	0.1369	0.8631	0.0143	0.9857	0.0000	1.0000	0.1546	0.8454	0.2809	0.7191
16.51	0.2570	0.7430	0.0260	0.9740	0.1108	0.8892	0.2327	0.7673	0.5062	0.4938
18.82	0.3744	0.6256	0.0851	0.9149	0.6698	0.3302	0.3049	0.6951	0.8686	0.1314


Combined Probability of Poor Performance Curve - Index Point D4 LM STA 3092+00 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Left Bank Calaveras River
Basin and Reach: Index Point D5

Levee Mile: STA 6535+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 17.54
L/S Toe Elev.: 4.10
W/S Toe Elev.: -6.30

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/19/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR1614_003B	15	20	9	133	45	6	15	10	88	67	CL	0.007	SM	0.28	40	44	9	547	20
WR1614_003C	12					23					CL	0.007	SM	0.28	40				
WR1614_004B	21					7					CL	0.007	SM	0.28	40				
WR1614_006B	32					23					ML	0.007	SP-SM	0.4	57				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR1614_003B	CL	15	0.007				15	SM	6	0.28							0.28
WR1614_003C	CL	12	0.007				12	SM	23	0.28							0.28
WR1614_004B	CL	21	0.007				21	SM	7	0.28							0.28
WR1614_006B	ML	32	0.007				32	SP-SM	23	0.4							0.4

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: Index Point D5

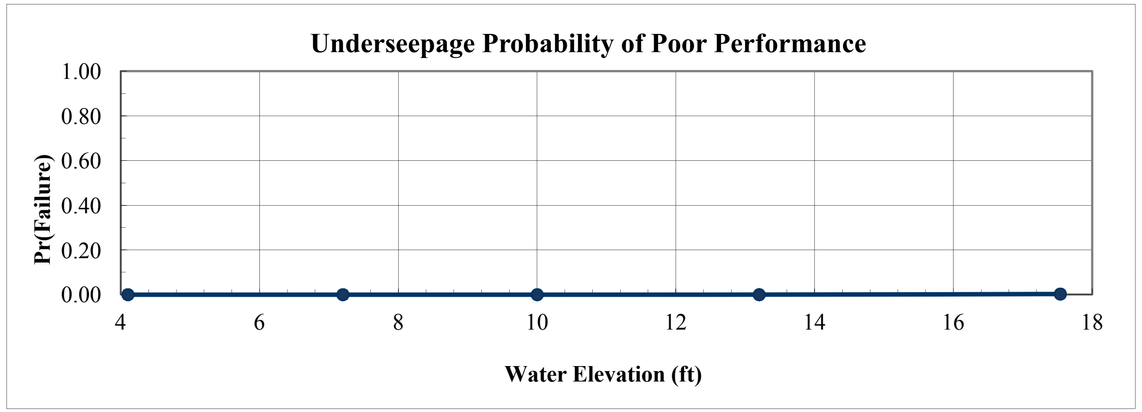
Levee Mile: STA 6535+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 17.54
L/S Toe Elev.: 4.10
W/S Toe Elev.: -6.30

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/19/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permaebility Ratio	44	9	20
Blanket Thickness (z)	20	9	45
Aquifer Thickness (d)	15	10	67

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	120	85	∞	112



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	4.10	0.0000
Toe+3ft	3.10	7.20	0.0000
Half Height	5.90	10.00	0.0000
200yr	9.10	13.20	0.0001
Crest	13.44	17.54	0.0028

Crest	**Rh**
Head = 13.44	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	44	20.00	15.00	89.57	114.89	0.0518	5.33	0.27		
2	53	20.00	15.00	93.38	126.10	0.0493	5.57	0.28	0.000225	1.57
3	35	20.00	15.00	84.50	102.47	0.0552	5.06	0.25		
4	44	29.00	15.00	96.85	138.35	0.0468	5.81	0.20	0.012100	84.32
5	44	11.00	15.00	75.59	85.21	0.0610	4.66	0.42		
6	44	20.00	25.00	99.24	148.32	0.0752	5.99	0.30	0.002025	14.11
7	44	20.00	5.00	62.87	66.33	0.0233	4.16	0.21		
								Total	0.014350	100.00

E[I] = 0.270000
Var[I]= 0.014350
σ[I]= 0.119791
V(I) = 0.443672

E[ln I] = -1.399178
σ [ln I] = 0.423897
ln(I crit) = -0.223144

Ic= 0.80

β = -3.300747
F(z) = 0.997234
Pr(f) % = 0.276571

Half Height	**Rh**
Head = 5.90	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	44	20.00	15.00	89.57	114.89	0.0518	2.34	0.12		
2	53	20.00	15.00	93.38	126.10	0.0493	2.44	0.12	0.000025	0.85
3	35	20.00	15.00	84.50	102.47	0.0552	2.22	0.11		
4	44	29.00	15.00	96.85	138.35	0.0468	2.55	0.09	0.002500	85.47
5	44	11.00	15.00	75.59	85.21	0.0610	2.05	0.19		
6	44	20.00	25.00	99.24	148.32	0.0752	2.63	0.13	0.000400	13.68
7	44	20.00	5.00	62.87	66.33	0.0233	1.83	0.09		
								Total	0.002925	100.00

E[I] = 0.120000
Var[I]= 0.002925
σ[I]= 0.054083
V(I) = 0.450694

E[ln I] = -2.212725
σ [ln I] = 0.430026
ln(I crit) = -0.223144

Ic= 0.80

β = -5.145561
F(z) = 0.999998
Pr(f) % = 0.000186

200yr	**Rh**
Head = 9.10	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	44	20.00	15.00	89.57	114.89	0.0518	3.61	0.18		
2	53	20.00	15.00	93.38	126.10	0.0493	3.77	0.19	0.000100	1.51
3	35	20.00	15.00	84.50	102.47	0.0552	3.43	0.17		
4	44	29.00	15.00	96.85	138.35	0.0468	3.93	0.14	0.005625	84.91
5	44	11.00	15.00	75.59	85.21	0.0610	3.15	0.29		
6	44	20.00	25.00	99.24	148.32	0.0752	4.06	0.20	0.000900	13.58
7	44	20.00	5.00	62.87	66.33	0.0233	2.82	0.14		
								Total	0.006625	100.00

E[I] = 0.180000
Var[I]= 0.006625
σ[I]= 0.081394
V(I) = 0.452189

E[ln I] = -1.807820
σ [ln I] = 0.431328
ln(I crit) = -0.223144

Ic= 0.80

β = -4.191287
F(z) = 0.999881
Pr(f) % = 0.011942

Toe+3ft	**Rh**
Head = 3.10	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	44	20.00	15.00	89.57	114.89	0.0518	1.23	0.06		
2	53	20.00	15.00	93.38	126.10	0.0493	1.28	0.06	0.000000	0.00
3	35	20.00	15.00	84.50	102.47	0.0552	1.17	0.06		
4	44	29.00	15.00	96.85	138.35	0.0468	1.34	0.05	0.000625	86.21
5	44	11.00	15.00	75.59	85.21	0.0610	1.07	0.10		
6	44	20.00	25.00	99.24	148.32	0.0752	1.38	0.07	0.000100	13.79
7	44	20.00	5.00	62.87	66.33	0.0233	0.96	0.05		
								Total	0.000725	100.00

E[I] = 0.060000
Var[I]= 0.000725
σ[I]= 0.026926
V(I) = 0.448764

E[ln I] = -2.905150
σ [ln I] = 0.428344
ln(I crit) = -0.223144

Ic= 0.80

β = -6.782287
F(z) = 1.000000
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: Index Point D5

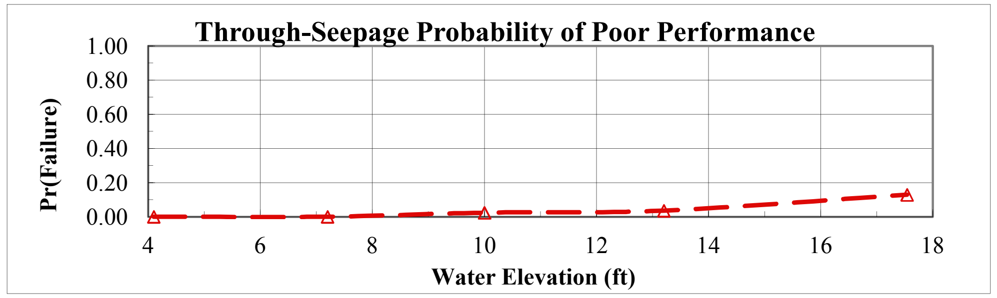
Levee Mile: STA 6535+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 17.54
L/S Toe Elev.: 4.10
W/S Toe Elev.: -6.30

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/19/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	2.9	0.3	10.00
Initial Porosity (n)	0.32	0.03	10.00
Initial Permeability (Ko)	2.00E-06	6.00E-07	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	4.10	0.0000
Toe+3ft	3.10	7.20	0.000000
Half Height	5.90	10.00	0.023480
200 yr	9.10	13.20	0.035575
Crest	13.44	17.54	0.128431

Crest | **Head =** 13.44 | **Horizontal Gradient (Ix) =** 0.330

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	2.90	0.32	2.00E-06	0.42	1.27		
2	2.61	0.32	2.00E-06	0.38	1.14	0.016064	26.44
3	3.19	0.32	2.00E-06	0.46	1.39		
4	2.90	0.29	2.00E-06	0.40	1.20	0.004026	6.63
5	2.90	0.35	2.00E-06	0.44	1.33		
6	2.90	0.32	1.40E-06	0.50	1.51	0.040655	66.93
7	2.90	0.32	2.60E-06	0.37	1.11		
E[FS] =	1.267443		E[ln FS] =	0.218443	Total	0.060746	100.00

Var[FS]= 0.060746
σ[FS]= 0.246466
σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00
ln(FS req'd) = 0.000000
β = 1.133841
F(z) = 0.128431
Pr(f) % = 12.843072

200 yr | **Head =** 9.10 | **Horizontal Gradient (Ix) =** 0.290

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	2.90	0.32	2.00E-06	0.42	1.44		
2	2.61	0.32	2.00E-06	0.38	1.30	0.020801	26.44
3	3.19	0.32	2.00E-06	0.46	1.59		
4	2.90	0.29	2.00E-06	0.40	1.37	0.005213	6.63
5	2.90	0.35	2.00E-06	0.44	1.51		
6	2.90	0.32	1.40E-06	0.50	1.72	0.052644	66.93
7	2.90	0.32	2.60E-06	0.37	1.26		
E[FS] =	1.442263		E[ln FS] =	0.347655	Total	0.078659	100.00

Var[FS]= 0.078659
σ[FS]= 0.280461
σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00
ln(FS req'd) = 0.000000
β = 1.804521
F(z) = 0.035575
Pr(f) % = 3.557483

Half Height | **Head =** 5.90 | **Horizontal Gradient (Ix) =** 0.280

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	2.90	0.32	2.00E-06	0.42	1.49		
2	2.61	0.32	2.00E-06	0.38	1.34	0.022314	26.44
3	3.19	0.32	2.00E-06	0.46	1.64		
4	2.90	0.29	2.00E-06	0.40	1.42	0.005592	6.63
5	2.90	0.35	2.00E-06	0.44	1.57		
6	2.90	0.32	1.40E-06	0.50	1.79	0.056471	66.93
7	2.90	0.32	2.60E-06	0.37	1.31		
E[FS] =	1.493772		E[ln FS] =	0.382746	Total	0.084377	100.00

Var[FS]= 0.084377
σ[FS]= 0.290478
σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00
ln(FS req'd) = 0.000000
β = 1.986664
F(z) = 0.023480
Pr(f) % = 2.347980

Toe+3ft | **Head =** 3.10 | **Horizontal Gradient (Ix) =** 0.090

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	2.90	0.32	2.00E-06	0.42	4.65		
2	2.61	0.32	2.00E-06	0.38	4.18	0.215973	26.44
3	3.19	0.32	2.00E-06	0.46	5.11		
4	2.90	0.29	2.00E-06	0.40	4.41	0.054129	6.63
5	2.90	0.35	2.00E-06	0.44	4.87		
6	2.90	0.32	1.40E-06	0.50	5.55	0.546588	66.93
7	2.90	0.32	2.60E-06	0.37	4.08		
E[FS] =	4.647291		E[ln FS] =	1.517726	Total	0.816690	100.00

Var[FS]= 0.816690
σ[FS]= 0.903709
σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00
ln(FS req'd) = 0.000000
β = 7.877839
F(z) = 0.000000
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

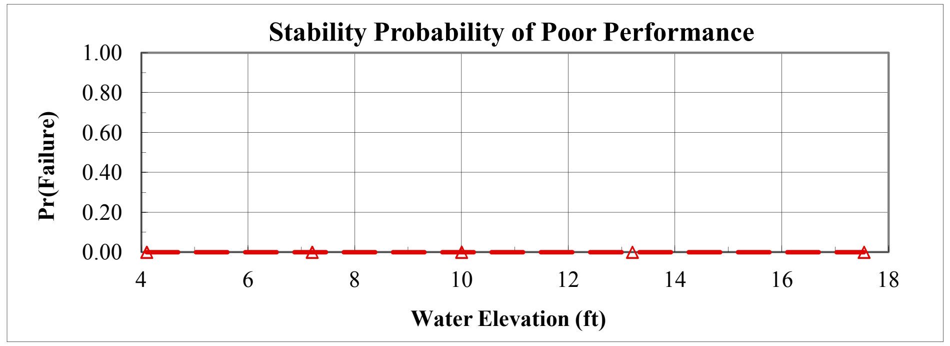
Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: Index Point D5

Levee Mile: STA 6535+00
River Mile: XX.XX
Analysis Case Without Project Conditions

Crest Elev.: 17.54
L/S Toe Elev.: 4.10
W/S Toe Elev.: -6.30

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hogan
Date: 9/19/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	31	4	13.00
Levee Cohesion	150	60	40.00
Levee γ	115	8	7.00
Foundation Φ	31	4	13.00
Foundation Cohesion	150	60	40.00



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	4.10	0.0000
Toe+3ft	3.10	7.20	0.000000
Half Height	5.90	10.00	0.000000
Crest-3ft	9.10	13.20	0.000000
Crest	13.44	17.54	0.000011

Crest	**Head =**	13.44	**Pr(f)=0**	NO

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	31	150	115	31	150	1.86		
2	27	150	115	31	150	1.84	0.000625	0.86
3	35	150	115	31	150	1.89		
4	31	90	115	31	150	1.82	0.001764	2.43
5	31	210	115	31	150	1.90		
6	31	150	107	31	150	1.84	0.000650	0.90
7	31	150	123	31	150	1.89		
8	31	150	115	27	150	1.74	0.014762	20.35
9	31	150	115	35	150	1.99		
10	31	150	115	31	90	1.61	0.054756	75.47
11	31	150	115	31	210	2.08		

E[FS] = 1.860000
Var[FS]= 0.072558
σ[FS]= 0.269365
V(FS) = 0.144820
FS req'd = 1.00

E[ln FS] = 0.610199
σ[ln FS]= 0.144069
ln(FS req'd) = 0.000000

Total 0.072558 100.00

β =	4.235458
F(z) =	0.000011
Pr(f) % =	0.001140

Crest-3ft	**Head =**	9.10	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	31	150	115	31	150	2.15		
2	27	150	115	31	150			
3	35	150	115	31	150			
4	31	90	115	31	150			
5	31	210	115	31	150			
6	31	150	107	31	150			
7	31	150	123	31	150			
8	31	150	115	27	150			
9	31	150	115	35	150			
10	31	150	115	31	90			
11	31	150	115	31	210			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	**Head =**	5.90	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	31	150	115	31	150	2.38		
2	27	150	115	31	150			
3	35	150	115	31	150			
4	31	90	115	31	150			
5	31	210	115	31	150			
6	31	150	107	31	150			
7	31	150	123	31	150			
8	31	150	115	27	150			
9	31	150	115	35	150			
10	31	150	115	31	90			
11	31	150	115	31	210			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	**Head =**	3.10	**Pr(f)=0**	YES

Run	**Levee Φ**	**Levee Cohesion**	**Levee γ**	**Foundation Φ**	**Foundation Cohesion**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	31	150	115	31	150	2.60		
2	27	150	115	31	150			
3	35	150	115	31	150			
4	31	90	115	31	150			
5	31	210	115	31	150			
6	31	150	107	31	150			
7	31	150	123	31	150			
8	31	150	115	27	150			
9	31	150	115	35	150			
10	31	150	115	31	90			
11	31	150	115	31	210			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =	
F(z) =	
Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

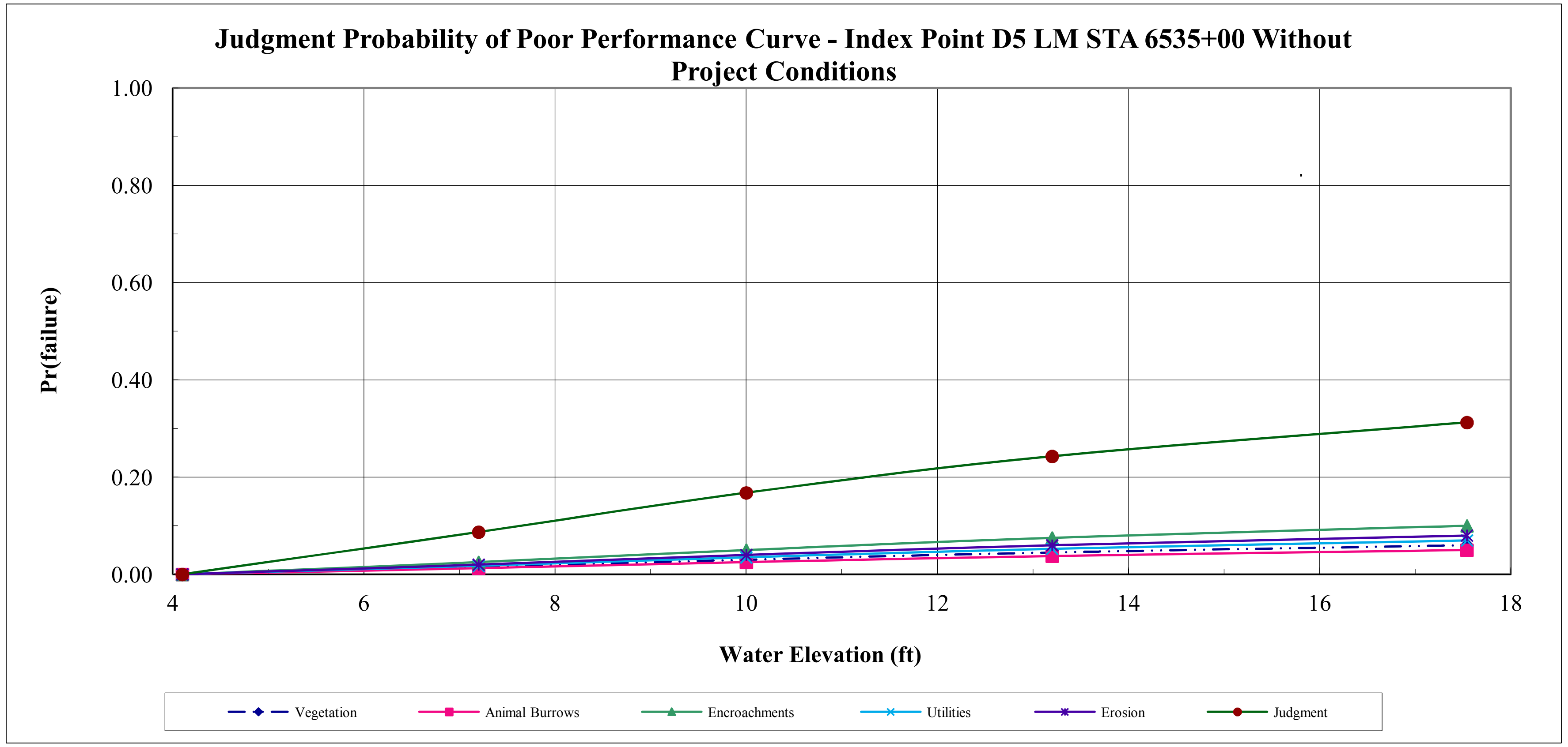
Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: Index Point D5

Levee Mile: STA 6535+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 17.54
L/S Toe Elev.: 4.10
W/S Toe Elev.: -6.30

Analysis By: G. Johnson
Checked By: M. Perlea, J.
Date: 9/19/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
4.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
7.20	0.0150	0.9850	0.0125	0.9875	0.0250	0.9750	0.0175	0.9825	0.0200	0.9800	0.0869	0.9131
10.00	0.0300	0.9700	0.0250	0.9750	0.0500	0.9500	0.0350	0.9650	0.0400	0.9600	0.1677	0.8323
13.20	0.0450	0.9550	0.0375	0.9625	0.0750	0.9250	0.0525	0.9475	0.0600	0.9400	0.2427	0.7573
17.54	0.0600	0.9400	0.0500	0.9500	0.1000	0.9000	0.0700	0.9300	0.0800	0.9200	0.3124	0.6876



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

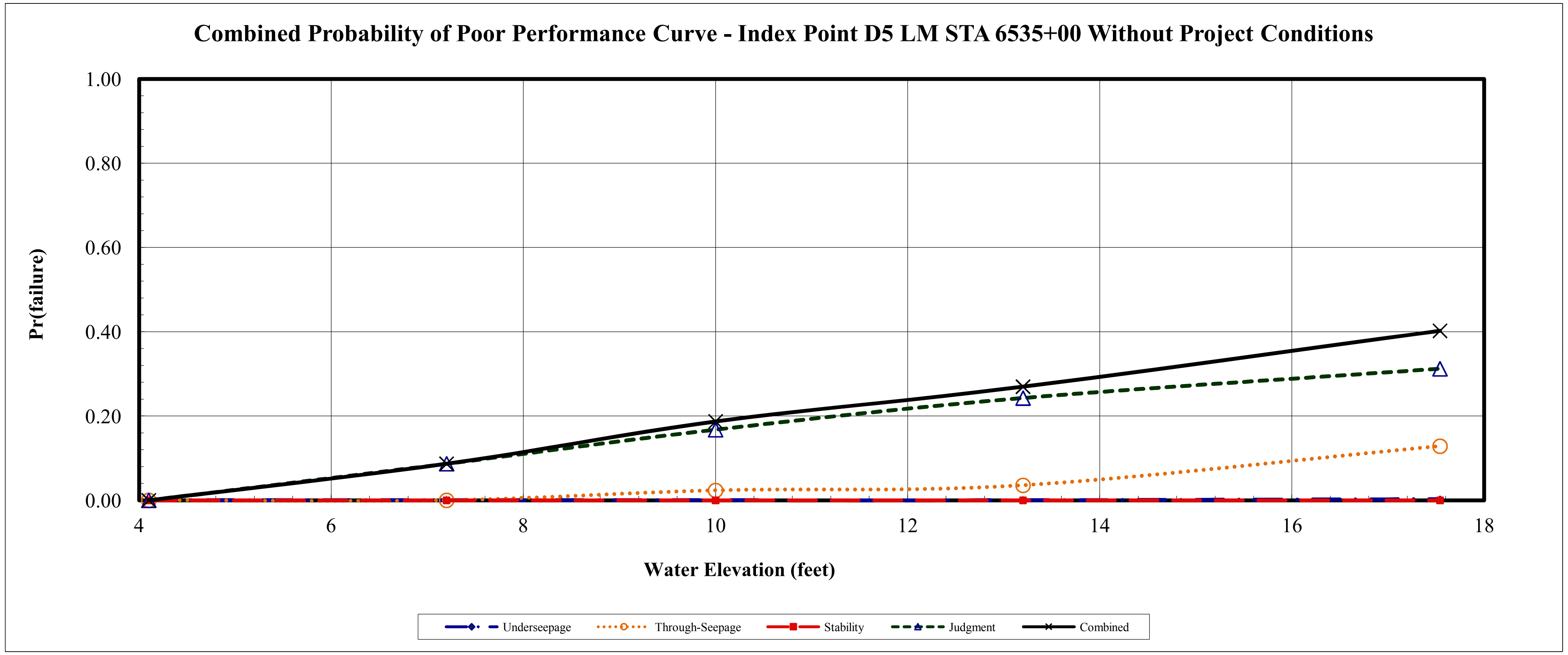
Project: Lower San Joaquin
Study Area: Left Bank Calaveras River
River Section: Index Point D5

Levee Mile: STA 6535+00
River Mile: XX.XX
Analysis Case: Without Project Conditions

Crest Elev.: 17.54
L/S Toe Elev.: 4.10
W/S Toe Elev.: -6.30

Analysis By: G. Johnson
Checked By: M. Perlea, J. Hog
Date: 9/19/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
4.10	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
7.20	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0869	0.9131	0.0869	0.9131
10.00	0.0000	1.0000	0.0235	0.9765	0.0000	1.0000	0.1677	0.8323	0.1872	0.8128
13.20	0.0001	0.9999	0.0356	0.9644	0.0000	1.0000	0.2427	0.7573	0.2698	0.7302
17.54	0.0028	0.9972	0.1284	0.8716	0.0000	1.0000	0.3124	0.6876	0.4023	0.5977


Combined Probability of Poor Performance Curve - Index Point D5 LM STA 6535+00 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Delta Front Brookside Study Area
Basin and Reach: Index Point D-BS
Coordinates: State Plane (ft), N 2183200, E 6311320

Levee Mile: Sta. 166+50
River Mile: XXXX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 18.00
L/S Toe Elev.: -3.50
W/S Toe Elev.: -7.50

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 3/14/2013

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR2074_013C	21	18	6	67	33	24	20	9	111	45	CL	0.0028	SP-SM	2.835	1013	607	402	180640	66
WR2074_014C	17					24					CL	0.0028	SP-SM	2.835	1013				
WR2074_011B	24					14					CL-ML	0.0283	SP-SM	2.835	100				
WR2074_015C	9					35					CL	0.0028	SM	1.134	405				
WR2074_016C	8					30					CL	0.0028	SM	1.134	405				
WR2074_008B	19					14					CL-ML	0.0283	SP-SM	2.835	100				
WR2074_018C	24					15					CL	0.0028	SM	1.134	405				
WR2074_012B	23					10					OH-CL	0.0028	SP-SM	2.835	1013				
WR2074_020C	21					10					OH-CL	0.0028	SP-SM	2.835	1013				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR2074_013C	CL	21	0.0028				21	SP-SM	24	2.835							2.835
WR2074_014C	CL	17	0.0028				17	SP-SM	24	2.835							2.835
WR2074_011B	CL-ML	24	0.0283				24	SP-SM	14	2.835							2.835
WR2074_015C	CL	9	0.0028				9	SM	35	1.134							1.134
WR2074_016C	CL	8	0.0028				8	SM	30	1.134							1.134
WR2074_008B	CL-ML	19	0.0283				19	SP-SM	14	2.835							2.835
WR2074_018C	CL	24	0.0028				24	SM	15	1.134							1.134
WR2074_012B	OH-CL	23	0.0028				23	SP-SM	10	2.835							2.835
WR2074_020C	OH-CL	21	0.0028				21	SP-SM	10	2.835							2.835

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Delta Front Brookside Study Area
River Section: Index Point D-BS
Coordinates: State Plane (ft), N 2183200, E 6311320

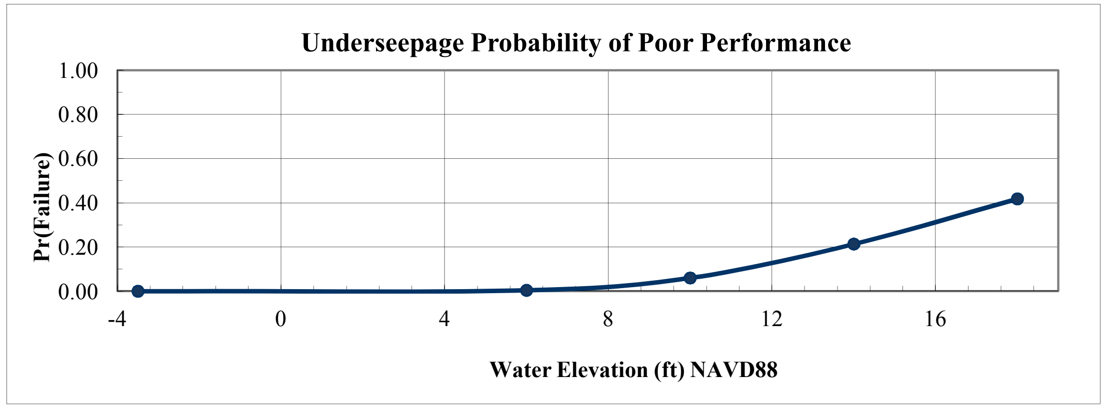
Levee Mile: Sta. 166+50
River Mile: XXXX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 18.00
L/S Toe Elev.: -3.50
W/S Toe Elev.: -7.50

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 3/14/2013

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permaebility Ratio	607	402	66
Blanket Thickness (z)	18	6	33
Aquifer Thickness (d)	20	9	45

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	100	138	∞	112



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	-3.50	0.0000
Elev. 6.0	9.50	6.00	0.0041
Elev. 10.0	13.50	10.00	0.0600
Elev. 14.0	17.50	14.00	0.2136
Crest	21.50	18.00	0.4180

Crest		**Rh**
Head =	21.50	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	607	18.00	20.00	98.50	467.46	0.0284	14.28	0.79		
2	1009	18.00	20.00	99.09	602.69	0.0238	15.43	0.86	0.012100	15.85
3	205	18.00	20.00	95.72	271.66	0.0396	11.56	0.64		
4	607	24.00	20.00	98.87	539.78	0.0258	14.94	0.62	0.060025	78.62
5	607	12.00	20.00	97.77	381.68	0.0324	13.29	1.11		
6	607	18.00	29.00	98.96	562.90	0.0363	15.13	0.84	0.004225	5.53
7	607	18.00	11.00	97.32	346.68	0.0189	12.81	0.71		
								Total	0.076350	100.00

E[I] = 0.790000
Var[I]= 0.076350
σ[I]= 0.276315
V(I) = 0.349766

E[ln I] = -0.293429

σ [ln I] = 0.339724

Ic= 0.80

ln(I crit) = -0.223144

β = -0.863726
F(z) = 0.581952
Pr(f) % = 41.804848

Elev. 14.0		**Rh**
Head =	17.50	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	607	18.00	20.00	98.50	467.46	0.0284	11.62	0.65		
2	1009	18.00	20.00	99.09	602.69	0.0238	12.56	0.70	0.008100	16.66
3	205	18.00	20.00	95.72	271.66	0.0396	9.41	0.52		
4	607	24.00	20.00	98.87	539.78	0.0258	12.16	0.51	0.038025	78.20
5	607	12.00	20.00	97.77	381.68	0.0324	10.82	0.90		
6	607	18.00	29.00	98.96	562.90	0.0363	12.32	0.68	0.002500	5.14
7	607	18.00	11.00	97.32	346.68	0.0189	10.42	0.58		
								Total	0.048625	100.00

E[I] = 0.650000
Var[I]= 0.048625
σ[I]= 0.220511
V(I) = 0.339247

E[ln I] = -0.485250

σ [ln I] = 0.330052

Ic= 0.80

ln(I crit) = -0.223144

β = -1.470225
F(z) = 0.786442
Pr(f) % = 21.355762

Elev. 10.0		**Rh**
Head =	13.50	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	607	18.00	20.00	98.50	467.46	0.0284	8.96	0.50		
2	1009	18.00	20.00	99.09	602.69	0.0238	9.69	0.54	0.004900	16.05
3	205	18.00	20.00	95.72	271.66	0.0396	7.26	0.40		
4	607	24.00	20.00	98.87	539.78	0.0258	9.38	0.39	0.024025	78.71
5	607	12.00	20.00	97.77	381.68	0.0324	8.35	0.70		
6	607	18.00	29.00	98.96	562.90	0.0363	9.50	0.53	0.001600	5.24
7	607	18.00	11.00	97.32	346.68	0.0189	8.04	0.45		
								Total	0.030525	100.00

E[I] = 0.500000
Var[I]= 0.030525
σ[I]= 0.174714
V(I) = 0.349428

E[ln I] = -0.750748

σ [ln I] = 0.339414

Ic= 0.80

ln(I crit) = -0.223144

β = -2.211894
F(z) = 0.939962
Pr(f) % = 6.003773

Elev. 6.0		**Rh**
Head =	9.50	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	607	18.00	20.00	98.50	467.46	0.0284	6.31	0.35		
2	1009	18.00	20.00	99.09	602.69	0.0238	6.82	0.38	0.002500	17.33
3	205	18.00	20.00	95.72	271.66	0.0396	5.11	0.28		
4	607	24.00	20.00	98.87	539.78	0.0258	6.60	0.28	0.011025	76.43
5	607	12.00	20.00	97.77	381.68	0.0324	5.87	0.49		
6	607	18.00	29.00	98.96	562.90	0.0363	6.69	0.37	0.000900	6.24
7	607	18.00	11.00	97.32	346.68	0.0189	5.66	0.31		
								Total	0.014425	100.00

E[I] = 0.350000
Var[I]= 0.014425
σ[I]= 0.120104
V(I) = 0.343155

E[ln I] = -1.105483

σ [ln I] = 0.333650

Ic= 0.80

ln(I crit) = -0.223144

β = -3.313303
F(z) = 0.995910
Pr(f) % = 0.409050

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Delta Front Brookside Study Area
River Section: Index Point D-BS
Coordinates: State Plane (ft), N 2183200, E 6311320

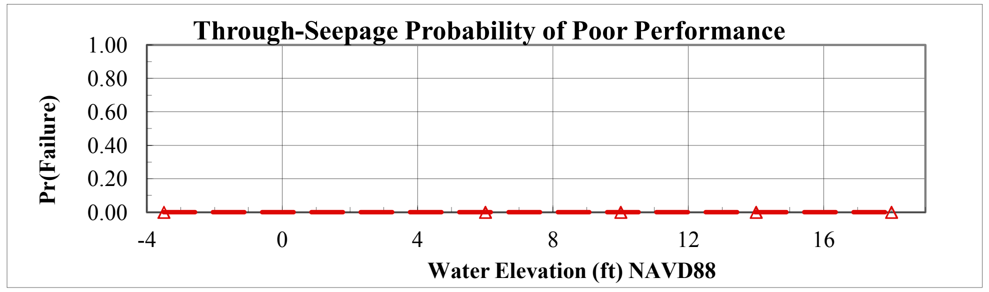
Levee Mile: Sta. 166+50
River Mile: XXXX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 18.00
L/S Toe Elev.: -3.50
W/S Toe Elev.: -7.50

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 3/14/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	25	2.5	10.00
Initial Porosity (n)	0.5	0.05	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	-3.50	0.0000
Elev. 6.0	9.50	6.00	0.000000
Elev. 10.0	13.50	10.00	0.000000
Elev. 14.0	17.50	14.00	0.000000
Crest	21.50	18.00	0.000000

Crest	Head =	21.50	Horizontal Gradient (Ix) =	0.410

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	25.00	0.50	1.00E-10	637.40	1554.62		
2	22.50	0.50	1.00E-10	573.66	1399.16	24168.580710	26.44
3	27.50	0.50	1.00E-10	701.14	1710.09		
4	25.00	0.45	1.00E-10	604.69	1474.85	6057.326543	6.63
5	25.00	0.55	1.00E-10	668.51	1630.50		
6	25.00	0.50	7.00E-11	761.83	1858.13	61166.160886	66.93
7	25.00	0.50	1.30E-10	559.03	1363.50		
E[FS] =	1554.624736		E[ln FS] =	7.330431	Total	91392.068138	100.00
Var[FS]=	91392.068138						
σ[FS]=	302.311211		σ[ln FS]=	0.192658		β =	38.048998
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		Pr(f) % =	0.000000

Elev. 14.0	Head =	17.50	Horizontal Gradient (Ix) =	0.300

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	25.00	0.50	1.00E-10	637.40	2124.65		
2	22.50	0.50	1.00E-10	573.66	1912.19	45141.537971	26.44
3	27.50	0.50	1.00E-10	701.14	2337.12		
4	25.00	0.45	1.00E-10	604.69	2015.62	11313.739909	6.63
5	25.00	0.55	1.00E-10	668.51	2228.36		
6	25.00	0.50	7.00E-11	761.83	2539.45	114244.796054	66.93
7	25.00	0.50	1.30E-10	559.03	1863.44		
E[FS] =	2124.653806		E[ln FS] =	7.642806	Total	170700.073934	100.00
Var[FS]=	170700.073934						
σ[FS]=	413.158655		σ[ln FS]=	0.192658		β =	39.670395
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		Pr(f) % =	0.000000

Elev. 10.0	Head =	13.50	Horizontal Gradient (Ix) =	0.260

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	25.00	0.50	1.00E-10	637.40	2451.52		
2	22.50	0.50	1.00E-10	573.66	2206.37	60099.680730	26.44
3	27.50	0.50	1.00E-10	701.14	2696.68		
4	25.00	0.45	1.00E-10	604.69	2325.72	15062.671477	6.63
5	25.00	0.55	1.00E-10	668.51	2571.18		
6	25.00	0.50	7.00E-11	761.83	2930.13	152101.059836	66.93
7	25.00	0.50	1.30E-10	559.03	2150.13		
E[FS] =	2451.523623		E[ln FS] =	7.785907	Total	227263.412042	100.00
Var[FS]=	227263.412042						
σ[FS]=	476.721525		σ[ln FS]=	0.192658		β =	40.413168
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		Pr(f) % =	0.000000

Elev. 6.0	Head =	9.50	Horizontal Gradient (Ix) =	0.210

Run	Tractive Stress (Tc)	Initial Porosity (n)	Initial Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	25.00	0.50	1.00E-10	637.40	3035.22		
2	22.50	0.50	1.00E-10	573.66	2731.70	92125.587695	26.44
3	27.50	0.50	1.00E-10	701.14	3338.74		
4	25.00	0.45	1.00E-10	604.69	2879.46	23089.265121	6.63
5	25.00	0.55	1.00E-10	668.51	3183.37		
6	25.00	0.50	7.00E-11	761.83	3627.78	233152.645009	66.93
7	25.00	0.50	1.30E-10	559.03	2662.06		
E[FS] =	3035.219723		E[ln FS] =	7.999481	Total	348367.497825	100.00
Var[FS]=	348367.497825						
σ[FS]=	590.226650		σ[ln FS]=	0.192658		β =	41.521736
V(FS) =	0.194459					F(z) =	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

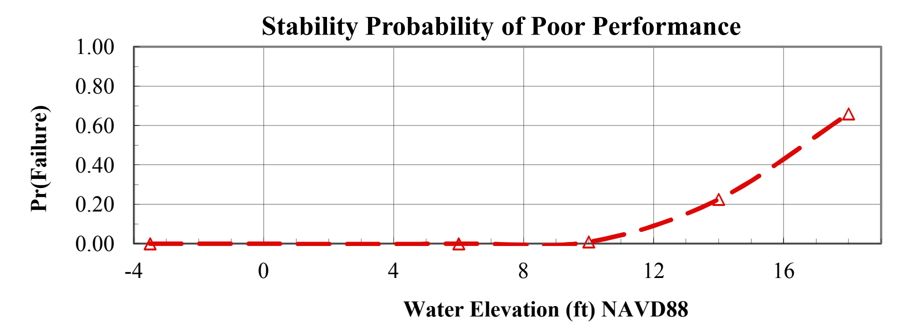
Project: Lower San Joaquin
Study Area: Delta Front Brookside Study Area
River Section: Index Point D-BS
Coordinates: State Plane (ft), N 2183200, E 6311320

Levee Mile: Sta. 166+50
River Mile: XXXX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 18.00
L/S Toe Elev.: -3.50
W/S Toe Elev.: -7.50

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 3/14/2013

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee Φ	30	4	13.00
Levee Cohesion	50	20	40.00
Levee γ	120	8	7.00
Foundation Φ	26	3	13.00
Foundation Cohesion	50	20	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	-3.50	0.0000
Elev. 6.0	9.50	6.00	0.000000
Elev. 10.0	13.50	10.00	0.009394
Elev. 14.0	17.50	14.00	0.225632
Crest	21.50	18.00	0.659676

Crest	Head =	21.50	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	120	26	50	0.94		
2	26	50	120	26	50	0.86	0.007832	22.19
3	34	50	120	26	50	1.03		
4	30	30	120	26	50	0.90	0.024964	70.71
5	30	70	120	26	50	1.22		
6	30	50	112	26	50	0.91	0.000420	1.19
7	30	50	128	26	50	0.96		
8	30	50	120	23	50	0.91	0.001156	3.27
9	30	50	120	29	50	0.98		
10	30	50	120	26	30	0.91	0.000930	2.64
11	30	50	120	26	70	0.97		

E[FS] =	0.940000	E[ln FS] =	-0.081463	Total	0.035303		100.00
Var[FS]=	0.035303						
σ[FS]=	0.187890	σ[ln FS]=	0.197929			β =	-0.411579
V(FS) =	0.199883					F(z) =	0.659676
FS req'd =	1.00	ln(FS req'd) =	0.000000			Pr(f) % =	65.967592

Elev. 14.0	Head =	17.50	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	120	26	50	1.13		
2	26	50	120	26	50	1.02	0.008372	28.40
3	34	50	120	26	50	1.21		
4	30	30	120	26	50	1.08	0.004225	14.33
5	30	70	120	26	50	1.21		
6	30	50	112	26	50	1.13	0.002704	9.17
7	30	50	128	26	50	1.23		
8	30	50	120	23	50	1.10	0.008556	29.02
9	30	50	120	29	50	1.28		
10	30	50	120	26	30	1.08	0.005625	19.08
11	30	50	120	26	70	1.23		

E[FS] =	1.133000	E[ln FS] =	0.113515	Total	0.029483		100.00
Var[FS]=	0.029483						
σ[FS]=	0.171705	σ[ln FS]=	0.150689			β =	0.753308
V(FS) =	0.151549					F(z) =	0.225632
FS req'd =	1.00	ln(FS req'd) =	0.000000			Pr(f) % =	22.563248

Elev. 10.0	Head =	13.50	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	120	26	50	1.27		
2	26	50	120	26	50	1.12	0.012769	79.39
3	34	50	120	26	50	1.34		
4	30	30	120	26	50	1.19	0.001156	7.19
5	30	70	120	26	50	1.26		
6	30	50	112	26	50	1.22	0.000016	0.10
7	30	50	128	26	50	1.23		
8	30	50	120	23	50	1.20	0.001722	10.71
9	30	50	120	29	50	1.29		
10	30	50	120	26	30	1.21	0.000420	2.61
11	30	50	120	26	70	1.25		

E[FS] =	1.270000	E[ln FS] =	0.234056	Total	0.016084		100.00
Var[FS]=	0.016084						
σ[FS]=	0.126821	σ[ln FS]=	0.099611			β =	2.349692
V(FS) =	0.099859					F(z) =	0.009394
FS req'd =	1.00	ln(FS req'd) =	0.000000			Pr(f) % =	0.939449

Elev. 6.0	Head =	9.50	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	30	50	120	26	50	1.30		
2	26	50	120	26	50			
3	34	50	120	26	50			
4	30	30	120	26	50			
5	30	70	120	26	50			
6	30	50	112	26	50			
7	30	50	128	26	50			
8	30	50	120	23	50			
9	30	50	120	29	50			
10	30	50	120	26	30			
11	30	50	120	26	70			

E[FS] =		E[ln FS] =		Total			
Var[FS]=							
σ[FS]=		σ[ln FS]=				β =	
V(FS) =						F(z) =	
FS req'd =	1.00	ln(FS req'd) =	0.000000			Pr(f) % =	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

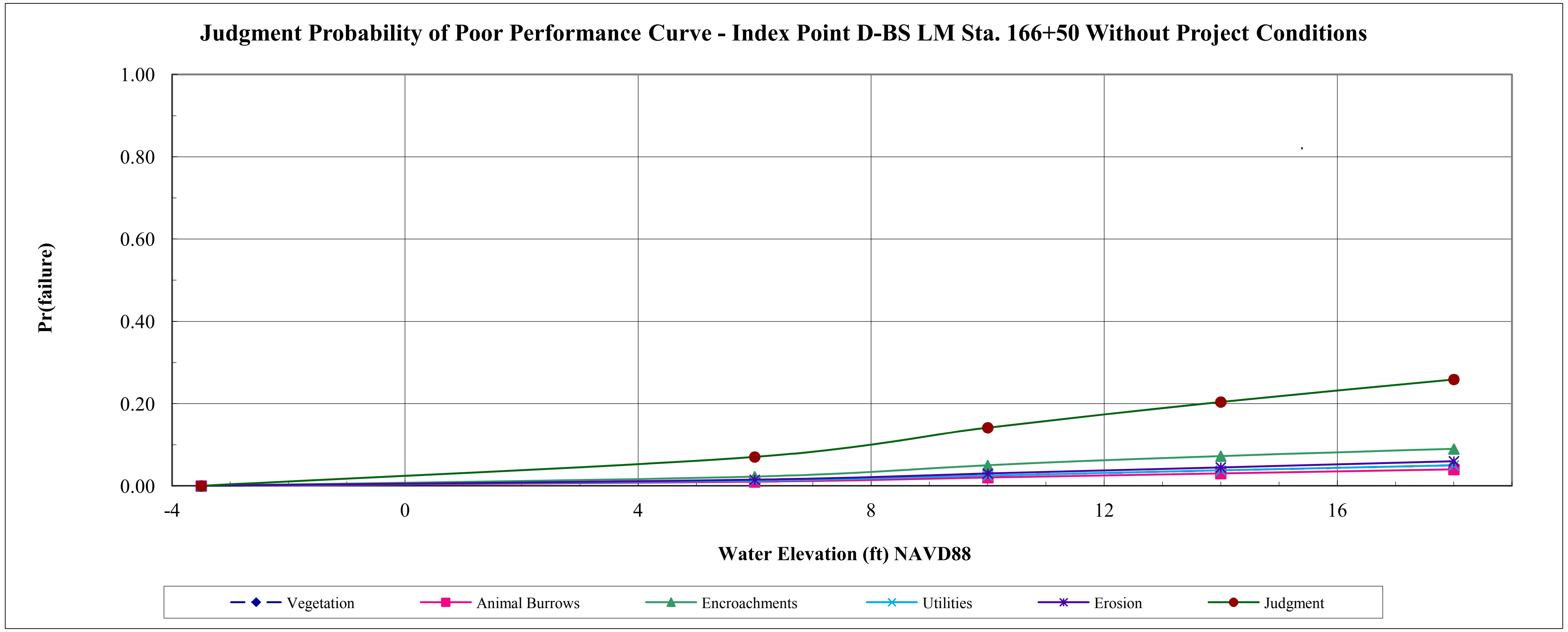
Project: Lower San Joaquin
Study Area: Delta Front Brookside Study Area
River Section: Index Point D-BS
Coordinates: State Plane (ft), N 2183200, E 6311320

Levee Mile: Sta. 166+50
River Mile: XXXX
Analysis Case: Without Project Conditions

Datum: NAVD 88
Crest Elev.: 18.00
L/S Toe Elev.: -3.50
W/S Toe Elev.: -7.50

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perle
Date: 3/14/2013

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
-3.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
6.00	0.0125	0.9875	0.0100	0.9900	0.0225	0.9775	0.0125	0.9875	0.0150	0.9850	0.0705	0.9295
10.00	0.0250	0.9750	0.0200	0.9800	0.0500	0.9500	0.0250	0.9750	0.0300	0.9700	0.1415	0.8585
14.00	0.0375	0.9625	0.0300	0.9700	0.0725	0.9275	0.0375	0.9625	0.0450	0.9550	0.2040	0.7960
18.00	0.0500	0.9500	0.0400	0.9600	0.0900	0.9100	0.0500	0.9500	0.0600	0.9400	0.2589	0.7411


Judgment Probability of Poor Performance Curve - Index Point D-BS LM Sta. 166+50 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

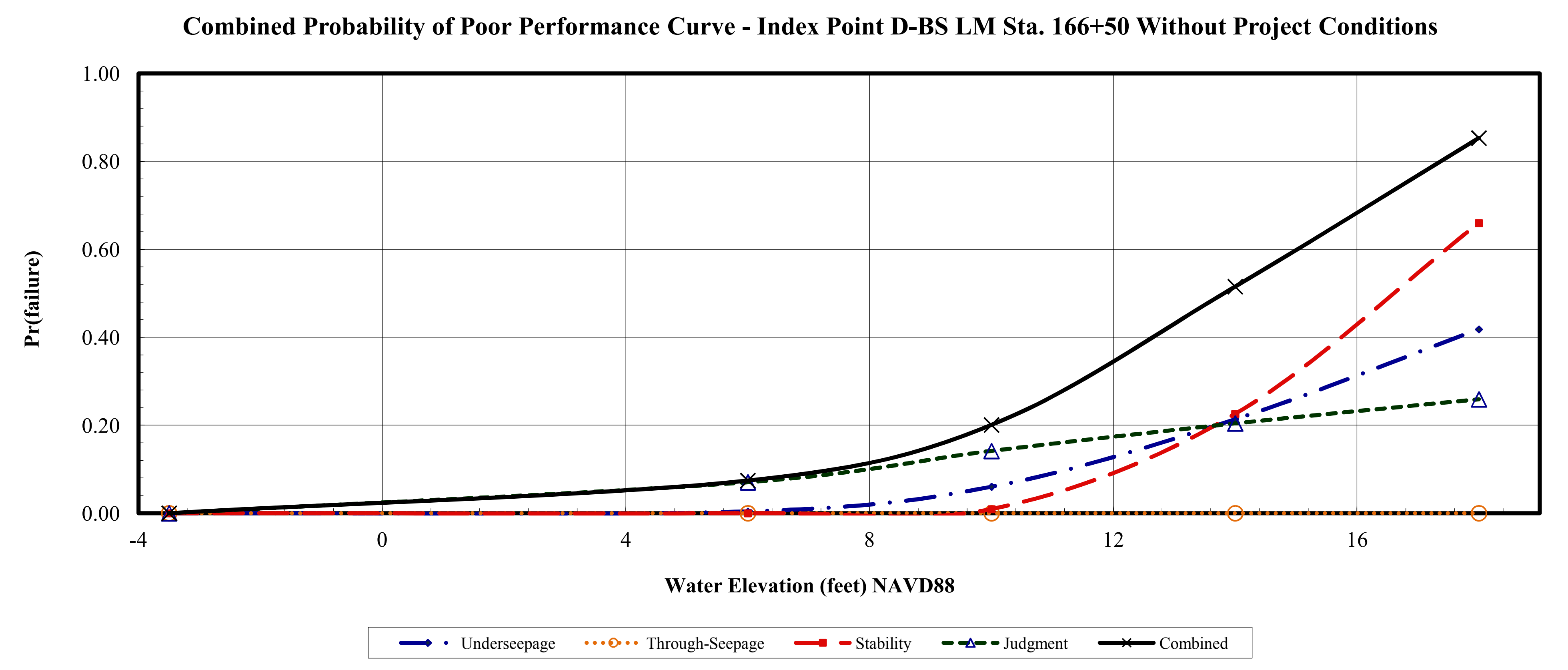
Project: Lower San Joaquin
Study Area: Delta Front Brookside Study Area
River Section: Index Point D-BS
Coordinates: State Plane (ft), N 2183200, E 6311320

Levee Mile: Sta. 166+50
River Mile: XXXX
Analysis Case: Without Project Conditions

Datum: NAVD 88
Crest Elev.: 18.00
L/S Toe Elev.: -3.50
W/S Toe Elev.: -7.50

Analysis By: G. Johnson
Checked By: J. Hogan, M. Per
Date: 3/14/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
-3.50	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
6.00	0.0041	0.9959	0.0000	1.0000	0.0000	1.0000	0.0705	0.9295	0.0743	0.9257
10.00	0.0600	0.9400	0.0000	1.0000	0.0094	0.9906	0.1415	0.8585	0.2006	0.7994
14.00	0.2136	0.7864	0.0000	1.0000	0.2256	0.7744	0.2040	0.7960	0.5153	0.4847
18.00	0.4180	0.5820	0.0000	1.0000	0.6597	0.3403	0.2589	0.7411	0.8532	0.1468


Combined Probability of Poor Performance Curve - Index Point D-BS LM Sta. 166+50 Without Project Conditions

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: Lower San Joaquin
Channel: Delta Front Lincoln Village
Basin and Reach: Index Point D-LV
Coordinates: State Plane (ft), N 2185939, E 6315555

Levee Mile: Sta. 162+50
River Mile: XXXX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 13.20
L/S Toe Elev.: 2.00
W/S Toe Elev.: 3.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 4/9/2013

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)									
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket		Aquifer Material		Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
											Material	Kb (ft/day)	Material	Kf (ft/day)					
WR1608_005M	16	12	7	68	58	6	21	9	161	43	OH	0.0284	SM	1.134	40	482	496	218512	98
WR1608_013B	14					12					OH	0.0284	SP-SM	2.835	100				
WR1608_001B	4					28					OH	0.0284	SP-SM	2.835	100				
WR1608_017C	6					26					OH	0.0284	SP-SM	2.835	100				
WR1608_010B	6					32					CL	0.0028	SP-SM	2.835	1013				
WR1608_011B	22					20					CL	0.0028	SP-SM	2.835	1013				
WR1608_018C	18					24					CL	0.0028	SP-SM	2.835	1013				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WR1608_005M	OH	16	0.0284				16	SM	6	1.134							1.134
WR1608_013B	OH	14	0.0284				14	SP-SM	12	2.835							2.835
WR1608_001B	OH	4	0.0284				4	SP-SM	28	2.835							2.835
WR1608_017C	OH	6	0.0284				6	SP-SM	26	2.835							2.835
WR1608_010B	CL	6	0.0028				6	SP-SM	32	2.835							2.835
WR1608_011B	CL	22	0.0028				22	SP-SM	20	2.835							2.835
WR1608_018C	CL	18	0.0028				18	SP-SM	24	2.835							2.835

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: Lower San Joaquin
Study Area: Delta Front Lincoln Village
River Section: Index Point D-LV
Coordinates: State Plane (ft), N 2185939, E 6315555

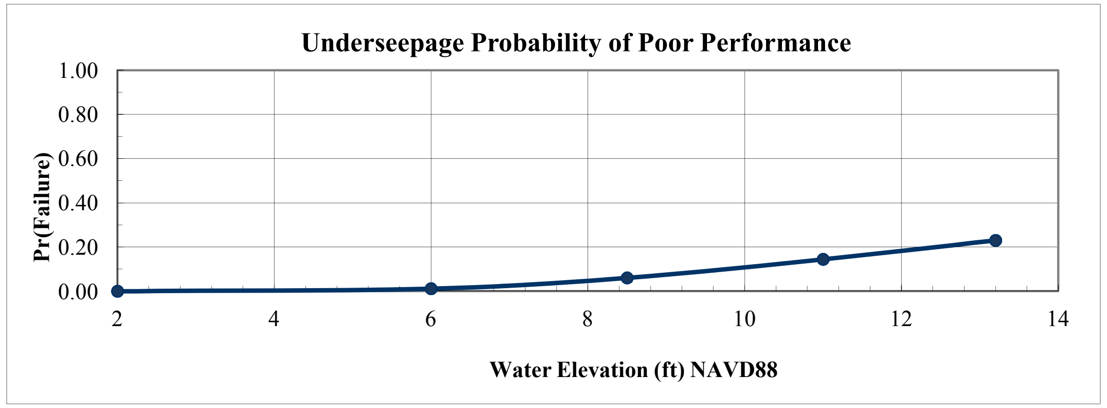
Levee Mile: Sta. 162+50
River Mile: XXXX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 13.20
L/S Toe Elev.: 2.00
W/S Toe Elev.: 3.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 4/9/2013

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Permaebility Ratio	482	472	98
Blanket Thickness (z)	12	7	58
Aquifer Thickness (d)	21	9	43

Blanket Theory Analysis Inputs					
Pr(f)=0	**BTA Case No.**	**L1**	**L2**	**L3**	**γ Blanket**
NO	7A	110	80	∞	112


Underseepage Probability of Poor Performance

Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	2.00	0.0000
Elev. 6.0	4.00	6.00	0.0115
Elev. 8.5	6.50	8.50	0.0602
Elev. 11.0	9.00	11.00	0.1443
Crest	11.20	13.20	0.2299

Crest	**Rh**
Head = 11.20	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	482	12.00	21.00	106.49	348.52	0.0393	7.30	0.61		
2	954	12.00	21.00	108.19	490.41	0.0309	8.09	0.67	0.042025	19.43
3	10	12.00	21.00	48.16	49.29	0.1183	3.11	0.26		
4	482	19.00	21.00	107.75	438.54	0.0335	7.84	0.41	0.172225	79.63
5	482	5.00	21.00	102.00	224.97	0.0516	6.19	1.24		
6	482	12.00	30.00	107.51	416.56	0.0497	7.72	0.64	0.002025	0.94
7	482	12.00	12.00	104.02	263.45	0.0268	6.59	0.55		
								Total	0.216275	100.00

E[I] = 0.610000
Var[I]= 0.216275
σ[I]= 0.465054
V(I) = 0.762383
Ic= 0.80

E[ln I] = -0.723397
σ [ln I] = 0.676906
ln(I crit) = -0.223144

β = -1.068682
F(z) = 0.770056
Pr(f) % = 22.994448

Elev. 11.0	**Rh**
Head = 9.00	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	482	12.00	21.00	106.49	348.52	0.0393	5.86	0.49		
2	954	12.00	21.00	108.19	490.41	0.0309	6.50	0.54	0.027225	19.30
3	10	12.00	21.00	48.16	49.29	0.1183	2.50	0.21		
4	482	19.00	21.00	107.75	438.54	0.0335	6.30	0.33	0.112225	79.56
5	482	5.00	21.00	102.00	224.97	0.0516	4.98	1.00		
6	482	12.00	30.00	107.51	416.56	0.0497	6.21	0.52	0.001600	1.13
7	482	12.00	12.00	104.02	263.45	0.0268	5.30	0.44		
								Total	0.141050	100.00

E[I] = 0.490000
Var[I]= 0.141050
σ[I]= 0.375566
V(I) = 0.766462
Ic= 0.80

E[ln I] = -0.944419
σ [ln I] = 0.679807
ln(I crit) = -0.223144

β = -1.389245
F(z) = 0.855655
Pr(f) % = 14.434498

Elev. 8.5	**Rh**
Head = 6.50	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	482	12.00	21.00	106.49	348.52	0.0393	4.23	0.35		
2	954	12.00	21.00	108.19	490.41	0.0309	4.70	0.39	0.014400	19.83
3	10	12.00	21.00	48.16	49.29	0.1183	1.81	0.15		
4	482	19.00	21.00	107.75	438.54	0.0335	4.55	0.24	0.057600	79.31
5	482	5.00	21.00	102.00	224.97	0.0516	3.59	0.72		
6	482	12.00	30.00	107.51	416.56	0.0497	4.48	0.37	0.000625	0.86
7	482	12.00	12.00	104.02	263.45	0.0268	3.83	0.32		
								Total	0.072625	100.00

E[I] = 0.350000
Var[I]= 0.072625
σ[I]= 0.269490
V(I) = 0.769972
Ic= 0.80

E[ln I] = -1.282587
σ [ln I] = 0.682297
ln(I crit) = -0.223144

β = -1.879807
F(z) = 0.939760
Pr(f) % = 6.024031

Elev. 6.0	**Rh**
Head = 4.00	

Run	**Kf/Kb**	**z**	**d**	**x1**	**x3**	**$**	**hx**	**I**	**Variance Component**	**% Variance**
1 (Mean)	482	12.00	21.00	106.49	348.52	0.0393	2.61	0.22		
2	954	12.00	21.00	108.19	490.41	0.0309	2.89	0.24	0.005625	20.93
3	10	12.00	21.00	48.16	49.29	0.1183	1.11	0.09		
4	482	19.00	21.00	107.75	438.54	0.0335	2.80	0.15	0.021025	78.23
5	482	5.00	21.00	102.00	224.97	0.0516	2.21	0.44		
6	482	12.00	30.00	107.51	416.56	0.0497	2.76	0.23	0.000225	0.84
7	482	12.00	12.00	104.02	263.45	0.0268	2.36	0.20		
								Total	0.026875	100.00

E[I] = 0.220000
Var[I]= 0.026875
σ[I]= 0.163936
V(I) = 0.745163
Ic= 0.80

E[ln I] = -1.734952
σ [ln I] = 0.664566
ln(I crit) = -0.223144

β = -2.610653
F(z) = 0.988543
Pr(f) % = 1.145657

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: Lower San Joaquin
Study Area: Delta Front Lincoln Village
River Section: Index Point D-LV
Coordinates: State Plane (ft), N 2185939, E 6315555

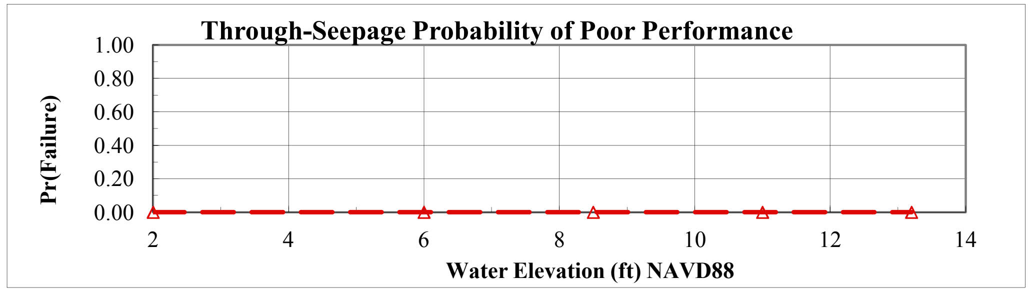
Levee Mile: Sta. 162+50
River Mile: XXXX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 13.20
L/S Toe Elev.: 2.00
W/S Toe Elev.: 3.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 4/9/2013

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	25	2.5	10.00
Initial Porosity (n)	0.5	0.05	10.00
Initial Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
NO



Analysis Case	**Head**	**Elevation**	**Pr(f)**
Toe	0.00	2.00	0.0000
Elev. 6.0	4.00	6.00	0.000000
Elev. 8.5	6.50	8.50	0.000000
Elev. 11.0	9.00	11.00	0.000000
Crest	11.20	13.20	0.000000

Crest	**Head =**	11.20	**Horizontal Gradient (Ix) =**	0.160

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	25.00	0.50	1.00E-10	637.40	3983.73		
2	22.50	0.50	1.00E-10	573.66	3585.35	158700.719428	26.44
3	27.50	0.50	1.00E-10	701.14	4382.10		
4	25.00	0.45	1.00E-10	604.69	3779.29	39774.866868	6.63
5	25.00	0.55	1.00E-10	668.51	4178.17		
6	25.00	0.50	7.00E-11	761.83	4761.46	401641.861129	66.93
7	25.00	0.50	1.30E-10	559.03	3493.96		

E[FS] =	3983.725887		E[ln FS] =	8.271414	Total	600117.447424	100.00
Var[FS]=	600117.447424						
σ[FS]=	774.672478		σ[ln FS]=	0.192658		**β =**	42.933222
V(FS) =	0.194459					**F(z) =**	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Elev. 11.0	**Head =**	9.00	**Horizontal Gradient (Ix) =**	0.140

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	25.00	0.50	1.00E-10	637.40	4552.83		
2	22.50	0.50	1.00E-10	573.66	4097.55	207282.572314	26.44
3	27.50	0.50	1.00E-10	701.14	5008.11		
4	25.00	0.45	1.00E-10	604.69	4319.19	51950.846521	6.63
5	25.00	0.55	1.00E-10	668.51	4775.05		
6	25.00	0.50	7.00E-11	761.83	5441.67	524593.451270	66.93
7	25.00	0.50	1.30E-10	559.03	3993.10		

E[FS] =	4552.829585		E[ln FS] =	8.404946	Total	783826.870105	100.00
Var[FS]=	783826.870105						
σ[FS]=	885.339974		σ[ln FS]=	0.192658		**β =**	43.626324
V(FS) =	0.194459					**F(z) =**	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Elev. 8.5	**Head =**	6.50	**Horizontal Gradient (Ix) =**	0.100

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	25.00	0.50	1.00E-10	637.40	6373.96		
2	22.50	0.50	1.00E-10	573.66	5736.57	406273.841735	26.44
3	27.50	0.50	1.00E-10	701.14	7011.36		
4	25.00	0.45	1.00E-10	604.69	6046.87	101823.659182	6.63
5	25.00	0.55	1.00E-10	668.51	6685.07		
6	25.00	0.50	7.00E-11	761.83	7618.34	1028203.164490	66.93
7	25.00	0.50	1.30E-10	559.03	5590.33		

E[FS] =	6373.961419		E[ln FS] =	8.741418	Total	1536300.665407	100.00
Var[FS]=	1536300.665407						
σ[FS]=	1239.475964		σ[ln FS]=	0.192658		**β =**	45.372802
V(FS) =	0.194459					**F(z) =**	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Elev. 6.0	**Head =**	4.00	**Horizontal Gradient (Ix) =**	0.010

Run	**Tractive Stress (Tc)**	**Initial Porosity (n)**	**Initial Permeability (Ko)**	**Critical Gradient (Ic)**	**FS**	**Variance Component**	**% Variance**
1 (Mean)	25.00	0.50	1.00E-10	637.40	63739.61		
2	22.50	0.50	1.00E-10	573.66	57365.65	40627384.173499	26.44
3	27.50	0.50	1.00E-10	701.14	70113.58		
4	25.00	0.45	1.00E-10	604.69	60468.71	10182365.918159	6.63
5	25.00	0.55	1.00E-10	668.51	66850.67		
6	25.00	0.50	7.00E-11	761.83	76183.41	102820316.449005	66.93
7	25.00	0.50	1.30E-10	559.03	55903.34		

E[FS] =	63739.614192		E[ln FS] =	11.044003	Total	153630066.540663	100.00
Var[FS]=	153630066.540663						
σ[FS]=	12394.759640		σ[ln FS]=	0.192658		**β =**	57.324494
V(FS) =	0.194459					**F(z) =**	0.000000
FS req'd =	1.00		ln(FS req'd) =	0.000000		**Pr(f) % =**	0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

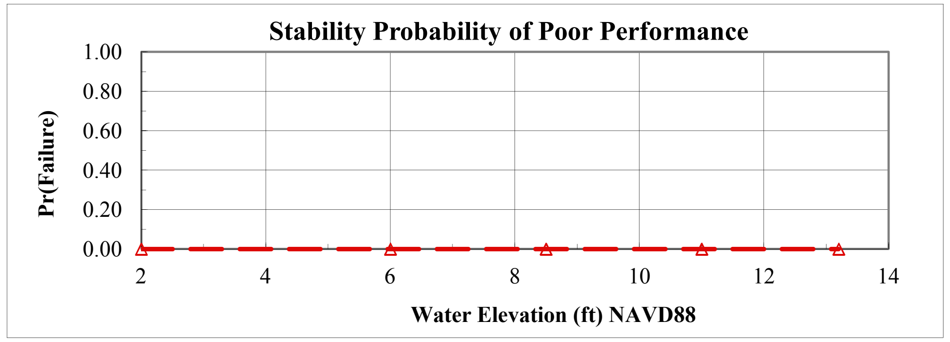
Project: Lower San Joaquin
Study Area: Delta Front Lincoln Village
River Section: Index Point D-LV
Coordinates: State Plane (ft), N 2185939, E 6315555

Levee Mile: Sta. 162+50
River Mile: XXXX
Analysis Case Without Project Conditions

Datum: NAVD 88
Crest Elev.: 13.20
L/S Toe Elev.: 2.00
W/S Toe Elev.: 3.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perlea
Date: 4/9/2013

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	27	4	13.00
Levee Cohesion	50	20	40.00
Levee γ	120	8	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	25	10	40.00


Stability Probability of Poor Performance

Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	2.00	0.0000
Elev. 6.0	4.00	6.00	0.000000
Elev. 8.5	6.50	8.50	0.000000
Elev. 11.0	9.00	11.00	0.000000
Crest	11.20	13.20	0.000000

Crest	Head =	11.20	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	27	50	120	28	25	1.83		
2	23	50	120	28	25	1.74	0.003906	15.00
3	31	50	120	28	25	1.86		
4	27	30	120	28	25	1.79	0.001764	6.77
5	27	70	120	28	25	1.87		
6	27	50	112	28	25	1.87	0.001190	4.57
7	27	50	128	28	25	1.80		
8	27	50	120	24	25	1.62	0.018906	72.61
9	27	50	120	32	25	1.89		
10	27	50	120	28	15	1.81	0.000272	1.05
11	27	50	120	28	35	1.85		

E[FS] = 1.830000
E[ln FS] = 0.600443
Total 0.026039 100.00
Var[FS]= 0.026039
σ[FS]= 0.161366
σ[ln FS]= 0.088007
β = 6.822640
V(FS) = 0.088178
F(z) = 0.000000
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 0.000000

Elev. 11.0	Head =	9.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	27	50	120	28	25	1.94		
2	23	50	120	28	25			
3	31	50	120	28	25			
4	27	30	120	28	25			
5	27	70	120	28	25			
6	27	50	112	28	25			
7	27	50	128	28	25			
8	27	50	120	24	25			
9	27	50	120	32	25			
10	27	50	120	28	15			
11	27	50	120	28	35			

E[FS] =
E[ln FS] =
Total
Var[FS]=
σ[FS]=
σ[ln FS]=
β =
V(FS) =
F(z) =
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 0.000000

Elev. 8.5	Head =	6.50	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	27	50	120	28	25	2.04		
2	23	50	120	28	25			
3	31	50	120	28	25			
4	27	30	120	28	25			
5	27	70	120	28	25			
6	27	50	112	28	25			
7	27	50	128	28	25			
8	27	50	120	24	25			
9	27	50	120	32	25			
10	27	50	120	28	15			
11	27	50	120	28	35			

E[FS] =
E[ln FS] =
Total
Var[FS]=
σ[FS]=
σ[ln FS]=
β =
V(FS) =
F(z) =
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 0.000000

Elev. 6.0	Head =	4.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	27	50	120	28	25	2.13		
2	23	50	120	28	25			
3	31	50	120	28	25			
4	27	30	120	28	25			
5	27	70	120	28	25			
6	27	50	112	28	25			
7	27	50	128	28	25			
8	27	50	120	24	25			
9	27	50	120	32	25			
10	27	50	120	28	15			
11	27	50	120	28	35			

E[FS] =
E[ln FS] =
Total
Var[FS]=
σ[FS]=
σ[ln FS]=
β =
V(FS) =
F(z) =
FS req'd = 1.00
ln(FS req'd) = 0.000000
Pr(f) % = 0.000000

Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

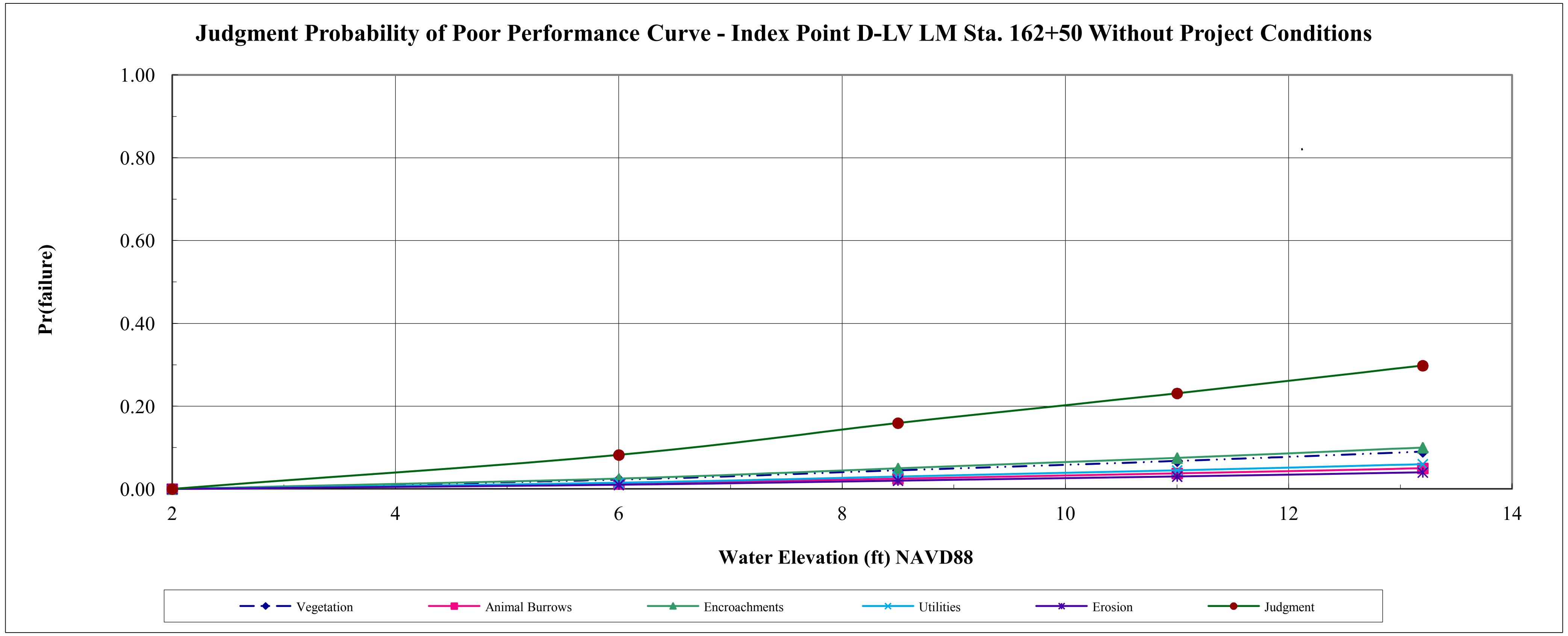
Project: Lower San Joaquin
Study Area: Delta Front Lincoln Village
River Section: Index Point D-LV
Coordinates: State Plane (ft), N 2185939, E 6315555

Levee Mile: Sta. 162+50
River Mile: XXXX
Analysis Case: Without Project Conditions

Datum: NAVD 88
Crest Elev.: 13.20
L/S Toe Elev.: 2.00
W/S Toe Elev.: 3.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perl
Date: 4/9/2013

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
2.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
6.00	0.0225	0.9775	0.0125	0.9875	0.0250	0.9750	0.0150	0.9850	0.0100	0.9900	0.0822	0.9178
8.50	0.0450	0.9550	0.0250	0.9750	0.0500	0.9500	0.0300	0.9700	0.0200	0.9800	0.1591	0.8409
11.00	0.0675	0.9325	0.0375	0.9625	0.0750	0.9250	0.0450	0.9550	0.0300	0.9700	0.2309	0.7691
13.20	0.0900	0.9100	0.0500	0.9500	0.1000	0.9000	0.0600	0.9400	0.0400	0.9600	0.2979	0.7021



Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

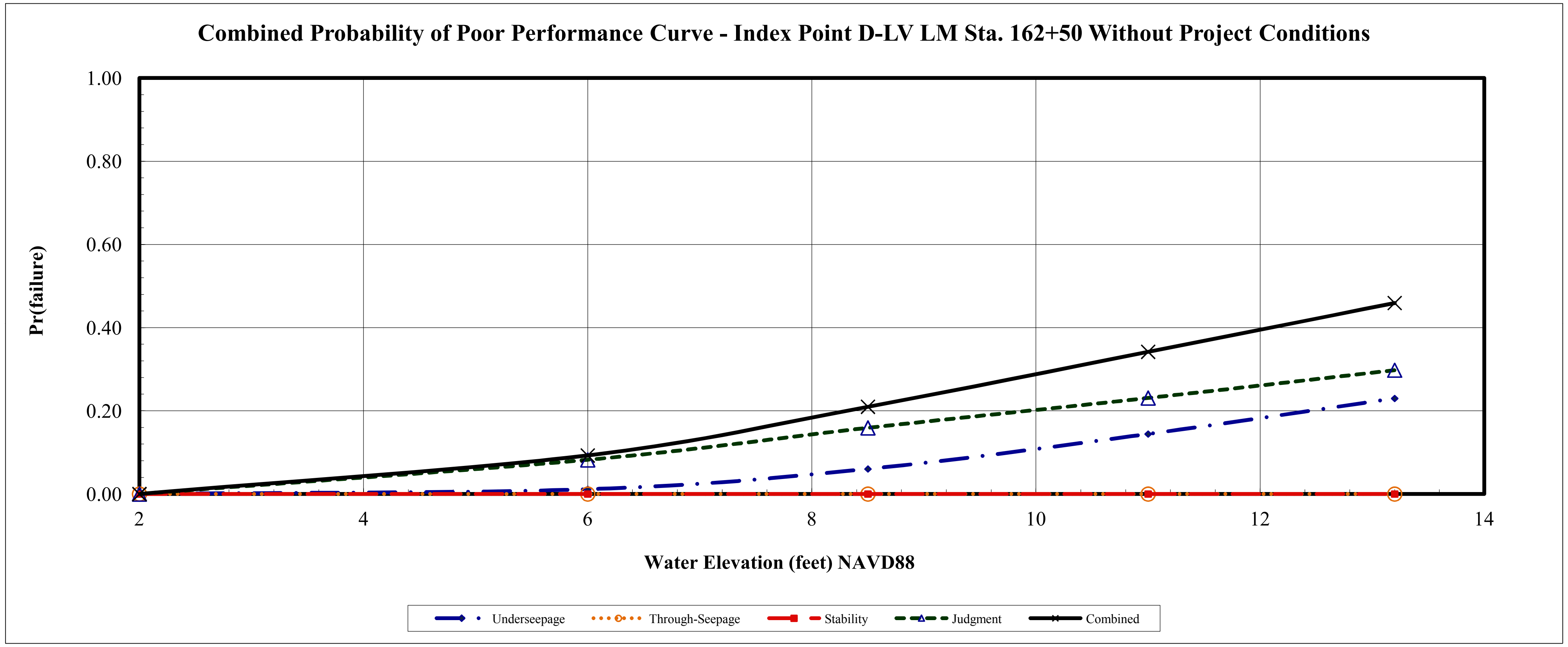
Project: Lower San Joaquin
Study Area: Delta Front Lincoln Village
River Section: Index Point D-LV
Coordinates: State Plane (ft), N 2185939, E 6315555

Levee Mile: Sta. 162+50
River Mile: XXXX
Analysis Case: Without Project Conditions

Datum: NAVD 88
Crest Elev.: 13.20
L/S Toe Elev.: 2.00
W/S Toe Elev.: 3.00

Analysis By: G. Johnson
Checked By: J. Hogan, M. Perle
Date: 4/9/2013

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
2.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
6.00	0.0115	0.9885	0.0000	1.0000	0.0000	1.0000	0.0822	0.9178	0.0928	0.9072
8.50	0.0602	0.9398	0.0000	1.0000	0.0000	1.0000	0.1591	0.8409	0.2098	0.7902
11.00	0.1443	0.8557	0.0000	1.0000	0.0000	1.0000	0.2309	0.7691	0.3419	0.6581
13.20	0.2299	0.7701	0.0000	1.0000	0.0000	1.0000	0.2979	0.7021	0.4593	0.5407



LOWER SAN JOAQUIN RIVER
FEASIBILITY STUDY

GEOTECHNICAL REPORT

ENCLOSURE E4
SEISMIC AND LIQUEFACTION ANALYSES

LOWER SAN JOAQUIN LEVEE
Seismic Vulnerability Evaluation

1. Introduction and Scope

The purpose of this study was to assess the vulnerability to seismic action of the levees in the Lower San Joaquin Levee System. Some of the levees in the northern portion of the system are frequently hydraulically loaded and, therefore, their severe damaging due to a strong earthquake in vicinity may induce immediately loss of flood protection capability.

The vulnerability evaluation considered only the significant loss of strength of cohesionless or low plasticity soils through liquefaction due to dynamic loading. The liquefaction and seismic evaluation was focused on examining potential layers that could experience liquefaction and their associated impact to global slope stability of the levee. The computed factors of safety against slope stability refer exclusively to failure surfaces potentially affected by liquefaction; in some cases the static factor of safety can be lower than the computed factor of safety affected by liquefaction. The static stability, which can be controlled by the presence of weak cohesive soils was not within the scope of this analysis, even if the strength of these materials may be affected by the seismic action.

In most of the cases/segments it was determined that liquefaction was primarily isolated to the deeper foundation layers and that it had minimal effect on the global stability of the levee and foundation. In four of the examined cases only, three in RD 17 Unit and one in RD 404 Unit, the liquefiable layer was shallow enough such that it could pose a significant effect on the stability of the levee (list the locations).

Even though global instability resulting from liquefaction does not appear to be a primary concern when the layer is located at greater depths, there could be other seismic performance concerns given the geologic nature of the area and the potential for differential settlement. The foundations for many of the segments consist of numerous geomorphologic channels that run orthogonal to the levee axis. As a result there are variable foundation conditions along the axis of the levee. The variability of the foundation coupled with the potential for transverse cracking due to liquefaction and differential settlement is a concern and should be carefully considered in the alternatives evaluation.

2. Study Area and Sites Seismicity

The main units of the Lower San Joaquin Levee System are presented on Figure 1.1 and will be separately evaluated from the seismic vulnerability point of view:

- RD (River District) 17 – Southern part
- RD 17 – Northern part
- RD 404
- Calaveras River

- Stockton Diverting Canal
- Mormon Slough
- Brookside
- Lincoln Village

The USGS Interactive Deaggregations (Beta) accessible at the following URL address: https://geohazards.usgs.gov/deaggint/2008/ was used for the seismicity assessment at locations along the levee. The following parameters were used as input:

- Location, through latitude and longitude; the coordinates corresponding to each unit were used in evaluations.

- Exceedance probability of the seismic event within a given exposure period of time. The 20% exceedance probability in 50 years was selected, which corresponds approximately to the average return period (ARP) of 224 years. This was considered an appropriate approximation of the 200-year ARP recommended by California Department of Water Resources (DWR) for urban levee seismic evaluation (ULE).

- Spectral period. For liquefaction triggering evaluation the Peak Ground Acceleration (PGA) was the main desired result of the seismicity assessment.

- Shear wave velocity of the upper 30 m of the site (Vs_{30}).

Shear wave velocity measurements were not available; therefore, correlation with N (SPT) was used to estimate the median Vs_{30}; for each unit N_{60} was evaluated based on available deep borings, as shown in Appendix B.

Vs_{30} was evaluated through correlations with N_{60} available in literature, as shown in Figure 2.1 [Figures 23 for large data base of all types of soils and Figure 24 for granular soils, from USACE WES (1987)]. Based on these graphs, the data in Table 2-1 were suggested for use in this study and other evaluations.

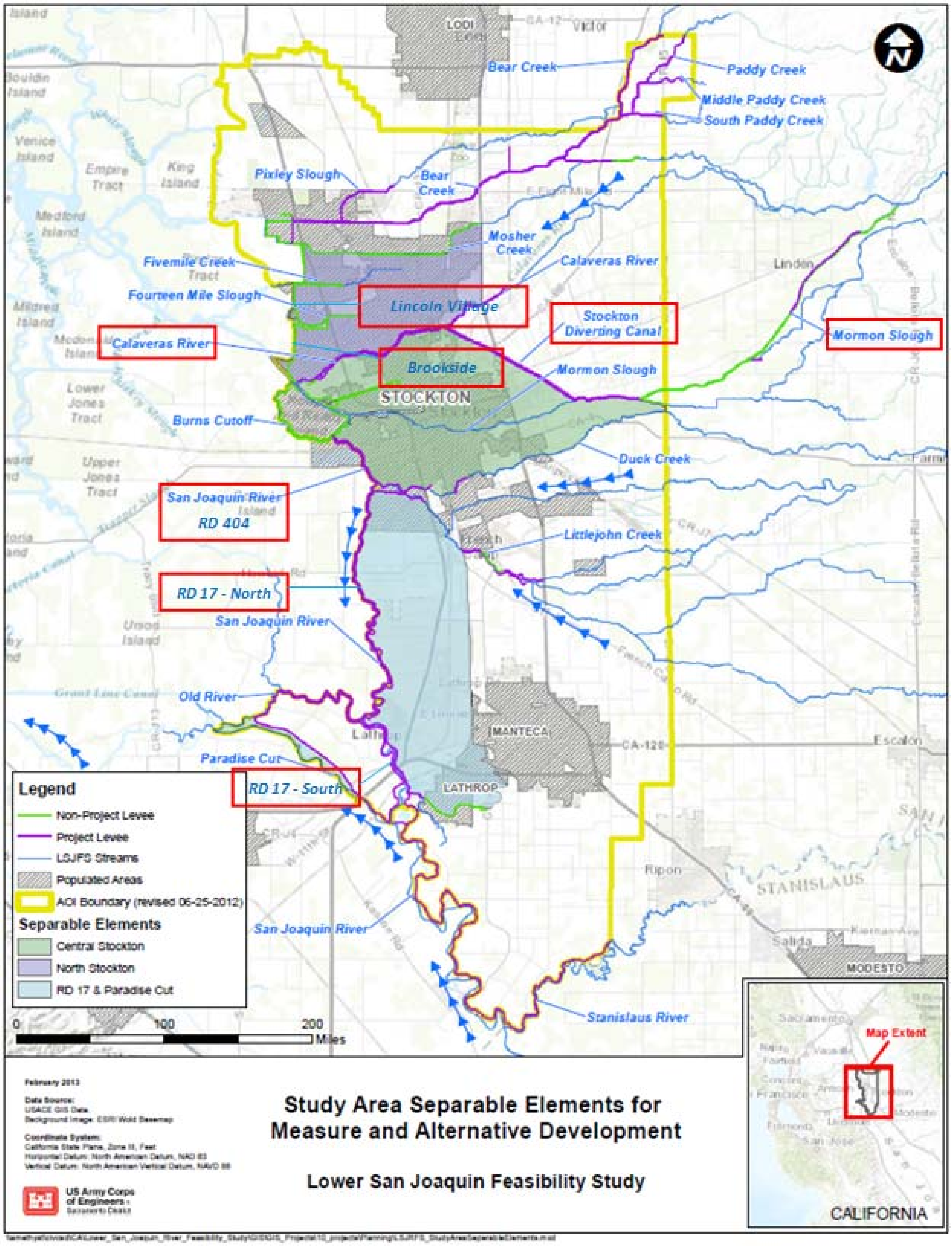


Figure 1.1. Main units of the Lower San Joaquin Levee System.

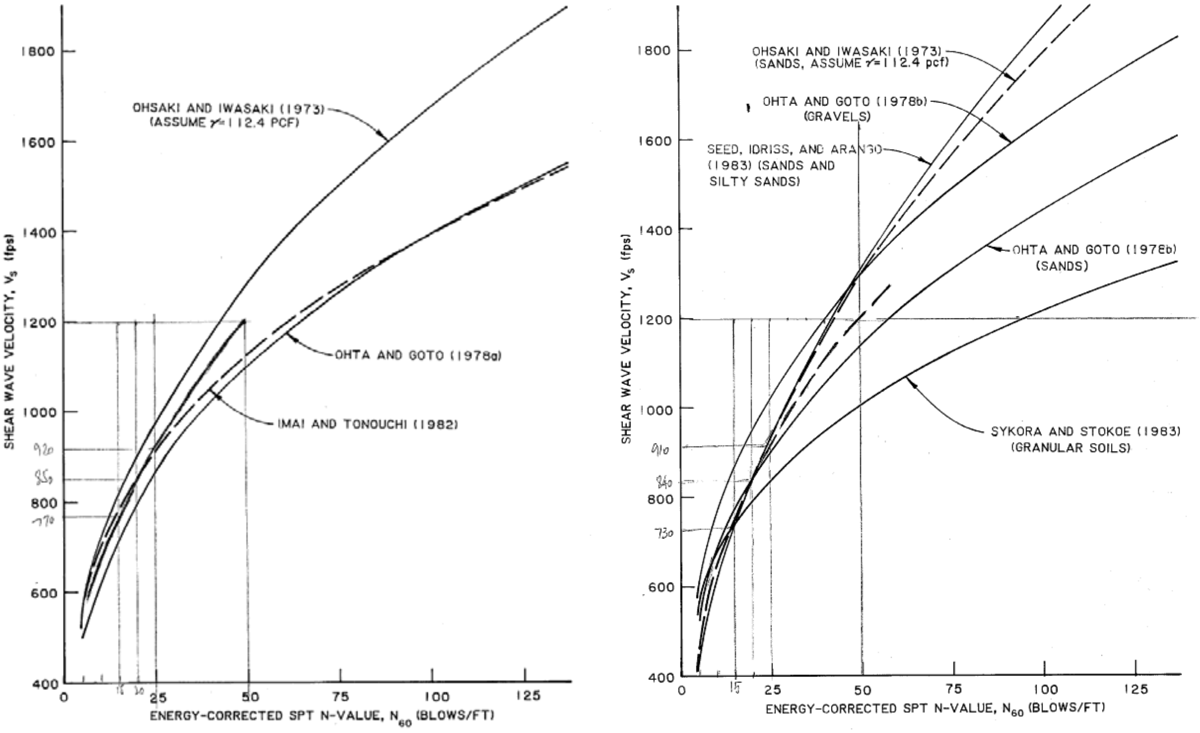


Figure 23. Comparison of results for N versus V_s correlations (proposed by select studies)

Figure 24. Comparison of results for N versus V_s correlations in granular soils (proposed by select studies)

Figure 2.1. Excerpt of USACE WES (1987): Average curves were considered that pass through the point represented by N_{60} = 50 and Vs = 1200 fps, which is the boundary between stiff soil and soft rock in USGS classification.

Table 2-1. Suggested Correlation between Vs and N_{60}

Mean N_{60}	Vs (m/s)	Mean N_{60}	Vs (m/s)	Mean N_{60}	Vs (m/s)	Mean N_{60}	Vs (m/s)
≤ 7	180*	15	230	23	270	32.5	308
8	181	16	235	24	275	35	317
9	189	17	241	25	279	37.5	326
10	197	18	246	26	283	40	334
11	204	19	251	27	287	42.5	342
12	211	20	256	28	291	45	349
13	217	21	261	29	295	50	364
14	224	22	266	30	299	100	474

Note: * The minimum Vs accepted by the USGS 2008 Interactive Deaggregations web program is 180 m/s, which corresponds to the boundary between stiff and soft soils (USGS Site Classes D and E).

In what follows the parameters for each units are listed, as well as the corresponding site seismicity parameters obtained from the USGS web site. Details on parameter evaluation are included in Appendix B.

2.1. RD 17 – Southern part (Stations 1480 to 1840)

Mid-point coordinates: latitude 37.809, longitude -121.321
Harmonic mean SPT – N_{60}: 21.6
Evaluated Vs_{30}: 265 m/s (detail in Appendix B)
Peak Ground Acceleration: 0.21g
Moment magnitude: 6.4

2.2. RD 17 – Northern part (Stations 1000 to 1480)

Mid-point coordinates: latitude 37.890, longitude -121.329
Harmonic mean SPT – N_{60}: 18.9
Evaluated Vs_{30}: 252 m/s (detail in Appendix B)
Peak Ground Acceleration: 0.225g
Moment magnitude: 6.4

2.3. RD 404

Mid-point coordinates: latitude 37.937, longitude -121.334
Harmonic mean SPT – N_{60}: 22.0
Evaluated Vs_{30}: 267 m/s (detail in Appendix B)
Peak Ground Acceleration: 0.20g
Moment magnitude: 6.4

2.4. Calaveras River

Western end coordinates: latitude 37.966, longitude -121.370
No deep boring was available; N_{60} and Vs_{30} were assumed as for RD 404.
Peak Ground Acceleration: 0.20g
Moment magnitude: 6.4

2.5. Stockton Diverting Canal and Mormon Slough

Western end coordinates: latitude 37.994, longitude -121.280
Eastern end coordinates: latitude 37.961, longitude -121.165
No deep boring was available; N_{60} and Vs_{30} were assumed as for RD 404.
Peak Ground Acceleration: 0.18g (0.165g for Mormon Slough)
Moment magnitude: 6.4

2.6. **Brookside** and **Lincoln Village**

Mid-point coordinates:	latitude 38.014, longitude -121.370

No deep boring was available; N_{60} and Vs_{30} were assumed as for RD 404.

Peak Ground Acceleration:	0.20g
Moment magnitude:	6.4

3. First Screening.

It would have been no need for seismic evaluation if PGA < 0.1g; however, with the estimated PGA = 0.165g to 0.225g we should proceed with liquefaction assessment on all sections.

4. Water Level Conditions.

Two water elevations are of interest:

- Level of ground water when SPT's were done;
- Coincident water level with seismic action.

They were not readily available. For each zone the water level during investigation was approximated from piezometer readings at the same time of the year (sometimes in a different year than when the investigation had been done).

When information was available, the coincident water level was assumed the maximum occurred in a year without flood event; if this was not found, the conservative assumption of water at the ground surface was considered (i.e. unsaturated material in levee and saturated material – therefore potentially liquefiable – in the entire foundation soil).

The influence on the liquefaction assessment results of the ground water level during field testing is relatively minor. However, the assumed coincident water elevation (CWE) is of huge impact:

- Primarily because of relative location of some potentially liquefiable layers with respect to CWE: if these layers are above CWE they should be considered non-saturated and, therefore, non-liquefiable.
- Secondly, but not much less important, CWE has a major impact on the ratio between the total vertical stress and the effective vertical stress at the depth analyzed for liquefaction. The cyclic stress ratio (CSR) varies in direct proportionality with this ratio, which roughly can vary between 1.0 and 2.0. Consequently CSR may vary between simple and double depending on CWE and FS_{liq} may vary between a maximum value when CWE is exactly at the depth of evaluation and half of that when CWE is at the ground surface.

Taking into account the major impact of CWE selection, there is a low confidence in the calculated FS_{liq} when CWE is not well defined. The (believed) conservative assumption of CWE at the ground surface may be over-conservative. This aspect is detailed based on some actual evaluations in Appendix E.

5. Liquefaction Triggering Analysis.

The liquefaction triggering analysis was based on the procedure described in the summary report of the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, published as part of the Journal of Geotechnical and Geoenvironmental Engineering, dated October 2001 (Youd et al., October 2001). This is also the procedure recommended by the draft ETL 1110-2-580.

An Excel spreadsheet developed by the Geotechnical Branch, USACE Sacramento District, was used in this analysis. The corresponding procedure calculates the vertical stresses induced by the levee surcharge and takes them into account in normalization of N-data and, consequently, in calculation of the cyclic resistance ratio, CRR. However, these additional stresses were not included in the calculation of CSR, the cyclic stress ratio; therefore the calculated factor of safety against liquefaction corresponds to the free field, without the influence of the surcharge, for compliance with how PGA was defined. It is conservative to assume that if liquefaction would occur in free field it will also occur in the immediate vicinity of the levee and underneath it.

It was postulated that the materials labeled with soil type CL (based on either laboratory tests or visual examination by the field geologist) are not liquefiable. Although theoretically some cohesive soils, including some CL materials, may be susceptible to liquefaction, this possibility was not taken into account based on the relatively low seismicity of the zone. However, where Atterberg Limits were available, CL or ML materials were considered liquefiable when PI < 10.

6. Seismic Vulnerability Evaluation.

The results of seismic evaluations are presented in appendices as follows:

Appendix A shows primarily the location of the evaluated borings:

Plate 1 - RD 17 – Southern part (Stations 1480 to 1840):	8 borings
Plate 2 - RD 17 – Northern part (Stations 1000 to 1480):	11 borings
Plate 3 - RD 404:	10 borings
Plate 4 - Calaveras River:	9 borings
- Stockton Diverting Canal:	5 borings
- Mormon Slough:	2 borings
Plate 5 - Brookside:	9 borings
Plate 6 - Lincoln Village:	14 borings
Total analyzed borings:	68

Appendix B includes copies of Excel files used for the evaluation of harmonic mean N_{60}, correlated with the average shear wave velocity, at all locations were borings with SPT deeper than 100 feet were available:

RD 17 – Northern Part: average Vs_{30} based on 5 borings
RD 17 – Southern Part: average Vs_{30} based on 4 borings
RD 404: average Vs_{30} based on 1 boring

The results of the liquefaction triggering evaluation are presented in Appendix C. Each plot of the factor of safety against liquefaction with depth is followed by the corresponding Excel spreadsheet. Only the first spreadsheet (for boring WR0017_063B) includes the bottom notes; however, they apply to all spreadsheets. A summary of the results follows. In the tables corresponding to each unit, the locations where liquefaction was found probable under the assumption of design earthquake occurrence had the boring number shown in bold on shaded background and the corresponding boring log was included in Appendix D.

6.1. **RD 17 – Southern part** (Stations 1480 to 1840)

Station	Boring	Figure	CWE	Comments
1506+19	WR0017_063B	C-1	8.0	Mostly clayey soils in the upper 40 feet of foundation. No SPT data for thin cohesionless layers. Marginally liquefiable soil 40+ feet below the levee base.
1553+82	**WR0017_069B** (see App. D)	C-2	8.7	One test showed potentially liquefiable soil; both above and below that, the soil was found marginally liquefiable.
1595+33	**WR0017_074B** (see App. D)	C-3	7.7	Liquefaction predicted at two depths and marginally liquefiable soil above, below, and in-between. A 12-foot layer is clearly liquefiable.
1642+75	WR0017_080B	C-4	7.5	No liquefaction predicted. Marginally liquefiable soil immediately below CWE.
1684+57	WR0017_085B	C-5	7.4	No liquefaction predicted.
1724+68	WR0017_090B	C-6	7.1	No liquefaction predicted.
1784+83	WR0017_096B	C-7	6.8	No liquefaction predicted. Marginally liquefiable soil immediately below CWE.
1825+94	WR0017_102B	C-8	6.8	No liquefaction predicted. Marginally liquefiable soil between elevations -15 and -25 and at about elevation -31. See Appendix E for the effect of CWE selection.

6.2. **RD 17 – Northern part** (Stations 1000 to 1480)

Station	Boring	Figure	CWE	Comments
1007+42	WR0017_002B	C-9	2.8	Mostly clayey soils in the upper 50 feet of foundation. Thin marginally liquefiable SM layer at approximately elevation -31.0. See Appendix E for the effect of CWE selection.
1048+79	WR0017_007B	C-10	2.8	No liquefaction predicted. See Appendix E for the effect of CWE selection.

Station	Boring	Figure	CWE	Comments
1099+90	WR0017_013B	C-11	3.6	No liquefaction predicted. Mostly clayey soils in the upper 50 feet of foundation.
1151+06	**WR0017_019B** (see App. D)	C-12	4.4	A liquefiable layer was detected between elevations +1 and -2.
1191+43	**WR0017_024B** (see App. D)	C-13	4.6	Two liquefiable layers were detected: one at about elevation -3.0 and another one between elevations -13.2 and -20.3.
1231+82	WR0017_029B	C-14	4.8	No liquefaction predicted. Marginally liquefiable SM soils were detected through tests at elevations +1 and -4.
1292+29	WR0017_036B	C-15	4.8	No liquefaction predicted. Marginally liquefiable SM soils were detected through tests at elevations -26 and -31.
1330+01	WR0017_041B	C-16	5.0	No liquefaction predicted. See Appendix E for the effect of CWE selection.
1377+73	WR0017_047B	C-17	5.3	No liquefaction predicted. Marginally liquefiable soils were detected through tests at elevations +1, -20 and -24. See Appendix E for the effect of CWE selection.
1416+93	WR0017_052B	C-18	5.5	No liquefaction predicted.
1455+64	WR0017_057B	C-19	7.0	No liquefaction predicted. Marginally liquefiable soils were detected through tests at elevations +7 and -8.

6.3. **RD 404**

Station	Boring	Figure	CWE	Comments
1003+04	WR0404_030B	C-20	0.0	No liquefaction predicted. Clayey soils with PI of 10 or greater were detected in the upper 44 feet of foundation.
1201+00	WR0404_040B	C-21	4.1	No liquefaction predicted. Marginally liquefiable soil (part of test possibly in CL material) was detected at elevation -25.
1175+01	**WR0404_041B** (see App. D)	C-22	4.1	Liquefiable SW-SM layer between elevations +1.3 and -4.7 was detected through one test at elevation -1.1.
1139+55	WR0404_044B	C-23	0.0	No liquefaction predicted.
1112+49	WR0404_047B	C-24	0.0	No liquefaction predicted. One marginally liquefiable spot was found at elevation -47, too deep for affecting the levee.
1108+07	WR0404_048B	C-25	0.0	No liquefaction predicted. Mostly clayey soils or ML with PI = 10 were detected in the upper 60 feet of foundation.

Station	Boring	Figure	CWE	Comments
1087+77	WR0404_053B	C-26	0.0	No liquefaction predicted.
1070+28	WR0404_056B	C-27	0.0	No liquefaction predicted. A shallow marginally liquefiable SM/ML layer was detected at the approximate elevation -2.
1042+70	WR0404_059B	C-28	0.0	No liquefaction predicted.
1028+00	WR0404_060B	C-29	0.0	No liquefaction predicted.

From the above table it is evident the levees in the unit RD 404 have a low seismic vulnerability. Only one of the ten analyzed borings predicted liquefaction occurrence (10%). The ten analyzed borings had sufficient SPT information (especially with reference to type of sampler and delivered energy efficiency).

Recently URS performed a similar study on the levees of RD 404, analyzing 22 borings. Of these 22 borings, 17 (77%) predicted liquefaction. In general, the results obtained by the Corps and URS on the same borings were similar. Most of them did not predict liquefaction; however, in two cases in which the Corps did not consider liquefaction because the material was CL, URS found that the PI was less than 10 so liquefaction was determined to be possible. The big difference was that URS analyzed several borings that the Corps did not have access to; including, where multiple tests (up to 6 in some borings) with predicted liquefaction: Borings 1-B2, 1-B4, 1-B5, 1-B6, 1-B8, 1-B9, 1-B12, WR0404_003B, _015B, _018B, _023B, _032B, _053B, and _061B.

The length of levees (on each side of the San Joaquin River) of RD 404 is about 22,000 feet; therefore, with ten analyzed borings the average distance between them was 2200 feet (actually the distance between borings was up to 4200 feet). Such "spot checking" may not detect problem zones if they are of local extent. It should be noted that all borings the Corps did not have access to but that URS analyzed showed liquefaction potential. They may have included incomplete characterization and conservative assumptions (e.g. with respect to energy efficiency).

6.4. **Calaveras River**

Station	Boring	Figure	CWE	Comments
6505+30	WR1614_017B	C-30	3.4*	No liquefaction predicted. A blowcount of zero at elevation -35 indicated FS_{liq} = 0.53, but it was in soil with PI = 61.
3072+94	WR2074_016B	C-31	-1.0	No liquefaction predicted.
3087+75	WCNBCR_010B	C-32	-1.0	No liquefaction predicted.
6565+02	**WR1614_018B** (see App. D)	C-33	1.4*	An SP-SM layer between elevations -18.4 and -23 was determined as liquefiable (FS_{liq} = 0.4).
3130+53	WCNBCR_011B	C-34	-1.0	No liquefaction predicted.
3156+02	WCNBCR_012B	C-35	-1.0	No liquefaction predicted. Marginally liquefiable material (FS_{liq} = 1.08) was found at elevation -14.

Station	Boring	Figure	CWE	Comments
6669+40	**WR1614_019B** (see App. D)	C-36	4.0	Liquefiable material (FS_{liq} = 0.6) was found at elevation -12 (layer -10.8 to -16.0).
3238+00	WCNBCR_013B	C-37	-1.0	No liquefaction predicted.
6762+29	WCSBCR_004B	C-38	3.0	No liquefaction predicted.

Note: * CWE could not be evaluated and was conservatively considered at the ground surface elevation.

6.5. **Stockton Diverting Canal** and **Mormon Slough**

Station	Boring	Figure	CWE	Comments
811+98	WCSBDC_001B	C-39	24.8*	No liquefaction predicted.
883+93	WCSBDC_005B	C-40	24.2*	No liquefaction predicted.
940+82	WCSBDC_008B	C-41	27.4*	No liquefaction predicted.
978+49	WCSBDC_013B	C-42	33.0*	No liquefaction predicted.
1029+16	WCSBDC_014B	C-43	35.0*	No liquefaction predicted.
2527+95	WCSBMS_003B	C-44	44.0*	No liquefaction predicted.
2583+28	WCSBMS_002B	C-45	51.4*	No liquefaction predicted.

Note: * CWE could not be evaluated and was conservatively considered at the ground surface elevation or slightly (less than 1 foot) below.

From the above table it is evident that liquefaction was not predicted even with a very conservative CWE assumed. Therefore, it was not necessary to evaluate a more credible CWE along Stockton Diverting Canal and Mormon Slough.

6.6. **Brookside**

Station	Boring	Figure	CWE	Comments
117+51	**WR2074_003M** (see App. D)	C-46	3.2	There are two liquefiable layers: between elevations -15.5 and -18 and between elevations -21 and -23 (the deeper layer was disregarded).
118+02	**WR2074_009B** (see App. D)	C-47	1.1	There is one liquefiable layer between elevations -22.4 and -31.9.
133+44	WR2074_010B	C-48	-0.6*	No liquefaction predicted.
133+82	**WR2074_007B** (see App. D)	C-49	5.5*	There are two 2-foot liquefiable layers: between elevations -9.8 and -11.8 and between elevations -20.8 and -22.8 (FS_{liq} = 0.99 in both cases).
160+48	WR2074_011B	C-50	0.6*	No liquefaction predicted.
185+70	WR2074_008B	C-51	1.1	No liquefaction predicted. Marginal liquefiability (FS_{liq} = 1.23) was detected at elevation -28.5.
217+77	WR2074_012B	C-52	0.9*	No liquefaction predicted.

Station	Boring	Figure	CWE	Comments
247+31	WR2074_013B	C-53	-1.1*	No liquefaction predicted.
248+41	WR2074_005M	C-54	3.2	No liquefaction predicted. Marginal liquefiability (FS_{liq} = 1.27) was detected at elevation -17.6.

Note: * CWE was considered at the ground surface.

6.7. **Lincoln Village**

Station	Boring	Figure	CWE	Comments
5+23	WR1608_002B	C-55	5.4*	No liquefaction predicted. However, only one SPT was performed for 16 feet of cohesionless soil.
43+00	**WR1608_002M** (see App. D)	C-56	3.3*	Liquefiable SM layer was detected between elevations -10.7 and -26.7.
43+58	WR1608_001M	C-57	3.3*	No liquefaction predicted. Marginally liquefiable SM layer (FS_{liq} = 1.01 and 1.11) was found between elevations -7.4 and -26.7, probably the same as the SM above.
50+79	WR1608_004B	C-58	5.4*	No liquefaction predicted. Marginally liquefiable SP-SM layer (FS_{liq} = 1.19 and 1.02, based on Standard California sampler**) was found between elevations -7.1 and -26.6, probably the same as the SM above.
89+65	WR1608_004M	C-59	5.7*	No liquefaction predicted. However, the boring penetrated 22 feet only in foundation soil (down to elevation -16.5).
89+67	WR1608_003M	C-60	4.8*	No liquefaction predicted. Except for a 2-foot non-liquefiable cohesionless layer, only clayey soils were encountered down to 40 feet in depth (elevation -36.7).
109+90	**WR1608_008B** (see App. D)	C-61	1.0*	A thin liquefiable layer was detected (FS_{liq} = 0.89, based on Standard California sampler**).
150+00	WR1608_013B	C-62	3.2*	No liquefaction predicted. A marginally liquefiable SP-SM layer was detected (FS_{liq} = 1.25, based on Standard California sampler**).
159+20	WR1608_001B	C-63	3.1*	No liquefaction predicted. A marginally liquefiable SP-SM layer was detected (FS_{liq} = 1.27, based on Standard California sampler**).
159+41	WR1608_009B	C-64	4.1*	No liquefaction predicted. A marginally liquefiable SM layer was detected (FS_{liq} = 1.27, based on Standard California sampler**).

Station	Boring	Figure	CWE	Comments
159+48	**WR1608_010B** (see App. D)	C-65	3.7*	Liquefiable SM or SP-SM layer was detected between elevations -7.8 and -25.3.
164+99	**WR1608_011B** (see App. D)	C-66	3.6*	Liquefiable ML layer was detected between elevations -27.4 and -30.4. Marginally liquefiable layers were detected both above and below the liquefiable layer, but separated by non-liquefiable layers.
142+28	WR1608_005M	C-67	4.9*	No liquefaction predicted. Marginally liquefiable SM layers were found both above and below a cohesive layer.
201+51	**WCNBFM_001 B** (see App. D)	C-68	6.6*	Liquefiable SM layer was detected between elevations -17 and -27. Marginally liquefiable soil was found at elevation -3.

Notes: * CWE could not be evaluated and was conservatively considered at the ground surface elevation.

** Many SPT‘s at Lincoln Village unit were performed with a “Standard California” sampler (also known as Dames & Moore sampler). A factor of 0.55 was applied to blowcounts obtained with the California sampler for converting them to regular SPT; however, there is a large scatter in correlation data; also ASTM D6066 “Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential” states: “6.3.3 Larger diameter split barrel samplers, 3 and 31⁄2-in. (75 and 88 mm) O.D., can be used with and without retainers to recover coarse grained soils. They are not acceptable for determining penetration resistance *N* values.” Therefore, conventional SPT data were always preferred and Standard California data (multiplied by 0.55) were used only when regular SPT’s were not at all available in a particular boring or in other borings in vicinity.

7. Post-Earthquake Stability Evaluation.

7.1. **General**

In accordance with draft ETL 1110-2-580 “Guidelines for Seismic Evaluation of Levees” at all locations where liquefaction potential was detected a post-earthquake stability analysis should be performed assuming residual shear strength mobilized in all potentially liquefiable layers. This analysis was performed using UTexas4 and the results are presented in Appendix F.

In accordance with the above referenced ETL, the selection of the residual strength should be done based on two state-of-the-practice procedures and selecting the lowest obtained factor of safety as final result.

The two state-of-the-practice procedures for the evaluation of the residual (post-liquefaction) undrained shear strength, S_r, of soils were: Seed and Harder, 1990 and Olson and Stark, 2002. (See references in ETL 1110-2-580.) An average relationship (actually corresponding to the lower third of the specified range) for the first procedure was recommended by Idriss and Boulanger, 2007:

a. Seed and Harder, 1990 approach:

$$S_r = \exp \{(N_1)_{60cs\text{-}Sr} / 5.1 - [(N_1)_{60cs\text{-}Sr} / 16.5]^2 + [(N_1)_{60\text{-}cs\text{-}Sr} / 21.4]^3 + 0.8\} / 0.0479 \quad \text{(psf)}$$

where:
$(N_1)_{60cs\text{-}Sr} = (N_1)_{60cs} + \Delta(N_1)_{60cs\text{-}Sr}$
and
$\Delta(N_1)_{60cs\text{-}Sr}$ is a function of fines content, as shown in Table 7-1.

Table 7-1. Correction for Fines

Fines Content, F (% < 0.074 mm)	$\Delta(N_1)_{60cs\text{-}Sr}$
≤ 5	0
10	1
25	2
50	4
75	5

Interpolation between values in table was based on the curve and equation in Figure 7.1.

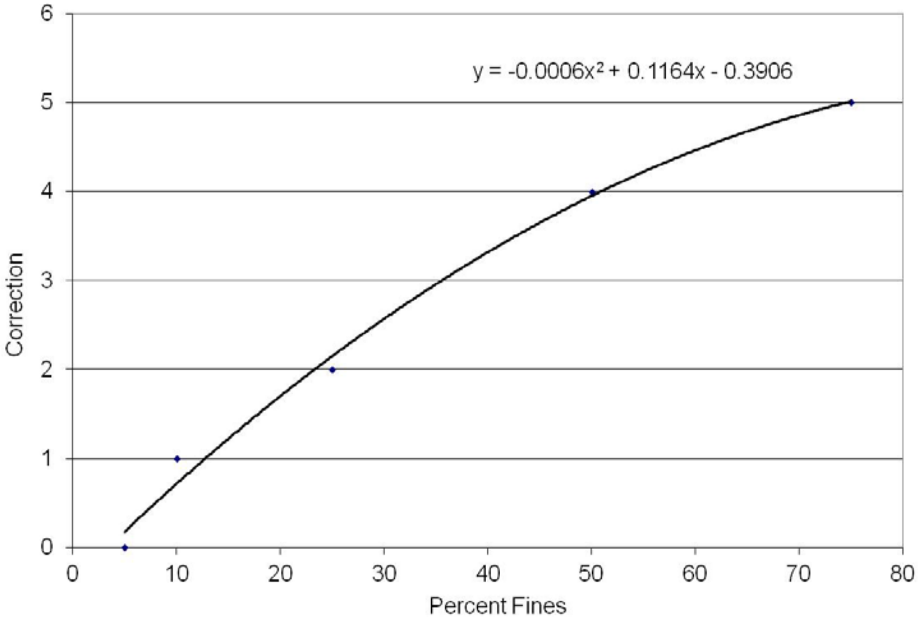


Figure 7.1. Correction for fines.

The undrained shear strength obtained through the Seed and Harder, 1990 procedure is presented in graphical form in Figure 7.2.

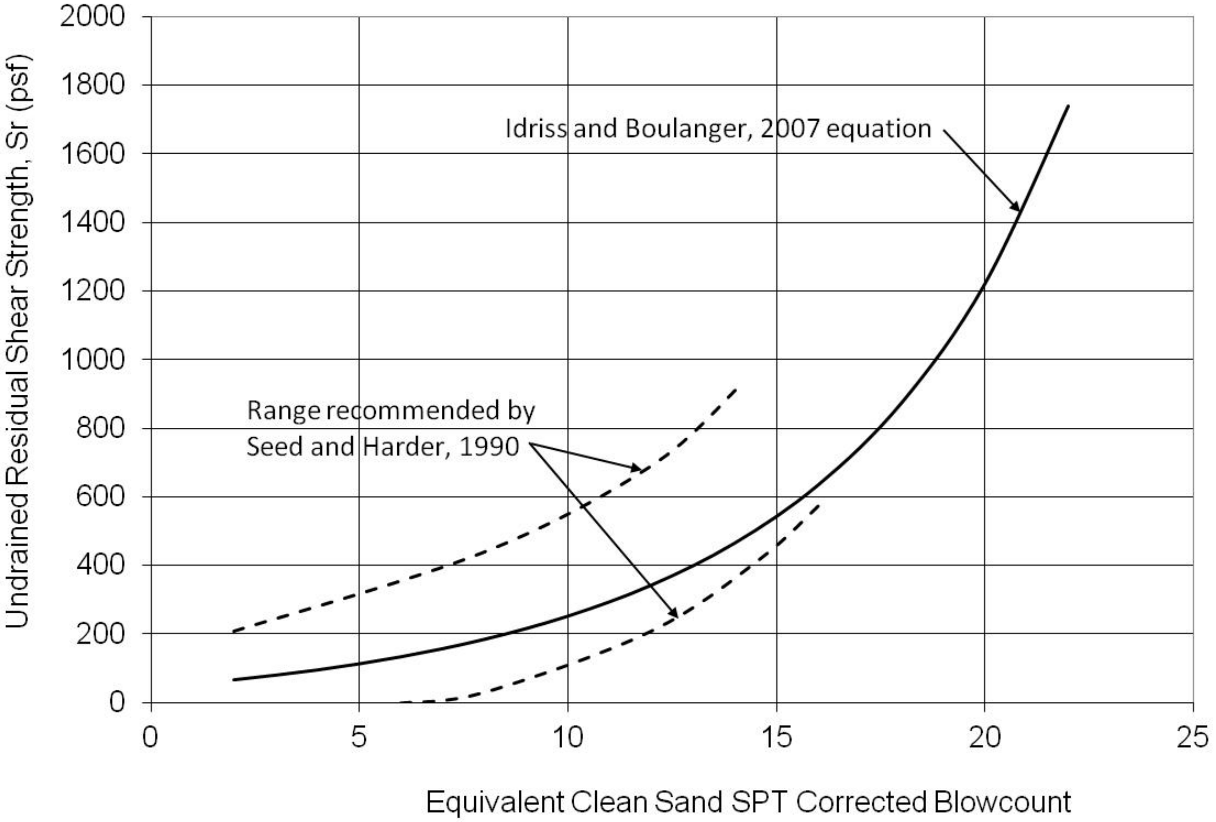


Figure 7.2. Results of Idriss and Boulanger, 2007 equation for approximation of Seed and Harder, 1990 procedure.

b. Olson and Stark, 2002 approach:

$S_r/\sigma'_{v0} = 0.03 + 0.0075\ [(N_1)_{60}]$

(Note that no correction for fines is applied.)

The calculated S_r, which under this definition varies with depth, was input in the limit equilibrium evaluations as an equivalent Φ-angle defined as follows:

$\Phi_{eq} = \tan^{-1}(S_r/\sigma'_{v0})$ and $S_r = \tan \Phi_{eq} * \sigma'_{v0}$

The results are summarized below. The minimum factors or safety are shown in bold if they are less than one; they are also shown on shaded background if they are critical for a given variant. Therefore, a shaded zone on a line identifies location where the levee can fail during a 200-year earthquake.

7.1. **RD 17 – Southern part** (Stations 1480 to 1840)

a. Seed and Harder, 1990 approach:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Sr (psf)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
1553+82	69B	+1.3 to -5.7	365	**0.84**	**0.95**	1.49	1.61
1595+33	74B	+10.0 to -2.0	133	1.07*	1.19	1.26	1.26

Note: * Critical slip circle does not affect the levee.

b. Olson and Stark, 2002 approach:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Φ_{eq} (degrees)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
1553+82	69B	+1.3 to -5.7	6.9	**0.37**	**0.80**	1.29	1.37
1595+33	74B	+10.0 to -2.0	3.9	0.95*	1.07	1.32	1.27

Note: * Critical slip circle does not affect the levee.

7.2. **RD 17 – Northern part** (Stations 1000 to 1480)

a. Seed and Harder, 1990 approach:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Sr (psf)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
1151+06	19B	+1.0 to -2.0	201	1.00	1.15	1.93	1.59
1191+43	24B	-2.7 to -3.7 -13.2 to -20.3	164 111	**0.88**	1.38	1.62	1.31

b. Olson and Stark, 2002 approach:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Φ_{eq} (degrees)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
1151+06	19B	+1.0 to -2.0	5.2	**0.87**	1.15	1.86	1.54
1191+43	24B	-2.7 to -3.7 -13.2 to -20.3	4.3 2.7	1.19	1.37	1.61	1.60

7.3. **RD 404**

a. <u>Seed and Harder, 1990 approach</u>:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Sr (psf)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
1175+01	41B	+1.3 to -4.7	113	**0.88**	**0.73**	1.40	1.15

b. <u>Olson and Stark, 2002 approach</u>:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Φ_{eq} (degrees)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
1175+01	41B	+1.3 to -4.7	3.6	**0.82**	**0.65**	1.38	1.12

7.4. **Calaveras River**

a. <u>Seed and Harder, 1990 approach</u>:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Sr (psf)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
6565+02	18B	-18.4 to -23.0	77	1.76	1.40	N/A	N/A
6669+40	19B	-10.8 to -16.0	98	2.10	1.97	N/A	N/A

b. <u>Olson and Stark, 2002 approach</u>:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Φ_{eq} (degrees)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
6565+02	18B	-18.4 to -23.0	2.6	1.80	1.45	N/A	N/A
6669+40	19B	-10.8 to -16.0	1.7	2.04	1.86	N/A	N/A

7.5. **Stockton Diverting Canal** and **Mormon Slough**

No potential liquefaction was detected.

7.6. **Brookside**

a. Seed and Harder, 1990 approach:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Sr (psf)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
117+51	3M	-15.5 to -18.0	189	N/A	N/A	3.78	3.14
118+02	9M	-22.4 to -31.9	151	N/A	N/A	2.17	1.58
133+82	7B	-9.8 to -11.8	242	N/A	N/A	1.62	1.68

b. Olson and Stark, 2002 approach:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Φ_{eq} (degrees)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
117+51	3M	-15.5 to -18.0	4.3	N/A	N/A	3.69	2.95
118+02	9M	-22.4 to -31.9	4.3	N/A	N/A	2.21	1.71
133+82	7B	-9.8 to -11.8	5.1	N/A	N/A	1.48	1.49

7.7. **Lincoln Village**

a. Seed and Harder, 1990 approach:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Sr (psf)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
43+57	2M	-10.7 to -26.7	201	1.67	1.61	1.55	1.52
109+90	8B	-13.0 to -16.0	282	1.60	1.49	2.01	2.31
159+48	10B	-7.8 to -25.3	207	1.68	1.64	1.40	1.42
164+99	11B	-27.4 to -30.4	224	4.47	4.03	3.79	3.22
201+51	1B	-17.0 to -27.0	201	3.83	4.01	3.59	4.05

b. Olson and Stark, 2002 approach:

Station	Boring	Liquefiable Layer(s)		Factor of safety (FS)			
		Elevations	Φ_{eq} (degrees)	Water Side		Land Side	
				Circle	Wedge	Circle	Wedge
43+57	2M	-10.7 to -26.7	4.7	1.58	1.53	1.41	1.42
109+90	8B	-13.0 to -16.0	6.0	1.44	1.27	1.84	1.63
159+48	10B	-7.8 to -25.3	5.1	1.53	1.51	1.24	1.21
164+99	11B	-27.4 to -30.4	3.4	4.36	3.86	3.69	3.04
201+51	1B	-17.0 to -27.0	4.7	3.65	4.01	3.41	3.75

The following sections have been identified as susceptible of flow failures under the loading with the 200-year earthquake; therefore, immediately after the earthquake occurrence the levee flood retention capability may be compromised:

- **RD 17 – Southern part** 1553+82

- **RD 17 – Northern part** 1151+06
  1191+43

- **RD 404** 1175+01

The following section has the minimum factor of safety between 1.0 and 1.2, so the levee at this location may experience significant deformation under the loading with the 200-year earthquake:

- **RD 17 – Southern part** 1595+33

However, the factor of safety is marginally 1.2 (1.19 and 1.07 with residual strength per Seed and Harder, 1990 and per Olson and Stark, 2002 for a very shallow potential failure surface); therefore, additional deformation analysis was not considered necessary for this location.

8. Conclusions.

Fifteen of the 68 borings evaluated indicated potentially liquefiable material under the 200-year earthquake loading. It is noted that not all layers had SPT's and in some cases the less reliable tests with the Standard California sampler had to be considered. However, the upper 50 feet of the soil were found generally non-liquefiable, including non-liquefiable cohesive soils that are predominant.

The fifteen locations with possible liquefaction occurrence were evaluated for post-earthquake stability. In three cases the potential for flow failure, i.e. complete loss of levee capability for flood protection were found. Four locations with potential flow failure condition were found in units RD 17 and RD 404. The corresponding segments of levees should be further investigated for potential vulnerability.

The rest of levee units will likely not be affected by the 200-year design level earthquake. This is due to both the relatively rare presence of liquefiable layers and in some cases their depth. In general, it was found that the layer was only vulnerable if the liquefiable layer was above or slightly below the elevation 0.0, i.e. at shallow depth in foundation. For these cases the levee was found vulnerable to the seismic action.

Report prepared by
Vlad Perlea
Laszlo Nagy
Soil Design Section

APPENDIX A

Plates

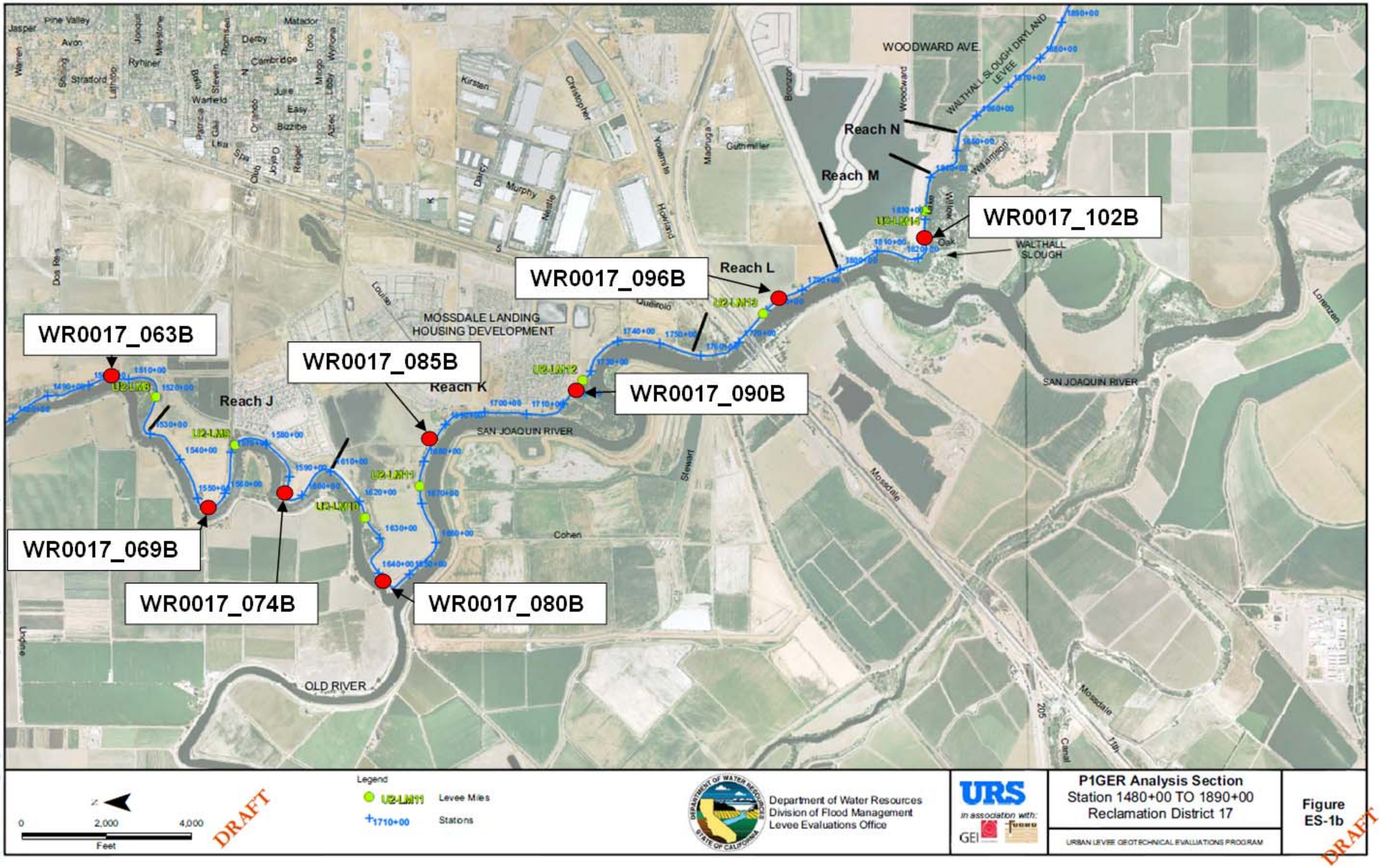


Plate 1. **RD 17 – Southern part** (Stations 1480 to 1840).

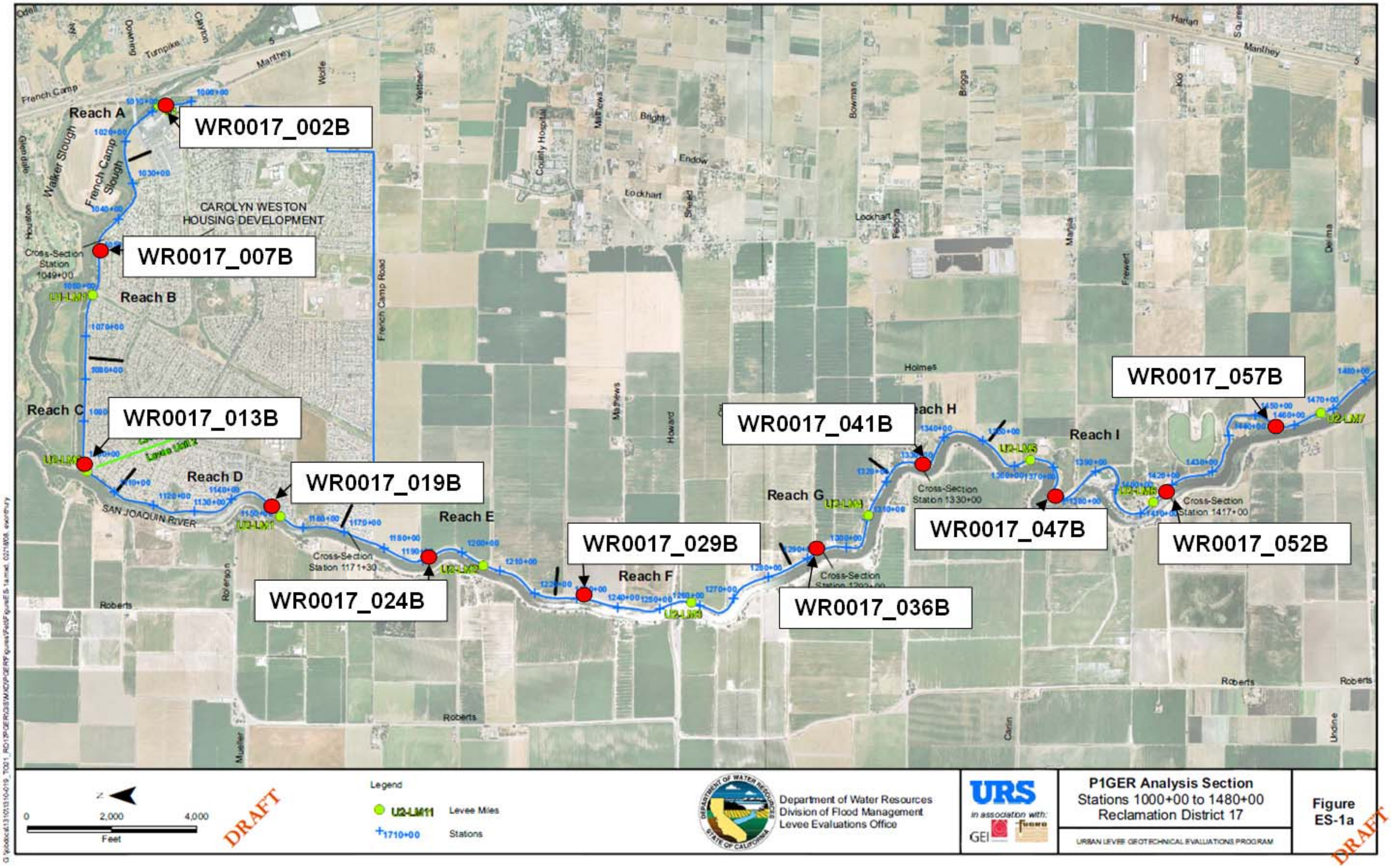


Plate 2. **RD 17 – Northern part** (Stations 1000 to 1480).

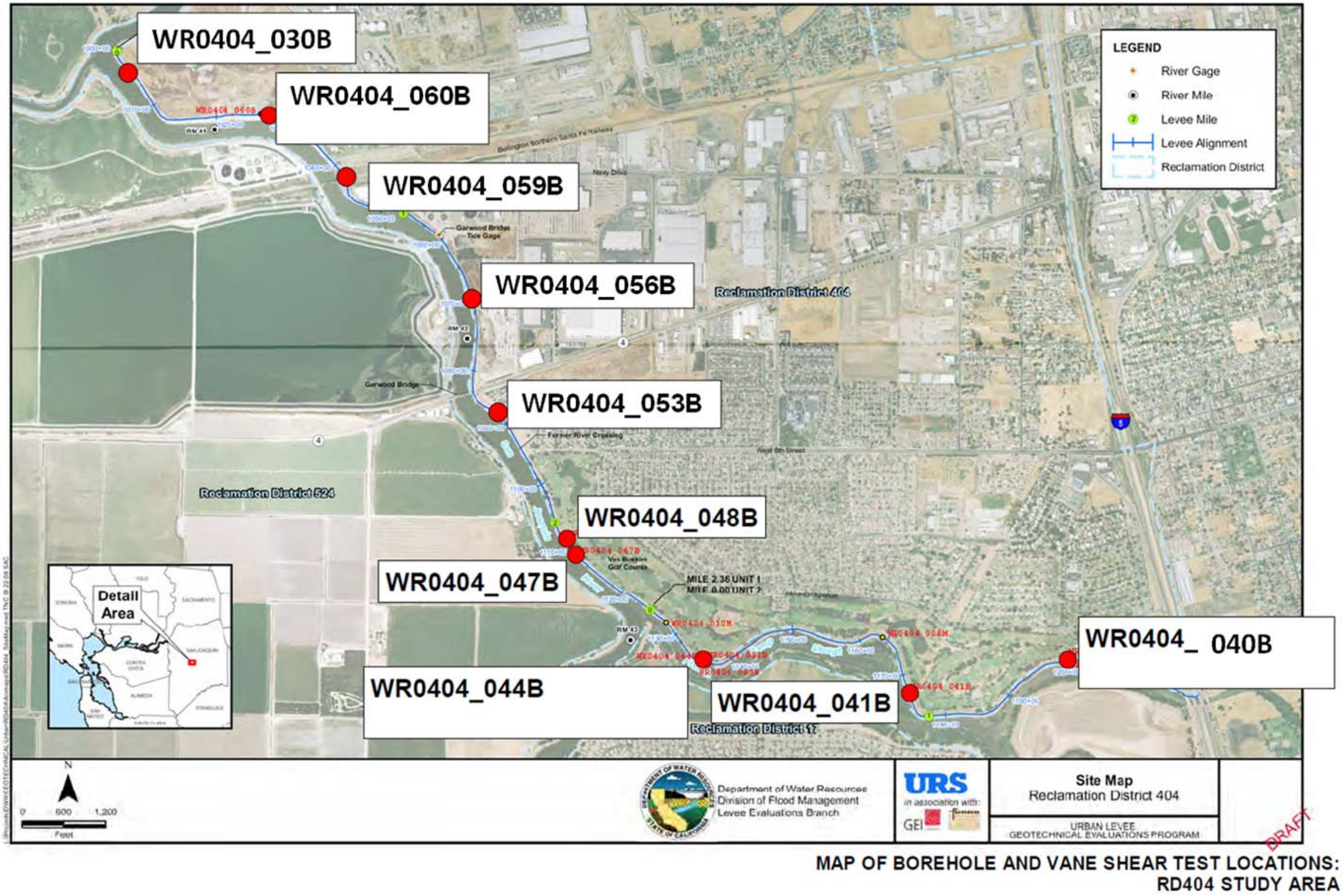


Plate 3. **RD 404.**

Plate 4. **Calaveras River, Stockton Diverting Canal** and **Mormon Slough**

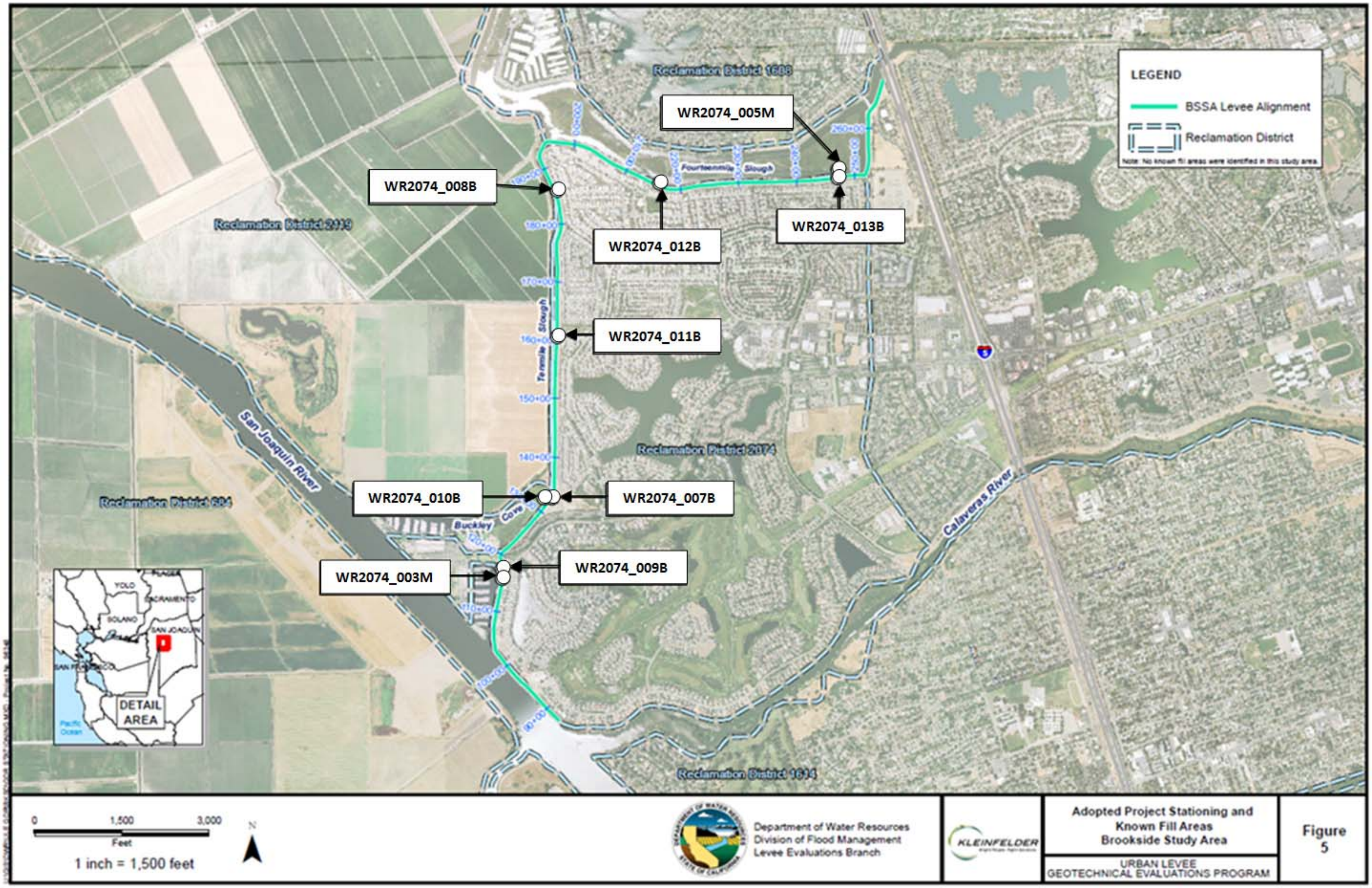


Plate 5. **Brookside**

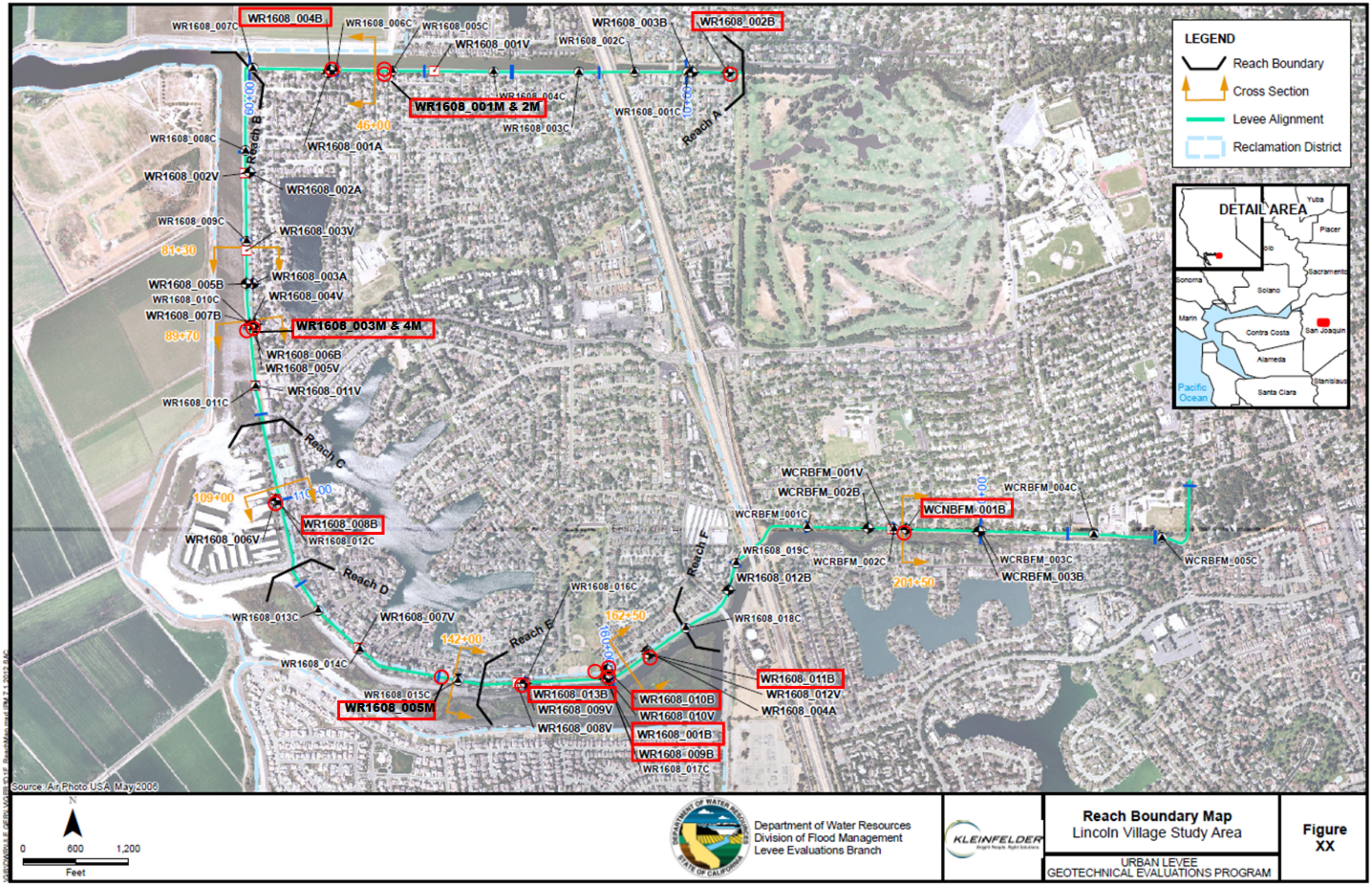
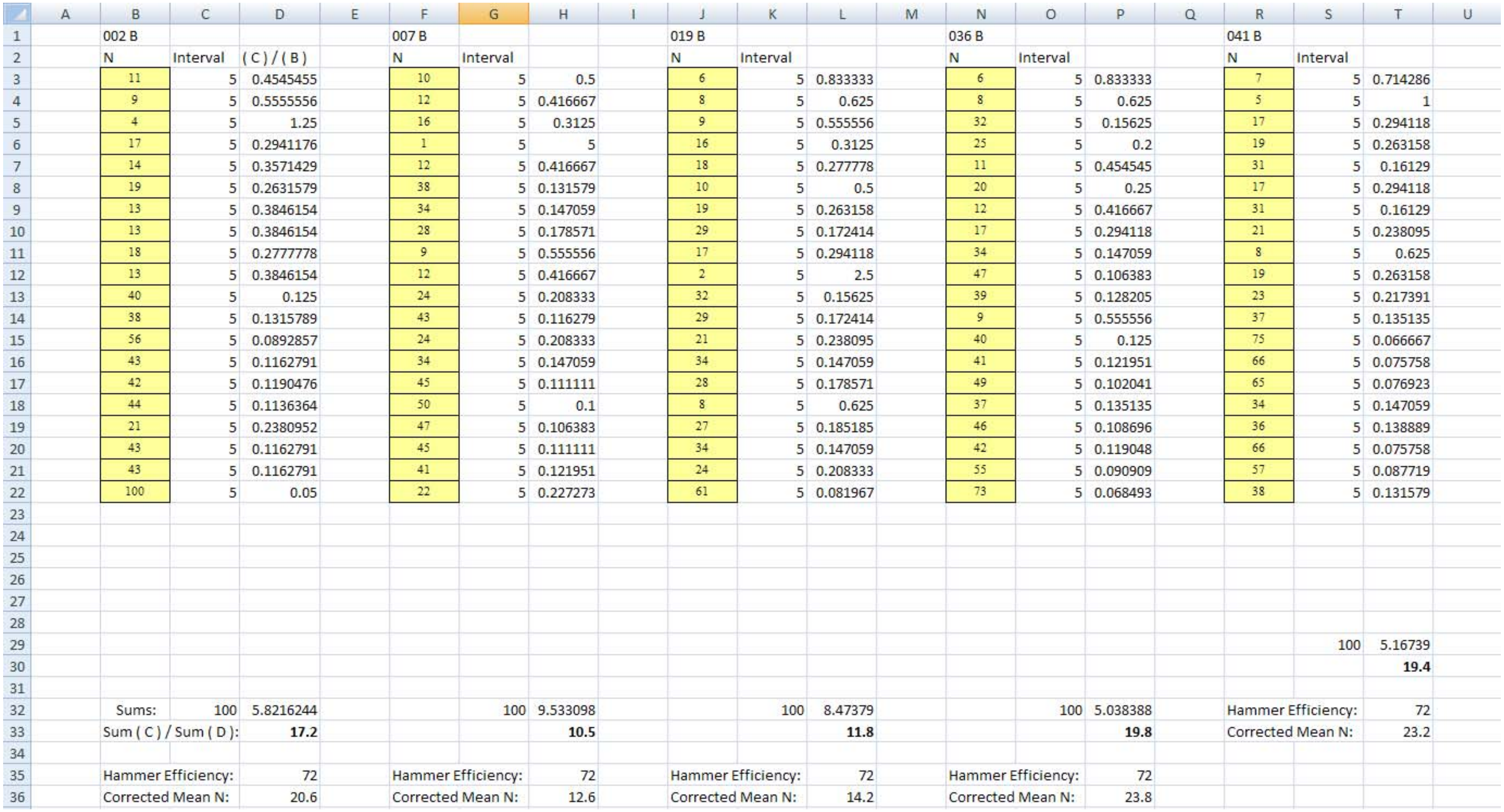


Plate 6. **Lincoln Village**

APPENDIX B

Evaluation of Weighted Harmonic Mean N (SPT)

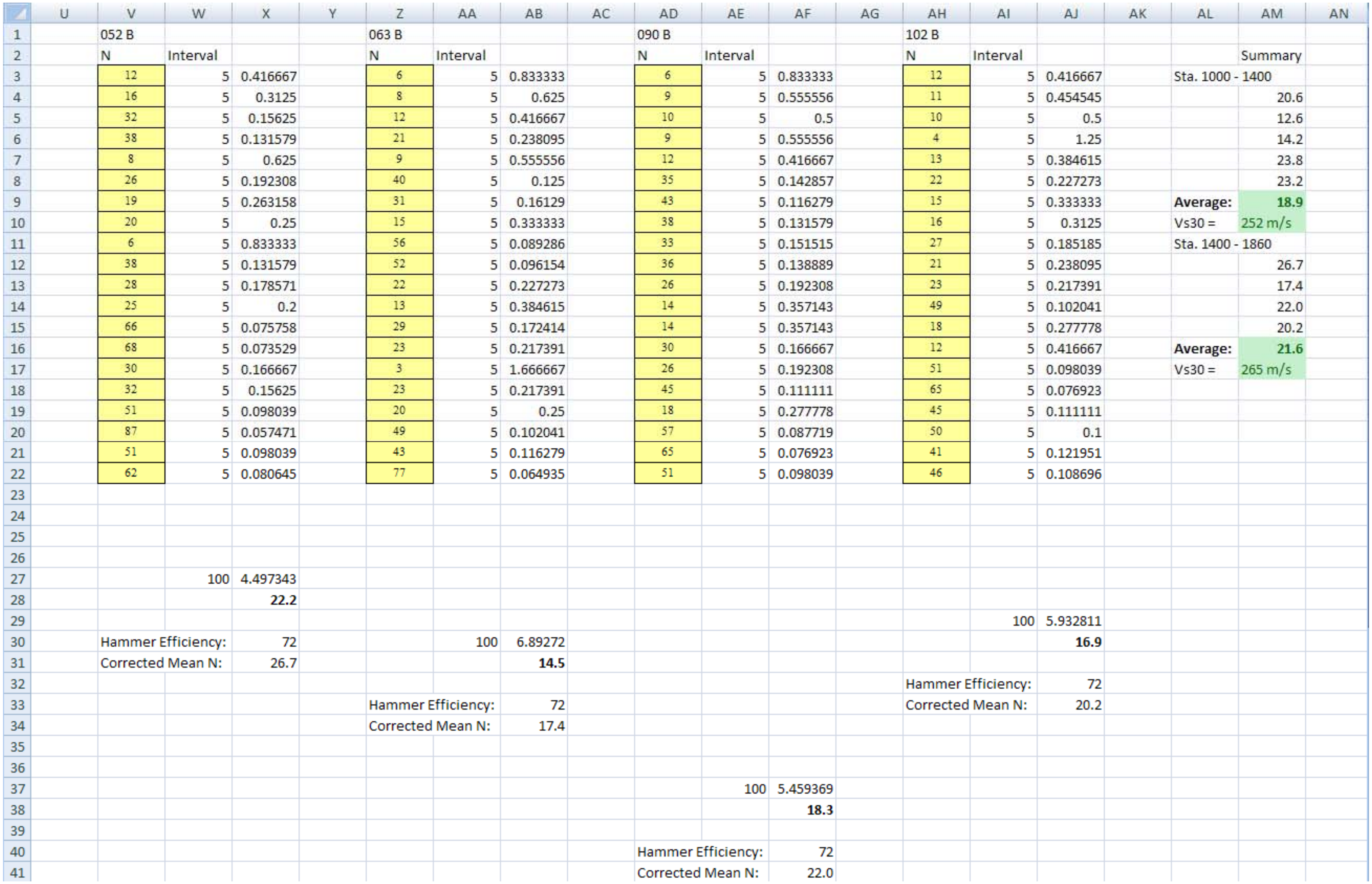
RD 17 – Northern part: Harmonic mean of N corrected for hammer efficiency (N60) for borings 100 feet deep.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1		002 B				007 B				019 B				036 B				041 B			
2		N	Interval	(C) / (B)		N	Interval			N	Interval			N	Interval			N	Interval		
3		11	5	0.4545455		10	5	0.5		6	5	0.833333		6	5	0.833333		7	5	0.714286	
4		9	5	0.5555556		12	5	0.416667		8	5	0.625		8	5	0.625		5	5	1	
5		4	5	1.25		16	5	0.3125		9	5	0.555556		32	5	0.15625		17	5	0.294118	
6		17	5	0.2941176		1	5	5		16	5	0.3125		25	5	0.2		19	5	0.263158	
7		14	5	0.3571429		12	5	0.416667		18	5	0.277778		11	5	0.454545		31	5	0.16129	
8		19	5	0.2631579		38	5	0.131579		10	5	0.5		20	5	0.25		17	5	0.294118	
9		13	5	0.3846154		34	5	0.147059		19	5	0.263158		12	5	0.416667		31	5	0.16129	
10		13	5	0.3846154		28	5	0.178571		29	5	0.172414		17	5	0.294118		21	5	0.238095	
11		18	5	0.2777778		9	5	0.555556		17	5	0.294118		34	5	0.147059		8	5	0.625	
12		13	5	0.3846154		12	5	0.416667		2	5	2.5		47	5	0.106383		19	5	0.263158	
13		40	5	0.125		24	5	0.208333		32	5	0.15625		39	5	0.128205		23	5	0.217391	
14		38	5	0.1315789		43	5	0.116279		29	5	0.172414		9	5	0.555556		37	5	0.135135	
15		56	5	0.0892857		24	5	0.208333		21	5	0.238095		40	5	0.125		75	5	0.066667	
16		43	5	0.1162791		34	5	0.147059		34	5	0.147059		41	5	0.121951		66	5	0.075758	
17		42	5	0.1190476		45	5	0.111111		28	5	0.178571		49	5	0.102041		65	5	0.076923	
18		44	5	0.1136364		50	5	0.1		8	5	0.625		37	5	0.135135		34	5	0.147059	
19		21	5	0.2380952		47	5	0.106383		27	5	0.185185		46	5	0.108696		36	5	0.138889	
20		43	5	0.1162791		45	5	0.111111		34	5	0.147059		42	5	0.119048		66	5	0.075758	
21		43	5	0.1162791		41	5	0.121951		24	5	0.208333		55	5	0.090909		57	5	0.087719	
22		100	5	0.05		22	5	0.227273		61	5	0.081967		73	5	0.068493		38	5	0.131579	
23																					
24																					
25																					
26																					
27																					
28																					
29																			100	5.16739	
30																				**19.4**	
31																					
32		Sums:	100	5.8216244			100	9.533098			100	8.47379			100	5.038388		Hammer Efficiency:		72	
33		Sum (C) / Sum (D):		**17.2**				**10.5**				**11.8**				**19.8**		Corrected Mean N:		23.2	
34																					
35		Hammer Efficiency:		72		Hammer Efficiency:		72		Hammer Efficiency:		72		Hammer Efficiency:		72					
36		Corrected Mean N:		20.6		Corrected Mean N:		12.6		Corrected Mean N:		14.2		Corrected Mean N:		23.8					

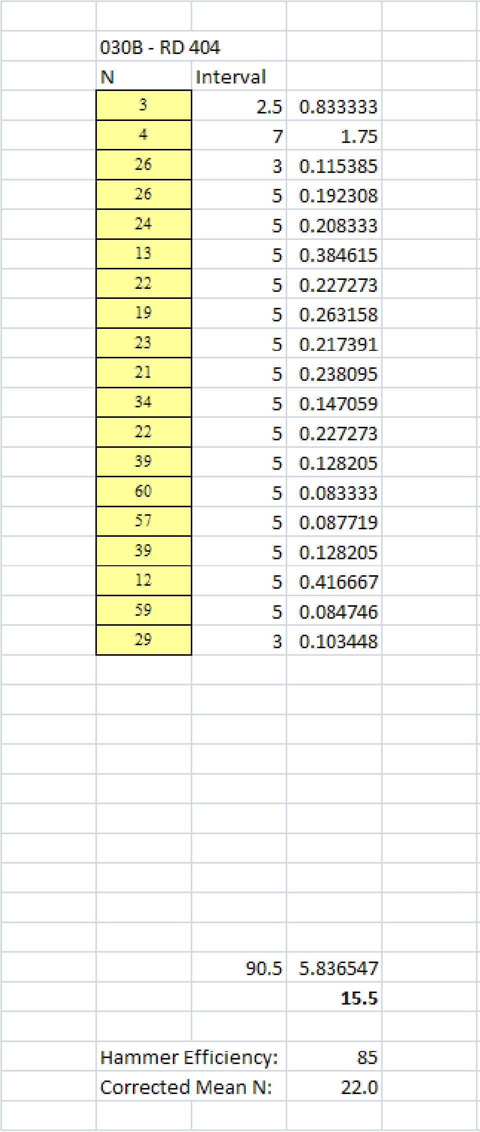
RD 17 – Southern part: Harmonic mean of N corrected for hammer efficiency (N60) for borings 100 feet deep.

Summary for both northern
and southern parts of RD 17



	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN
1		052 B				063 B				090 B				102 B						
2		N	Interval			N	Interval			N	Interval			N	Interval				Summary	
3		12	5	0.416667		6	5	0.833333		6	5	0.833333		12	5	0.416667		Sta. 1000 - 1400		
4		16	5	0.3125		8	5	0.625		9	5	0.555556		11	5	0.454545			20.6	
5		32	5	0.15625		12	5	0.416667		10	5	0.5		10	5	0.5			12.6	
6		38	5	0.131579		21	5	0.238095		9	5	0.555556		4	5	1.25			14.2	
7		8	5	0.625		9	5	0.555556		12	5	0.416667		13	5	0.384615			23.8	
8		26	5	0.192308		40	5	0.125		35	5	0.142857		22	5	0.227273			23.2	
9		19	5	0.263158		31	5	0.16129		43	5	0.116279		15	5	0.333333		**Average:**	**18.9**	
10		20	5	0.25		15	5	0.333333		38	5	0.131579		16	5	0.3125		Vs30 =	252 m/s	
11		6	5	0.833333		56	5	0.089286		33	5	0.151515		27	5	0.185185		Sta. 1400 - 1860		
12		38	5	0.131579		52	5	0.096154		36	5	0.138889		21	5	0.238095			26.7	
13		28	5	0.178571		22	5	0.227273		26	5	0.192308		23	5	0.217391			17.4	
14		25	5	0.2		13	5	0.384615		14	5	0.357143		49	5	0.102041			22.0	
15		66	5	0.075758		29	5	0.172414		14	5	0.357143		18	5	0.277778			20.2	
16		68	5	0.073529		23	5	0.217391		30	5	0.166667		12	5	0.416667		**Average:**	**21.6**	
17		30	5	0.166667		3	5	1.666667		26	5	0.192308		51	5	0.098039		Vs30 =	265 m/s	
18		32	5	0.15625		23	5	0.217391		45	5	0.111111		65	5	0.076923				
19		51	5	0.098039		20	5	0.25		18	5	0.277778		45	5	0.111111				
20		87	5	0.057471		49	5	0.102041		57	5	0.087719		50	5	0.1				
21		51	5	0.098039		43	5	0.116279		65	5	0.076923		41	5	0.121951				
22		62	5	0.080645		77	5	0.064935		51	5	0.098039		46	5	0.108696				
23																				
24																				
25																				
26																				
27			100	4.497343																
28				**22.2**																
29															100	5.932811				
30		Hammer Efficiency:		72			100	6.89272								**16.9**				
31		Corrected Mean N:		26.7				**14.5**												
32														Hammer Efficiency:		72				
33						Hammer Efficiency:		72						Corrected Mean N:		20.2				
34						Corrected Mean N:		17.4												
35																				
36																				
37											100	5.459369								
38												**18.3**								
39																				
40										Hammer Efficiency:		72								
41										Corrected Mean N:		22.0								

RD 404: Harmonic mean of N corrected for hammer efficiency (N60) for the only one available boring deeper than 100 feet.



030B - RD 404		
N	Interval	
3	2.5	0.833333
4	7	1.75
26	3	0.115385
26	5	0.192308
24	5	0.208333
13	5	0.384615
22	5	0.227273
19	5	0.263158
23	5	0.217391
21	5	0.238095
34	5	0.147059
22	5	0.227273
39	5	0.128205
60	5	0.083333
57	5	0.087719
39	5	0.128205
12	5	0.416667
59	5	0.084746
29	3	0.103448
	90.5	5.836547
		15.5
Hammer Efficiency:		85
Corrected Mean N:		22.0

APPENDIX C

Liquefaction Triggering Evaluation

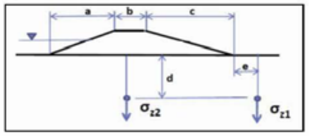
Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1506+19
Boring Number: WR0017_063B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	28.6 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	17.1 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	0.6 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	8.0 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	29.9 ft
Crest Width, b (ft)	21.0 ft
Landside/Downstream Slope, c (ft)	36.8 ft
Dist. of Boring from Levee Toe[1] (ft)	-47.3 ft
Embankment Height, H (ft)	11.5 ft

Boring WR0017_063B
Boring on the crest
SPT Ground Elevation Used in Analysis
28.60 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
1.0	27.6	10	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	15.3	1.55	1.03	17.3	n.a.	1.00	#N/A	1.00	0.72	#N/A	#N/A
6.0	22.6	25	SC	36	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	40.8	5.00	1.20	54.0	n.a.	0.99	#N/A	1.00	0.60	#N/A	#N/A
11.0	17.6	16	CL	94	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	20.7	5.00	1.20	29.8	n.a.	0.97	#N/A	1.00	0.67	#N/A	#N/A
13.5	15.1	6	SC	42	Unsaturated	120	125	1619.4	1619.4	1379.4	1620.0	1620.0	1.14	1	0.95	1.00	7.2	5.00	1.20	13.6	n.a.	0.97	0.14	1.00	0.80	1.00	#N/A
16.0	12.6	6	CL	94	Unsaturated	120	125	1913.8	1913.8	1373.8	1920.0	1920.0	1.05	1	0.95	1.00	7.2	5.00	1.20	13.6	n.a.	0.96	0.14	1.00	0.80	1.00	#N/A
21.0	7.6	8	CL	94	Clay	120	125	2476.6	2476.6	1336.6	1142.0	1117.0	0.92	1	0.95	1.00	n.a.	5.00	1.20	n.a.	2.00	0.95	0.14	1.00	0.60	1.00	#N/A
26.0	2.6	12	CL	94	Clay	120	125	3011.5	3011.5	1271.5	1767.0	1430.0	0.84	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.94	0.17	1.00	0.60	1.00	#N/A
31.0	-2.4	21	CL	94	Clay	120	125	3548.4	3361.2	1193.4	2392.0	1743.0	0.79	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.92	0.18	1.00	0.60	1.00	#N/A
36.0	-7.4	9	CL	94	Clay	120	125	4092.6	3593.4	1112.6	3017.0	2056.0	0.77	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.88	0.19	1.00	0.60	1.00	#N/A
42.5	-13.9	40	CL	94	Clay	120	125	4804.4	3899.6	1011.9	3829.5	2462.9	0.74	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.83	0.19	1.00	0.60	0.94	#N/A
46.0	-17.4	31	SC	22		120	125	5191.3	4068.1	961.3	4267.0	2682.0	0.72	1	1	1.00	26.8	3.93	1.09	33.3	2.00	0.80	0.19	1.00	0.62	0.91	3.00
51.0	-22.4	15	SC	20		120	125	5749.2	4314.0	894.2	4892.0	2995.0	0.70	1	1	1.00	12.6	3.61	1.08	17.2	0.18	0.76	0.18	1.00	0.74	0.91	1.39
56.0	-27.4	56	SC	20		120	125	6313.4	4566.2	833.4	5517.0	3308.0	0.68	1	1	1.00	45.7	3.61	1.08	53.0	2.00	0.72	0.18	1.00	0.60	0.84	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

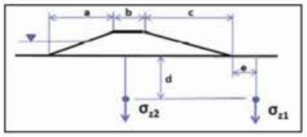
Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1553+82
Boring Number: WR0017_069B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	29.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	11.9 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	3.4 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	8.7 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	40.3 ft
Crest Width, b (ft)	21.0 ft
Landside/Downstream Slope, c (ft)	36.8 ft
Dist. of Boring from Levee Toe[1] (ft)	-47.3 ft
Embankment Height, H (ft)	17.5 ft

Boring WR0017_069B
Boring on the crest
SPT Ground Elevation Used in Analysis
29.40 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
1.0	28.4	31	SM	15	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	47.4	2.50	1.05	52.2	n.a.	1.00	#N/A	1.00	0.60	#N/A	#N/A
7.5	21.9	13	SP-SM	5	Unsaturated	120	125	900.0	900.0	0.0	Embankment	Embankment	1.53	1	0.85	1.00	20.3	0.00	1.00	20.3	n.a.	0.98	#N/A	1.00	0.67	#N/A	#N/A
12.5	16.9	5	SP	2	Unsaturated	120	125	1500.0	1500.0	0.0	Embankment	Embankment	1.19	1	0.85	1.00	6.1	0.00	1.00	6.1	n.a.	0.97	#N/A	1.00	0.80	#N/A	#N/A
18.0	11.4	7	ML	50	Unsaturated	120	125	2160.0	2160.0	2100.0	2160.0	2160.0	0.99	1	0.95	1.00	7.9	5.00	1.20	14.5	n.a.	0.96	0.14	1.00	0.79	1.00	#N/A
23.0	6.4	12	SM	19		120	125	2745.7	2745.7	2085.7	671.5	528.0	0.88	1	0.95	1.00	12.0	3.43	1.07	16.3	0.17	0.95	0.18	1.00	0.75	1.00	1.48
26.0	3.4	16	SP-SM	6		120	125	3075.8	3075.8	2055.8	1046.5	715.8	0.83	1	1	1.00	15.9	0.03	1.00	16.0	0.17	0.94	0.20	1.00	0.71	1.00	1.27
35.0	-5.6	13	SP-SM	6		120	125	4036.7	3475.1	1891.7	2171.5	1279.2	0.78	1	1	1.00	12.2	0.03	1.00	12.3	0.13	0.89	0.22	1.00	0.75	1.00	0.91
36.0	-6.6	9	ML	50		120	125	4139.9	3515.9	1869.9	2296.5	1341.8	0.78	1	1	1.00	8.4	5.00	1.20	15.1	0.16	0.88	0.22	1.00	0.79	1.00	1.09
44.5	-15.1	14	ML	50		120	125	5012.6	3858.2	1680.1	3359.0	1873.9	0.74	1	1	1.00	12.4	5.00	1.20	19.9	0.21	0.81	0.21	1.00	0.75	1.00	1.51
47.5	-18.1	17	SM	15		120	125	5322.3	3980.7	1614.8	3734.0	2061.7	0.73	1	1	1.00	14.9	2.50	1.05	18.1	0.19	0.79	0.21	1.00	0.72	1.00	1.39
55.0	-25.6	30	SM	26		120	125	6106.3	4296.7	1461.3	4671.5	2531.2	0.70	1	1	1.00	25.3	4.39	1.12	32.7	2.00	0.73	0.20	1.00	0.64	0.94	3.00
57.5	-28.1	58	SP	4		120	125	6371.3	4405.7	1413.8	4984.0	2687.7	0.69	1	1	1.00	48.2	0.00	1.00	48.2	2.00	0.71	0.19	1.00	0.60	0.91	3.00
65.0	-35.6	58	SM	27		120	125	7178.1	4744.5	1283.1	5921.5	3157.2	0.67	1	1	1.00	46.5	4.48	1.13	57.0	2.00	0.64	0.18	1.00	0.60	0.85	3.00
73.0	-43.6	16	CL		Clay	120	125	8057.1	5124.3	1162.1	6921.5	3658.0	0.64	1	1	1.00	n.a.	0.00	1.00	n.a.	2.00	0.58	0.16	1.00	0.60	0.80	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

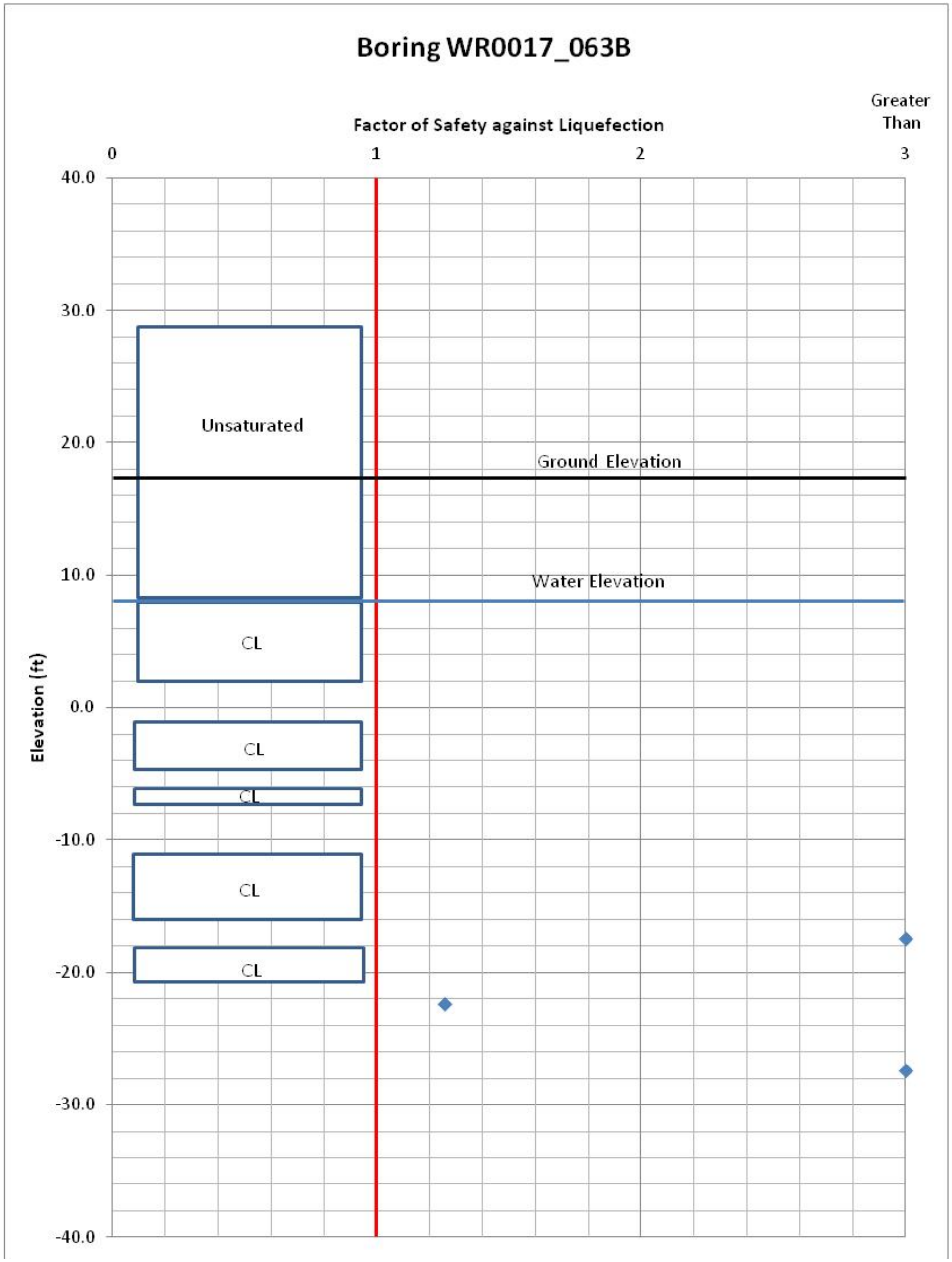


Fig. C-1. RD 17 South, Station 1506+19

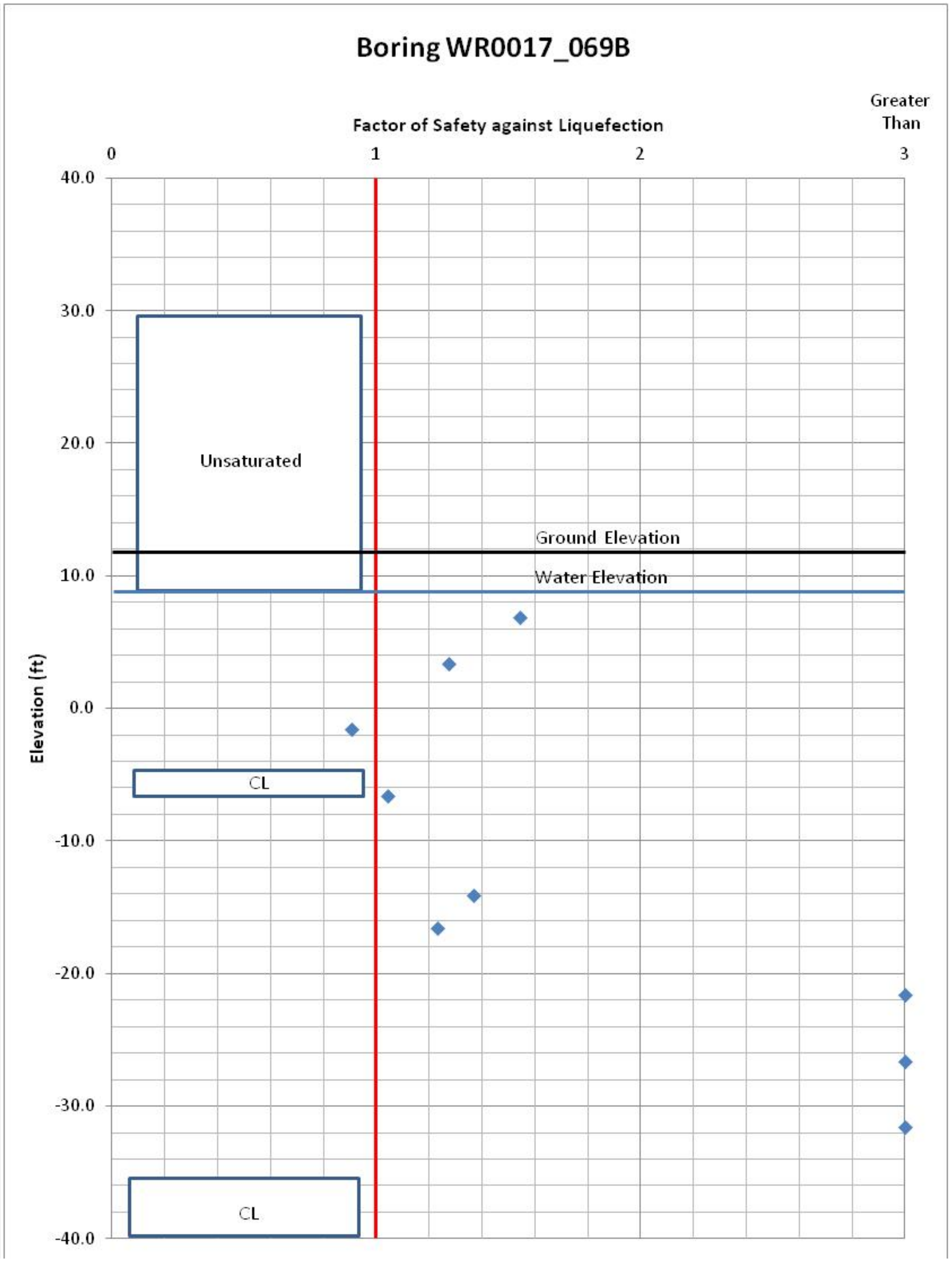


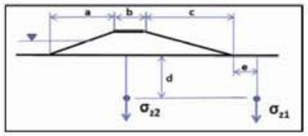
Fig. C-2. RD 17 South, Station 1553+82

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1595+33
Boring Number: WR0017_074B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	29.9 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	19.9 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	4.4 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	7.7 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	35.0 ft
Crest Width, b (ft)	18.0 ft
Landside/Downstream Slope, c (ft)	43.0 ft
Dist. of Boring from Levee Toe[1] (ft)	-52.0 ft
Embankment Height, H (ft)	10.0 ft

Boring **WR0017_074B**
Boring on the crest
SPT Ground Elevation Used in Analysis
29.90 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
4.0	25.9	30	CL	94	Unsaturated	120	125	480.0	480.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	49.0	5.00	1.20	63.8	n.a.	0.99	#N/A	1.00	0.60	#N/A	#N/A
6.0	23.9	12	SP	4	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	19.6	0.00	1.00	19.6	n.a.	0.99	#N/A	1.00	0.68	#N/A	#N/A
12.0	17.9	6	ML	65	Unsaturated	120	125	1439.4	1439.4	1199.4	1440.0	1440.0	1.21	1	0.85	1.00	7.4	5.00	1.20	13.9	n.a.	0.97	0.14	1.00	0.80	1.00	#N/A
20.0	9.9	6	CL	94	Unsaturated	120	125	2354.2	2354.2	1154.2	2400.0	2400.0	0.95	1	0.95	1.00	6.5	5.00	1.20	12.8	n.a.	0.95	0.14	1.00	0.80	0.98	#N/A
23.0	6.9	7	SP-SM	12		120	125	2680.9	2680.9	1120.9	1564.0	1514.1	0.89	1	0.95	1.00	7.1	1.55	1.03	8.9	0.10	0.95	0.14	1.00	0.80	1.00	1.08
26.0	3.9	5	SP-SM	11		120	125	3005.7	2974.5	1083.2	1939.0	1701.9	0.84	1	1	1.00	5.1	1.21	1.03	6.4	0.08	0.94	0.16	1.00	0.80	1.00	0.79
32.0	-2.1	10	SP-SM	11		120	125	3675.7	3270.1	1003.2	2689.0	2077.5	0.80	1	1	1.00	9.7	1.21	1.03	11.1	0.12	0.91	0.17	1.00	0.77	1.00	1.07
36.0	-6.1	13	SC	14		120	125	4122.5	3467.3	950.0	3189.0	2327.9	0.78	1	1	1.00	12.2	2.20	1.04	14.9	0.16	0.88	0.18	1.00	0.75	0.98	1.32
42.5	-12.6	12	SC	13		120	125	4853.2	3792.4	868.2	4001.5	2734.8	0.75	1	1	1.00	10.8	1.89	1.04	13.0	0.14	0.83	0.18	1.00	0.76	0.94	1.12
47.5	-17.6	11	SW-SC	11		120	125	5420.4	4047.6	810.4	4626.5	3047.8	0.72	1	1	1.00	9.5	1.21	1.03	11.0	0.12	0.79	0.17	1.00	0.77	0.92	0.97
51.0	-21.1	41	SW	4		120	125	5820.3	4229.1	772.8	5064.0	3266.9	0.71	1	1	1.00	34.8	0.00	1.00	34.8	2.00	0.76	0.17	1.00	0.60	0.84	3.00
57.5	-27.6	30	SC	13		120	125	6569.1	4572.3	709.1	5876.5	3673.8	0.68	1	1	1.00	24.5	1.89	1.04	27.3	0.35	0.71	0.17	1.00	0.64	0.82	2.58
61.0	-31.1	39	SC	13		120	125	6975.5	4760.3	678.0	6314.0	3892.9	0.67	1	1	1.00	31.2	1.89	1.04	34.2	2.00	0.68	0.16	1.00	0.60	0.78	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

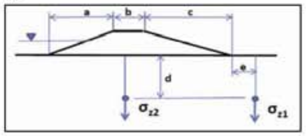
Updated April 2013

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1642+75
Boring Number: WR0017_080B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	30.6 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	18.6 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	6.1 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	7.5 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	36.0 ft
Crest Width, b (ft)	17.0 ft
Landside/Downstream Slope, c (ft)	40.8 ft
Dist. of Boring from Levee Toe[1] (ft)	-49.3 ft
Embankment Height, H (ft)	12.0 ft

Boring **WR0017_080B**
Boring on the crest
SPT Ground Elevation Used in Analysis
30.60 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
1.0	29.6	13	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	19.9	1.55	1.03	22.1	n.a.	1.00	#N/A	1.00	0.68	#N/A	#N/A
7.5	23.1	8	SP	1	Unsaturated	120	125	900.0	900.0	0.0	Embankment	Embankment	1.53	1	0.85	1.00	12.5	0.00	1.00	12.5	n.a.	0.98	#N/A	1.00	0.74	#N/A	#N/A
11.0	19.6	5	ML	50	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	6.5	5.00	1.20	12.7	n.a.	0.97	#N/A	1.00	0.80	#N/A	#N/A
16.0	14.6	6	CL	94	Unsaturated	120	125	1914.0	1914.0	1434.0	1920.0	1920.0	1.05	1	0.95	1.00	7.2	5.00	1.20	13.6	n.a.	0.96	0.14	1.00	0.80	1.00	#N/A
21.0	9.6	8	SP-SM	8	Unsaturated	120	125	2472.7	2472.7	1392.7	2520.0	2520.0	0.93	1	0.95	1.00	8.4	0.30	1.01	8.8	n.a.	0.95	0.14	1.00	0.79	0.96	#N/A
26.0	4.6	9	SM	17		120	125	3010.4	2916.8	1322.9	1694.5	1513.5	0.85	1	1	1.00	9.2	3.01	1.06	12.8	0.14	0.94	0.15	1.00	0.78	1.00	1.35
31.0	-0.4	18	SM	26		120	125	3554.4	3148.8	1241.9	2319.5	1826.5	0.82	1	1	1.00	17.7	4.39	1.12	24.3	0.28	0.92	0.17	1.00	0.69	1.00	2.44
36.0	-5.4	13	CL	94	Clay	120	125	4097.0	3379.4	1159.5	2944.5	2139.5	0.79	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.88	0.18	1.00	0.60	1.00	#N/A
41.0	-10.4	39	SP-SM	11		120	125	4642.7	3613.1	1080.2	3569.5	2452.5	0.77	1	1	1.00	35.8	1.21	1.03	38.0	2.00	0.84	0.18	1.00	0.60	0.94	3.00
47.5	-16.9	53	SP-SM	11		120	125	5359.9	3924.7	984.9	4382.0	2859.4	0.73	1	1	1.00	46.7	1.21	1.03	49.1	2.00	0.79	0.18	1.00	0.60	0.89	3.00
51.0	-20.4	44	SW	4		120	125	5750.4	4096.8	937.9	4819.5	3078.5	0.72	1	1	1.00	37.9	0.00	1.00	37.9	2.00	0.76	0.17	1.00	0.60	0.86	3.00
56.0	-25.4	65	SP	4		120	125	6313.3	4347.7	875.8	5444.5	3391.5	0.70	1	1	1.00	54.4	0.00	1.00	54.4	2.00	0.72	0.17	1.00	0.60	0.83	3.00
60.0	-29.4	59	SP	4		120	125	6767.8	4552.6	830.3	5944.5	3641.9	0.68	1	1	1.00	48.3	0.00	1.00	48.3	2.00	0.69	0.16	1.00	0.60	0.80	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

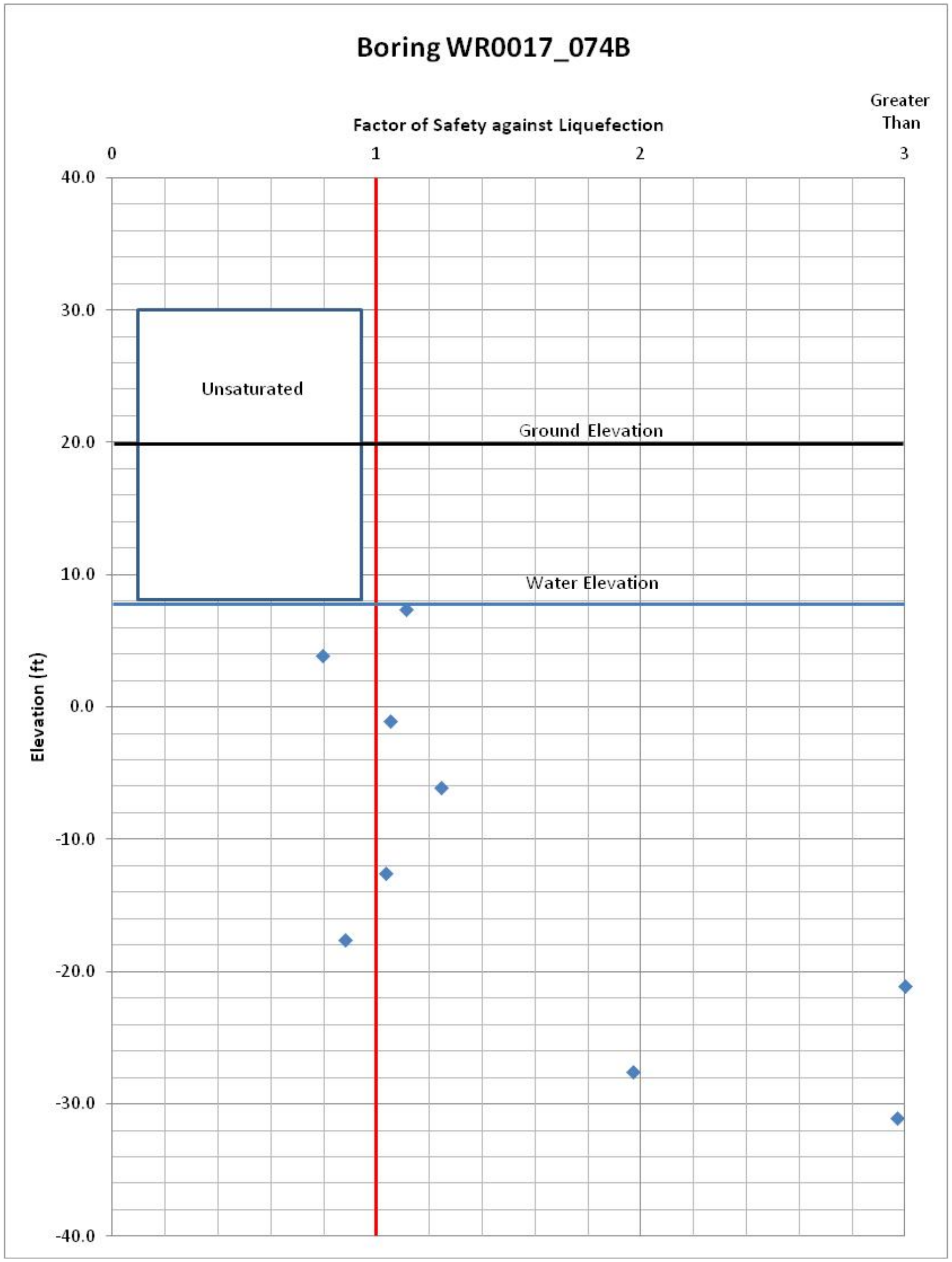


Fig. C-3. RD 17 South, Station 1595+33

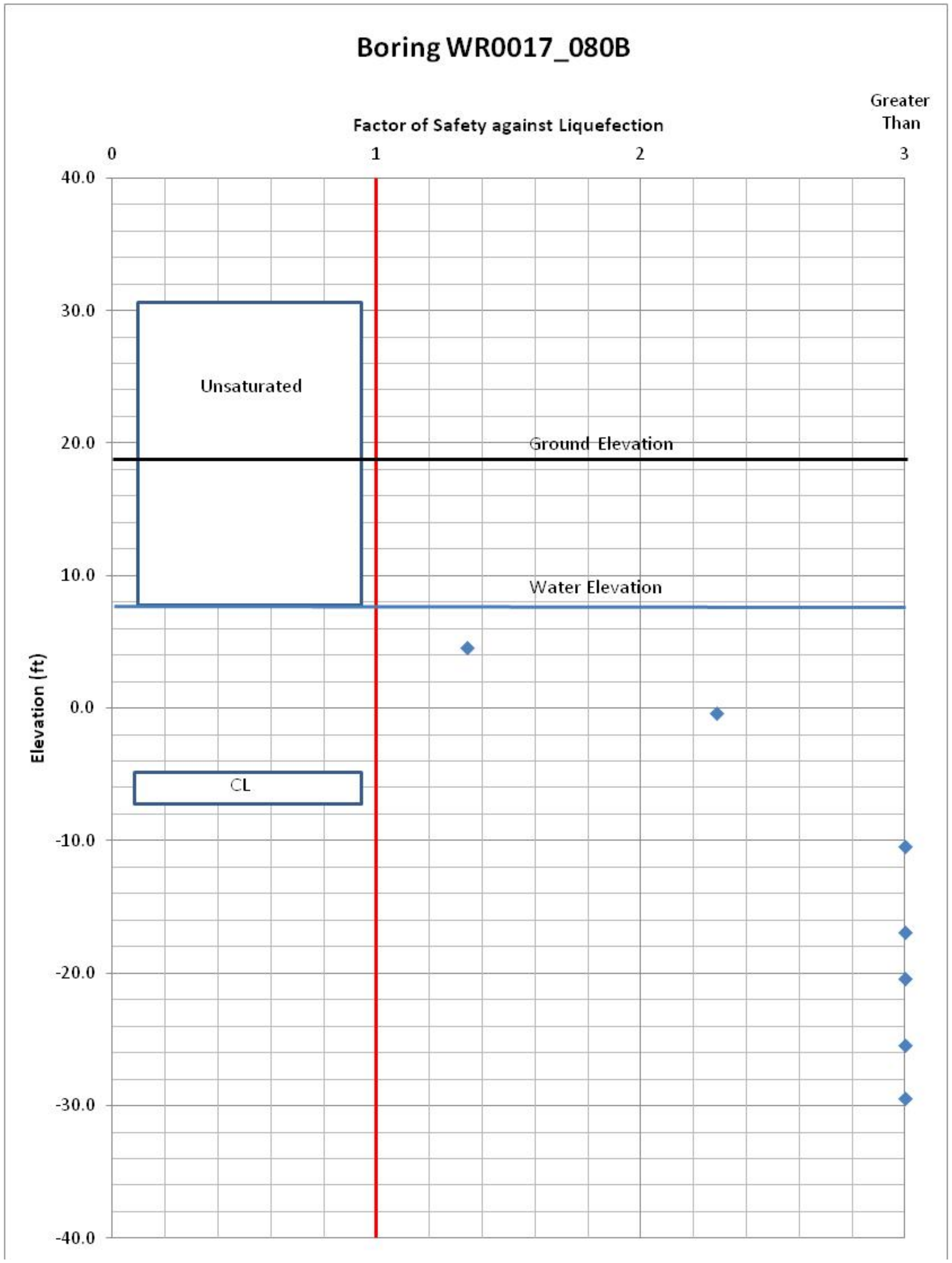


Fig. C-4. RD 17 South, Station 1642+75

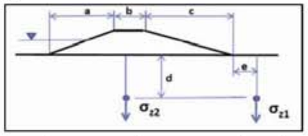
Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1684+57
Boring Number: WR0017_085B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	31.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	18.9 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	4.9 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	7.4 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	42.5 ft
Crest Width, b (ft)	18.0 ft
Landside/Downstream Slope, c (ft)	30.0 ft
Dist. of Boring from Levee Toe[1] (ft)	-39.0 ft
Embankment Height, H (ft)	12.5 ft

Boring WR0017_085B
Boring on the crest
SPT Ground Elevation Used in Analysis
31.40 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
1.0	30.4	24	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	36.7	1.55	1.03	39.4	n.a.	1.00	#N/A	1.00	0.60	#N/A	#N/A
7.5	23.9	26	SM	31	Unsaturated	120	125	900.0	900.0	0.0	Embankment	Embankment	1.53	1	0.85	1.00	40.7	4.77	1.16	52.0	n.a.	0.98	#N/A	1.00	0.60	#N/A	#N/A
11.0	20.4	24	SP	20	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	31.0	3.61	1.08	37.1	n.a.	0.97	#N/A	1.00	0.60	#N/A	#N/A
17.5	13.9	9	CL	94	Unsaturated	120	125	2088.8	2088.8	1488.8	2100.0	2100.0	1.01	1	0.95	1.00	10.3	5.00	1.20	17.4	n.a.	0.96	0.14	1.00	0.77	1.00	#N/A
22.5	8.9	13	SP-SC	8	Unsaturated	120	125	2638.0	2638.0	1438.0	2700.0	2700.0	0.90	1	0.95	1.00	13.3	0.30	1.01	13.7	n.a.	0.95	0.14	1.00	0.74	0.94	#N/A
26.0	5.4	13	SM	21		120	125	3005.0	3005.0	1385.0	1630.0	1505.2	0.84	1	1	1.00	13.1	3.78	1.09	18.0	0.19	0.94	0.15	1.00	0.74	1.00	1.93
31.0	0.4	10	ML	63		120	125	3541.2	3260.4	1298.7	2255.0	1818.2	0.81	1	1	1.00	9.7	5.00	1.20	16.6	0.18	0.92	0.17	1.00	0.77	1.00	1.58
36.0	-4.6	28	SM	15		120	125	4077.7	3484.9	1210.2	2880.0	2131.2	0.78	1	1	1.00	26.2	2.50	1.05	29.9	0.46	0.88	0.17	1.00	0.63	1.00	3.00
42.5	-11.1	40	SW-SC	6		120	125	4780.4	3782.0	1100.4	3692.5	2538.1	0.75	1	1	1.00	35.9	0.03	1.00	36.1	2.00	0.83	0.18	1.00	0.60	0.93	3.00
46.0	-14.6	35	SM	15		120	125	5163.0	3946.2	1045.5	4130.0	2757.2	0.73	1	1	1.00	30.8	2.50	1.05	34.7	2.00	0.80	0.18	1.00	0.60	0.90	3.00
51.0	-19.6	37	SM	15		120	125	5715.3	4186.5	972.8	4755.0	3070.2	0.71	1	1	1.00	31.6	2.50	1.05	35.6	2.00	0.76	0.17	1.00	0.60	0.86	3.00
56.0	-24.6	31	SP	4		120	125	6274.3	4433.5	906.8	5380.0	3383.2	0.69	1	1	1.00	25.7	0.00	1.00	25.7	0.31	0.72	0.17	1.00	0.63	0.84	2.32
62.5	-31.1	43	SW	4		120	125	7010.6	4764.2	830.6	6192.5	3790.1	0.67	1	1	1.00	34.4	0.00	1.00	34.4	2.00	0.67	0.16	1.00	0.60	0.79	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

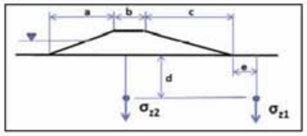
Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1724+68
Boring Number: WR0017_090B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	32.1 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	15.1 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	5.1 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	7.1 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	54.4 ft
Crest Width, b (ft)	20.0 ft
Landside/Downstream Slope, c (ft)	40.8 ft
Dist. of Boring from Levee Toe[1] (ft)	-50.8 ft
Embankment Height, H (ft)	17.0 ft

Boring WR0017_090B
Boring on the crest
SPT Ground Elevation Used in Analysis
32.10 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
1.0	31.1	14	ML	50	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	21.4	5.00	1.20	30.7	n.a.	1.00	#N/A	1.00	0.67	#N/A	#N/A
7.5	24.6	6	CL/SC	51	Unsaturated	120	125	900.0	900.0	0.0	Embankment	Embankment	1.53	1	0.85	1.00	9.4	5.00	1.20	16.3	n.a.	0.98	#N/A	1.00	0.78	#N/A	#N/A
11.0	21.1	6	CL	94	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	7.7	5.00	1.20	14.3	n.a.	0.97	#N/A	1.00	0.79	#N/A	#N/A
16.0	16.1	9	ML	50	Unsaturated	120	125	1920.0	1920.0	0.0	Embankment	Embankment	1.05	1	0.95	1.00	10.8	5.00	1.20	17.9	n.a.	0.96	#N/A	1.00	0.76	#N/A	#N/A
23.5	8.6	10	CL	94	Unsaturated	120	125	2800.3	2800.3	2020.3	2820.0	2820.0	0.87	1	0.95	1.00	9.9	5.00	1.20	16.9	n.a.	0.95	0.14	1.00	0.77	0.94	#N/A
26.0	6.1	9	ML	74		120	125	3075.6	3075.6	1995.6	1085.0	1022.6	0.83	1	1	1.00	9.0	5.00	1.20	15.7	0.17	0.94	0.15	1.00	0.78	1.00	1.73
31.0	1.1	12	SM/ML	46		120	125	3622.8	3373.2	1922.8	1710.0	1335.6	0.79	1	1	1.00	11.4	5.00	1.20	18.7	0.20	0.92	0.17	1.00	0.76	1.00	1.74
36.0	-3.9	35	SP-SC	6		120	125	4157.7	3596.1	1832.7	2335.0	1648.6	0.77	1	1	1.00	32.2	0.03	1.00	32.4	2.00	0.88	0.18	1.00	0.60	1.00	3.00
41.0	-8.9	43	SM/ML	18		120	125	4686.5	3812.9	1736.5	2960.0	1961.6	0.74	1	1	1.00	38.4	3.23	1.07	44.2	2.00	0.84	0.19	1.00	0.60	1.00	3.00
46.0	-13.9	38	SP	4		120	125	5215.4	4029.8	1640.4	3585.0	2274.6	0.72	1	1	1.00	33.0	0.00	1.00	33.0	2.00	0.80	0.18	1.00	0.60	0.97	3.00
51.0	-18.9	33	SP	4		120	125	5747.5	4249.9	1547.5	4210.0	2587.6	0.71	1	1	1.00	27.9	0.00	1.00	27.9	0.37	0.76	0.18	1.00	0.62	0.93	2.83
56.0	-23.9	36	SP-SM	6		120	125	6284.6	4475.0	1459.6	4835.0	2900.6	0.69	1	1	1.00	29.7	0.03	1.00	29.9	0.46	0.72	0.18	1.00	0.60	0.88	3.00
61.0	-28.9	26	SP-SM	6		120	125	6827.4	4705.8	1377.4	5460.0	3213.6	0.67	1	1	1.00	20.9	0.03	1.00	21.0	0.23	0.68	0.17	1.00	0.67	0.87	1.78

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

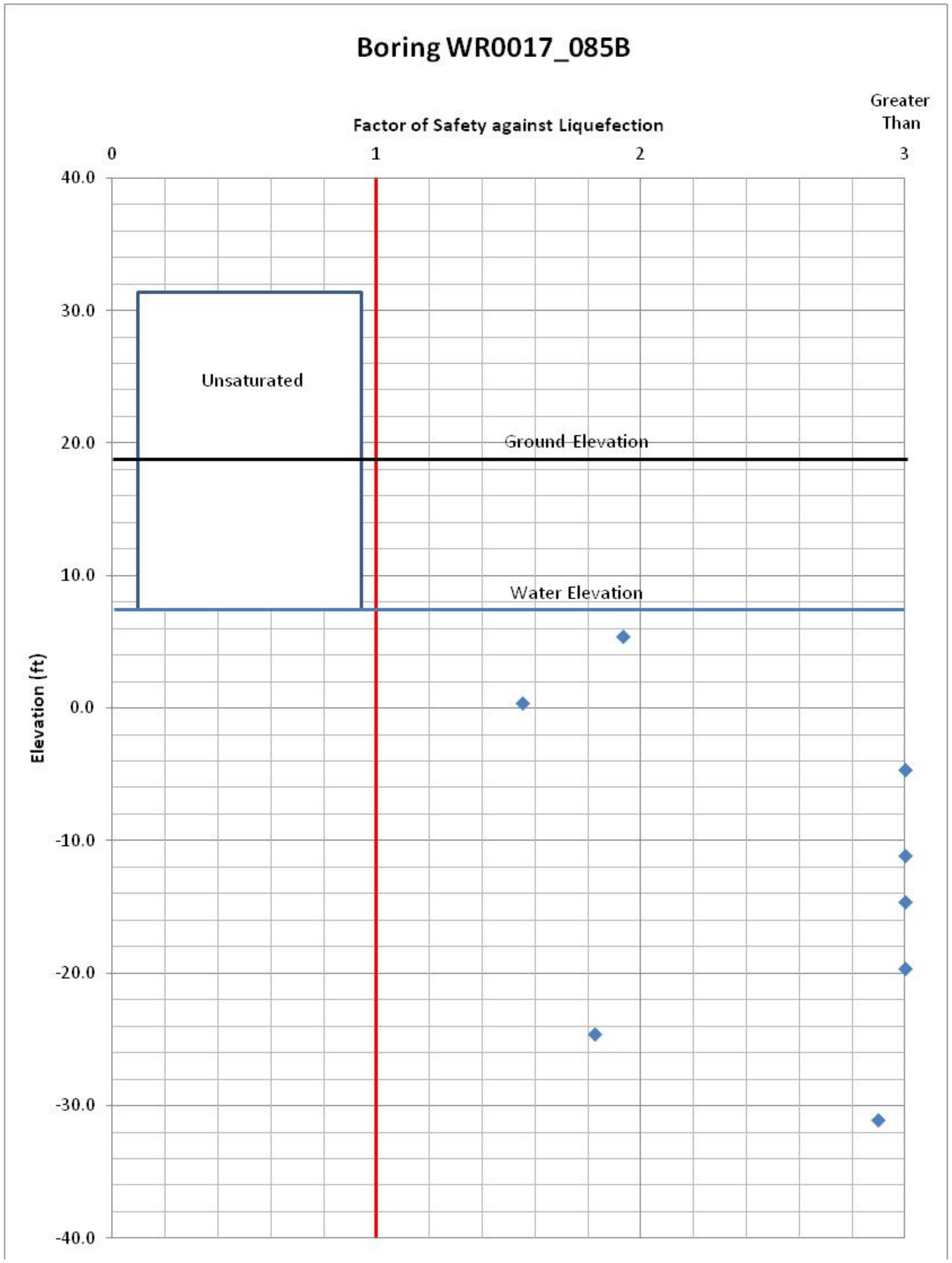


Fig. C-5. RD 17 South, Station 1684+57

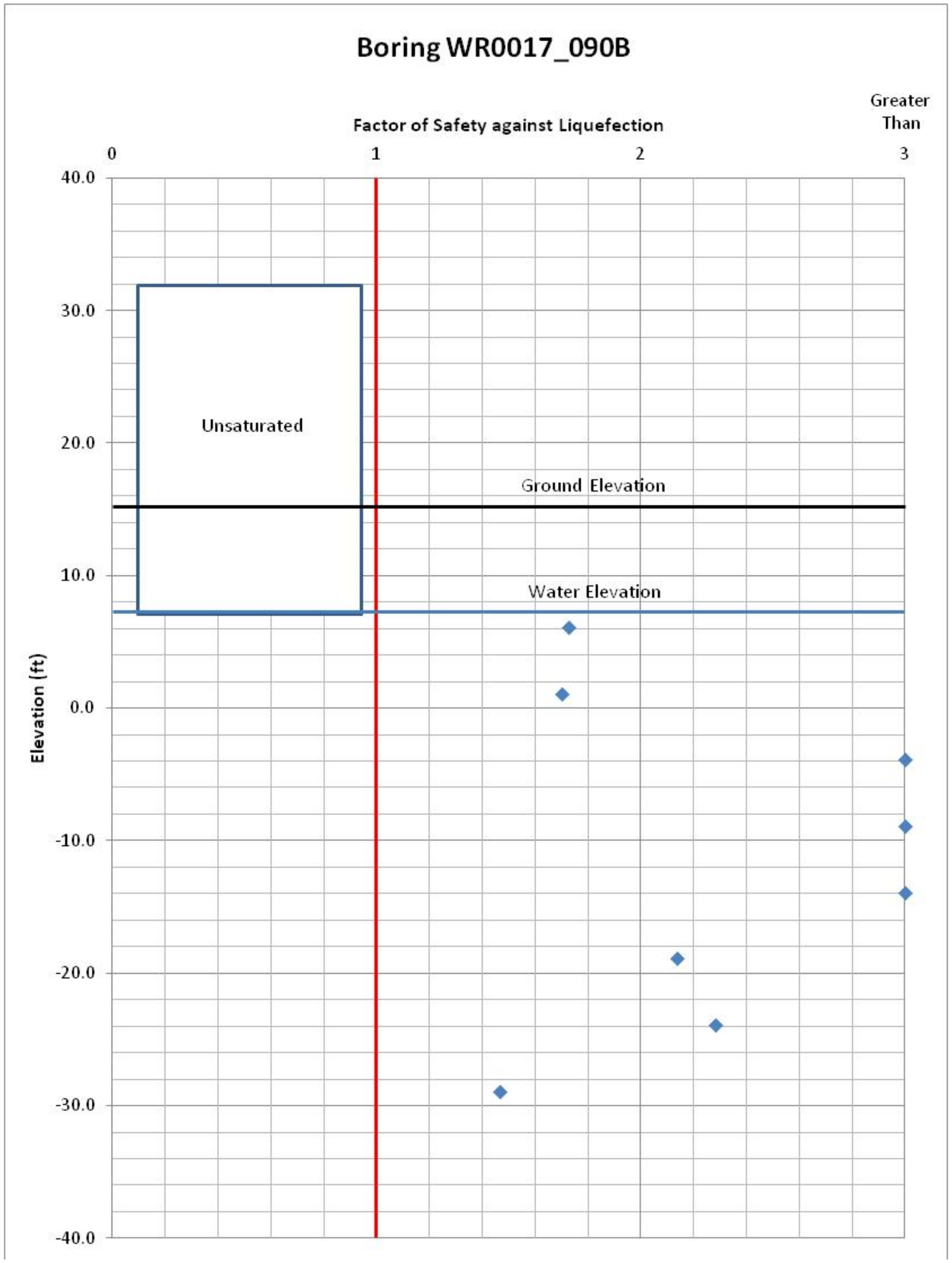


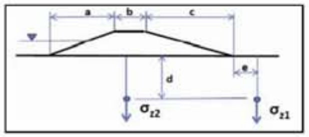
Fig. C-6. RD 17 South, Station 1724+68

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1784+83
Boring Number: WR0017_096B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	32.8 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	19.3 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	3.8 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	6.8 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	47.3 ft
Crest Width, b (ft)	18.0 ft
Landside/Downstream Slope, c (ft)	41.9 ft
Dist. of Boring from Levee Toe[1] (ft)	-50.9 ft
Embankment Height, H (ft)	13.5 ft

Boring **WR0017_096B**
Boring on the crest
SPT Ground Elevation Used in Analysis
32.80 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_σ	f parameter	K_α	FS against Liquefaction
1.0	31.8	8	SP-SM	8	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	12.2	0.30	1.01	12.7	n.a.	1.00	#N/A	1.00	0.75	#N/A	#N/A
6.0	26.8	19	SP-SM	6	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	31.0	0.03	1.00	31.2	n.a.	0.99	#N/A	1.00	0.60	#N/A	#N/A
11.0	21.8	5	SP-SC	12	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	6.5	1.55	1.03	8.2	n.a.	0.97	#N/A	1.00	0.80	#N/A	#N/A
16.0	16.8	6	SC	20	Unsaturated	120	125	1918.6	1918.6	1618.6	1920.0	1920.0	1.05	1	0.95	1.00	6.6	3.61	1.08	10.7	n.a.	0.96	0.14	1.00	0.80	1.00	#N/A
23.5	9.3	3	CL	94	Unsaturated	120	125	2765.6	2765.6	1565.6	2820.0	2820.0	0.87	1	0.95	1.00	3.0	5.00	1.20	8.6	n.a.	0.95	0.14	1.00	0.80	0.94	#N/A
28.5	4.3	9	SC	16		120	125	3295.8	3295.8	1495.8	1812.5	1656.5	0.80	1	1	1.00	8.7	2.77	1.05	11.9	0.13	0.93	0.15	1.00	0.78	1.00	1.31
31.0	1.8	9	SC	16		120	125	3566.3	3441.5	1456.3	2125.0	1813.0	0.78	1	1	1.00	8.5	2.77	1.05	11.7	0.13	0.92	0.16	1.00	0.79	1.00	1.22
36.0	-3.2	17	SC	16		120	125	4109.3	3672.5	1374.3	2750.0	2126.0	0.76	1	1	1.00	15.5	2.77	1.05	19.1	0.20	0.88	0.17	1.00	0.72	1.00	1.84
41.0	-8.2	17	SC	16		120	125	4652.6	3903.8	1292.6	3375.0	2439.0	0.74	1	1	1.00	15.0	2.77	1.05	18.6	0.20	0.84	0.17	1.00	0.72	0.96	1.68
46.0	-13.2	23	SC	16		120	125	5199.0	4138.2	1214.0	4000.0	2752.0	0.72	1	1	1.00	19.7	2.77	1.05	23.6	0.27	0.80	0.17	1.00	0.68	0.92	2.16
51.0	-18.2	48	SP-SM	11		120	125	5750.1	4377.3	1140.1	4625.0	3065.0	0.70	1	1	1.00	40.0	1.21	1.03	42.3	2.00	0.76	0.17	1.00	0.60	0.86	3.00
56.0	-23.2	56	SW-SM	12		120	125	6306.4	4621.6	1071.4	5250.0	3378.0	0.68	1	1	1.00	45.5	1.55	1.03	48.5	2.00	0.72	0.16	1.00	0.60	0.83	3.00
61.0	-28.2	63	SP	4		120	125	6868.1	4871.3	1008.1	5875.0	3691.0	0.66	1	1	1.00	49.8	0.00	1.00	49.8	2.00	0.68	0.16	1.00	0.60	0.80	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method, answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

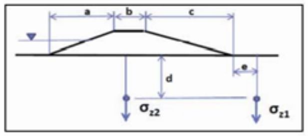
Updated April 2013

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1825+94
Boring Number: WR0017_102B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	34.5 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	14.0 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	5.9 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	6.8 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	34.9 ft
Crest Width, b (ft)	13.0 ft
Landside/Downstream Slope, c (ft)	43.1 ft
Dist. of Boring from Levee Toe[1] (ft)	-49.6 ft
Embankment Height, H (ft)	20.5 ft

Boring **WR0017_102B**
Boring on the crest
SPT Ground Elevation Used in Analysis
34.50 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_σ	f parameter	K_α	FS against Liquefaction
1.0	33.5	10	SC	42	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	15.3	5.00	1.20	23.4	n.a.	1.00	#N/A	1.00	0.72	#N/A	#N/A
6.0	28.5	4	ML	50	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	6.5	5.00	1.20	12.8	n.a.	0.99	#N/A	1.00	0.80	#N/A	#N/A
11.0	23.5	5	CL	94	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	6.5	5.00	1.20	12.7	n.a.	0.97	#N/A	1.00	0.80	#N/A	#N/A
18.5	16.0	7	CL	94	Unsaturated	120	125	2220.0	2220.0	0.0	Embankment	Embankment	0.98	1	0.95	1.00	7.3	5.00	1.20	13.8	n.a.	0.96	#N/A	1.00	0.80	#N/A	#N/A
23.5	11.0	11	CL	94	Unsaturated	120	125	2812.5	2812.5	2452.5	2820.0	2820.0	0.87	1	0.95	1.00	10.9	5.00	1.20	18.1	n.a.	0.95	0.14	1.00	0.76	0.93	#N/A
33.5	1.0	10	CL	94	Clay	120	125	3822.8	3517.1	2238.3	1589.0	1227.1	0.78	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.90	0.17	1.00	0.60	1.00	#N/A
36.0	-1.5	4	CL	94	Clay	120	125	4060.7	3599.0	2163.7	1901.5	1383.6	0.77	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.88	0.18	1.00	0.60	1.00	#N/A
41.0	-6.5	13	SC	39		120	125	4534.8	3761.0	2012.8	2526.5	1696.6	0.75	1	1	1.00	11.7	5.00	1.20	19.0	0.20	0.84	0.18	1.00	0.75	1.00	1.67
46.0	-11.5	22	SP	4		120	125	5014.4	3928.6	1867.4	3151.5	2009.6	0.73	1	1	1.00	19.4	0.00	1.00	19.4	0.21	0.80	0.18	1.00	0.68	1.00	1.70
51.0	-16.5	15	SP-SM	7		120	125	5503.9	4106.1	1731.9	3776.5	2322.6	0.72	1	1	1.00	12.9	0.12	1.01	13.2	0.14	0.76	0.18	1.00	0.74	0.98	1.15
56.0	-21.5	16	SP-SM	7		120	125	6004.8	4295.1	1607.8	4401.5	2635.6	0.70	1	1	1.00	13.5	0.12	1.01	13.7	0.15	0.72	0.18	1.00	0.74	0.94	1.19
61.0	-26.5	27	SP-SM	7		120	125	6517.4	4495.7	1495.4	5026.5	2948.6	0.69	1	1	1.00	22.2	0.12	1.01	22.5	0.25	0.68	0.17	1.00	0.66	0.89	1.98
66.0	-31.5	21	SP-SM	7		120	125	7041.1	4707.3	1394.1	5651.5	3261.6	0.67	1	1	1.00	16.9	0.12	1.01	17.2	0.18	0.64	0.16	1.00	0.70	0.88	1.49

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method, answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

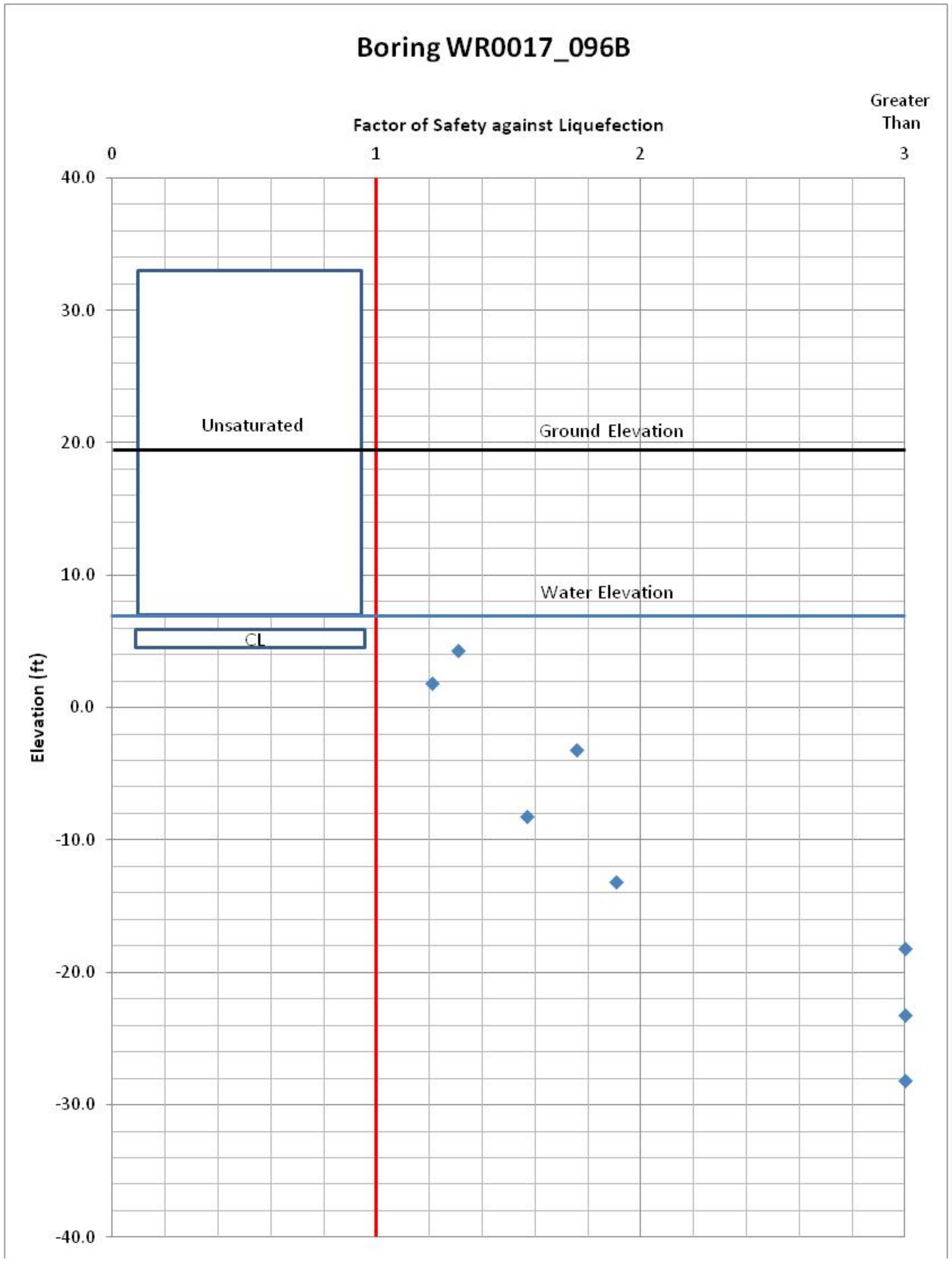


Fig. C-7. RD 17 South, Station 1784+83

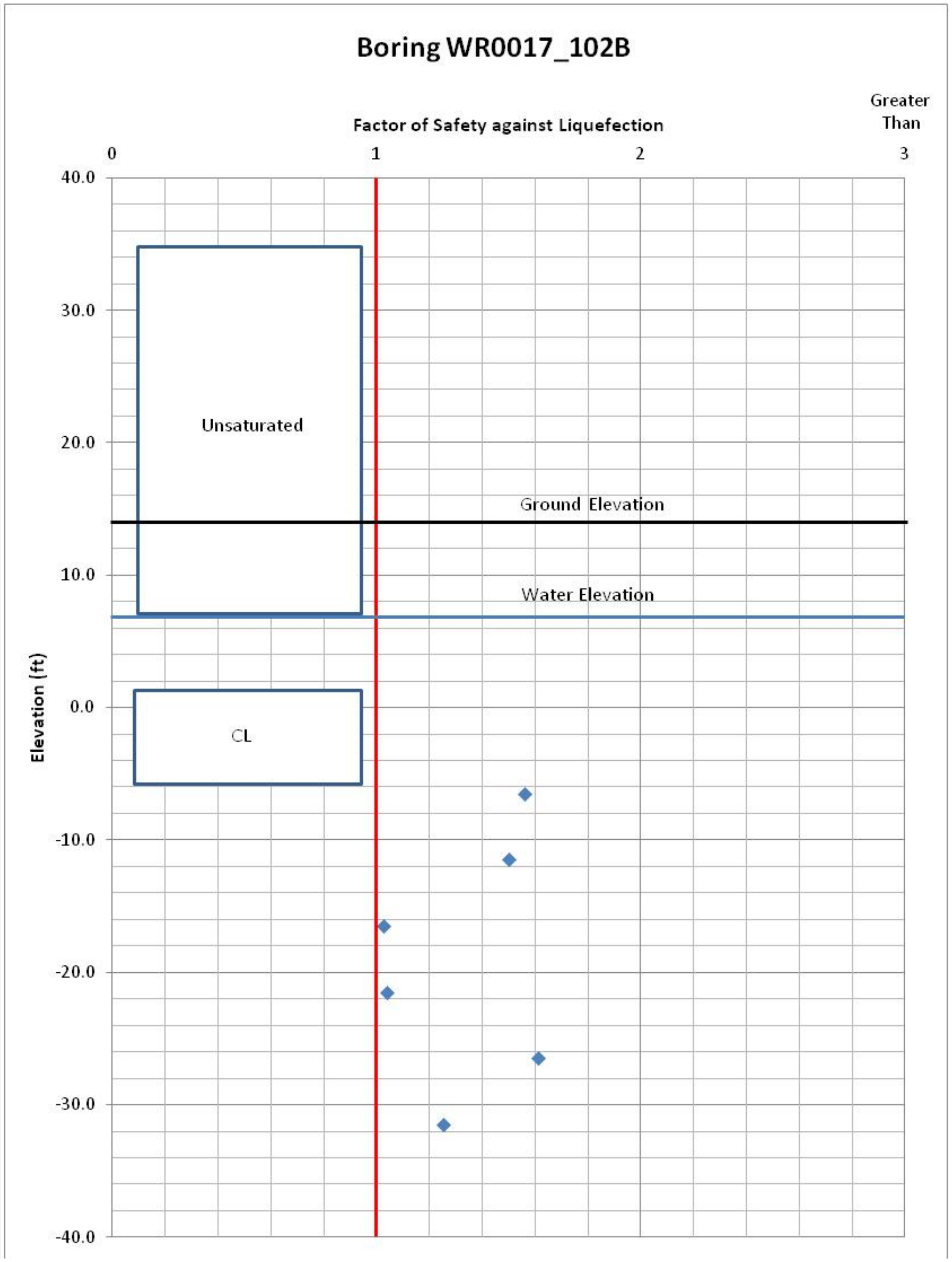


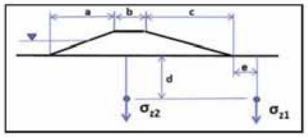
Fig. C-8. RD 17 South, Station 1825+94

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1007+42
Boring Number: WR0017_002B

Prepared by: Vlad Perlea
Checked by:

Date: 5/3/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	20.2 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	12.7 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.21
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	1.7 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	2.8 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	15.8 ft
Crest Width, b (ft)	40.0 ft
Landside/Downstream Slope, c (ft)	37.5 ft
Dist. of Boring from Levee Toe[1] (ft)	-57.5 ft
Embankment Height, H (ft)	7.5 ft

Boring	**WR0017_002B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
20.20 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
1.0	19.2	10	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	15.3	1.55	1.03	17.3	n.a.	1.00	#N/A	1.00	0.72	#N/A	#N/A
6.0	14.2	6	SM	15	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	9.8	2.50	1.05	12.8	n.a.	0.99	#N/A	1.00	0.77	#N/A	#N/A
11.0	9.2	7	SM	15	Unsaturated	120	125	1319.3	1319.3	899.3	1320.0	1320.0	1.27	1	0.85	1.00	9.0	2.50	1.05	12.0	n.a.	0.97	0.13	1.00	0.78	1.00	#N/A
16.0	4.2	11	CL	94	Unsaturated	120	125	1911.3	1911.3	891.3	1920.0	1920.0	1.05	1	0.95	1.00	13.2	5.00	1.20	20.8	n.a.	0.96	0.13	1.00	0.74	1.00	#N/A
21.0	-0.8	9	CL	94	Clay	120	125	2503.1	2347.1	870.6	1638.0	1413.4	0.95	1	0.95	1.00	n.a.	5.00	1.20	n.a.	2.00	0.95	0.15	1.00	0.60	1.00	#N/A
26.0	-5.8	4	CL	94	Clay	120	125	3095.8	2627.8	838.3	2263.0	1726.4	0.90	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.94	0.17	1.00	0.60	1.00	#N/A
32.5	-12.3	17	CL	94	Clay	120	125	3855.9	2982.3	785.9	3075.5	2133.3	0.84	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.91	0.18	1.00	0.60	1.00	#N/A
36.0	-15.8	14	CL	94	Clay	120	125	4263.1	3171.1	755.6	3513.0	2352.4	0.82	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.88	0.18	1.00	0.60	0.96	#N/A
42.5	-22.3	19	CL	94	Clay	120	125	5019.2	3521.6	699.2	4325.5	2759.3	0.78	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.83	0.18	1.00	0.60	0.90	#N/A
46.0	-25.8	13	CH	100	Clay	120	125	5427.5	3711.5	670.0	4763.0	2978.4	0.76	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.80	0.17	1.00	0.60	0.87	#N/A
51.0	-30.8	13	SM	15		120	125	6012.7	3984.7	630.2	5388.0	3291.4	0.73	1	1	1.00	11.4	2.50	1.05	14.4	0.15	0.76	0.17	1.00	0.76	0.90	1.23
56.0	-35.8	18	CL	94	Clay	120	125	6600.7	4260.7	593.2	6013.0	3604.4	0.70	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.72	0.16	1.00	0.60	0.81	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

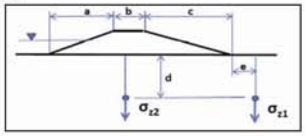
Updated April 2013

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1048+79
Boring Number: WR0017_007B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	21.7 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	8.7 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.21
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	1.7 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	2.8 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	39.0 ft
Crest Width, b (ft)	15.0 ft
Landside/Downstream Slope, c (ft)	45.5 ft
Dist. of Boring from Levee Toe[1] (ft)	-53.0 ft
Embankment Height, H (ft)	13.0 ft

Boring	**WR0017_007B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
21.70 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
1.0	20.7	17	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	26.0	1.55	1.03	28.4	n.a.	1.00	#N/A	1.00	0.63	#N/A	#N/A
6.0	15.7	7	CL	94	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	11.4	5.00	1.20	18.7	n.a.	0.99	#N/A	1.00	0.76	#N/A	#N/A
11.0	10.7	7	CL	94	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	9.0	5.00	1.20	15.8	n.a.	0.97	#N/A	1.00	0.78	#N/A	#N/A
16.0	5.7	10	CL	94	Unsaturated	120	125	1916.6	1916.6	1556.6	1920.0	1920.0	1.05	1	0.95	1.00	12.0	5.00	1.20	19.4	n.a.	0.96	0.13	1.00	0.75	1.00	#N/A
22.5	-0.8	12	SC	23		120	125	2650.6	2494.6	1498.1	1158.0	933.4	0.92	1	0.95	1.00	12.6	4.06	1.10	17.9	0.19	0.95	0.16	1.00	0.74	1.00	1.79
26.0	-4.3	16	SC	23		120	125	3035.2	2660.8	1445.2	1595.5	1152.5	0.89	1	1	1.00	17.1	4.06	1.10	22.9	0.26	0.94	0.18	1.00	0.70	1.00	2.16
31.0	-9.3	1	CL	94	Clay	120	125	3575.5	2889.1	1360.5	2220.5	1465.5	0.86	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.92	0.19	1.00	0.60	1.00	#N/A
36.0	-14.3	12	CL	94	Clay	120	125	4113.9	3115.5	1273.9	2845.5	1778.5	0.82	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.88	0.19	1.00	0.60	1.00	#N/A
41.0	-19.3	38	ML	54		120	125	4655.1	3344.7	1190.1	3470.5	2091.5	0.80	1	1	1.00	36.3	5.00	1.20	48.5	2.00	0.84	0.19	1.00	0.60	1.00	3.00
46.0	-24.3	34	ML	54		120	125	5201.4	3579.0	1111.4	4095.5	2404.5	0.77	1	1	1.00	31.4	5.00	1.20	42.6	2.00	0.80	0.19	1.00	0.60	0.95	3.00
52.5	-30.8	28	CL	94	Clay	120	125	5920.4	3892.4	1017.9	4908.0	2811.4	0.74	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.75	0.18	1.00	0.60	0.89	#N/A
56.0	-34.3	9	CL	94	Clay	120	125	6311.8	4065.4	971.8	5345.5	3030.5	0.72	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.72	0.17	1.00	0.60	0.87	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

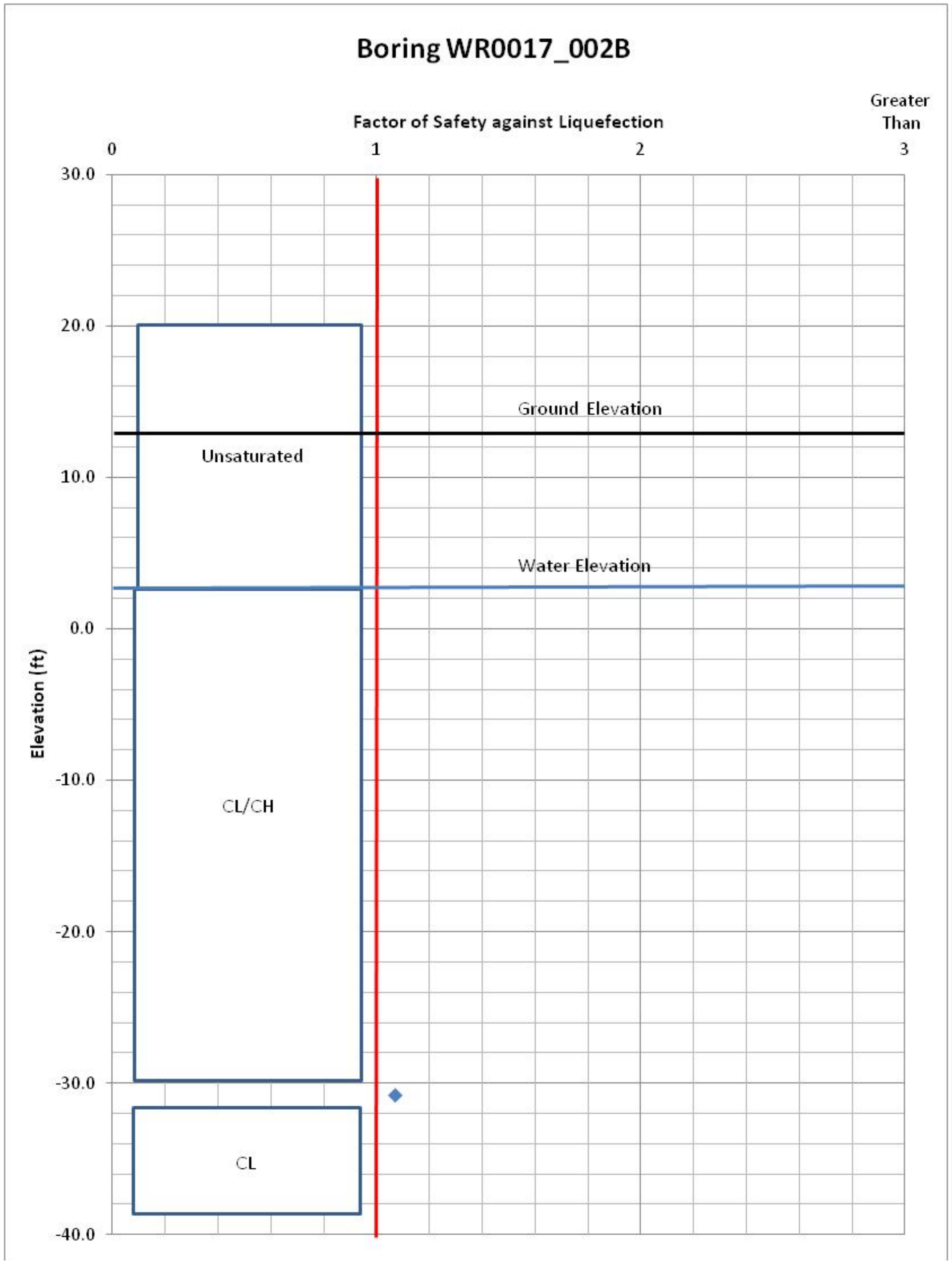


Fig. C-9. RD 17 North, Station 1007+42

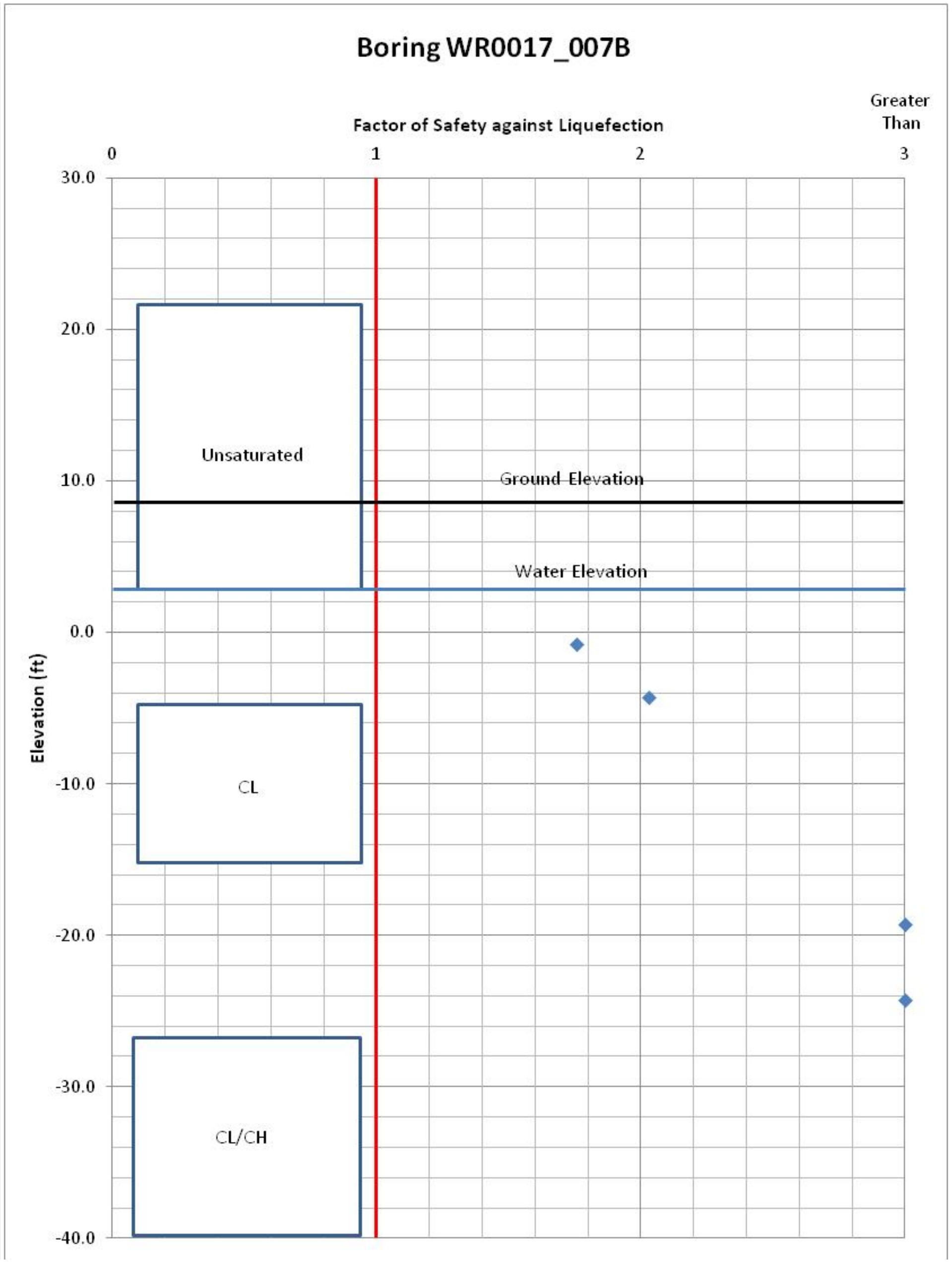


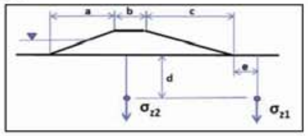
Fig. C-10. RD 17 North, Station 1048+79

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1099+90
Boring Number: WR0017_013B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	22.8 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	9.8 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.21
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	2.8 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.6 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	31.2 ft
Crest Width, b (ft)	25.0 ft
Landside/Downstream Slope, c (ft)	52.0 ft
Dist. of Boring from Levee Toe[1] (ft)	-64.5 ft
Embankment Height, H (ft)	13.0 ft

Boring	**WR0017_013B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
22.80 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description[2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
1.0	21.8	11	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	16.8	1.55	1.03	18.9	n.a.	1.00	#N/A	1.00	0.70	#N/A	#N/A
8.5	14.3	15	CL	94	Unsaturated	120	125	1020.0	1020.0	0.0	Embankment	Embankment	1.44	1	0.85	1.00	22.0	5.00	1.20	31.4	n.a.	0.98	#N/A	1.00	0.66	#N/A	#N/A
13.5	9.3	18	SM	26	Unsaturated	120	125	1620.0	1620.0	1560.0	1620.0	1620.0	1.14	1	0.95	1.00	23.5	4.39	1.12	30.7	n.a.	0.97	0.13	1.00	0.65	1.00	#N/A
16.0	6.8	7	SM	30	Unsaturated	120	125	1918.7	1918.7	1558.7	1920.0	1920.0	1.05	1	0.95	1.00	8.4	4.71	1.15	14.4	n.a.	0.96	0.13	1.00	0.79	1.00	#N/A
21.0	1.8	6	CL	94	Clay	120	125	2504.3	2441.9	1539.3	969.0	856.7	0.93	1	0.95	1.00	n.a.	5.00	1.20	n.a.	2.00	0.95	0.15	1.00	0.60	1.00	#N/A
26.0	-3.2	3	CL	94	Clay	120	125	3082.6	2708.2	1492.6	1594.0	1169.7	0.88	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.94	0.17	1.00	0.60	1.00	#N/A
31.0	-8.2	24	ML/SM	48		120	125	3642.4	2956.0	1427.4	2219.0	1482.7	0.85	1	1	1.00	24.4	5.00	1.20	34.2	2.00	0.92	0.19	1.00	0.64	1.00	3.00
36.0	-13.2	3	CL	94	Clay	120	125	4193.6	3195.2	1353.6	2844.0	1795.7	0.81	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.88	0.19	1.00	0.60	1.00	#N/A
41.0	-18.2	20	CL	94	Clay	120	125	4742.8	3432.4	1277.8	3469.0	2108.7	0.79	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.84	0.19	1.00	0.60	1.00	#N/A
46.0	-23.2	18	CL	94	Clay	120	125	5293.6	3671.2	1203.6	4094.0	2421.7	0.76	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.80	0.18	1.00	0.60	0.95	#N/A
51.0	-28.2	18	CL	94	Clay	120	125	5848.1	3913.7	1133.1	4719.0	2734.7	0.74	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.76	0.18	1.00	0.60	0.90	#N/A
56.0	-33.2	20	CH	100	Clay	120	125	6407.1	4160.7	1067.1	5344.0	3047.7	0.71	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.72	0.17	1.00	0.60	0.86	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

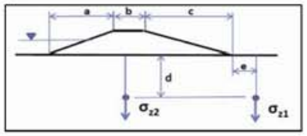
Updated April 2013

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1151+06
Boring Number: WR0017_019B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	22.9 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	9.9 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.21
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-0.1 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.4 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	19.5 ft
Crest Width, b (ft)	23.0 ft
Landside/Downstream Slope, c (ft)	28.6 ft
Dist. of Boring from Levee Toe[1] (ft)	-40.1 ft
Embankment Height, H (ft)	13.0 ft

Boring	**WR0017_019B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
22.90 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description[2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
6.0	16.9	6	CL	80	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	9.8	5.00	1.20	16.8	n.a.	0.99	#N/A	1.00	0.77	#N/A	#N/A
10.0	12.9	7	SC-SM	30	Unsaturated	120	125	1200.0	1200.0	0.0	Embankment	Embankment	1.33	1	0.85	1.00	9.5	4.71	1.15	15.7	n.a.	0.98	#N/A	1.00	0.78	#N/A	#N/A
14.0	8.9	6	SC	16	Unsaturated	120	125	1679.9	1679.9	1559.9	1680.0	1680.0	1.12	1	0.95	1.00	7.7	2.77	1.05	10.9	n.a.	0.97	0.13	1.00	0.79	1.00	#N/A
18.5	4.4	6	CL	94	Unsaturated	120	125	2206.2	2206.2	1546.2	2220.0	2220.0	0.98	1	0.95	1.00	6.7	5.00	1.20	13.0	n.a.	0.96	0.13	1.00	0.80	0.99	#N/A
22.5	0.4	8	SP-SC	6		120	125	2643.4	2643.4	1503.4	1160.0	910.4	0.89	1	0.95	1.00	8.2	0.03	1.00	8.2	0.10	0.95	0.16	1.00	0.79	1.00	0.89
26.0	-3.1	9	CL	94	Clay	120	125	3020.2	2833.0	1445.2	1597.5	1129.5	0.86	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.94	0.18	1.00	0.60	1.00	#N/A
31.0	-8.1	16	ML	50		120	125	3544.6	3045.4	1344.6	2222.5	1442.5	0.83	1	1	1.00	16.0	5.00	1.20	24.2	0.28	0.92	0.19	1.00	0.71	1.00	2.14
36.0	-13.1	18	ML	50		120	125	4063.8	3252.6	1238.8	2847.5	1755.5	0.81	1	1	1.00	17.4	5.00	1.20	25.9	0.31	0.88	0.20	1.00	0.70	1.00	2.39
41.0	-18.1	10	CL	94	Clay	120	125	4587.4	3464.2	1137.4	3472.5	2068.5	0.78	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.84	0.19	1.00	0.60	1.00	#N/A
46.0	-23.1	19	CL	94	Clay	120	125	5119.4	3684.2	1044.4	4097.5	2381.5	0.76	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.80	0.19	1.00	0.60	0.95	#N/A
51.0	-28.1	29	SM	26		120	125	5661.0	3913.8	961.0	4722.5	2694.5	0.74	1	1	1.00	25.6	4.39	1.12	33.1	2.00	0.76	0.18	1.00	0.63	0.92	3.00
56.0	-33.1	17	CL	94	Clay	120	125	6211.9	4152.7	886.9	5347.5	3007.5	0.71	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.72	0.17	1.00	0.60	0.87	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

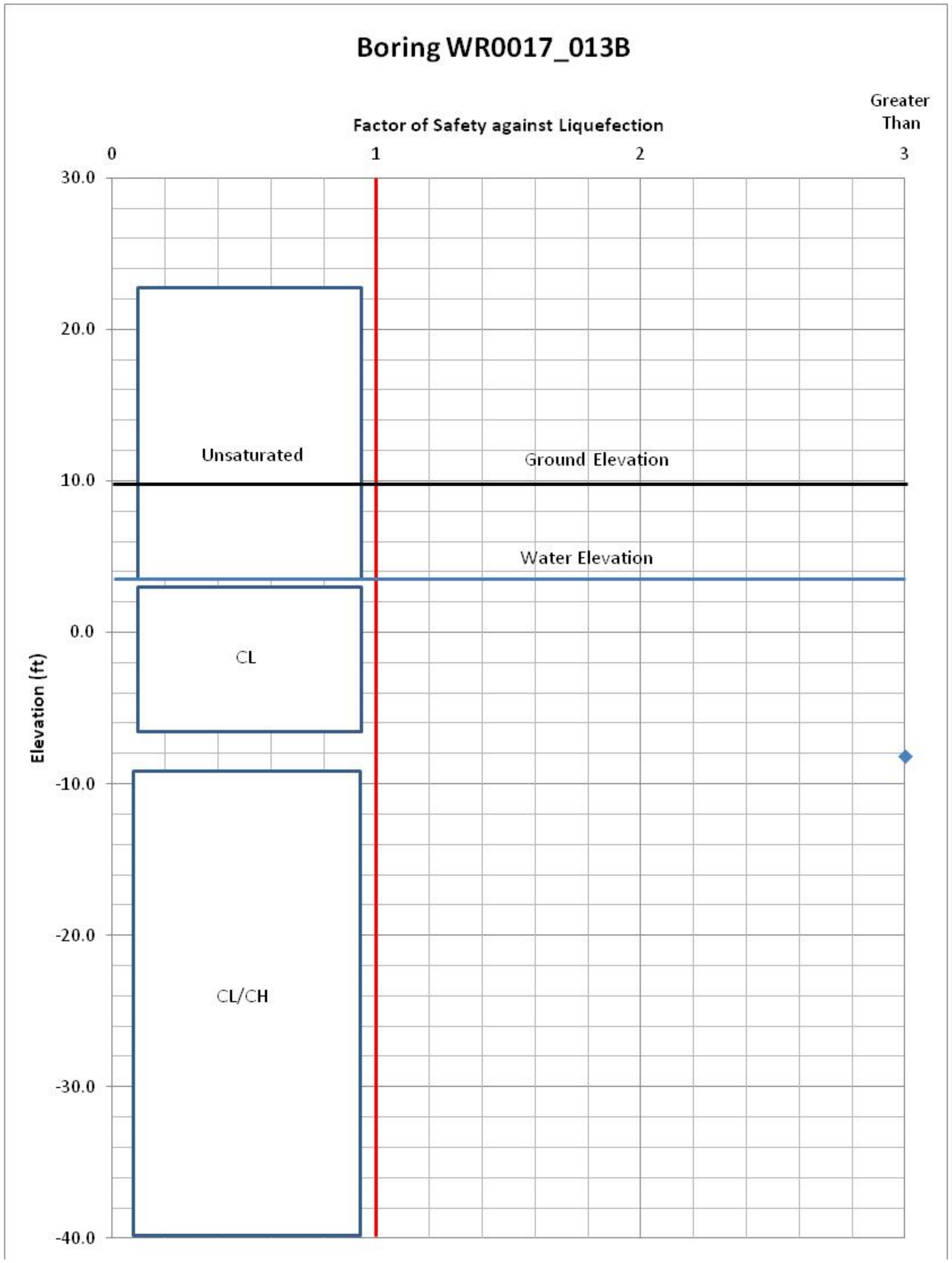


Fig. C-11. RD 17 North, Station 1099+90

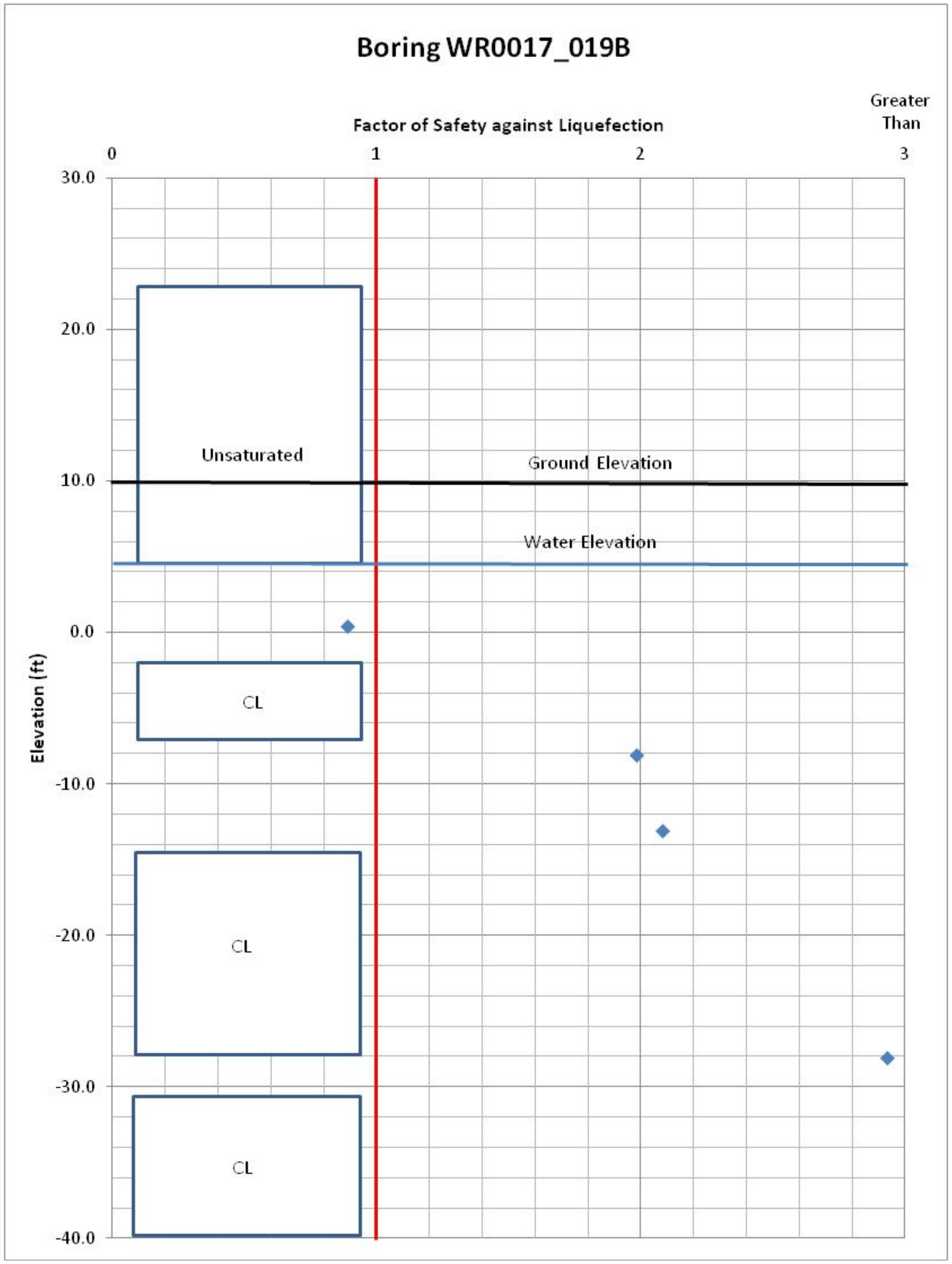


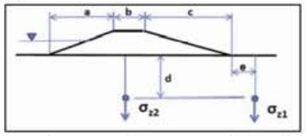
Fig. C-12. RD 17 North, Station 1151+06

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1191+43
Boring Number: WR0017_024B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	22.8 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	7.8 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.21
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-0.2 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.6 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	31.5 ft
Crest Width, b (ft)	34.0 ft
Landside/Downstream Slope, c (ft)	36.0 ft
Dist. of Boring from Levee Toe[1] (ft)	-53.0 ft
Embankment Height, H (ft)	15.0 ft

Boring	**WR0017_024B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
22.80 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_σ	f parameter	K_α	FS against Liquefaction
1.0	21.8	13	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	19.9	1.55	1.03	22.1	n.a.	1.00	#N/A	1.00	0.68	#N/A	#N/A
6.0	16.8	13	CL	63	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	21.2	5.00	1.20	30.5	n.a.	0.99	#N/A	1.00	0.67	#N/A	#N/A
11.0	11.8	9	CL	94	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	11.6	5.00	1.20	18.9	n.a.	0.97	#N/A	1.00	0.75	#N/A	#N/A
18.5	4.3	6	CH	100	Clay	120	125	2218.5	2218.5	1798.5	421.5	402.8	0.98	1	0.95	1.00	n.a.	5.00	1.20	n.a.	2.00	0.96	0.14	1.00	0.60	1.00	#N/A
23.5	-0.7	6	CL	69	Clay	120	125	2804.1	2772.9	1781.6	1046.5	715.8	0.87	1	0.95	1.00	n.a.	5.00	1.20	n.a.	2.00	0.95	0.19	1.00	0.60	1.00	#N/A
26.0	-3.2	6	SM	15		120	125	3098.6	2911.4	1763.6	1359.0	872.3	0.85	1	1	1.00	6.1	2.50	1.05	8.9	0.10	0.94	0.20	1.00	0.80	1.00	0.73
31.0	-8.2	14	ML	90		120	125	3669.4	3170.2	1709.4	1984.0	1185.3	0.82	1	1	1.00	13.7	5.00	1.20	21.5	0.23	0.92	0.21	1.00	0.73	1.00	1.67
36.0	-13.2	16	SC	28		120	125	4222.5	3411.3	1637.5	2609.0	1498.3	0.79	1	1	1.00	15.1	4.56	1.14	21.8	0.24	0.88	0.21	1.00	0.72	1.00	1.71
41.0	-18.2	3	SC	28		120	125	4766.2	3643.0	1556.2	3234.0	1811.3	0.76	1	1	1.00	2.7	4.56	1.14	7.7	0.09	0.84	0.20	1.00	0.80	1.00	0.68
46.0	-23.2	31	SC	27		120	125	5306.7	3871.5	1471.7	3859.0	2124.3	0.74	1	1	1.00	27.5	4.48	1.13	35.6	2.00	0.80	0.20	1.00	0.62	1.00	3.00
51.0	-28.2	10	CH	100	Clay	120	125	5848.3	4101.1	1388.3	4484.0	2437.3	0.72	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.76	0.19	1.00	0.60	0.95	#N/A
56.0	-33.2	21	CL	94	Clay	120	125	6393.3	4334.1	1308.3	5109.0	2750.3	0.70	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.72	0.18	1.00	0.60	0.90	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

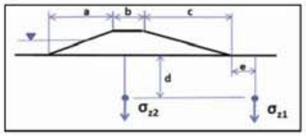
Updated April 2013

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1231+82
Boring Number: WR0017_029B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	23.7 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	11.2 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.21
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	0.7 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.8 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	25.0 ft
Crest Width, b (ft)	35.0 ft
Landside/Downstream Slope, c (ft)	36.3 ft
Dist. of Boring from Levee Toe[1] (ft)	-53.8 ft
Embankment Height, H (ft)	12.5 ft

Boring	**WR0017_029B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
23.70 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_σ	f parameter	K_α	FS against Liquefaction
1.0	22.7	21	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	32.1	1.55	1.03	34.7	n.a.	1.00	#N/A	1.00	0.60	#N/A	#N/A
6.0	17.7	6	SC	51	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	9.8	5.00	1.20	16.8	n.a.	0.99	#N/A	1.00	0.77	#N/A	#N/A
12.5	11.2	8	SM	38	Unsaturated	120	125	1500.0	1500.0	1500.0	Embankment	Embankment	1.19	1	0.85	1.00	9.7	5.00	1.20	16.6	n.a.	0.97	#N/A	1.00	0.77	#N/A	#N/A
17.5	6.2	8	CL	94	Unsaturated	120	125	2096.4	2096.4	1496.4	2100.0	2100.0	1.00	1	0.95	1.00	9.2	5.00	1.20	16.0	n.a.	0.96	0.13	1.00	0.78	1.00	#N/A
22.5	1.2	6	SM	37		120	125	2675.4	2675.4	1475.4	1218.0	993.4	0.89	1	0.95	1.00	6.1	5.00	1.20	12.3	0.13	0.95	0.16	1.00	0.80	1.00	1.27
27.5	-3.8	11	SM	15		120	125	3254.6	2973.8	1432.1	1843.0	1306.4	0.84	1	1	1.00	11.1	2.50	1.05	14.2	0.15	0.94	0.18	1.00	0.76	1.00	1.26
32.5	-8.8	19	SP	4		120	125	3819.4	3226.6	1371.9	2468.0	1619.4	0.81	1	1	1.00	18.5	0.00	1.00	18.5	0.20	0.91	0.19	1.00	0.69	1.00	1.56
36.0	-12.3	20	CL	94	Clay	120	125	4208.8	3397.6	1323.8	2905.5	1838.5	0.79	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.88	0.19	1.00	0.60	1.00	#N/A
41.0	-17.3	9	CL	94	Clay	120	125	4761.5	3638.3	1251.5	3530.5	2151.5	0.76	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.84	0.19	1.00	0.60	0.99	#N/A
46.0	-22.3	17	SC	42		120	125	5313.8	3878.6	1178.8	4155.5	2464.5	0.74	1	1	1.00	15.1	5.00	1.20	23.1	0.26	0.80	0.18	1.00	0.72	0.96	2.02
51.0	-27.3	20	SC	26		120	125	5868.6	4121.4	1108.6	4780.5	2777.5	0.72	1	1	1.00	17.2	4.39	1.12	23.7	0.27	0.76	0.18	1.00	0.70	0.92	2.08
56.0	-32.3	27	SC	26		120	125	6427.4	4368.2	1042.4	5405.5	3090.5	0.70	1	1	1.00	22.6	4.39	1.12	29.7	0.45	0.72	0.17	1.00	0.66	0.88	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

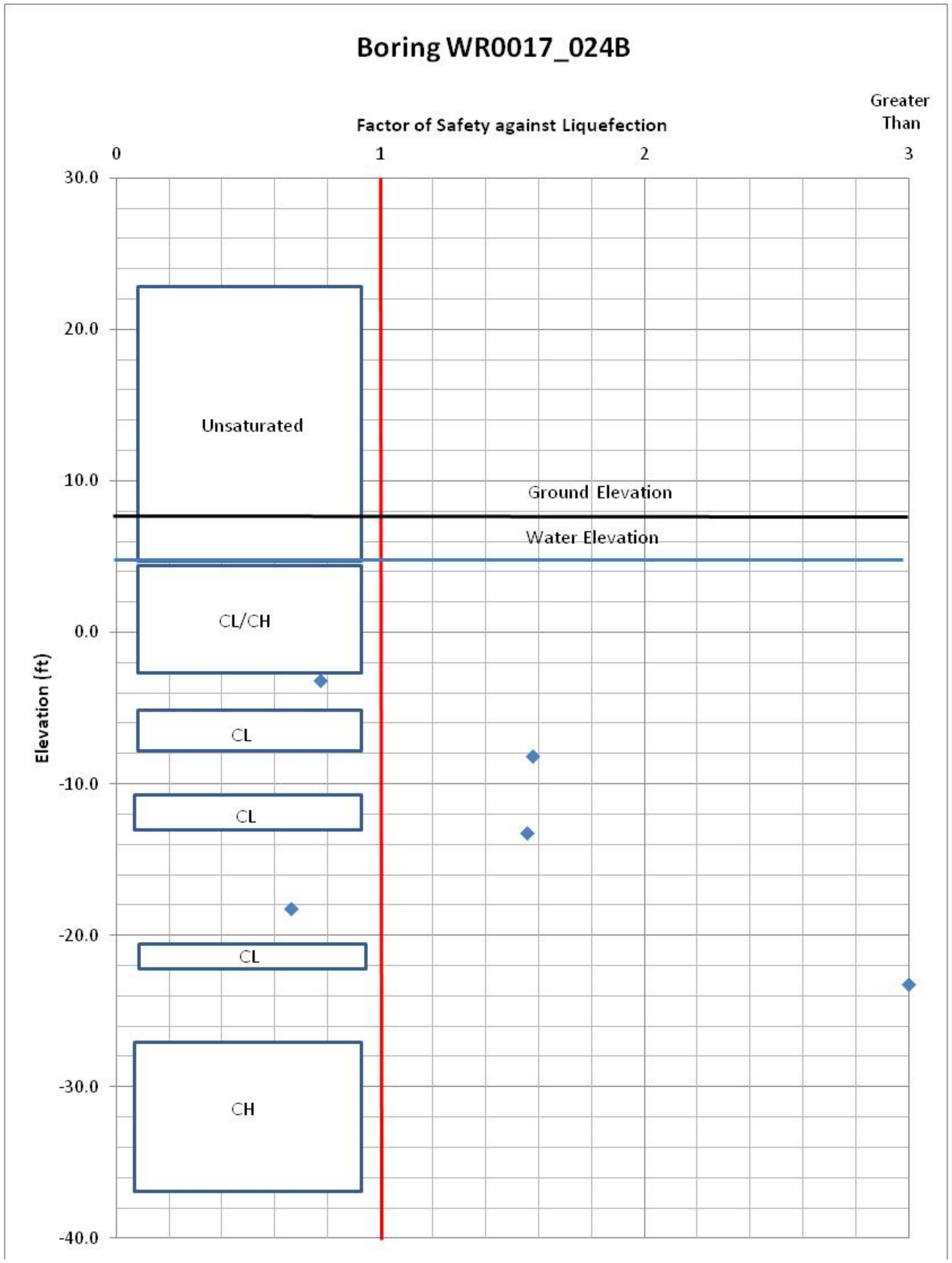


Fig. C-13. RD 17 North, Station 1191+43

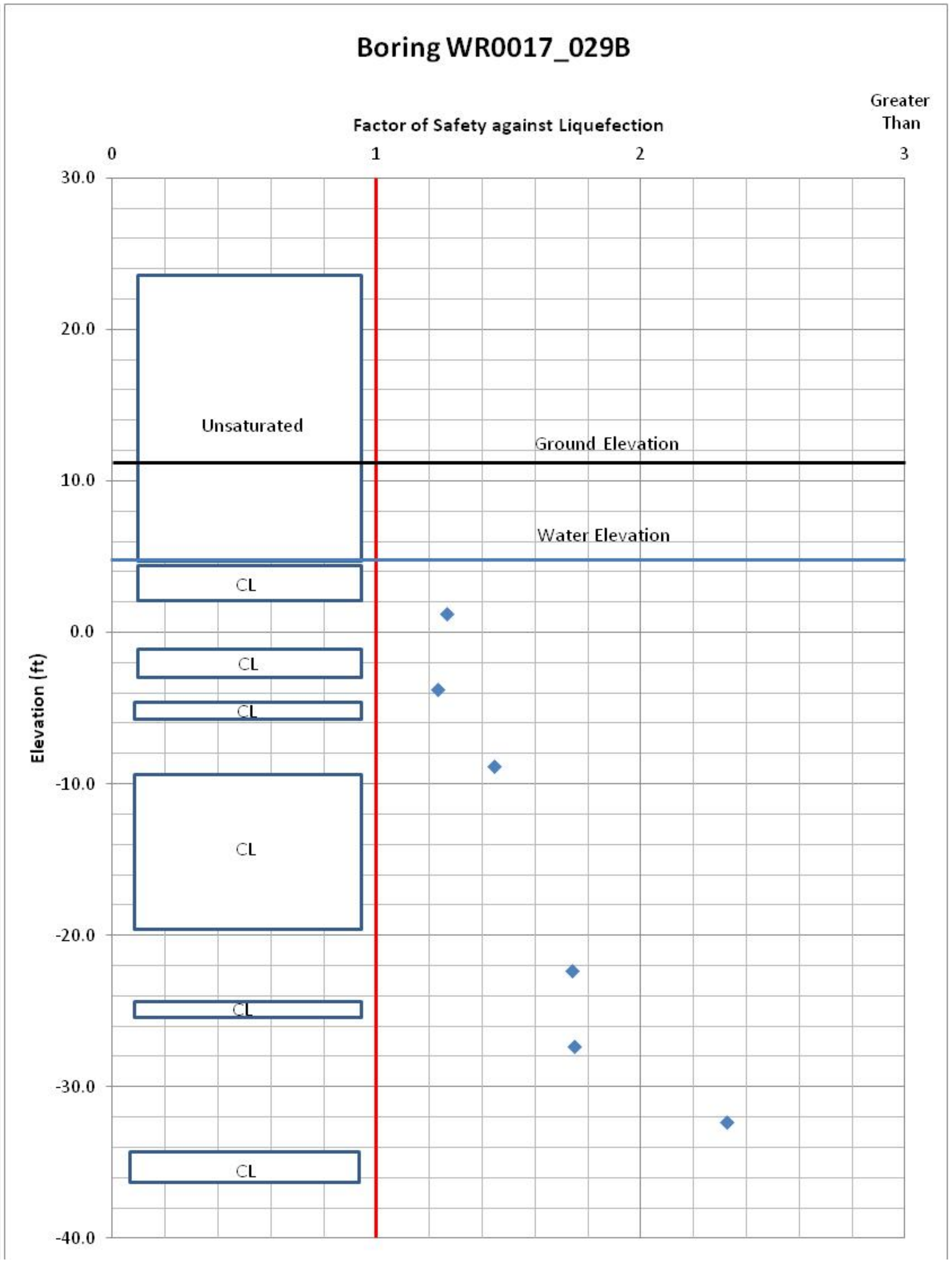


Fig. C-14. RD 17 North, Station 1231+82

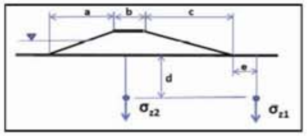
Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1292+29
Boring Number: WR0017_036B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	25.2 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	12.7 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.21
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	2.2 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.8 ft				120.0 pcf



Surcharge Information

Waterside/Upstream Slope, a (ft)	33.8 ft
Crest Width, b (ft)	19.0 ft
Landside/Downstream Slope, c (ft)	37.5 ft
Dist. of Boring from Levee Toe[1] (ft)	-47.0 ft
Embankment Height, H (ft)	12.5 ft

Boring	WR0017_036B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
25.20 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
1.0	24.2	8	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	12.2	1.55	1.03	14.2	n.a.	1.00	#N/A	1.00	0.75	#N/A	#N/A
6.0	19.2	6	CL	94	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	9.8	5.00	1.20	16.8	n.a.	0.99	#N/A	1.00	0.77	#N/A	#N/A
12.5	12.7	5	ML	50	Unsaturated	120	125	1500.0	1500.0	1500.0	Embankment	Embankment	1.19	1	0.85	1.00	6.1	5.00	1.20	12.3	n.a.	0.97	#N/A	1.00	0.80	#N/A	#N/A
16.0	9.2	4	ML	50	Unsaturated	120	125	1916.2	1916.2	1496.2	1920.0	1920.0	1.05	1	0.95	1.00	4.8	5.00	1.20	10.8	n.a.	0.96	0.13	1.00	0.80	1.00	#N/A
21.0	4.2	6	CL	94	Clay	120	125	2480.6	2480.6	1460.6	1023.0	985.6	0.92	1	0.95	1.00	n.a.	5.00	1.20	n.a.	2.00	0.95	0.13	1.00	0.60	1.00	#N/A
27.5	-2.3	8	CL	94	Clay	120	125	3190.3	2909.5	1367.8	1835.5	1392.5	0.85	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.94	0.17	1.00	0.60	1.00	#N/A
31.0	-5.8	32	SM	15		120	125	3568.3	3069.1	1308.3	2273.0	1611.6	0.83	1	1	1.00	31.9	2.50	1.05	35.9	2.00	0.92	0.18	1.00	0.60	1.00	3.00
36.0	-10.8	25	CL	94	Clay	120	125	4106.0	3294.8	1221.0	2898.0	1924.6	0.80	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.88	0.18	1.00	0.60	1.00	#N/A
41.0	-15.8	11	CL	94	Clay	120	125	4646.3	3523.1	1136.3	3523.0	2237.6	0.77	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.84	0.18	1.00	0.60	0.98	#N/A
46.0	-20.8	20	CL	94	Clay	120	125	5191.7	3756.5	1056.7	4148.0	2550.6	0.75	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.80	0.18	1.00	0.60	0.93	#N/A
51.0	-25.8	12	SM	15		120	125	5743.6	3996.4	983.6	4773.0	2863.6	0.73	1	1	1.00	10.5	2.50	1.05	13.5	0.15	0.76	0.17	1.00	0.77	0.93	1.17
56.0	-30.8	17	SM	15		120	125	6302.0	4242.8	917.0	5398.0	3176.6	0.71	1	1	1.00	14.4	2.50	1.05	17.6	0.19	0.72	0.17	1.00	0.73	0.89	1.51
61.0	-35.8	34	SM	15		120	125	6866.8	4495.6	856.8	6023.0	3489.6	0.69	1	1	1.00	28.0	2.50	1.05	31.8	2.00	0.68	0.16	1.00	0.62	0.82	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method, answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

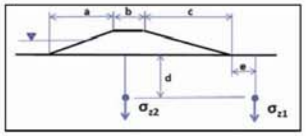
Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1330+01
Boring Number: WR0017_041B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	25.7 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	14.2 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.21
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	2.7 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	5.0 ft				120.0 pcf



Surcharge Information

Waterside/Upstream Slope, a (ft)	42.6 ft
Crest Width, b (ft)	18.0 ft
Landside/Downstream Slope, c (ft)	39.1 ft
Dist. of Boring from Levee Toe[1] (ft)	-48.1 ft
Embankment Height, H (ft)	11.5 ft

Boring	WR0017_041B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
25.70 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
1.0	24.7	18	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	27.5	1.55	1.03	30.0	n.a.	1.00	#N/A	1.00	0.62	#N/A	#N/A
6.0	19.7	10	ML	86	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	16.3	5.00	1.20	24.6	n.a.	0.99	#N/A	1.00	0.71	#N/A	#N/A
11.0	14.7	7	ML	86	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	9.0	5.00	1.20	15.8	n.a.	0.97	#N/A	1.00	0.78	#N/A	#N/A
17.5	8.2	7	SP	2	Unsaturated	120	125	2085.4	2085.4	1365.4	2100.0	2100.0	1.01	1	0.95	1.00	8.0	0.00	1.00	8.0	n.a.	0.96	0.13	1.00	0.79	1.00	#N/A
21.0	4.7	5	ML	79		120	125	2475.3	2475.3	1335.3	1141.5	1122.8	0.92	1	0.95	1.00	5.3	5.00	1.20	11.3	0.12	0.95	0.13	1.00	0.80	1.00	1.42
26.0	-0.3	17	SP-SM	8		120	125	3027.9	2840.7	1272.9	1766.5	1435.8	0.86	1	1	1.00	17.6	0.30	1.01	18.1	0.19	0.94	0.16	1.00	0.70	1.00	1.84
31.0	-5.3	19	SP-SM	8		120	125	3580.3	3081.1	1200.3	2391.5	1748.8	0.83	1	1	1.00	18.9	0.30	1.01	19.4	0.21	0.92	0.17	1.00	0.69	1.00	1.82
36.0	-10.3	31	SP-SM	8		120	125	4130.8	3319.6	1125.8	3016.5	2061.8	0.80	1	1	1.00	29.7	0.30	1.01	30.4	2.00	0.88	0.18	1.00	0.60	1.00	3.00
41.0	-15.3	17	CL	94	Clay	120	125	4683.4	3560.2	1053.4	3641.5	2374.8	0.77	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.84	0.18	1.00	0.60	0.95	#N/A
46.0	-20.3	31	SC	26		120	125	5240.2	3805.0	985.2	4266.5	2687.8	0.75	1	1	1.00	27.7	4.39	1.12	35.5	2.00	0.80	0.17	1.00	0.62	0.91	3.00
52.5	-26.8	21	CL	94	Clay	120	125	5971.3	4130.5	903.8	5079.0	3094.7	0.72	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.75	0.17	1.00	0.60	0.86	#N/A
56.0	-30.3	8	CL	94	Clay	120	125	6368.7	4309.5	863.7	5516.5	3313.8	0.70	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.72	0.16	1.00	0.60	0.84	#N/A
61.0	-35.3	19	SC	50		120	125	6940.5	4569.3	810.5	6141.5	3626.8	0.68	1	1	1.00	15.5	5.00	1.20	23.6	0.27	0.68	0.16	1.00	0.71	0.86	2.19

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method, answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

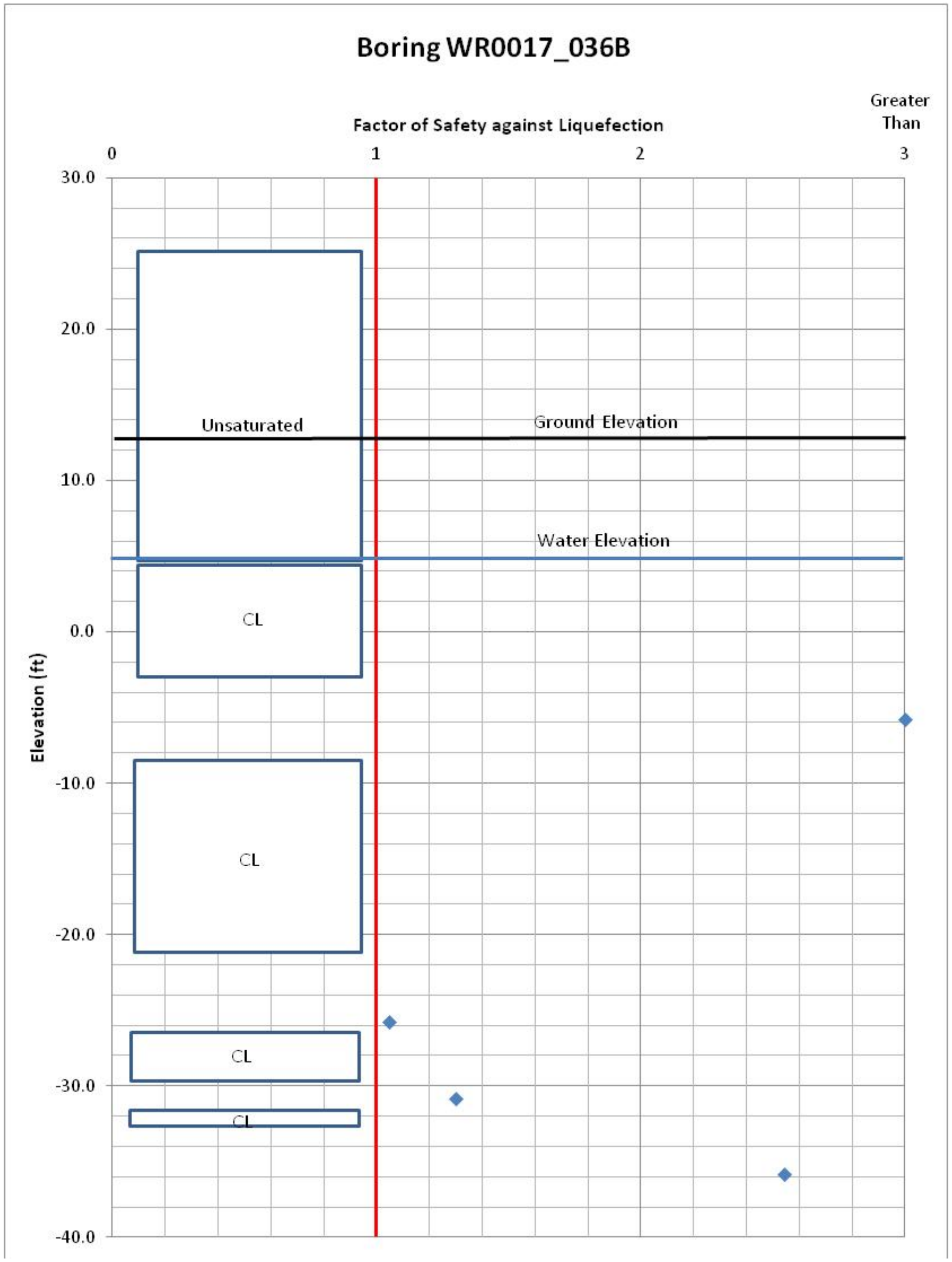


Fig. C-15. RD 17 North, Station 1292+29

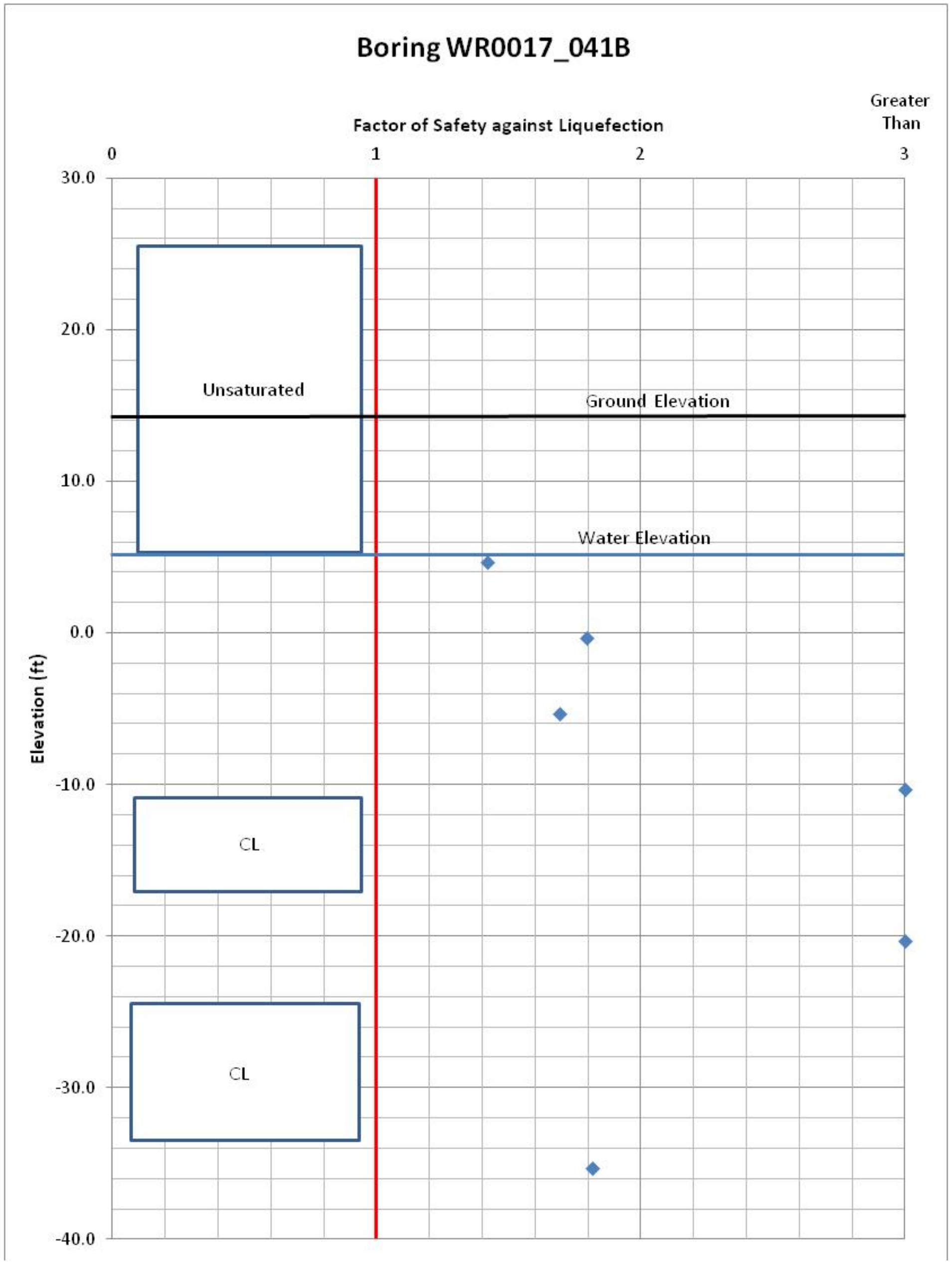


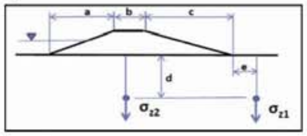
Fig. C-16. RD 17 North, Station 1330+01

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1377+73
Boring Number: WR0017_047B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	27.2 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	14.2 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.21
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	4.2 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	5.3 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	33.8 ft
Crest Width, b (ft)	19.0 ft
Landside/Downstream Slope, c (ft)	32.5 ft
Dist. of Boring from Levee Toe[1] (ft)	-42.0 ft
Embankment Height, H (ft)	13.0 ft

Boring **WR0017_047B**
Boring on the crest
SPT Ground Elevation Used in Analysis
27.20 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	CRR$_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
1.0	26.2	15	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	23.0	1.55	1.03	25.2	n.a.	1.00	#N/A	1.00	0.65	#N/A	#N/A
7.5	19.7	21	SC	32	Unsaturated	120	125	900.0	900.0	0.0	Embankment	Embankment	1.53	1	0.85	1.00	32.8	4.83	1.17	43.3	n.a.	0.98	#N/A	1.00	0.60	#N/A	#N/A
11.0	16.2	5	SP	4	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	6.5	0.00	1.00	6.5	n.a.	0.97	#N/A	1.00	0.80	#N/A	#N/A
16.0	11.2	6	ML	50	Unsaturated	120	125	1917.3	1917.3	1557.3	1920.0	1920.0	1.05	1	0.95	1.00	6.6	5.00	1.20	12.9	n.a.	0.96	0.13	1.00	0.80	1.00	#N/A
21.0	6.2	11	SC	14	Unsaturated	120	125	2482.3	2482.3	1522.3	2520.0	2520.0	0.92	1	0.95	1.00	11.6	2.20	1.04	14.3	n.a.	0.95	0.13	1.00	0.75	0.96	#N/A
26.0	1.2	5	SC-SM	33		120	125	3024.4	2837.2	1449.4	1580.5	1324.7	0.86	1	1	1.00	5.2	4.88	1.18	11.0	0.12	0.94	0.15	1.00	0.80	1.00	1.20
31.0	-3.8	11	SM	29		120	125	3558.5	3059.3	1358.5	2205.5	1637.7	0.83	1	1	1.00	11.0	4.64	1.15	17.2	0.18	0.92	0.17	1.00	0.76	1.00	1.62
36.0	-8.8	17	SM	29		120	125	4088.6	3277.4	1263.6	2830.5	1950.7	0.80	1	1	1.00	16.4	4.64	1.15	23.4	0.26	0.88	0.17	1.00	0.71	1.00	2.27
41.0	-13.8	23	SP-SC	10		120	125	4621.6	3498.4	1171.6	3455.5	2263.7	0.78	1	1	1.00	21.5	0.87	1.02	22.8	0.25	0.84	0.18	1.00	0.67	0.98	2.13
47.5	-20.3	16	SP-SC	10		120	125	5324.0	3795.2	1061.5	4268.0	2670.6	0.75	1	1	1.00	14.3	0.87	1.02	15.5	0.17	0.79	0.17	1.00	0.73	0.94	1.35
51.0	-23.8	18	SP-SC	10		120	125	5707.3	3960.1	1007.3	4705.5	2889.7	0.73	1	1	1.00	15.8	0.87	1.02	17.0	0.18	0.76	0.17	1.00	0.71	0.91	1.47
56.0	-28.8	19	ML	69		120	125	6261.4	4202.2	936.4	5330.5	3202.7	0.71	1	1	1.00	16.2	5.00	1.20	24.4	0.28	0.72	0.16	1.00	0.71	0.89	2.29
61.0	-33.8	7	CL	94	Clay	120	125	6822.5	4451.3	872.5	5955.5	3515.7	0.69	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.68	0.16	1.00	0.60	0.82	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

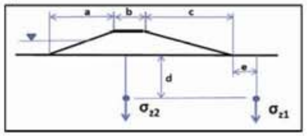
Updated April 2013

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1416+93
Boring Number: WR0017_052B

Prepared by: Vlad Perlea
Checked by:

Date: 5/7/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	27.6 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	14.1 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	5.1 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	5.5 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	32.4 ft
Crest Width, b (ft)	16.0 ft
Landside/Downstream Slope, c (ft)	29.7 ft
Dist. of Boring from Levee Toe[1] (ft)	-37.7 ft
Embankment Height, H (ft)	13.5 ft

Boring **WR0017_052B**
Boring on the crest
SPT Ground Elevation Used in Analysis
27.60 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	CRR$_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
1.0	26.6	18	ML	50	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	27.5	5.00	1.20	38.0	n.a.	1.00	#N/A	1.00	0.62	#N/A	#N/A
7.5	20.1	21	SM	43	Unsaturated	120	125	900.0	900.0	0.0	Embankment	Embankment	1.53	1	0.85	1.00	32.8	5.00	1.20	44.4	n.a.	0.98	#N/A	1.00	0.60	#N/A	#N/A
11.0	16.6	3	SM	43	Unsaturated	120	125	1320.0	1320.0	0.0	Embankment	Embankment	1.27	1	0.85	1.00	3.9	5.00	1.20	9.6	n.a.	0.97	#N/A	1.00	0.80	#N/A	#N/A
16.0	11.6	3	SP	4	Unsaturated	120	125	1917.6	1917.6	1617.6	1920.0	1920.0	1.05	1	0.95	1.00	3.6	0.00	1.00	3.6	n.a.	0.96	0.14	1.00	0.80	1.00	#N/A
21.0	6.6	12	SC	24	Unsaturated	120	125	2473.9	2473.9	1573.9	2520.0	2520.0	0.92	1	0.95	1.00	12.7	4.18	1.11	18.2	n.a.	0.95	0.14	1.00	0.74	0.96	#N/A
26.0	1.6	16	SC	24		120	125	3001.6	2783.2	1484.1	1519.5	1276.1	0.87	1	1	1.00	16.7	4.18	1.11	22.7	0.25	0.94	0.16	1.00	0.70	1.00	2.32
32.5	-4.9	32	SM	14		120	125	3673.9	3049.9	1343.9	2332.0	1683.0	0.83	1	1	1.00	32.0	2.20	1.04	35.5	2.00	0.91	0.18	1.00	0.60	1.00	3.00
36.0	-8.4	38	SP	4	Clay	120	125	4035.8	3193.4	1268.3	2769.5	1902.1	0.81	1	1	1.00	n.a.	0.00	1.00	n.a.	2.00	0.88	0.19	1.00	0.60	1.00	#N/A
41.0	-13.4	8	CL	94	Clay	120	125	4558.5	3404.1	1166.0	3394.5	2215.1	0.79	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.84	0.19	1.00	0.60	0.98	#N/A
46.0	-18.4	26	CL	94	Clay	120	125	5090.1	3623.7	1072.6	4019.5	2528.1	0.76	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.80	0.19	1.00	0.60	0.93	#N/A
51.0	-23.4	19	CL	94	Clay	120	125	5631.3	3852.9	988.8	4644.5	2841.1	0.74	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.76	0.18	1.00	0.60	0.89	#N/A
56.0	-28.4	20	CL	94	Clay	120	125	6181.6	4091.2	914.1	5269.5	3154.1	0.72	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.72	0.18	1.00	0.60	0.85	#N/A
61.0	-33.4	6	CL	94	Clay	120	125	6740.4	4338.0	847.9	5894.5	3467.1	0.70	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.68	0.17	1.00	0.60	0.82	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

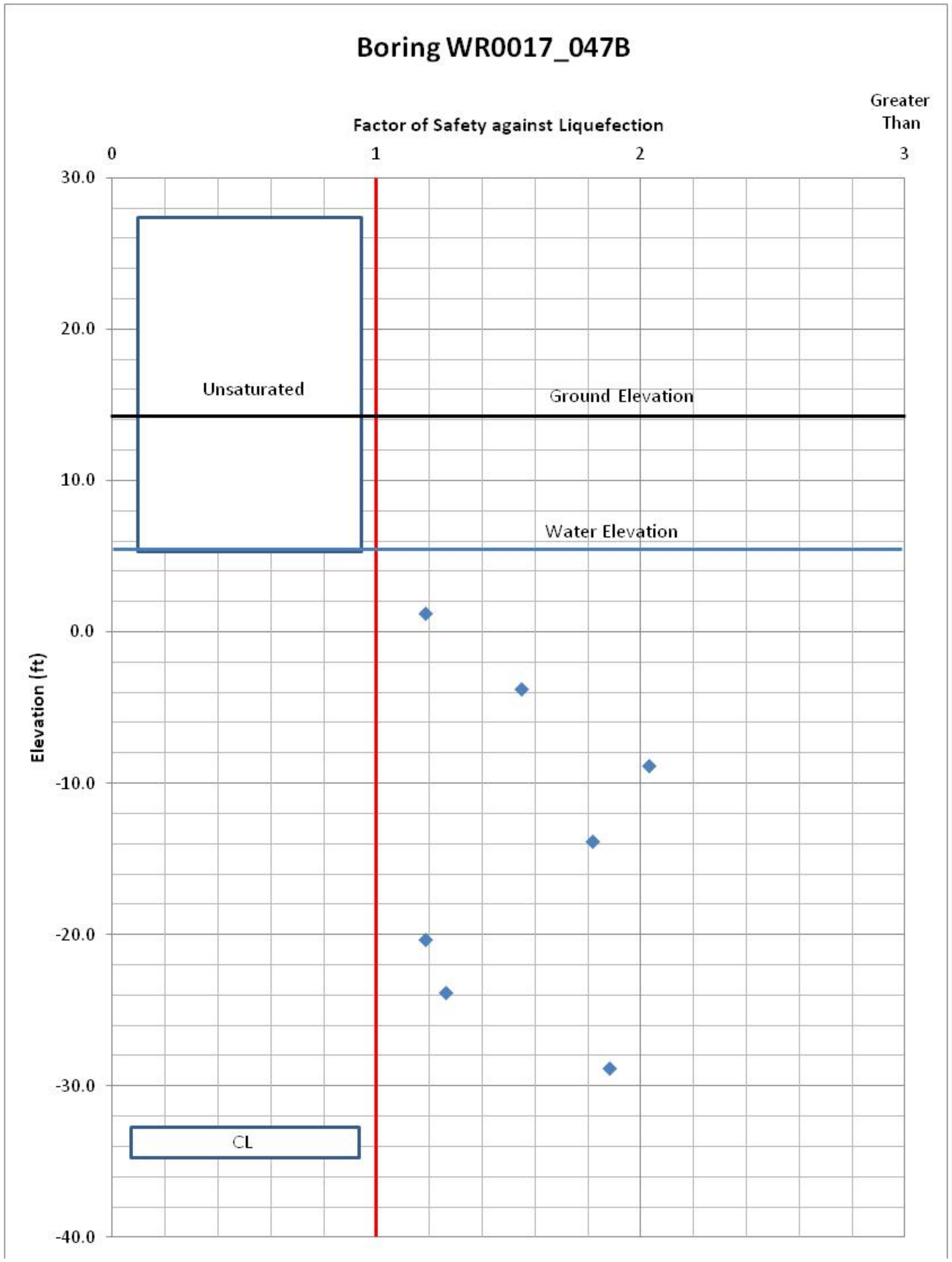


Fig. C-17. RD 17 North, Station 1377+73

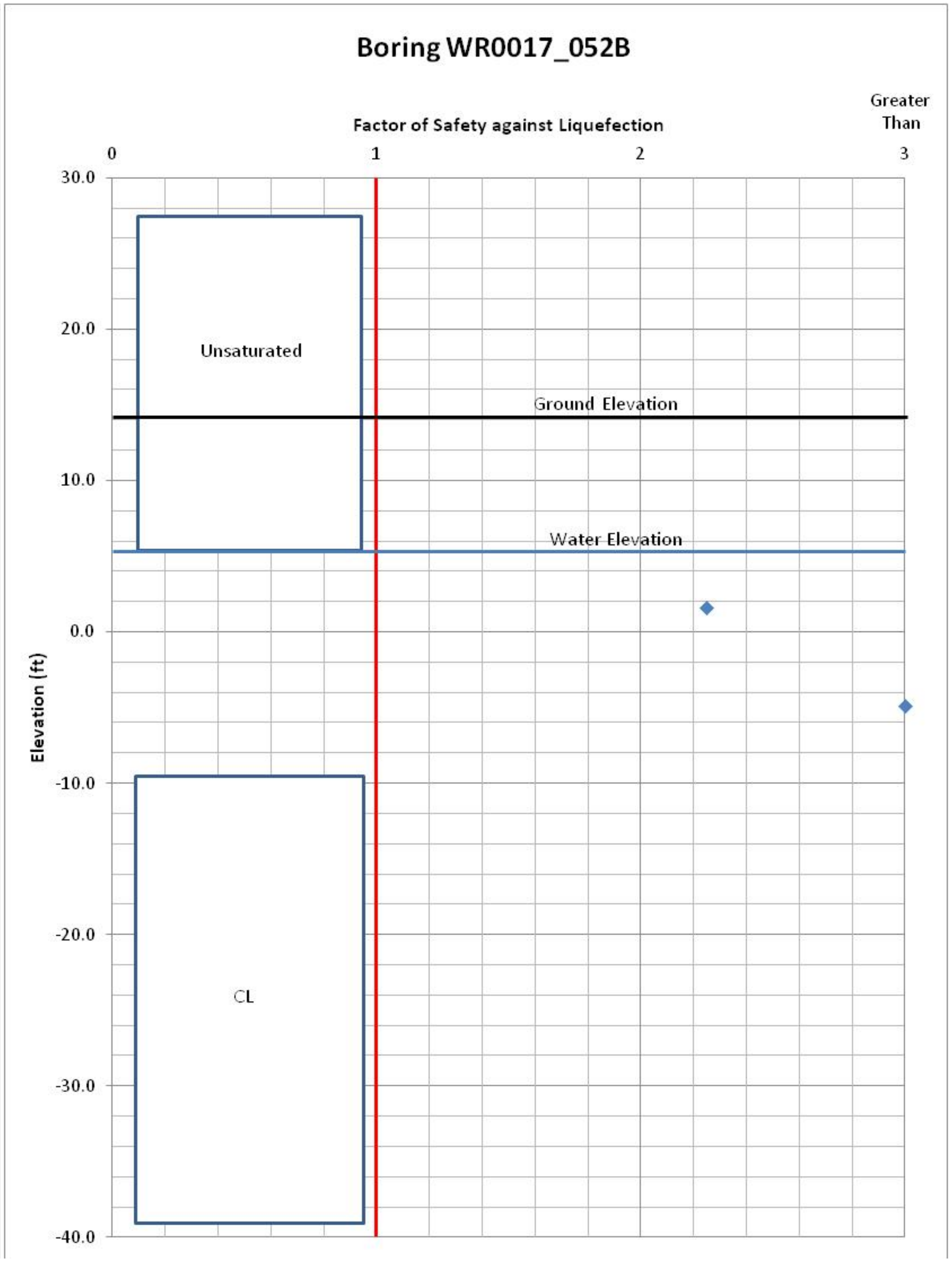


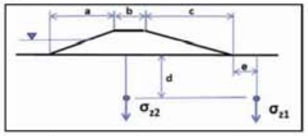
Fig. C-18. RD 17 North, Station 1416+93

Project: Lower San Joaquin
Study Area: RD 17
River Section: Sta. 1455+64
Boring Number: WR0017_057B

Prepared by: Vlad Perlea
Checked by:

Date: 5/6/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	27.7 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	17.7 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.225
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	5.7 ft	Hammer Efficiency	72	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	7.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	24.0 ft
Crest Width, b (ft)	23.0 ft
Landside/Downstream Slope, c (ft)	21.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-32.5 ft
Embankment Height, H (ft)	10.0 ft

Boring **WR0017_057B**
Boring on the crest
SPT Ground Elevation Used in Analysis
27.70 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
1.0	26.7	16	GC	12	Unsaturated	120	125	120.0	120.0	0.0	Embankment	Embankment	1.70	1	0.75	1.00	24.5	1.55	1.03	26.8	n.a.	1.00	#N/A	1.00	0.64	#N/A	#N/A
6.0	21.7	6	CL	94	Unsaturated	120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	9.8	5.00	1.20	16.8	n.a.	0.99	#N/A	1.00	0.77	#N/A	#N/A
11.0	16.7	7	ML	50	Unsaturated	120	125	1319.9	1319.9	1199.9	1320.0	1320.0	1.27	1	0.85	1.00	9.0	5.00	1.20	15.8	n.a.	0.97	0.14	1.00	0.78	1.00	#N/A
16.0	11.7	5	SM	42	Unsaturated	120	125	1906.1	1906.1	1186.1	1920.0	1920.0	1.05	1	0.95	1.00	6.0	5.00	1.20	12.2	n.a.	0.96	0.14	1.00	0.80	1.00	#N/A
21.0	6.7	10	SP	4		120	125	2456.6	2456.6	1136.6	1321.5	1302.8	0.93	1	0.95	1.00	10.6	0.00	1.00	10.6	0.12	0.95	0.14	1.00	0.76	1.00	1.26
26.0	1.7	11	SC	28		120	125	3002.0	2752.4	1062.0	1946.5	1615.8	0.88	1	1	1.00	11.6	4.56	1.14	17.7	0.19	0.94	0.17	1.00	0.75	1.00	1.71
31.0	-3.3	15	SC	23		120	125	3543.6	2982.0	978.6	2571.5	1928.8	0.84	1	1	1.00	15.2	4.06	1.10	20.7	0.22	0.92	0.18	1.00	0.72	1.00	1.88
36.0	-8.3	15	SC	15		120	125	4086.7	3213.1	896.7	3196.5	2241.8	0.81	1	1	1.00	14.6	2.50	1.05	17.8	0.19	0.88	0.18	1.00	0.72	0.98	1.52
41.0	-13.3	40	SW-SM	10		120	125	4635.8	3450.2	820.8	3821.5	2554.8	0.78	1	1	1.00	37.6	0.87	1.02	39.3	2.00	0.84	0.18	1.00	0.60	0.93	3.00
46.0	-18.3	11	CL	94	Clay	120	125	5192.6	3695.0	752.6	4446.5	2867.8	0.76	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.80	0.18	1.00	0.60	0.89	#N/A
52.5	-24.8	18	CH	100	Clay	120	125	5928.0	4024.8	675.5	5259.0	3274.7	0.73	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.75	0.18	1.00	0.60	0.84	#N/A
56.0	-28.3	10	CH	100	Clay	120	125	6328.9	4207.3	638.9	5696.5	3493.8	0.71	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.72	0.17	1.00	0.60	0.82	#N/A
61.0	-33.3	19	CL	94	Clay	120	125	6907.0	4473.4	592.0	6321.5	3806.8	0.69	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.68	0.16	1.00	0.60	0.79	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

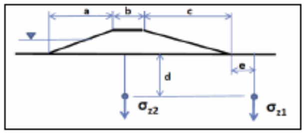
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: RD 404
Levee Station: 1003+04
Boring Number: WR0404_030B

Prepared by: Vlad Perlea
Checked by:

Date: 6/4/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	23.0 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	15.0 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.2 ft	Hammer Efficiency	85	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	8.8 ft
Crest Width, b (ft)	20.0 ft
Landside/Downstream Slope, c (ft)	80.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-90.0 ft
Embankment Height, H (ft)	8.0 ft

Boring **WR0404_030B**
Boring on the crest
SPT Ground Elevation Used in Analysis
23.00 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
56.0	-33.0	23	ML/SM	51		120	125	6450.1	4528.2	536.1	5925.0	3865.8	0.68	1	1	1.00	22.3	5.00	1.20	31.7	2.00	0.72	0.14	1.00	0.66	0.81	3.00
61.0	-38.0	21	CL	94	PI = 8	120	125	7046.7	4812.8	507.7	6550.0	4178.8	0.66	1	1	1.00	19.7	5.00	1.20	28.7	0.40	0.68	0.14	1.00	0.68	0.80	3.00
66.0	-43.0	34	SM	14		120	125	7646.0	5100.1	482.0	7175.0	4491.8	0.64	1	1	1.00	31.0	2.20	1.04	34.5	2.00	0.64	0.13	1.00	0.60	0.74	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

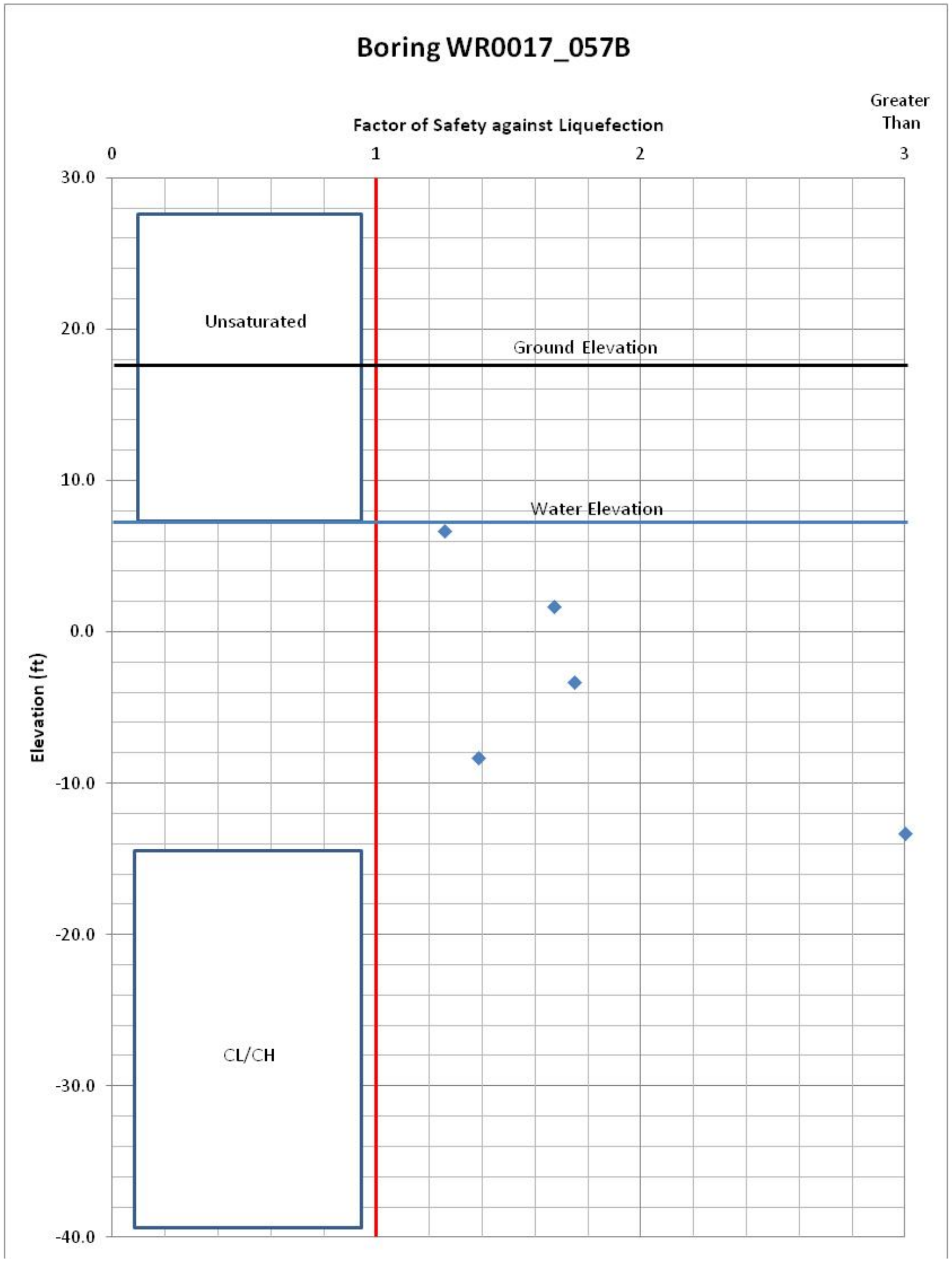


Fig. C-19. RD 17 North, Station 1455+64

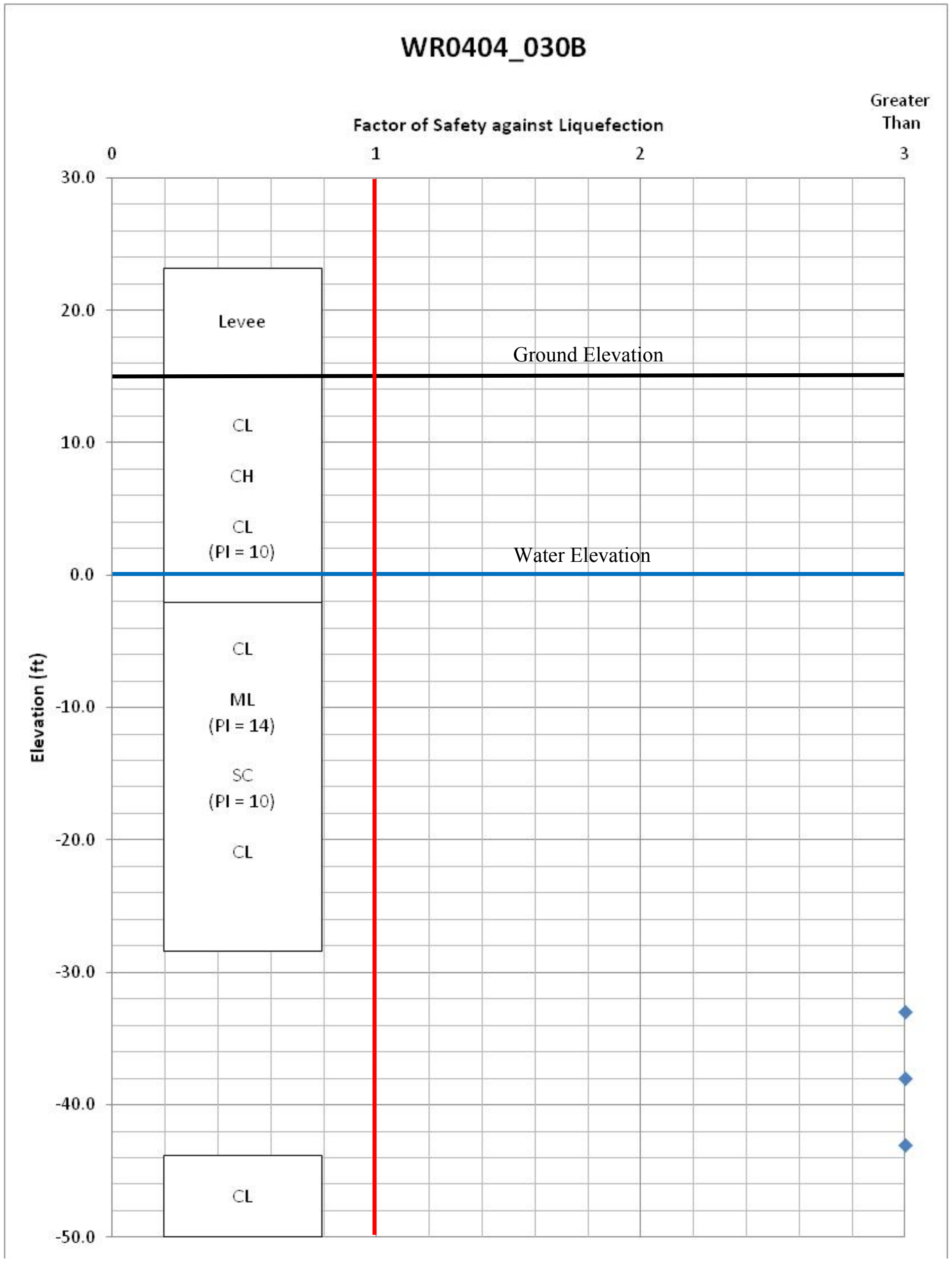


Fig. C-20. RD 404, Station 1003+04

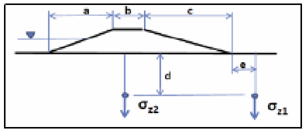
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: RD 404
Levee Station: 1201+00
Boring Number: WR0404_040B

Prepared by: Vlad Perlea
Checked by:

Date: 5/20/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	22.2 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	12.7 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.3 ft	Hammer Efficiency	80	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.1 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	28.4 ft
Crest Width, b (ft)	28.0 ft
Landside/Downstream Slope, c (ft)	50.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-64.0 ft
Embankment Height, H (ft)	9.5 ft

Boring	WR0404_040B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
22.20 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
15.5	6.7	17	ML	88	Unsaturated	120	125	1854.0	1854.0	1134.0	1860.0	1860.0	1.07	1	0.95	1.00	23.0	5.00	1.20	32.6	n.a.	0.96	0.13	1.00	0.65	1.00	#N/A
19.5	2.7	29	ML	50		120	125	2316.5	2316.5	1116.5	1207.0	1119.6	0.96	1	0.95	1.00	35.1	5.00	1.20	47.1	2.00	0.95	0.13	1.00	0.60	1.00	3.00
42.5	-20.3	20	SP	5		120	125	4938.4	3971.2	888.4	4082.0	2559.4	0.73	1	1	1.00	19.5	0.00	1.00	19.5	0.21	0.83	0.17	1.00	0.68	0.94	1.72
47.5	-25.3	17	SP	5		120	125	5511.6	4544.4	836.6	4707.0	2872.4	0.68	1	1	1.00	15.5	0.00	1.00	15.5	0.16	0.79	0.17	1.00	0.72	0.92	1.35
52.5	-30.3	55	SM	15		120	125	6087.9	5120.7	787.9	5332.0	3185.4	0.64	1	1	1.00	47.1	2.50	1.05	51.9	2.00	0.75	0.16	1.00	0.60	0.85	3.00
57.5	-35.3	68	SW-SM	8		120	125	6667.8	5700.6	742.8	5957.0	3498.4	0.61	1	1	1.00	55.2	0.30	1.01	56.2	2.00	0.71	0.16	1.00	0.60	0.82	3.00
72.5	-50.3	57	CL	94	Clay	120	125	8427.7	7460.5	627.7	7832.0	4437.4	0.53	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.58	0.13	1.00	0.60	0.74	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

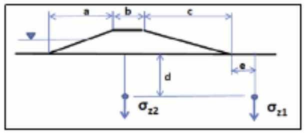
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: RD 404
Levee Station: 1175+01
Boring Number: WR0404_041B

Prepared by: Vlad Perlea
Checked by:

Date: 5/20/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	22.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	7.9 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.3 ft	Hammer Efficiency	80	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.1 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	20.3 ft
Crest Width, b (ft)	33.0 ft
Landside/Downstream Slope, c (ft)	52.2 ft
Dist. of Boring from Levee Toe [1] (ft)	-68.7 ft
Embankment Height, H (ft)	14.5 ft

Boring	WR0404_041B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
22.40 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
13.5	8.9	4	ML	63	Unsaturated	120	125	1620.0	1620.0	0.0	Embankment	Embankment	1.14	1	0.95	1.00	5.8	5.00	1.20	11.9	n.a.	0.97	#N/A	1.00	0.80	#N/A	#N/A
18.5	3.9	5	ML	54		120	125	2217.6	2217.6	1737.6	481.0	468.5	0.98	1	0.95	1.00	6.2	5.00	1.20	12.4	0.14	0.96	0.13	1.00	0.80	1.00	1.59
23.5	-1.1	4	SW-SM	8		120	125	2796.4	2796.4	1716.4	1106.0	781.5	0.87	1	0.95	1.00	4.4	0.30	1.01	4.8	0.07	0.95	0.17	1.00	0.80	1.00	0.61
58.0	-35.6	27	ML	55		120	125	6598.4	5756.0	1211.9	5418.5	2941.2	0.61	1	1	1.00	21.8	5.00	1.20	31.2	2.00	0.70	0.17	1.00	0.66	0.89	3.00
63.0	-40.6	57	SM	24		120	125	7155.1	6312.7	1143.6	6043.5	3254.2	0.58	1	1	1.00	44.0	4.18	1.11	52.9	2.00	0.66	0.16	1.00	0.60	0.84	3.00
73.0	-50.6	46	CH/CL	94	Clay	120	125	8284.2	7441.8	1022.7	7293.5	3880.2	0.53	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.58	0.14	1.00	0.60	0.78	#N/A

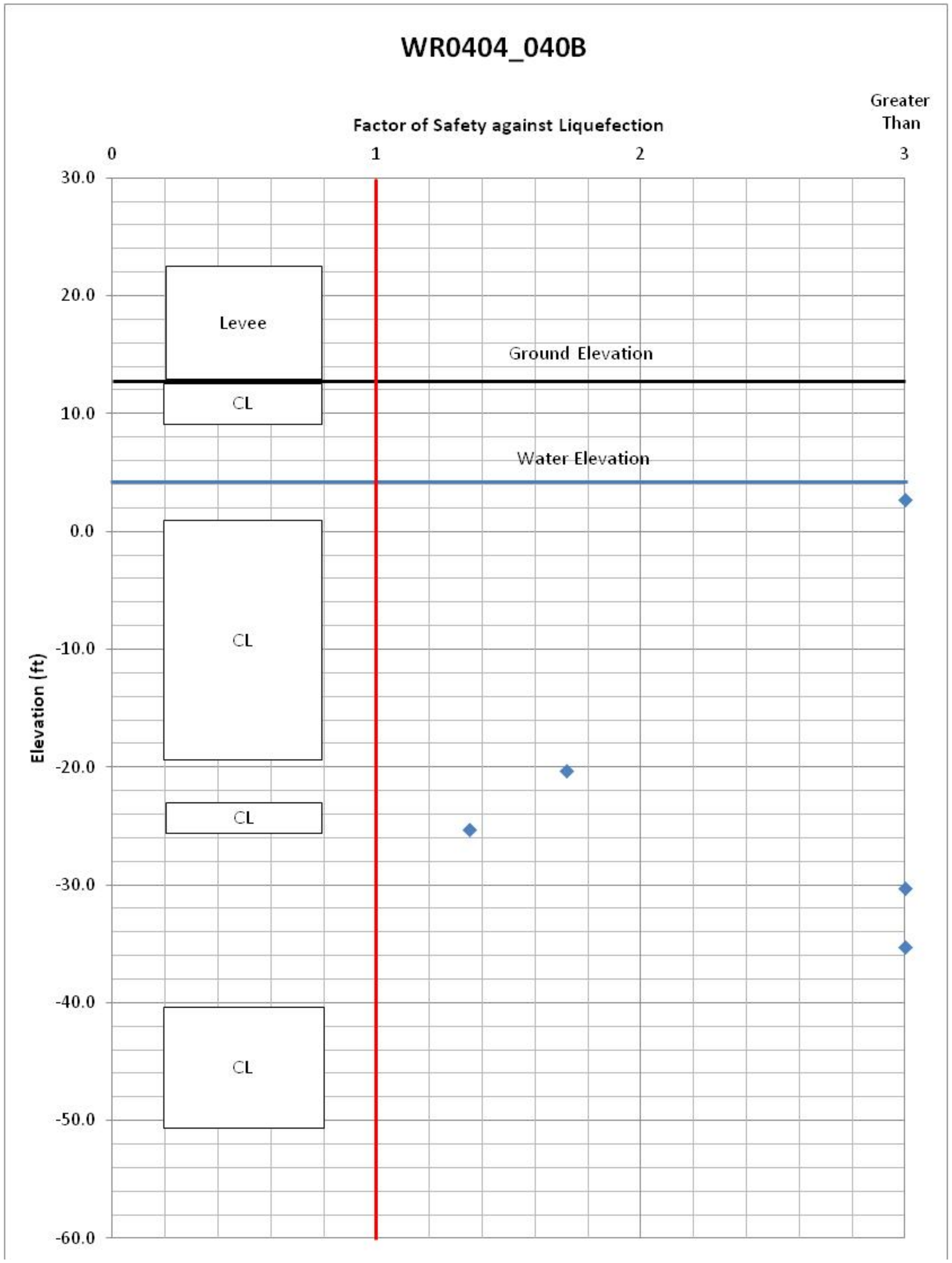


Fig. C-21. RD 404, Station 1201+00

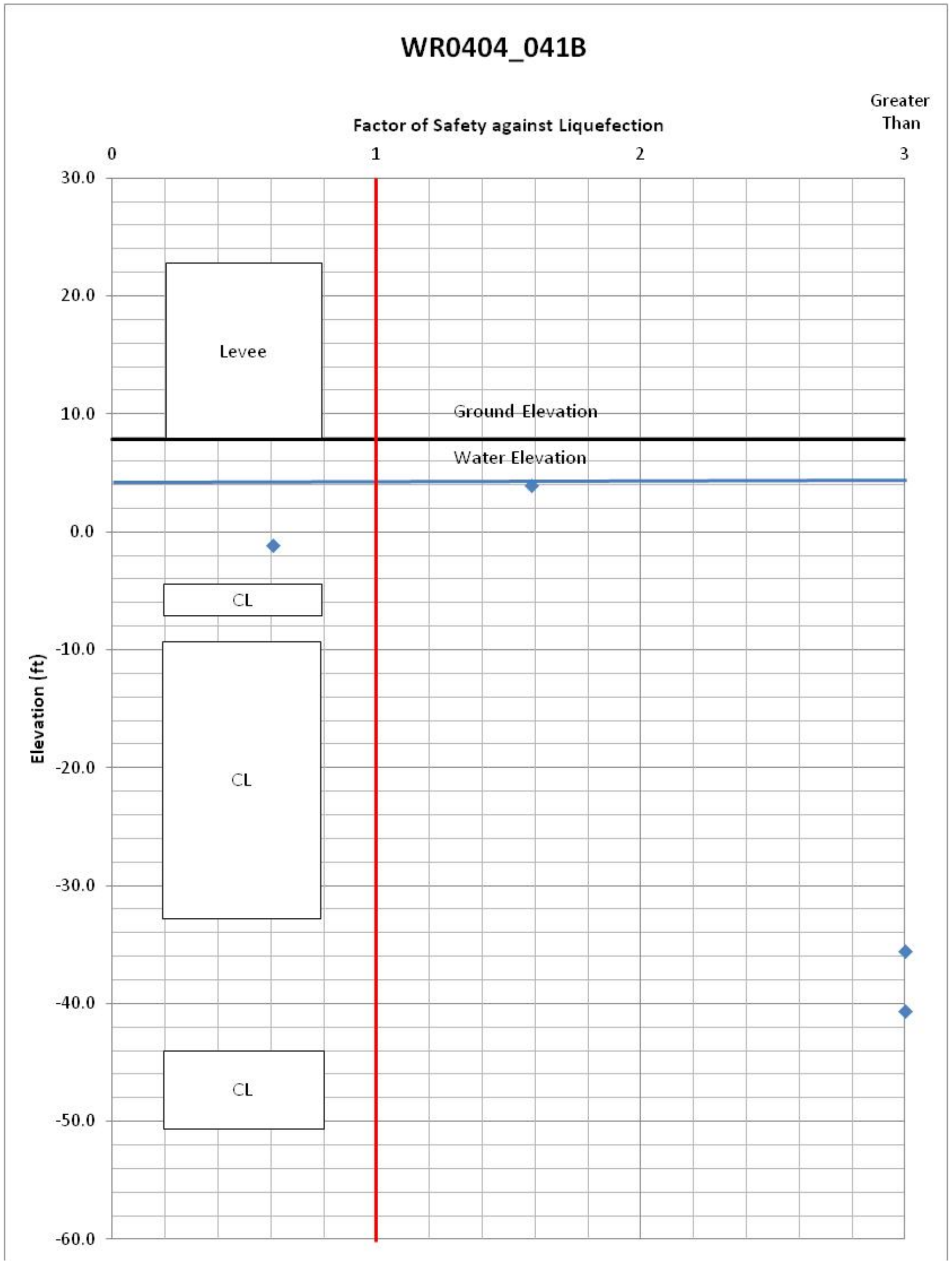


Fig. C-22. RD 404, Station 1175+01

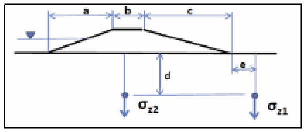
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: RD 404
Levee Station: 1139+55
Boring Number: WR0404_044B

Prepared by: Vlad Perlea
Checked by:

Date: 5/20/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	21.8 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	10.8 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.3 ft	Hammer Efficiency	80	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	28.4 ft
Crest Width, b (ft)	28.0 ft
Landside/Downstream Slope, c (ft)	50.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-64.0 ft
Embankment Height, H (ft)	11.0 ft

Boring WR0404_044B
Boring on the crest
SPT Ground Elevation Used in Analysis
21.80 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
23.5	-1.7	20	ML	95		120	125	2773.1	2773.1	1273.1	1508.5	1402.4	0.87	1	0.95	1.00	22.1	5.00	1.20	31.6	2.00	0.95	0.13	1.00	0.66	1.00	3.00
47.5	-25.7	30	SM	14		120	125	5483.3	4023.1	986.3	4508.5	2904.8	0.73	1	1	1.00	29.0	2.20	1.04	32.4	2.00	0.79	0.16	1.00	0.60	0.88	3.00
52.5	-30.7	21	SM	13		120	125	6050.8	4584.4	928.8	5133.5	3217.8	0.68	1	1	1.00	19.0	1.89	1.04	21.6	0.24	0.75	0.15	1.00	0.68	0.88	2.01
67.5	-45.7	50	SP-SM	10		120	125	7777.4	6311.0	780.4	7008.5	4156.8	0.58	1	1	1.00	38.6	0.87	1.02	40.3	2.00	0.62	0.14	1.00	0.60	0.76	3.00
72.5	-50.7	45	SP	5		120	125	8360.7	6894.3	738.7	7633.5	4469.8	0.55	1	1	1.00	33.2	0.00	1.00	33.2	2.00	0.58	0.13	1.00	0.60	0.74	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. AL, "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

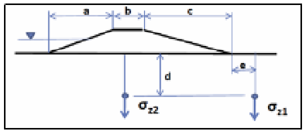
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: RD 404
Levee Station: 1112+49
Boring Number: WR0404_047B

Prepared by: Vlad Perlea
Checked by:

Date: 5/20/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	21.3 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	4.8 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.3 ft	Hammer Efficiency	80	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	24.6 ft
Crest Width, b (ft)	25.0 ft
Landside/Downstream Slope, c (ft)	47.6 ft
Dist. of Boring from Levee Toe [1] (ft)	-60.1 ft
Embankment Height, H (ft)	16.5 ft

Boring WR0404_047B
Boring on the crest
SPT Ground Elevation Used in Analysis
21.30 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
26.0	-4.7	12	ML	82		120	125	3084.6	2934.9	1932.6	1163.5	870.2	0.85	1	1	1.00	13.6	5.00	1.20	21.3	0.23	0.94	0.16	1.00	0.73	1.00	2.13
63.0	-41.7	13	ML	60		120	125	7015.2	5392.8	1238.2	5788.5	3186.4	0.63	1	1	1.00	10.9	5.00	1.20	18.0	0.19	0.66	0.16	1.00	0.76	0.91	1.68
68.0	-46.7	9	SM	15		120	125	7565.6	5943.2	1163.6	6413.5	3499.4	0.60	1	1	1.00	7.2	2.50	1.05	10.0	0.11	0.62	0.15	1.00	0.80	0.90	1.04
73.0	-51.7	24	CL	94	Clay	120	125	8122.7	6500.3	1096.7	7038.5	3812.4	0.57	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.58	0.14	1.00	0.60	0.79	#N/A

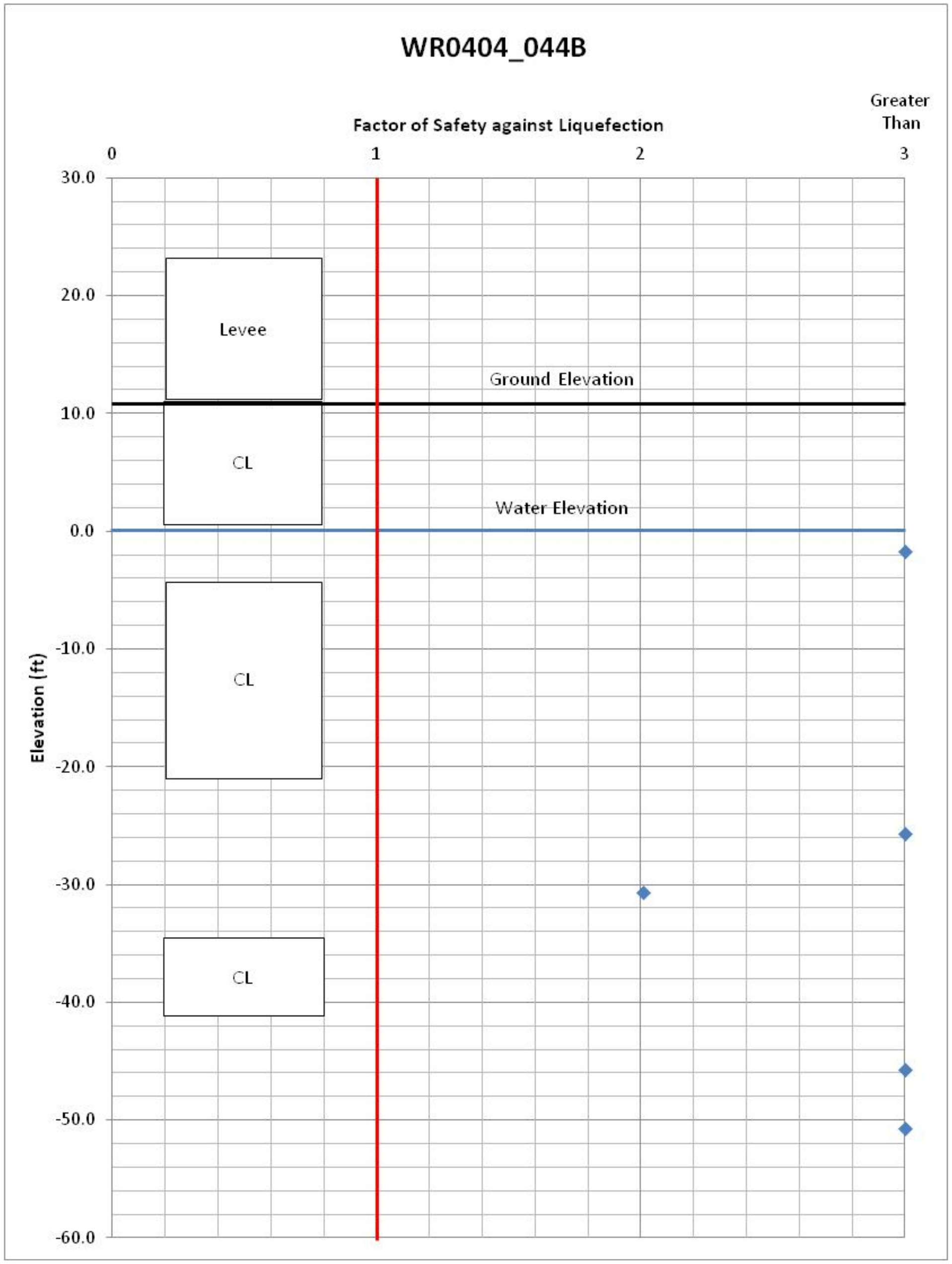


Fig. C-23. RD 404, Station 1139+55

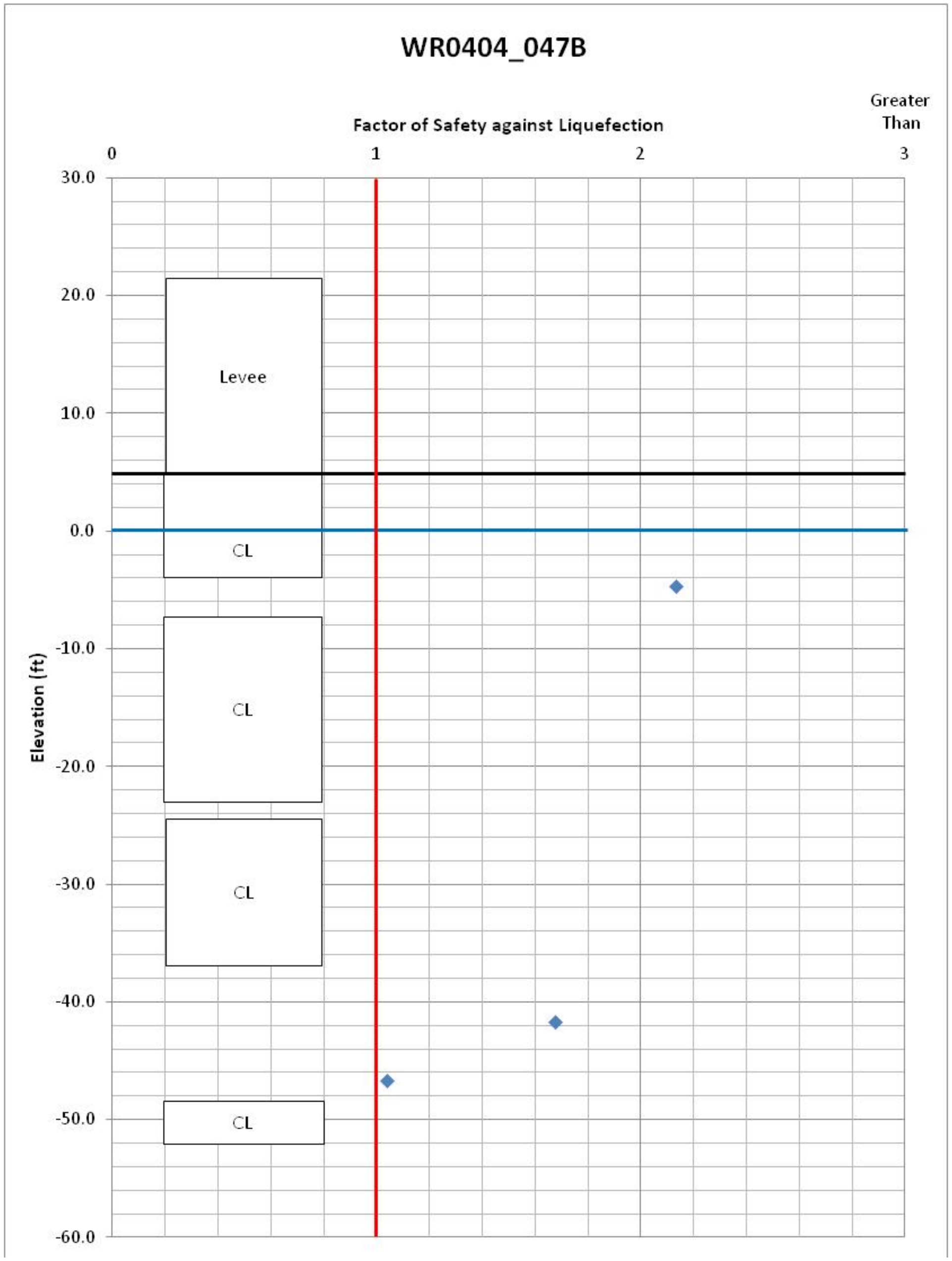
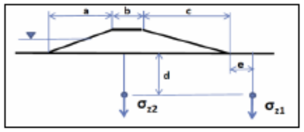


Fig. C-24. RD 404, Station 1112+49

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea
Study Area:	RD 404	**Checked by:**	
Levee Station:	January-03	**Date:**	6/4/2013
Boring Number:	WR0404_048B	**Date:**	



Input Parameters

Embankment Crest Elevation (ft)	21.5 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	12.1 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	9.4 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.2 ft	Hammer Efficiency	80	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.0 ft			120.0 pcf	

Surcharge Information

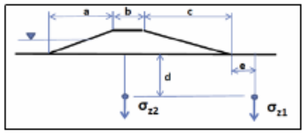
Waterside/Upstream Slope, a (ft)	24.5 ft
Crest Width, b (ft)	25.0 ft
Landside/Downstream Slope, c (ft)	48.0 ft
Dist. of Boring from Levee Toe [1] (ft)	0.0 ft
Embankment Height, H (ft)	9.4 ft

Boring WR0404_048B
Boring on waterside or landside field
SPT Ground Elevation Used in Analysis
12.10 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
38.0	-25.9	44	SM	25		120	125	4910.7	3431.8	232.2	4689.5	3073.3	0.79	1	1	1.00	46.1	4.29	1.12	55.7	2.00	0.86	0.17	1.00	0.60	0.86	3.00

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea
Study Area:	RD 404	**Checked by:**	
Levee Station:	1087+77	**Date:**	5/20/2013
Boring Number:	WR0404_053B	**Date:**	



Input Parameters

Embankment Crest Elevation (ft)	22.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	2.2 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.2 ft	Hammer Efficiency	80	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.0 ft			120.0 pcf	

Surcharge Information

Waterside/Upstream Slope, a (ft)	56.9 ft
Crest Width, b (ft)	18.0 ft
Landside/Downstream Slope, c (ft)	36.2 ft
Dist. of Boring from Levee Toe [1] (ft)	-45.2 ft
Embankment Height, H (ft)	20.2 ft

Boring WR0404_053B
Boring on the crest
SPT Ground Elevation Used in Analysis
22.40 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
28.5	-6.1	10	CL/ML	94		120	125	3386.4	3143.1	2370.9	1026.5	645.9	0.82	1	1	1.00	10.9	5.00	1.20	18.1	0.19	0.93	0.19	1.00	0.76	1.00	1.50
33.0	-10.6	11	CL/ML	94		120	125	3865.5	3341.3	2287.5	1589.0	927.6	0.80	1	1	1.00	11.7	5.00	1.20	19.0	0.20	0.91	0.20	1.00	0.75	1.00	1.51
58.0	-35.6	22	SM	13		120	125	6410.6	4632.2	1707.6	4714.0	2492.6	0.68	1	1	1.00	19.8	1.89	1.04	22.4	0.25	0.70	0.17	1.00	0.68	0.95	2.05
63.0	-40.6	49	SW-SM	11		120	125	6935.2	5156.8	1607.2	5339.0	2805.6	0.64	1	1	1.00	41.9	1.21	1.03	44.2	2.00	0.66	0.16	1.00	0.60	0.89	3.00
68.0	-45.6	37	SW-SM	11		120	125	7467.6	5689.2	1514.6	5964.0	3118.6	0.61	1	1	1.00	30.1	1.21	1.03	32.1	2.00	0.62	0.15	1.00	0.60	0.86	3.00
73.0	-50.6	54	SW-SM	11		120	125	8007.6	6229.2	1429.6	6589.0	3431.6	0.58	1	1	1.00	42.0	1.21	1.03	44.3	2.00	0.58	0.14	1.00	0.60	0.82	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. AL, "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

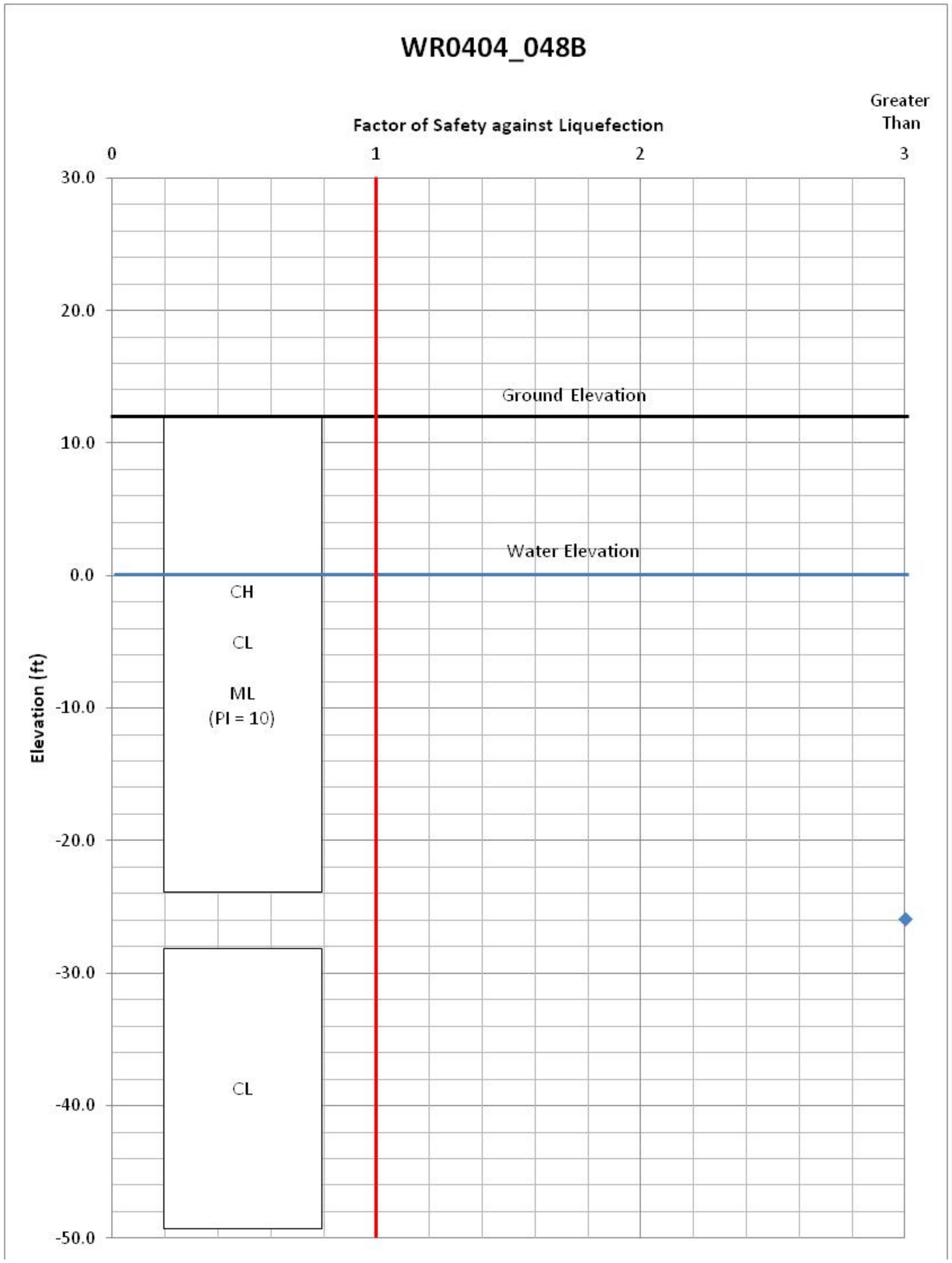


Fig. C-25. RD 404, Station 1108+07

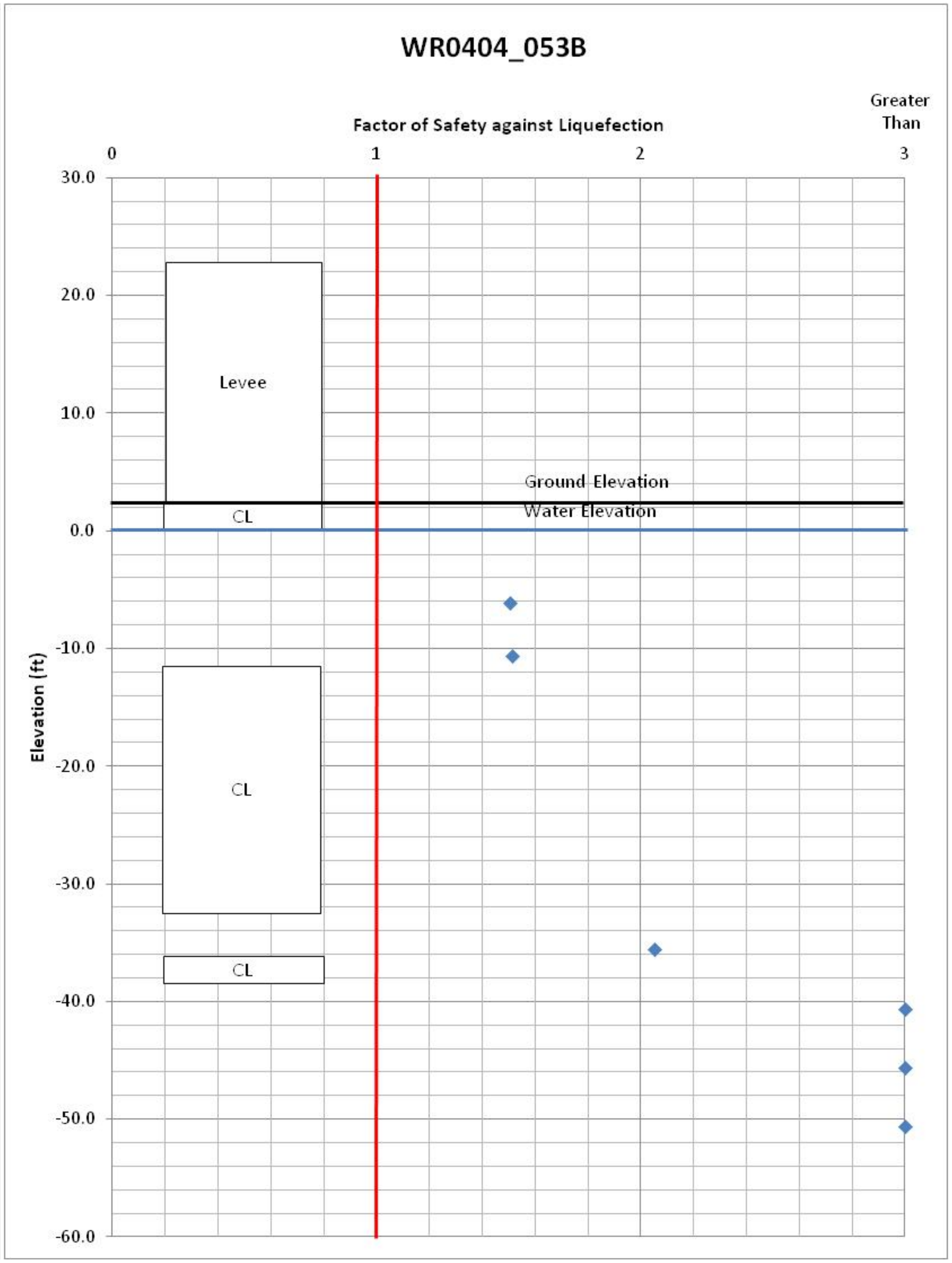


Fig. C-26. RD 404, Station 1087+77

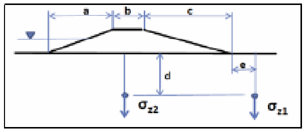
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: RD 404
Levee Station: 1070+28
Boring Number: WR0404_056B

Prepared by: Vlad Perlea
Checked by:

Date: 5/20/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	18.9 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.2 ft	Hammer Efficiency	80	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.0 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	17.5 ft
Crest Width, b (ft)	21.0 ft
Landside/Downstream Slope, c (ft)	166.3 ft
Dist. of Boring from Levee Toe [1] (ft)	-176.8 ft
Embankment Height, H (ft)	15.5 ft

Boring WR0404_058B
Boring on the crest
SPT Ground Elevation Used in Analysis
18.90 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
21.0	-2.1	4	SM/ML	49		120	125	2506.1	2506.1	1846.1	670.5	539.5	0.92	1	0.95	1.00	4.7	5.00	1.20	10.6	0.12	0.95	0.15	1.00	0.80	1.00	1.16
63.0	-44.1	21	SM	32		120	125	7152.1	5841.7	1242.6	5920.5	3168.7	0.60	1	1	1.00	16.9	4.83	1.17	24.6	0.28	0.66	0.16	1.00	0.70	0.89	2.35
68.0	-49.1	23	SP-SM	10		120	125	7728.1	6417.7	1193.6	6545.5	3481.7	0.57	1	1	1.00	17.6	0.87	1.02	18.9	0.20	0.62	0.15	1.00	0.70	0.86	1.71
75.0	-56.1	49	SP-SM	10		120	125	8541.9	7231.5	1132.4	7420.5	3919.9	0.54	1	1	1.00	35.3	0.87	1.02	37.0	2.00	0.56	0.14	1.00	0.60	0.78	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. AL, "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

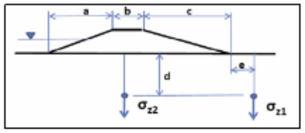
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: RD 404
Levee Station: 1042+70
Boring Number: WR0404_059B

Prepared by: Vlad Perlea
Checked by:

Date: 5/20/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	19.7 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.5 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.2 ft	Hammer Efficiency	80	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.0 ft				120.0 pcf



Surcharge Information	
Waterside/Upstream Slope, a (ft)	21.5 ft
Crest Width, b (ft)	36.0 ft
Landside/Downstream Slope, c (ft)	16.6 ft
Dist. of Boring from Levee Toe [1] (ft)	-34.6 ft
Embankment Height, H (ft)	16.2 ft

Boring WR0404_059B
Boring on the crest
SPT Ground Elevation Used in Analysis
19.70 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
27.5	-7.8	17	ML	88		120	125	3270.6	2921.2	1886.6	1395.0	908.3	0.85	1	1	1.00	19.3	5.00	1.20	28.1	0.37	0.94	0.19	1.00	0.68	1.00	3.00
47.5	-27.8	62	SM	15		120	125	5364.6	3767.1	1480.6	3895.0	2160.3	0.75	1	1	1.00	62.0	2.50	1.05	67.4	2.00	0.79	0.18	1.00	0.60	0.99	3.00
52.0	-32.3	26	ML/CL	80		120	125	5831.9	4115.9	1385.4	4457.5	2442.0	0.72	1	1	1.00	24.9	5.00	1.20	34.8	2.00	0.75	0.18	1.00	0.64	0.95	3.00
57.5	-37.8	17	ML/CL	95		120	125	6411.8	4695.8	1277.8	5145.0	2786.3	0.67	1	1	1.00	15.2	5.00	1.20	23.3	0.26	0.71	0.17	1.00	0.72	0.93	2.14
67.5	-47.8	14	CL/ML	95		120	125	7493.6	5777.6	1109.6	6395.0	3412.3	0.61	1	1	1.00	11.3	5.00	1.20	18.6	0.20	0.62	0.15	1.00	0.76	0.89	1.74
71.0	-51.3	29	CL/ML	85		120	125	7880.1	6164.1	1058.6	6832.5	3631.4	0.59	1	1	1.00	22.7	5.00	1.20	32.2	2.00	0.60	0.15	1.00	0.66	0.83	3.00

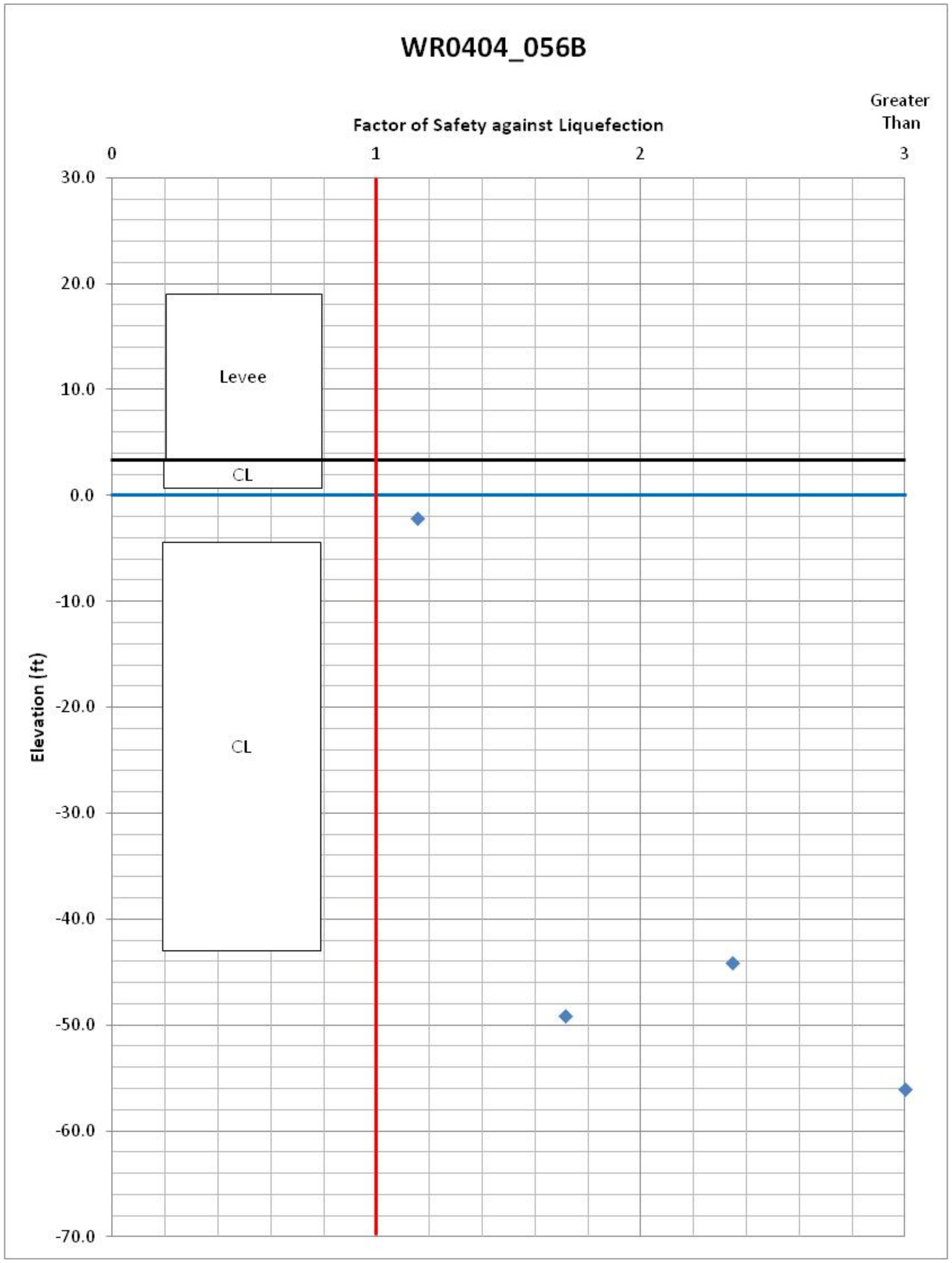


Fig. C-27. RD 404, Station 1070+28

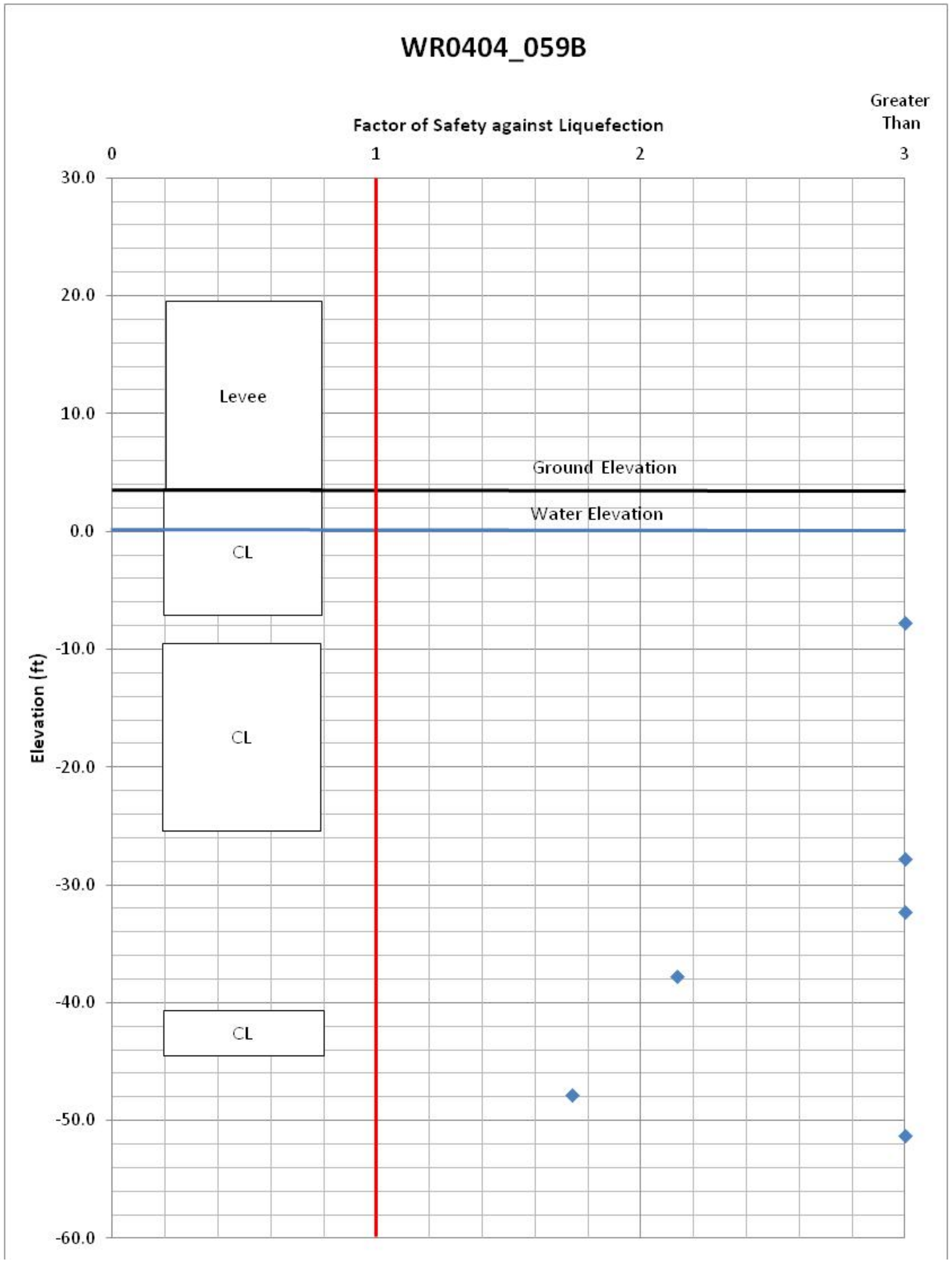


Fig. C-28. RD 404, Station 1042+70

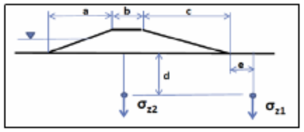
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: RD 404
Levee Station: 1028+00
Boring Number: WR0404_060B

Prepared by: Vlad Perlea
Checked by:

Date: 5/20/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	21.9 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	10.9 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.2 ft	Hammer Efficiency	80	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	12.1 ft
Crest Width, b (ft)	29.0 ft
Landside/Downstream Slope, c (ft)	132.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-146.5 ft
Embankment Height, H (ft)	11.0 ft

Boring WR0404_080B
Boring on the crest
SPT Ground Elevation Used in Analysis
21.90 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
53.0	-31.1	25	SM	21		120	125	6125.6	4322.2	941.1	5195.5	3254.9	0.70	1	1	1.00	23.3	3.78	1.09	29.1	0.42	0.74	0.15	1.00	0.65	0.86	3.00
58.0	-36.1	32	SM	21		120	125	6708.5	4593.1	899.0	5820.5	3567.9	0.68	1	1	1.00	29.0	3.78	1.09	35.2	2.00	0.70	0.15	1.00	0.60	0.81	3.00
63.0	-41.1	50	SM	21		120	125	7295.2	4867.9	860.7	6445.5	3880.9	0.66	1	1	1.00	44.0	3.78	1.09	51.5	2.00	0.66	0.14	1.00	0.60	0.78	3.00
68.0	-46.1	46	SM	21		120	125	7885.3	5146.0	825.8	7070.5	4193.9	0.64	1	1	1.00	39.3	3.78	1.09	46.5	2.00	0.62	0.14	1.00	0.60	0.76	3.00
73.0	-51.1	18	CL/CH	94	Clay	120	125	8478.4	5427.0	793.9	7695.5	4506.9	0.62	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.58	0.13	1.00	0.60	0.74	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

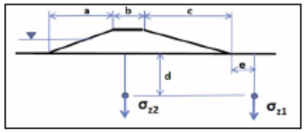
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Calaveras River and Stockton Diverting Canal
Levee Station: 6505+30
Boring Number: WR1614_017B

Prepared by: Vlad Perlea
Checked by:

Date: 5/21/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	16.0 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	1.0 ft	Hammer Efficiency	85	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.4 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	92.0 ft
Crest Width, b (ft)	208.0 ft
Landside/Downstream Slope, c (ft)	56.7 ft
Dist. of Boring from Levee Toe [1] (ft)	-158.6 ft
Embankment Height, H (ft)	12.6 ft

Boring WR1814_017B
Boring on the crest
SPT Ground Elevation Used in Analysis
16.00 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
50.5	-34.5	0	SM, MH	90		120	125	6224.2	4009.0	1498.7	4737.5	2372.5	0.73	1	1	1.00	0.0	5.00	1.20	5.0	0.07	0.76	0.20	1.00	0.80	0.98	0.53
58.0	-42.0	21	SM	15		120	125	7153.1	4469.9	1490.1	5675.0	2842.0	0.69	1	1	1.00	20.5	2.50	1.05	24.0	0.27	0.70	0.18	1.00	0.67	0.91	2.04
60.5	-44.5	27	SM	16		120	125	7462.2	4623.0	1486.7	5987.5	2998.5	0.68	1	1	1.00	25.9	2.77	1.05	30.0	2.00	0.68	0.18	1.00	0.63	0.88	3.00

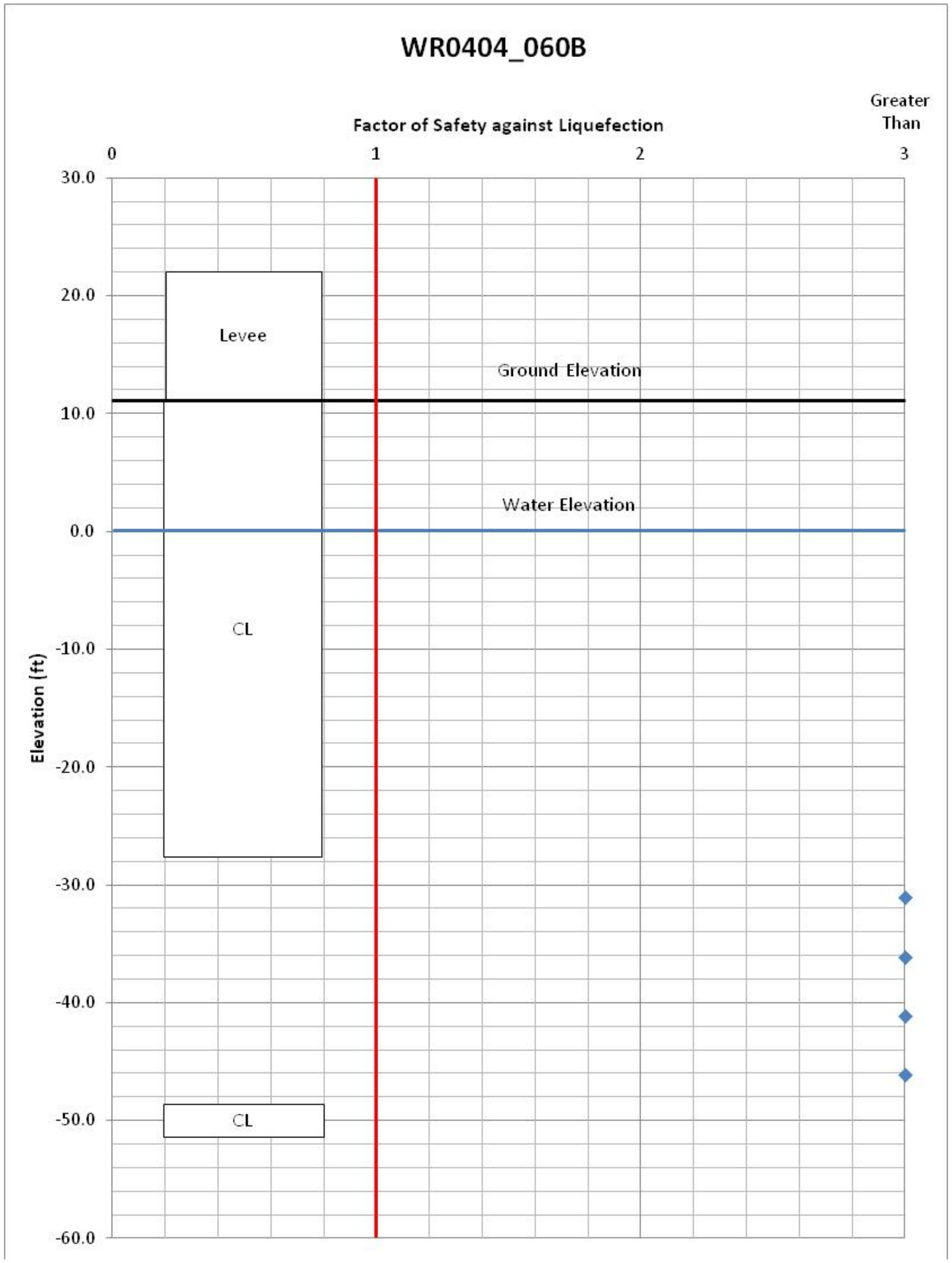


Fig. C-29. RD 404, Station 1028+00

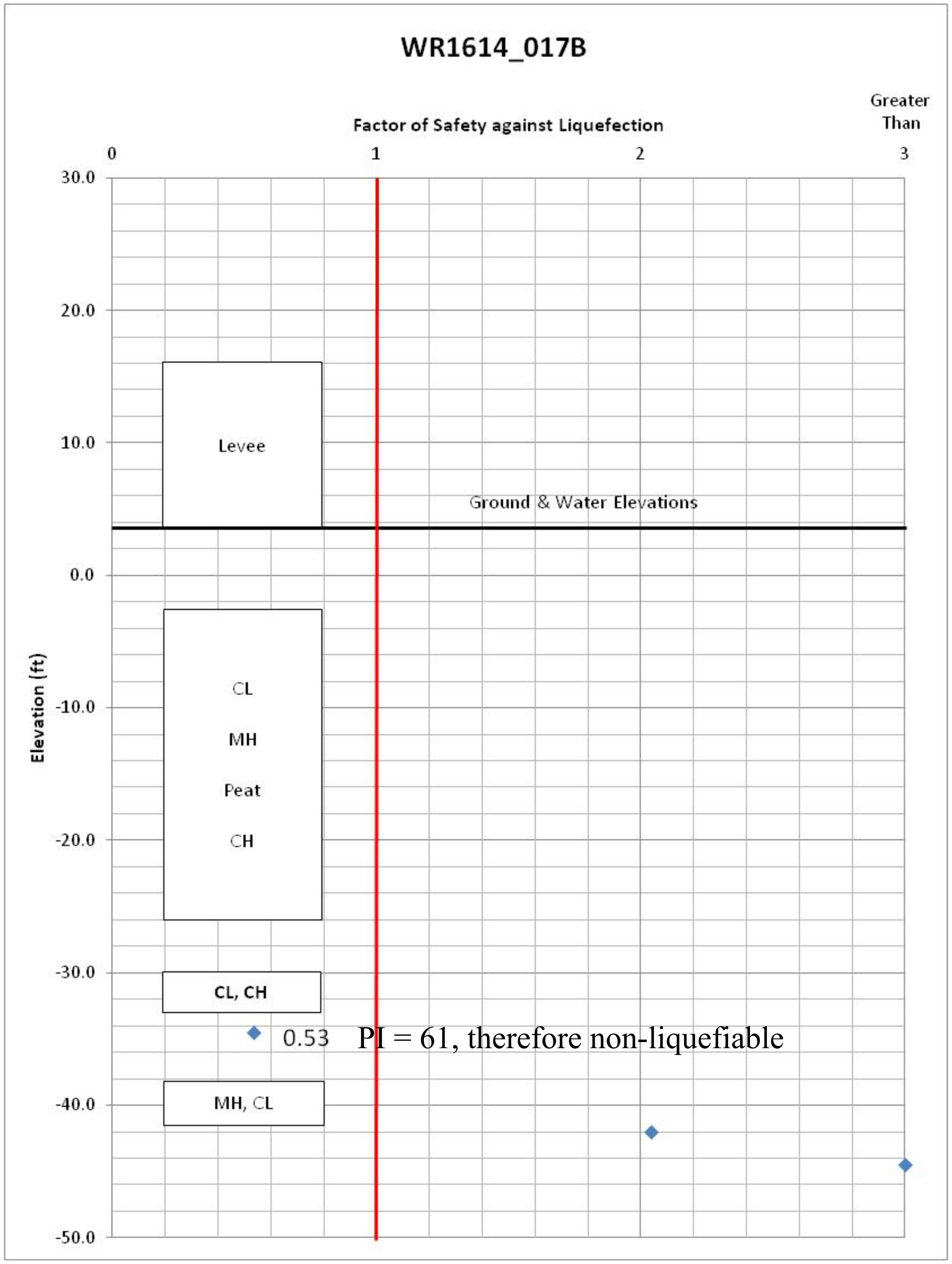


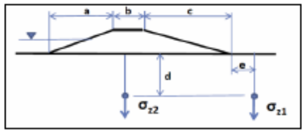
Fig. C-30. Calaveras River, Station 6505+30

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	5/21/2013
Study Area:	Calaveras River and Stockton Diverting Canal	**Checked by:**		**Date:**	
Levee Station:	3072+94				
Boring Number:	WR2074_016B				

Input Parameters

Embankment Crest Elevation (ft)	16.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.0 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	13.4 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-1.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	-1.0 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	41.6 ft
Crest Width, b (ft)	46.0 ft
Landside/Downstream Slope, c (ft)	31.9 ft
Dist. of Boring from Levee Toe [1] (ft)	21.7 ft
Embankment Height, H (ft)	13.4 ft

Boring	WR2074_016B
Boring on waterside or landside field	
SPT Ground Elevation Used in Analysis	
3.00 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
14.5	-11.5	7	ML	58		120	125	1814.9	1159.7	22.4	1792.5	1137.3	1.35	1	0.95	1.00	11.5	5.00	1.20	18.8	0.20	0.97	0.20	1.00	0.75	1.00	1.53
34.0	-31.0	21	SM	15		120	125	4365.0	3460.2	135.0	4230.0	2358.0	0.78	1	1	1.00	21.1	2.50	1.05	24.6	0.28	0.90	0.21	1.00	0.67	0.96	1.96
39.0	-36.0	27	SM	16		120	125	5021.7	4116.9	166.7	4855.0	2671.0	0.72	1	1	1.00	24.8	2.77	1.05	28.9	0.41	0.86	0.20	1.00	0.64	0.92	2.78
50.0	-47.0	21	CL	94	Clay	120	125	6459.3	5554.5	229.3	6230.0	3359.6	0.62	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.77	0.18	1.00	0.60	0.83	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

Updated April 2013

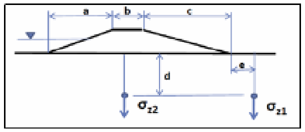
[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	5/21/2013
Study Area:	Calaveras River and Stockton Diverting Canal	**Checked by:**		**Date:**	
Levee Station:	3087+75				
Boring Number:	WCNBCR_010B				

Input Parameters

Embankment Crest Elevation (ft)	14.7 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	1.6 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	13.1 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-1.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	-1.0 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	19.7 ft
Crest Width, b (ft)	27.0 ft
Landside/Downstream Slope, c (ft)	53.2 ft
Dist. of Boring from Levee Toe [1] (ft)	198.7 ft
Embankment Height, H (ft)	13.1 ft

Boring	WCNBCR_010B
Boring on waterside or landside field	
SPT Ground Elevation Used in Analysis	
1.60 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
19.5	-17.9	13	SM	25		120	125	2424.6	1370.1	0.1	2424.5	1369.9	1.24	1	0.95	1.00	19.7	4.29	1.12	26.3	0.32	0.95	0.22	1.00	0.68	1.00	2.18
24.5	-22.9	19	SP-SM	8		120	125	3049.7	1832.9	0.2	3049.5	1682.9	1.07	1	0.95	1.00	24.9	0.30	1.01	25.5	0.30	0.94	0.22	1.00	0.64	1.00	2.04

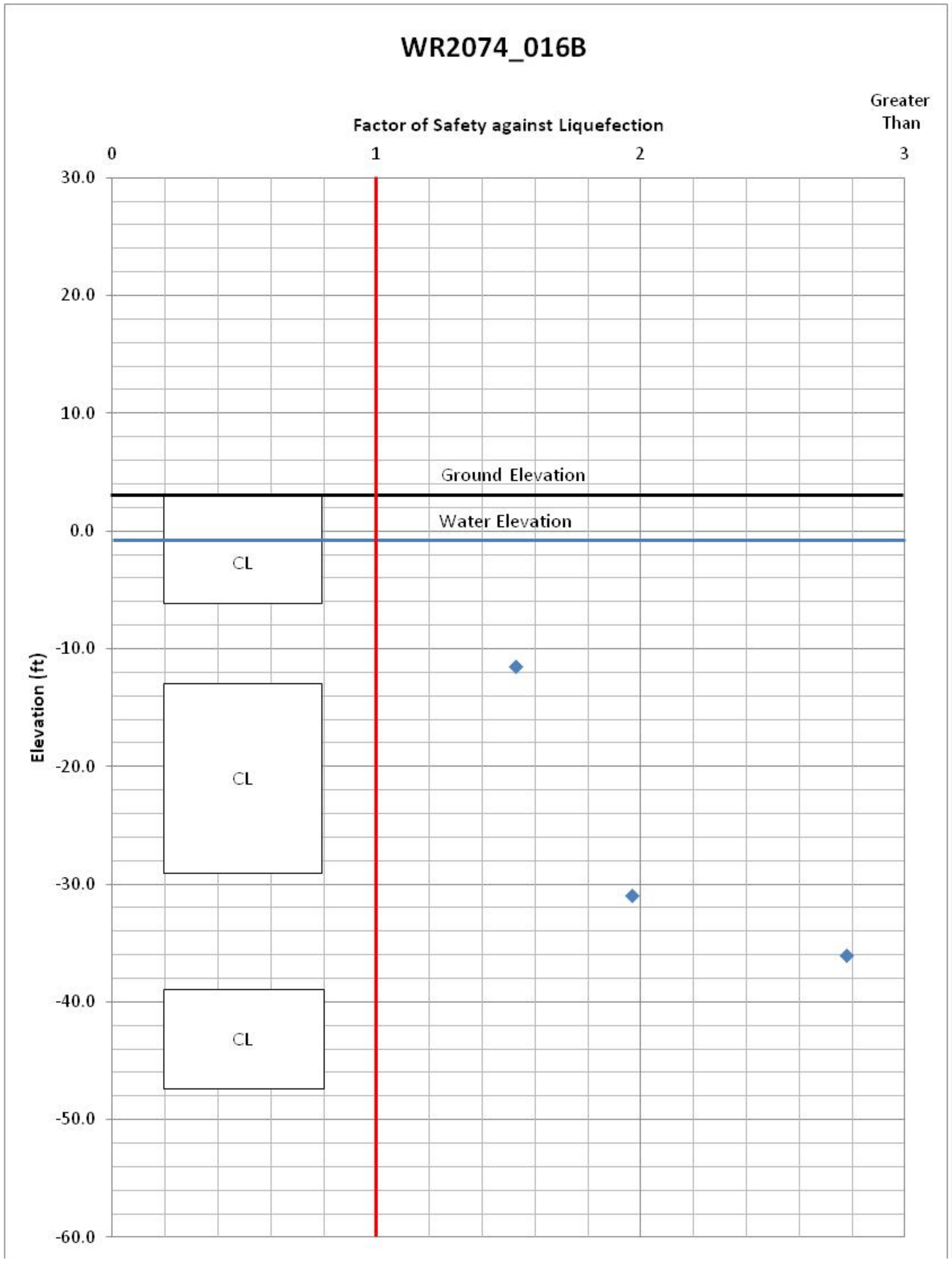


Fig. C-31. Calaveras River, Station 3072+94

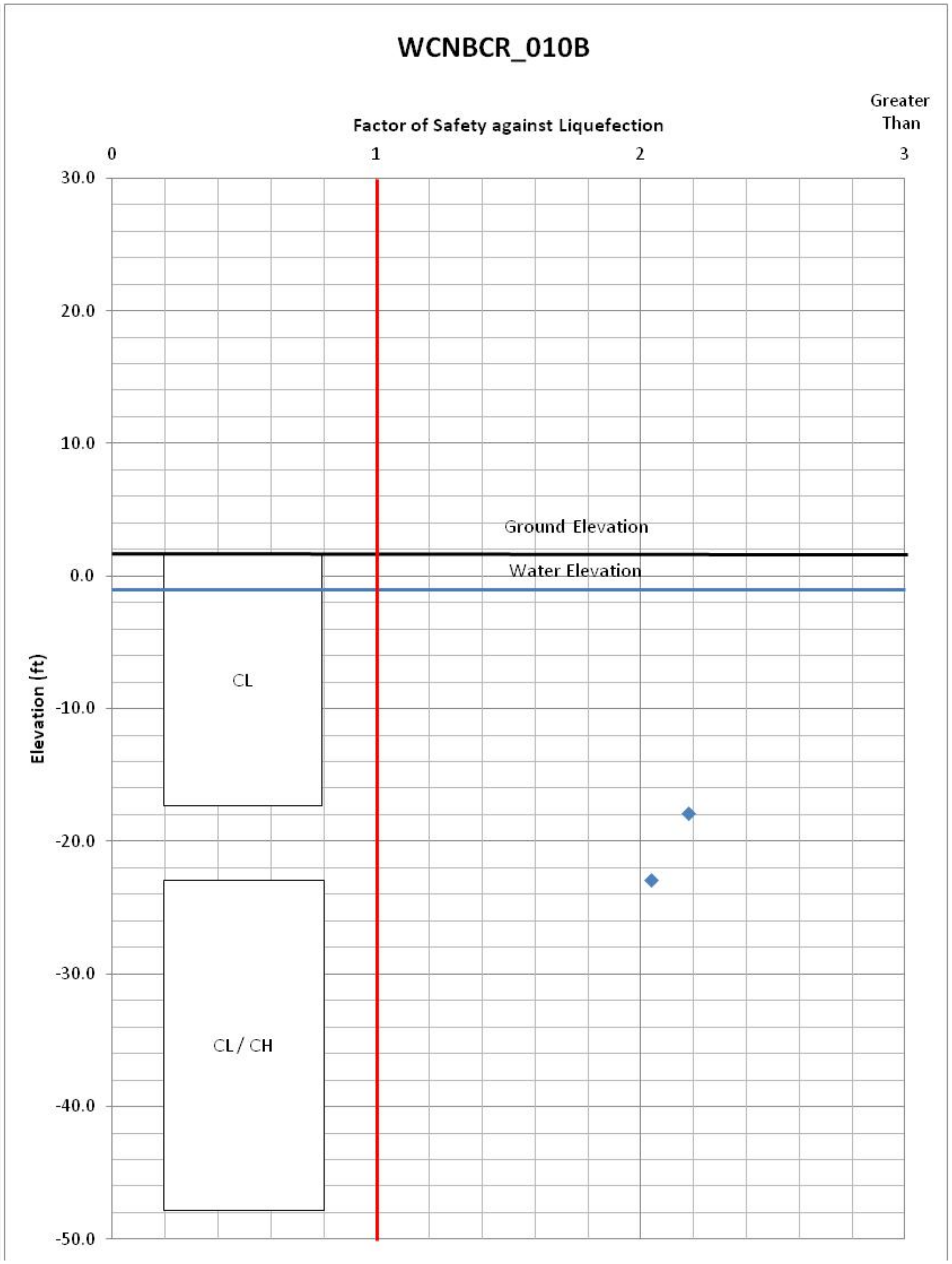


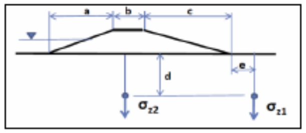
Fig. C-32. Calaveras River, Station 3087+75

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	5/21/2013
Study Area:	Calaveras River and Stockton Diverting Canal	**Checked by:**		**Date:**	
Levee Station:	6565+02				
Boring Number:	WR1614_018B				

Input Parameters

Embankment Crest Elevation (ft)	19.5 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	1.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	1.0 ft	Hammer Efficiency	85	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	1.4 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	29.0 ft
Crest Width, b (ft)	75.0 ft
Landside/Downstream Slope, c (ft)	34.5 ft
Dist. of Boring from Levee Toe [1] (ft)	-88.9 ft
Embankment Height, H (ft)	18.1 ft

Boring	**WR1614_018B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
19.50 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
41.5	-22.0	2	SP-SM	10		120	125	4975.0	3539.8	2052.0	2925.0	1464.8	0.77	1	1	1.00	2.2	0.87	1.02	3.1	0.06	0.84	0.22	1.00	0.80	1.00	0.41

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

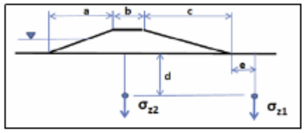
Updated April 2013

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	5/21/2013
Study Area:	Calaveras River and Stockton Diverting Canal	**Checked by:**		**Date:**	
Levee Station:	3130+53				
Boring Number:	WCNBCR_011B				

Input Parameters

Embankment Crest Elevation (ft)	19.0 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	7.3 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	11.7 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-1.5 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	-1.0 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	32.8 ft
Crest Width, b (ft)	18.0 ft
Landside/Downstream Slope, c (ft)	19.7 ft
Dist. of Boring from Levee Toe [1] (ft)	193.3 ft
Embankment Height, H (ft)	11.7 ft

Boring	**WCNBCR_011B**
Boring on waterside or landside field	
SPT Ground Elevation Used in Analysis	
7.30 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
6.0	1.3	12	ML	90	Unsaturated	120	125	720.0	720.0	0.0	720.0	720.0	1.70	1	0.8	1.00	20.9	5.00	1.20	30.1	n.a.	0.99	0.13	1.00	0.67	1.00	#N/A
10.0	-2.7	28	ML	90		120	125	1206.0	1131.1	0.0	1208.5	1102.4	1.37	1	0.85	1.00	41.8	5.00	1.20	55.1	2.00	0.98	0.14	1.00	0.60	1.00	3.00
15.0	-7.7	34	SM	45		120	125	1831.1	1456.7	0.1	1833.5	1415.4	1.21	1	0.95	1.00	50.0	5.00	1.20	65.0	2.00	0.97	0.16	1.00	0.60	1.00	3.00
20.0	-12.7	16	SM	20		120	125	2456.1	2081.7	0.1	2458.5	1728.4	1.01	1	0.95	1.00	19.7	3.61	1.08	24.8	0.29	0.95	0.18	1.00	0.68	1.00	2.46
25.0	-17.7	17	SM	20		120	125	3081.3	2706.9	0.3	3083.5	2041.4	0.88	1	0.95	1.00	18.3	3.61	1.08	23.4	0.26	0.94	0.18	1.00	0.69	1.00	2.14
30.0	-22.7	21	SM	20		120	125	3706.4	3332.0	0.4	3708.5	2354.4	0.80	1	1	1.00	21.5	3.61	1.08	26.8	0.33	0.93	0.19	1.00	0.67	0.96	2.53
45.0	-37.7	17	CL	94	Clay	120	125	5582.4	5208.0	1.4	5583.5	3293.4	0.64	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.81	0.18	1.00	0.60	0.84	#N/A

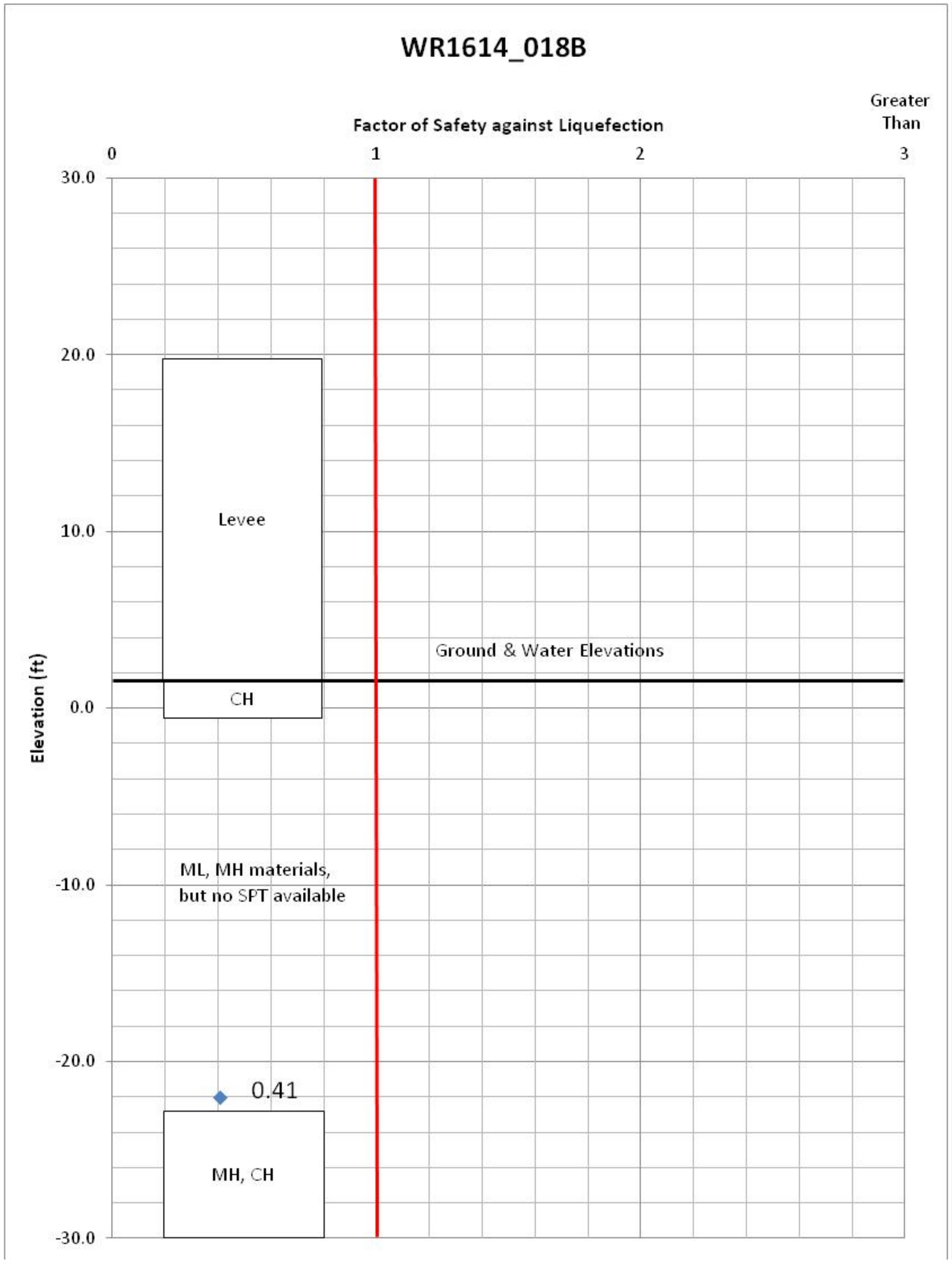


Fig. C-33. Calaveras River, Station 6565+02

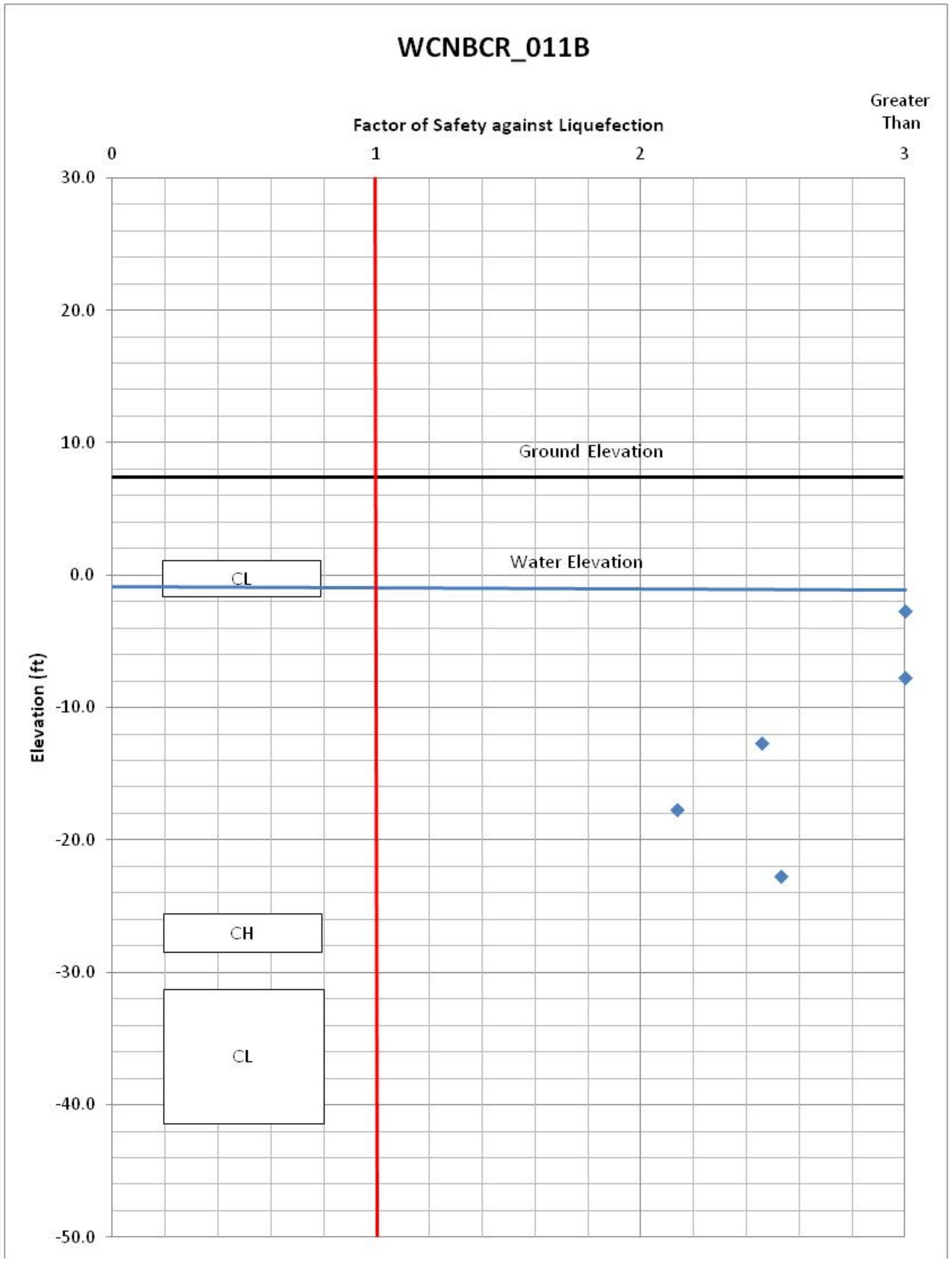


Fig. C-34. Calaveras River, Station 3130+53

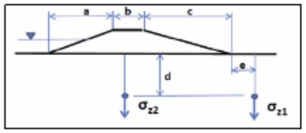
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Calaveras River and Stockton Diverting Canal
Levee Station: 3156+02
Boring Number: WCNBCR_012B

Prepared by: Vlad Perlea
Checked by:

Date: 5/21/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	23.1 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	13.6 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-1.5 ft	Hammer Efficiency	85	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	-1.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	24.8 ft
Crest Width, b (ft)	7.0 ft
Landside/Downstream Slope, c (ft)	20.1 ft
Dist. of Boring from Levee Toe [1] (ft)	-20.9 ft
Embankment Height, H (ft)	9.5 ft

Boring	WCNBCR_012B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
23.10 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
37.0	-13.9	5	SM	20		120	125	3970.0	3196.3	608.0	3364.5	2559.5	0.81	1	1	1.00	5.8	3.61	1.08	9.8	0.11	0.87	0.15	1.00	0.80	0.96	1.08
44.0	-20.9	10	SM	40		120	125	4758.1	3547.5	521.1	4239.5	2997.7	0.77	1	1	1.00	10.9	5.00	1.20	18.1	0.19	0.82	0.15	1.00	0.76	0.92	1.78

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

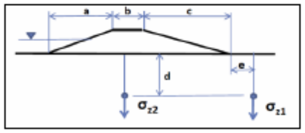
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Calaveras River and Stockton Diverting Canal
Levee Station: 6669+40
Boring Number: WR1514_019B

Prepared by: Vlad Perlea
Checked by:

Date: 5/21/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	25.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	15.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	10.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	1.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	21.5 ft
Crest Width, b (ft)	11.0 ft
Landside/Downstream Slope, c (ft)	28.1 ft
Dist. of Boring from Levee Toe [1] (ft)	22.5 ft
Embankment Height, H (ft)	10.0 ft

Boring	WR1614_019B
Boring on waterside or landside field	
SPT Ground Elevation Used in Analysis	
15.40 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
6.0	9.4	43	SM	40	Unsaturated	120	125	721.4	721.4	1.4	720.0	720.0	1.70	1	0.8	1.00	75.0	5.00	1.20	95.1	n.a.	0.99	0.13	1.00	0.60	1.00	#N/A
12.0	3.4	8	ML	81		120	125	1449.5	1449.5	9.5	1443.0	1405.6	1.21	1	0.85	1.00	10.5	5.00	1.20	17.7	0.19	0.97	0.13	1.00	0.76	1.00	2.17
17.0	-1.6	8	MH	100		120	125	2075.7	1913.5	22.7	2068.0	1718.6	1.05	1	0.95	1.00	10.3	5.00	1.20	17.3	0.18	0.96	0.15	1.00	0.77	1.00	1.84
22.0	-6.6	14	ML	60		120	125	2718.2	2343.8	40.2	2693.0	2031.6	0.95	1	0.95	1.00	16.2	5.00	1.20	24.5	0.28	0.95	0.16	1.00	0.71	1.00	2.58
27.0	-11.6	0	ML	53		120	125	3362.9	2988.5	59.9	3318.0	2344.6	0.84	1	1	1.00	0.0	5.00	1.20	5.0	0.07	0.94	0.17	1.00	0.80	0.98	0.61

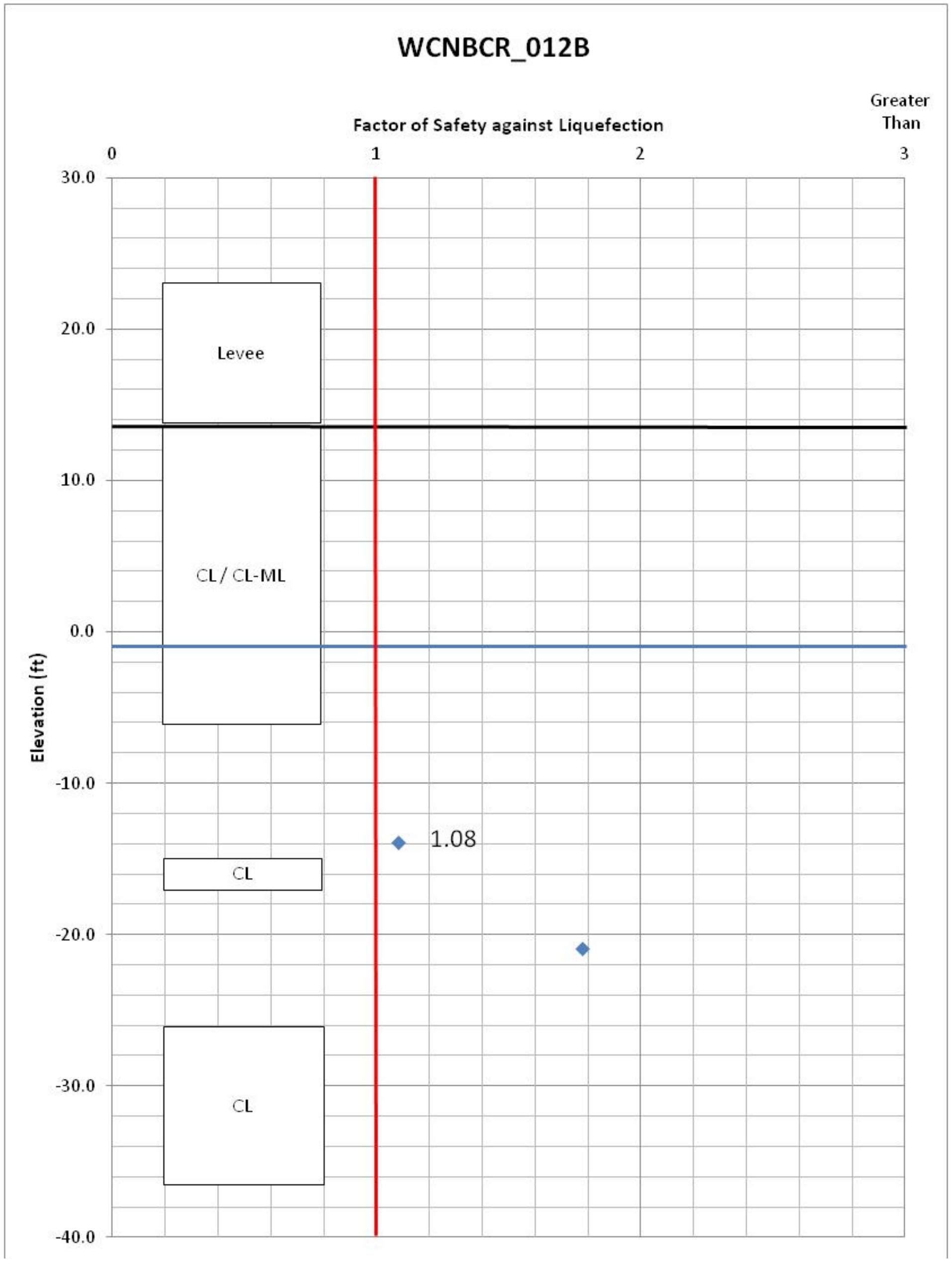


Fig. C-35. Calaveras River, Station 3156+02

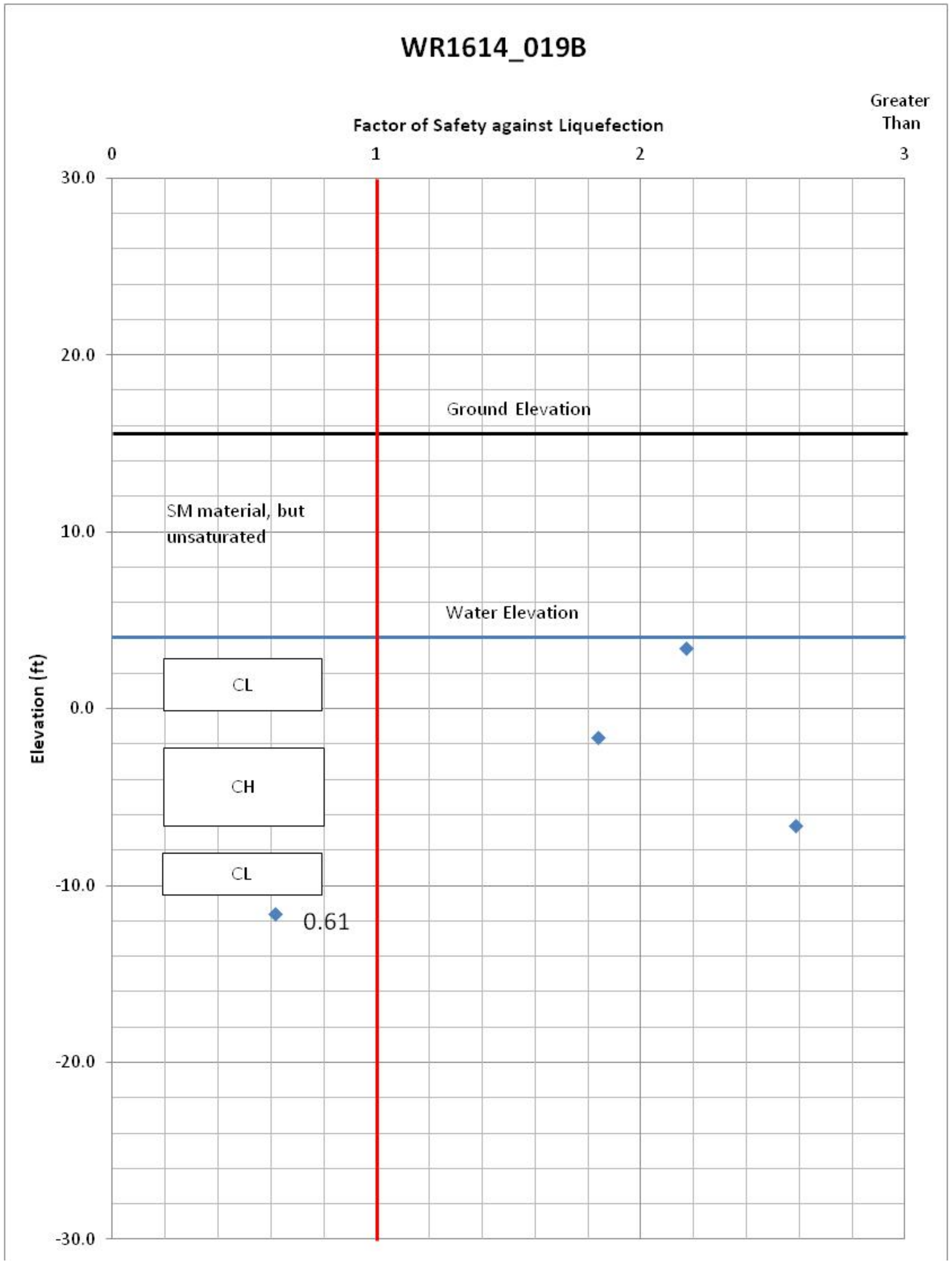


Fig. C-36. Calaveras River, Station 6669+40

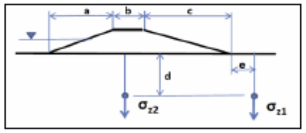
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Calaveras River and Stockton Diverting Canal
Levee Station: 3238+00
Boring Number: WCNBCR_013B

Prepared by: Vlad Perlea
Checked by:

Date: 5/21/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	25.5 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	14.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-1.5 ft	Hammer Efficiency	85	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	-1.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	83.3 ft
Crest Width, b (ft)	21.0 ft
Landside/Downstream Slope, c (ft)	21.1 ft
Dist. of Boring from Levee Toe [1] (ft)	-31.6 ft
Embankment Height, H (ft)	11.1 ft

Boring	**WCNBCR_013B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
25.50 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
24.0	1.5	15	SM	45	unsaturated	120	125	2803.4	2803.4	1255.4	2880.0	2880.0	0.87	1	0.95	1.00	17.5	5.00	1.20	26.0	n.a.	0.94	0.12	1.00	0.70	0.91	#N/A

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

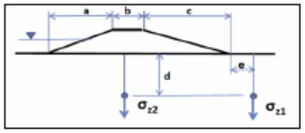
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Stockton Diverting Canal
Levee Station: 6762+29
Boring Number: WCSBCR_004B

Prepared by: Vlad Perlea
Checked by:

Date: 7/22/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	32.8 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	20.8 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.18
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-4.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	30.0 ft
Crest Width, b (ft)	25.0 ft
Landside/Downstream Slope, c (ft)	33.6 ft
Dist. of Boring from Levee Toe [1] (ft)	-46.1 ft
Embankment Height, H (ft)	12.0 ft

Boring	**WCSBCR_004B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
32.80 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
6.0	26.8	10	ML	60		120	125	720.0	720.0	0.0	Embankment	Embankment	1.70	1	0.8	1.00	17.5	5.00	1.20	25.9	0.31	0.99	#N/A	1.00	0.70	#N/A	#N/A
13.0	19.8	7	ML	70		120	125	1559.9	1559.9	1439.9	1560.0	1560.0	1.16	1	0.95	1.00	9.9	5.00	1.20	16.9	0.18	0.97	0.11	1.00	0.77	1.00	2.38
16.0	16.8	6	ML	62		120	125	1916.6	1916.6	1436.6	1920.0	1920.0	1.05	1	0.95	1.00	7.7	5.00	1.20	14.2	0.15	0.96	0.11	1.00	0.79	1.00	2.03
46.0	-13.2	27	ML	62		120	125	5168.7	4794.3	1042.7	4161.0	3150.1	0.66	1	1	1.00	23.0	5.00	1.20	32.6	2.00	0.80	0.12	1.00	0.65	0.87	3.00

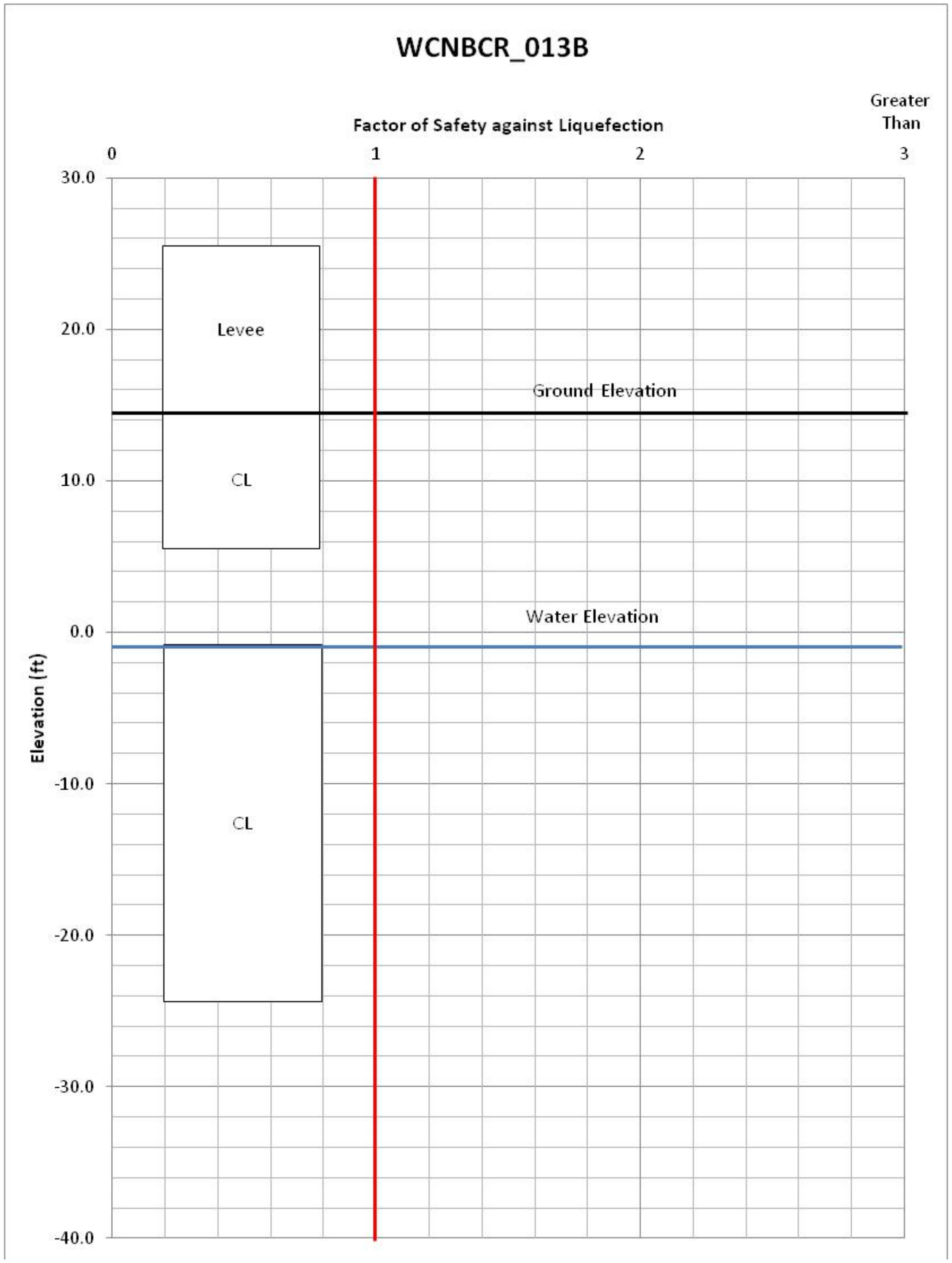


Fig. C-37. Calaveras River, Station 3238+00

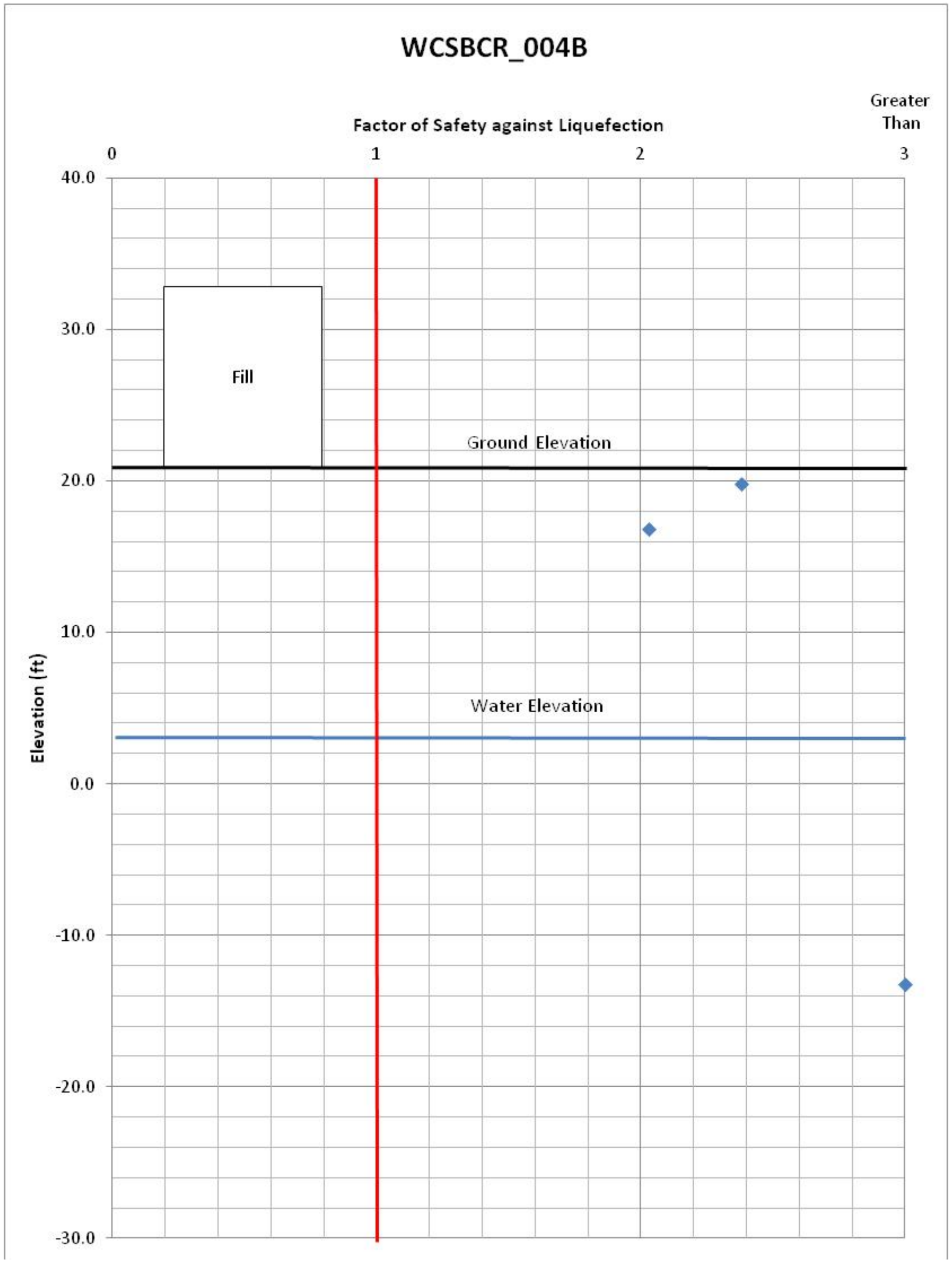


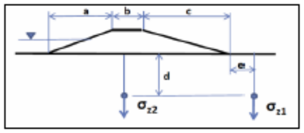
Fig. C-38. Calaveras River, Station 6762+29

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	7/22/2013
Study Area:	Stockton Diverting Canal	**Checked by:**		**Date:**	
Levee Station:	811+98				
Boring Number:	WCSBDC_001B				

Input Parameters

Embankment Crest Elevation (ft)	42.8 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	24.8 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.18
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4		
Groundwater Elevation during Drilling (ft)	-5.2 ft	Hammer Efficiency	84.5	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	24.8 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	41.4 ft
Crest Width, b (ft)	31.0 ft
Landside/Downstream Slope, c (ft)	41.4 ft
Dist. of Boring from Levee Toe [1] (ft)	-56.9 ft
Embankment Height, H (ft)	18.0 ft

Boring	WCSBDC_001B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
42.80 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
26.0	16.8	20	ML	77		120	125	3101.3	3101.3	2141.3	1000.0	500.8	0.83	1	1	1.00	23.3	5.00	1.20	32.9	2.00	0.94	0.22	1.00	0.65	1.00	3.00
31.0	11.8	29	SM	15		120	125	3654.8	3654.8	2094.8	1625.0	813.8	0.76	1	1	1.00	31.1	2.50	1.05	35.1	2.00	0.92	0.22	1.00	0.60	1.00	3.00
36.0	6.8	31	ML	80		120	125	4183.7	4183.7	2023.7	2250.0	1126.8	0.71	1	1	1.00	31.0	5.00	1.20	42.3	2.00	0.88	0.21	1.00	0.60	1.00	3.00
41.0	1.8	42	ML	80		120	125	4697.4	4697.4	1937.4	2875.0	1439.8	0.67	1	1	1.00	39.7	5.00	1.20	52.6	2.00	0.84	0.20	1.00	0.60	1.00	3.00
46.0	-3.2	46	ML	80		120	125	5204.1	5204.1	1844.1	3500.0	1752.8	0.64	1	1	1.00	41.3	5.00	1.20	54.6	2.00	0.80	0.19	1.00	0.60	1.00	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

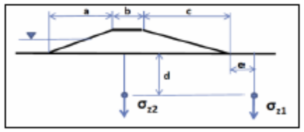
Updated April 2013

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	7/22/2013
Study Area:	Stockton Diverting Canal	**Checked by:**		**Date:**	
Levee Station:	883+93				
Boring Number:	WCSBDC_005B				

Input Parameters

Embankment Crest Elevation (ft)	39.2 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	24.2 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.18
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	6		
Groundwater Elevation during Drilling (ft)	-5.8 ft	Hammer Efficiency	83.5	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	24.2 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	34.5 ft
Crest Width, b (ft)	31.0 ft
Landside/Downstream Slope, c (ft)	34.5 ft
Dist. of Boring from Levee Toe [1] (ft)	-50.0 ft
Embankment Height, H (ft)	15.0 ft

Boring	WCSBDC_006B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
39.20 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
26.0	13.2	15	ML	87		120	125	3078.1	3078.1	1758.1	1375.0	688.6	0.83	1.05	1	1.00	18.2	5.00	1.20	26.8	0.33	0.94	0.22	1.00	0.69	1.00	2.28
31.0	8.2	16	ML	86		120	125	3618.2	3618.2	1698.2	2000.0	1001.6	0.76	1.05	1	1.00	17.9	5.00	1.20	26.5	0.32	0.92	0.22	1.00	0.69	1.00	2.26
36.0	3.2	34	ML	60		120	125	4141.0	4141.0	1621.0	2625.0	1314.6	0.71	1.05	1	1.00	35.5	5.00	1.20	47.6	2.00	0.88	0.21	1.00	0.60	1.00	3.00
42.5	-3.3	33	ML	73		120	125	4809.4	4809.4	1509.4	3437.5	1721.5	0.66	1.05	1	1.00	32.0	5.00	1.20	43.4	2.00	0.83	0.19	1.00	0.60	1.00	3.00
46.0	-6.8	54	ML	60		120	125	5173.3	5110.9	1448.3	3875.0	1940.6	0.64	1.05	1	1.00	50.8	5.00	1.20	65.9	2.00	0.80	0.19	1.00	0.60	1.00	3.00

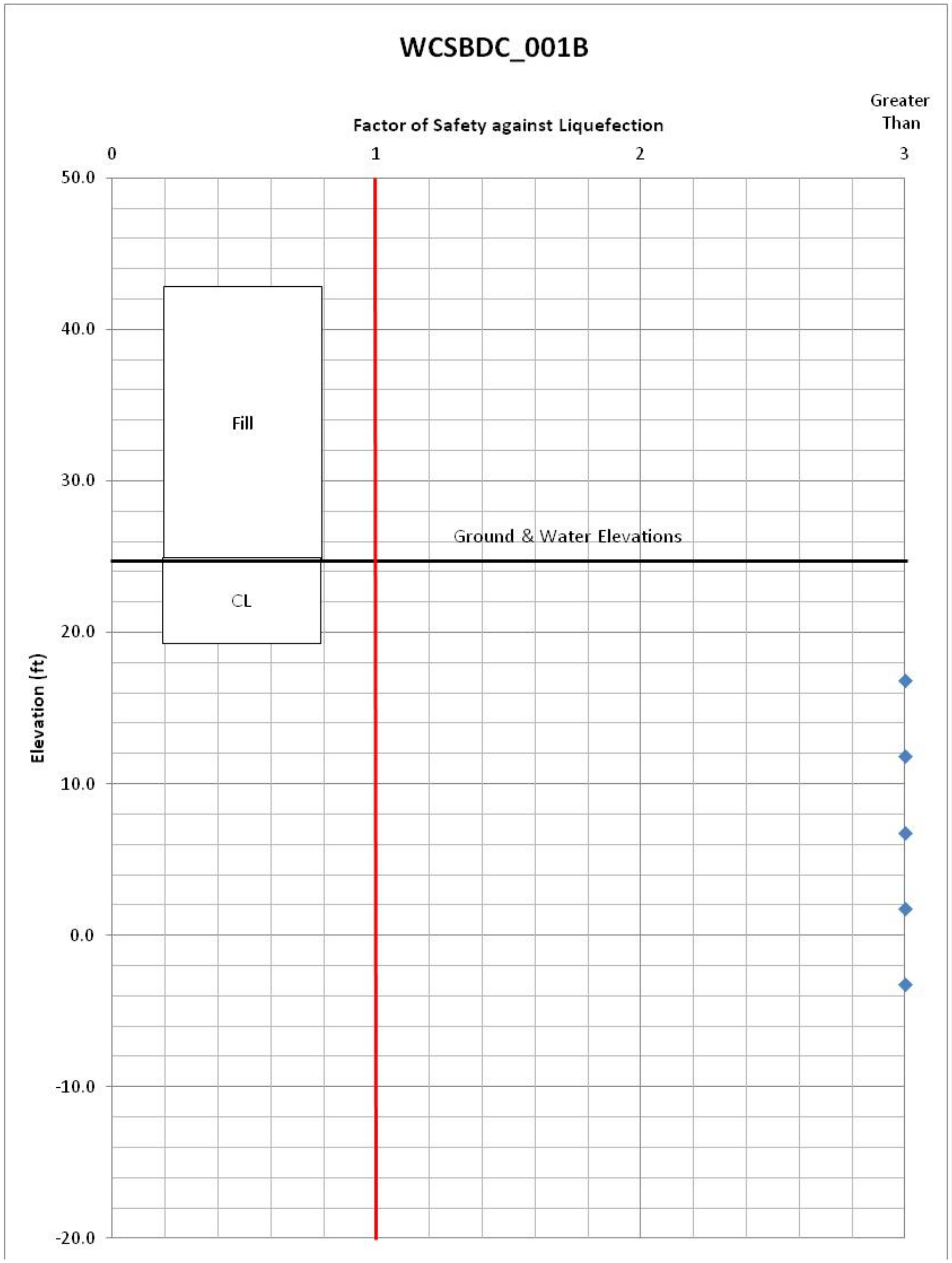


Fig. C-39. Stockton Diverting Canal, Station 811+98

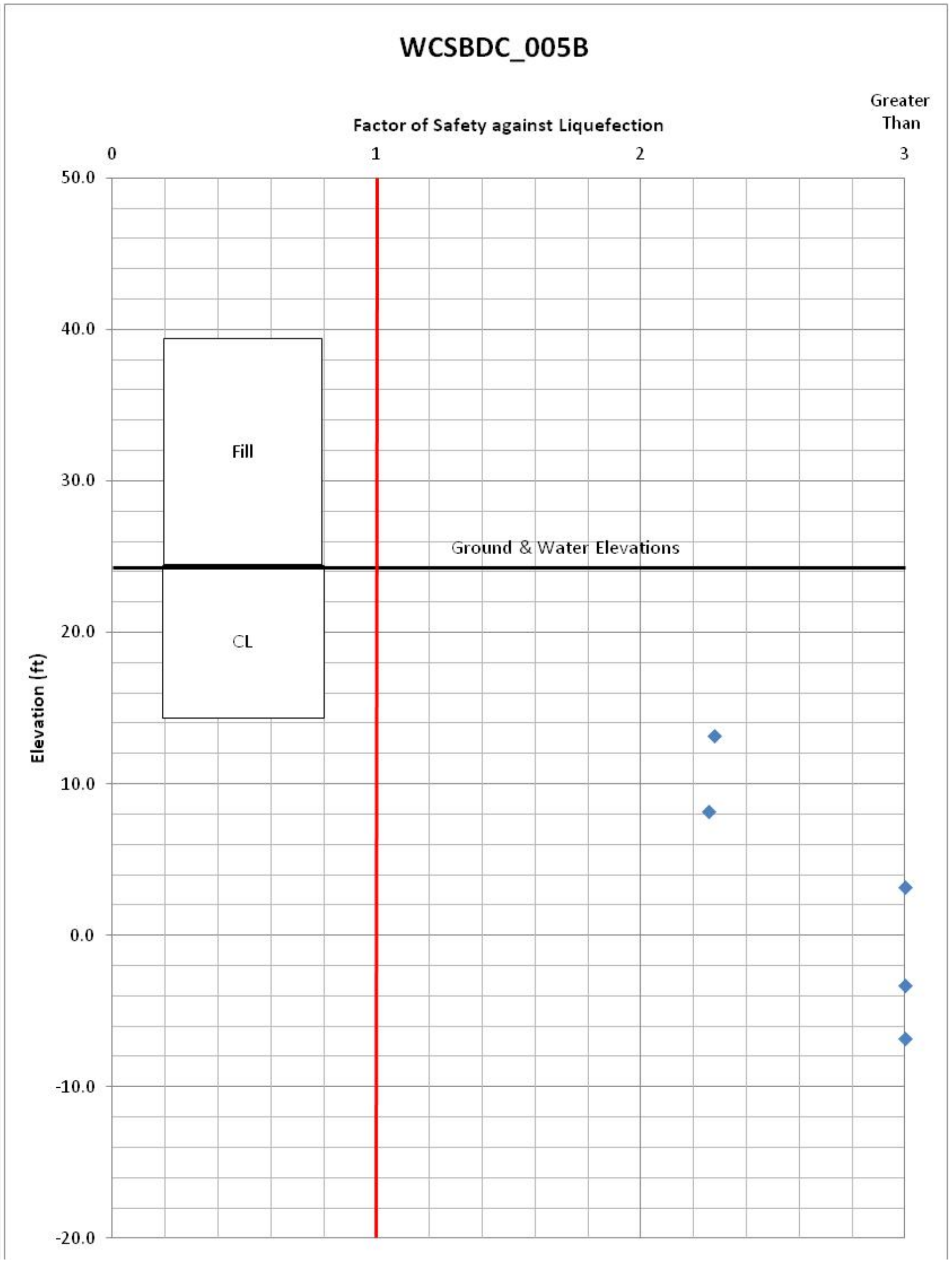


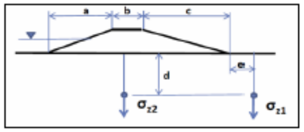
Fig. C-40. Stockton Diverting Canal, Station 883+93

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	7/23/2013
Study Area:	Stockton Diverting Canal	**Checked by:**		**Date:**	
Levee Station:	940+82				
Boring Number:	WCSBDC_008B				

Input Parameters

Embankment Crest Elevation (ft)	42.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	27.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.18
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	5		
Groundwater Elevation during Drilling (ft)	-2.6 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	27.4 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	34.5 ft
Crest Width, b (ft)	31.0 ft
Landside/Downstream Slope, c (ft)	34.5 ft
Dist. of Boring from Levee Toe [1] (ft)	-50.0 ft
Embankment Height, H (ft)	15.0 ft

Boring	WCSBDC_008B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
42.40 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
27.0	15.4	12	SM/ML	82		120	125	3188.0	3188.0	1748.0	1500.0	751.2	0.81	1	1	1.00	12.5	5.00	1.20	20.1	0.22	0.94	0.22	1.00	0.74	1.00	1.48
32.0	10.4	13	SM	30		120	125	3723.8	3723.8	1683.8	2125.0	1064.2	0.75	1	1	1.00	12.6	4.71	1.15	19.2	0.21	0.91	0.21	1.00	0.74	1.00	1.45
37.0	5.4	21	ML	77		120	125	4244.3	4244.3	1604.3	2750.0	1377.2	0.71	1	1	1.00	19.0	5.00	1.20	27.8	0.36	0.87	0.20	1.00	0.68	1.00	2.68
42.0	0.4	45	ML	77		120	125	4758.1	4758.1	1518.1	3375.0	1690.2	0.67	1	1	1.00	38.5	5.00	1.20	51.2	2.00	0.83	0.19	1.00	0.60	1.00	3.00
47.0	-4.6	17	ML	66		120	125	5281.0	5156.2	1431.0	4000.0	2003.2	0.64	1	1	1.00	14.0	5.00	1.20	21.8	0.24	0.79	0.18	1.00	0.73	1.00	1.94
52.0	-9.6	16	SM	34		120	125	5821.4	5384.6	1346.4	4625.0	2316.2	0.63	1	1	1.00	12.9	4.93	1.19	20.2	0.22	0.75	0.18	1.00	0.74	0.98	1.82

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

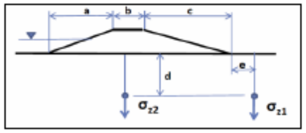
Updated April 2013

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	5/21/2013
Study Area:	Calaveras River and Stockton Diverting Canal	**Checked by:**		**Date:**	
Levee Station:	978+49				
Boring Number:	WCSBDC_013B				

Input Parameters

Embankment Crest Elevation (ft)	45.3 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	33.9 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.18
Height below Crest of Embankment (ft)	11.4 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	30.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	33.0 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	25.3 ft
Crest Width, b (ft)	31.0 ft
Landside/Downstream Slope, c (ft)	25.3 ft
Dist. of Boring from Levee Toe [1] (ft)	9.5 ft
Embankment Height, H (ft)	11.4 ft

Boring	WCSBDC_013B
Boring on waterside or landside field	
SPT Ground Elevation Used in Analysis	
33.90 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
6.0	27.9	37	SM	45		120	125	740.9	609.9	10.4	745.5	427.3	1.70	1	0.8	1.00	64.6	5.00	1.20	82.5	2.00	0.99	0.20	1.00	0.60	1.00	3.00
13.0	20.9	26	ML	100		120	125	1667.1	1292.7	61.6	1620.5	865.5	1.28	1	0.95	1.00	40.6	5.00	1.20	53.7	2.00	0.97	0.21	1.00	0.60	1.00	3.00
18.0	15.9	29	ML	88		120	125	2339.9	1965.5	109.4	2245.5	1178.5	1.04	1	0.95	1.00	36.7	5.00	1.20	49.0	2.00	0.96	0.21	1.00	0.60	1.00	3.00
23.0	10.9	24	ML	90		120	125	3011.8	2637.4	156.3	2870.5	1491.5	0.90	1	0.95	1.00	26.2	5.00	1.20	36.5	2.00	0.95	0.21	1.00	0.63	1.00	3.00
33.0	0.9	27	CL	94	Clay	120	125	4339.9	3965.5	234.4	4120.5	2117.5	0.73	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.91	0.21	1.00	0.60	1.00	#N/A

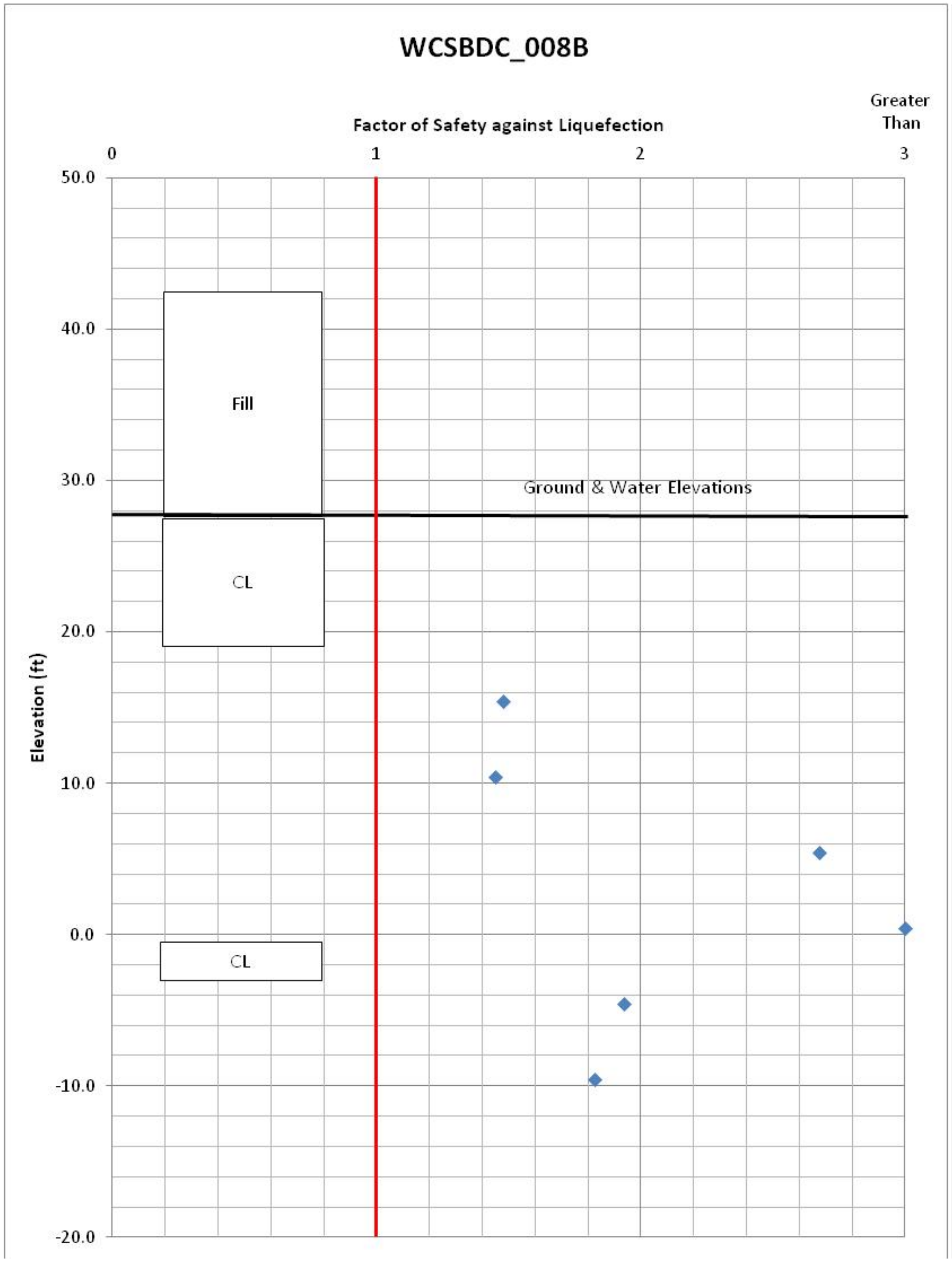


Fig. C-41. Stockton Diverting Canal, Station 940+82

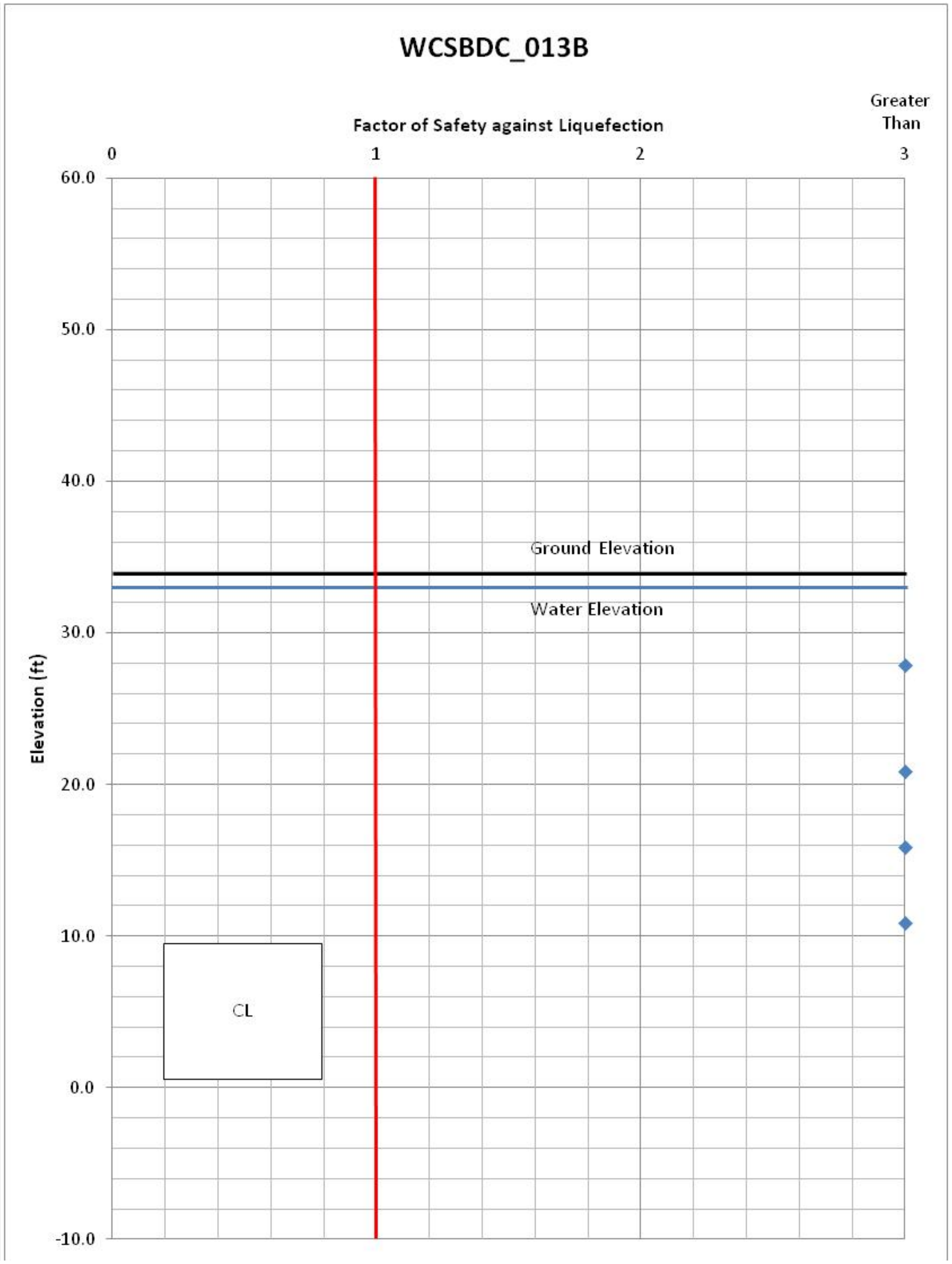


Fig. C-42. Stockton Diverting Canal, Station 978+49

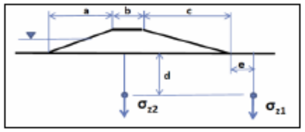
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Calaveras River and Stockton Diverting Canal
Levee Station: 1029+16
Boring Number: WCSBDC_014B

Prepared by: Vlad Perlea
Checked by:

Date: 5/21/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	51.3 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	35.7 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.18
Height below Crest of Embankment (ft)	15.6 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	30.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	35.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	26.6 ft
Crest Width, b (ft)	8.0 ft
Landside/Downstream Slope, c (ft)	28.2 ft
Dist. of Boring from Levee Toe [1] (ft)	63.6 ft
Embankment Height, H (ft)	15.6 ft

Boring	WCSBDC_014B
Boring on waterside or landside field	
SPT Ground Elevation Used in Analysis	
35.70 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
6.0	29.7	21	ML	74		120	125	721.6	702.9	0.1	746.5	415.8	1.70	1	0.8	1.00	36.7	5.00	1.20	49.0	2.00	0.99	0.21	1.00	0.60	1.00	3.00
12.0	23.7	20	SM / ML	68		120	125	1472.6	1098.2	1.1	1496.5	791.4	1.39	1	0.85	1.00	30.3	5.00	1.20	41.3	2.00	0.97	0.22	1.00	0.60	1.00	3.00
17.0	18.7	22	SM	13		120	125	2099.5	1725.1	3.0	2121.5	1104.4	1.11	1	0.95	1.00	29.7	1.89	1.04	32.7	2.00	0.96	0.22	1.00	0.60	1.00	3.00
32.0	3.7	91	GW-GM	10		120	125	3987.9	3613.5	16.4	3996.5	2043.4	0.77	1	1	1.00	89.4	0.87	1.02	92.2	2.00	0.91	0.21	1.00	0.60	1.00	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

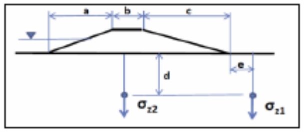
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Mormon Slough South
Levee Station: 2527+95
Boring Number: WCSBMS_003B

Prepared by: Vlad Perlea
Checked by:

Date: 5/21/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	50.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	44.6 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.165
Height below Crest of Embankment (ft)	5.8 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	40.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	44.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	23.8 ft
Crest Width, b (ft)	15.0 ft
Landside/Downstream Slope, c (ft)	50.5 ft
Dist. of Boring from Levee Toe [1] (ft)	10.2 ft
Embankment Height, H (ft)	5.8 ft

Boring	WCSBMS_003B
Boring on waterside or landside field	
SPT Ground Elevation Used in Analysis	
44.60 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
13.0	31.6	20	SM/ML	70		120	125	1617.8	1093.6	15.8	1622.0	848.2	1.39	1	0.95	1.00	33.9	5.00	1.20	45.7	2.00	0.97	0.20	1.00	0.60	1.00	3.00

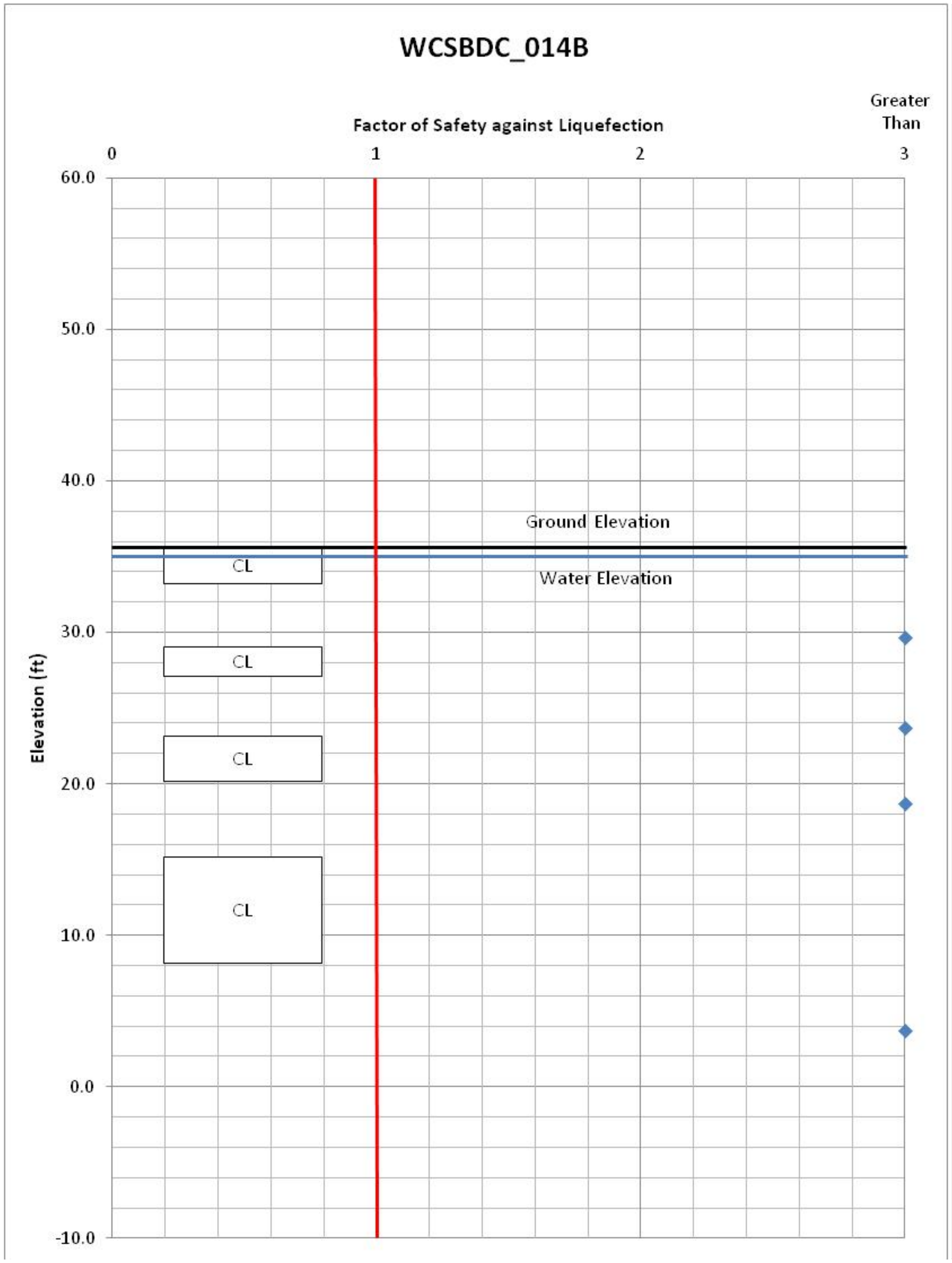


Fig. C-43. Stockton Diverting Canal, Station 1029+16

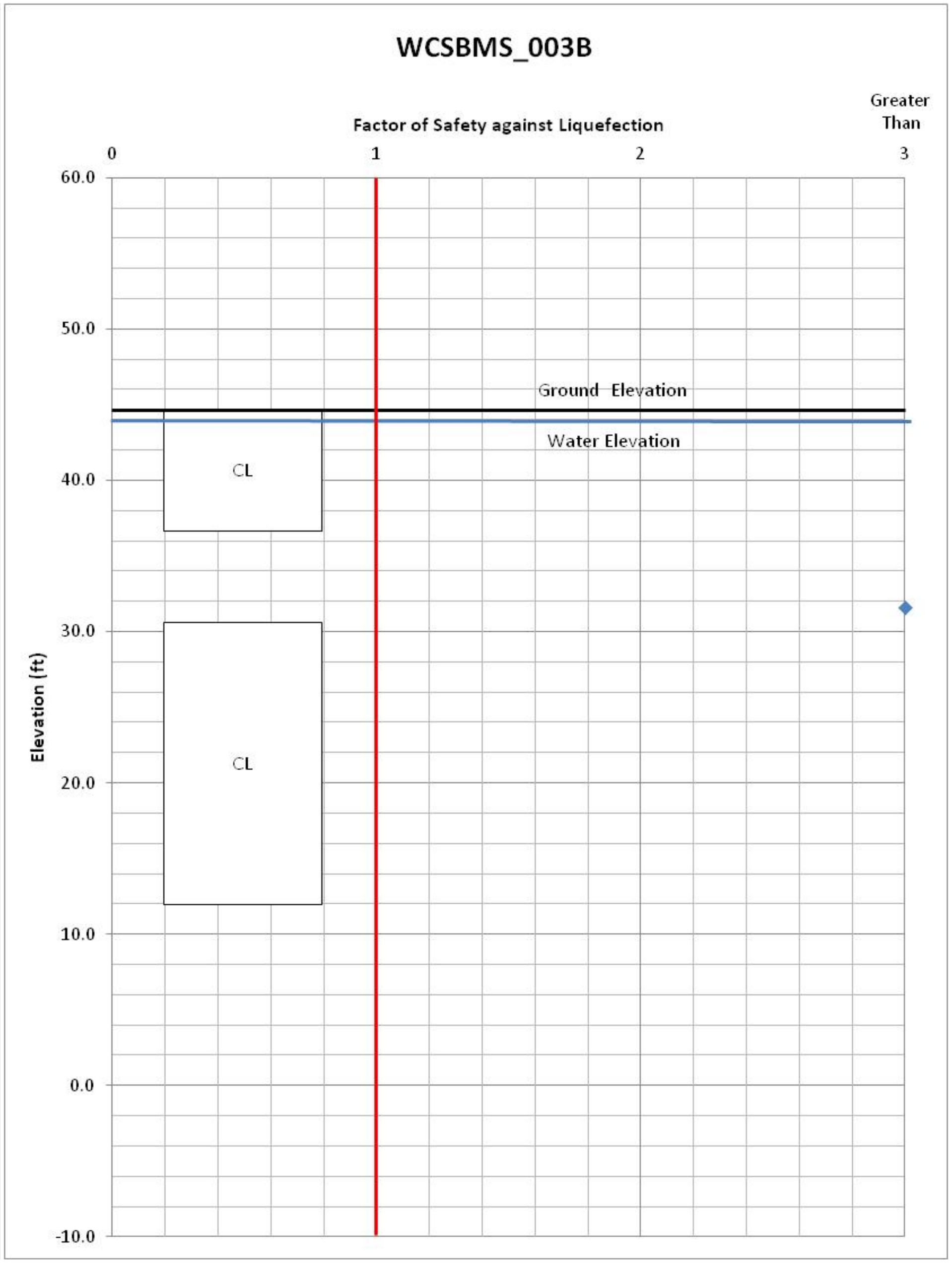


Fig. C-44. Mormon Slough, Station 2527+95

LIQUERFACTION TRIGGERING ANALYSIS

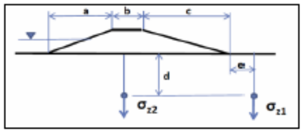
Project: Lower San Joaquin
Study Area: Stockton Diverting Canal
Levee Station: 2583+28
Boring Number: WCSBMS_002B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	56.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	51.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.165
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	5.75		
Groundwater Elevation during Drilling (ft)	-2.6 ft	Hammer Efficiency	84.5	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	51.4 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	16.0 ft
Crest Width, b (ft)	21.0 ft
Landside/Downstream Slope, c (ft)	9.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-19.5 ft
Embankment Height, H (ft)	5.0 ft

Boring	**WCSBMS_002B**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
56.35 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
13.0	43.4	29	ML	77		120	125	1532.7	1532.7	566.7	1006.3	503.9	1.17	1.05	0.95	1.00	47.9	5.00	1.20	62.4	2.00	0.97	0.21	1.00	0.60	1.00	3.00
16.0	40.4	40	ML	77		120	125	1864.6	1864.6	538.6	1381.3	691.7	1.07	1.05	0.95	1.00	59.9	5.00	1.20	76.8	2.00	0.96	0.21	1.00	0.60	1.00	3.00
33.0	23.4	46	ML	64		120	125	3728.5	3728.5	362.5	3506.3	1755.9	0.75	1.05	1	1.00	51.2	5.00	1.20	66.5	2.00	0.91	0.19	1.00	0.60	1.00	3.00
38.0	18.4	40	ML	65		120	125	4290.0	4290.0	324.0	4131.3	2068.9	0.70	1.05	1	1.00	41.5	5.00	1.20	54.9	2.00	0.86	0.19	1.00	0.60	1.00	3.00
48.0	8.4	52	SM	49		120	125	5430.6	5430.6	264.6	5381.3	2694.9	0.62	1.05	1	1.00	48.0	5.00	1.20	62.6	2.00	0.78	0.17	1.00	0.60	0.91	3.00

LIQUERFACTION TRIGGERING ANALYSIS

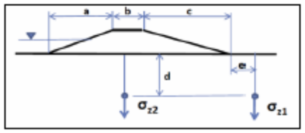
Project: Lower San Joaquin
Study Area: Brookside
Levee Station: 117+51
Boring Number: WR2074_003M

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	14.0 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	4.5 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	79	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.2 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	23.8 ft
Crest Width, b (ft)	18.2 ft
Landside/Downstream Slope, c (ft)	20.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-29.1 ft
Embankment Height, H (ft)	9.5 ft

Boring	**WR2074_003M**
Boring on the crest	
SPT Ground Elevation Used in Analysis	
14.00 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
31.5	-17.5	6	SM	25		120	125	3577.8	2610.6	860.3	2743.5	1451.8	0.90	1	1	1.00	7.1	4.29	1.12	12.2	0.13	0.92	0.23	1.00	0.80	1.00	0.89
36.0	-22.0	8	SP-SM	10		120	125	4066.2	2818.2	786.2	3306.0	1733.5	0.87	1	1	1.00	9.1	0.87	1.02	10.2	0.11	0.88	0.22	1.00	0.78	1.00	0.79

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

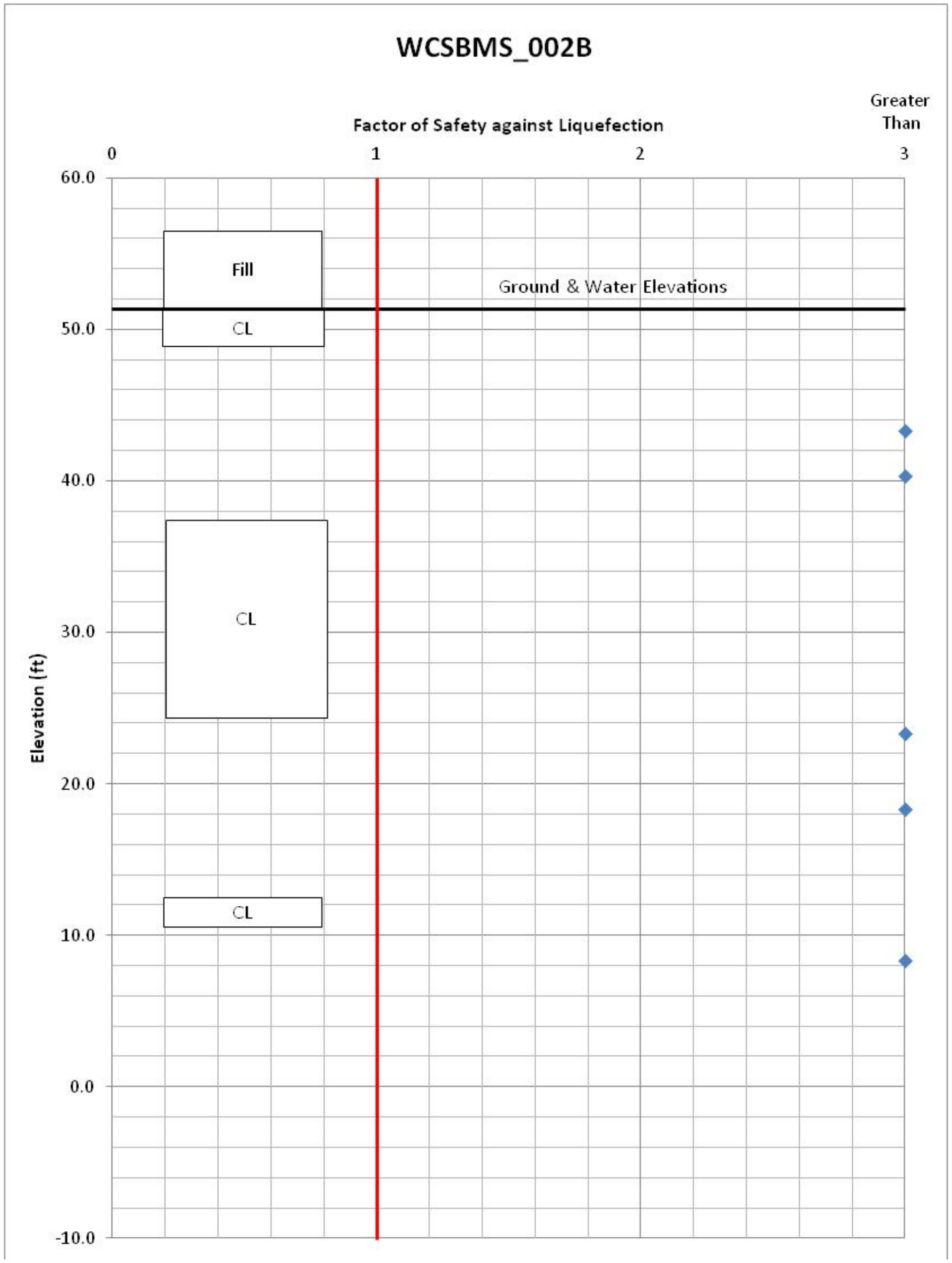


Fig. C-45. Mormon Slough, Station 2583+28

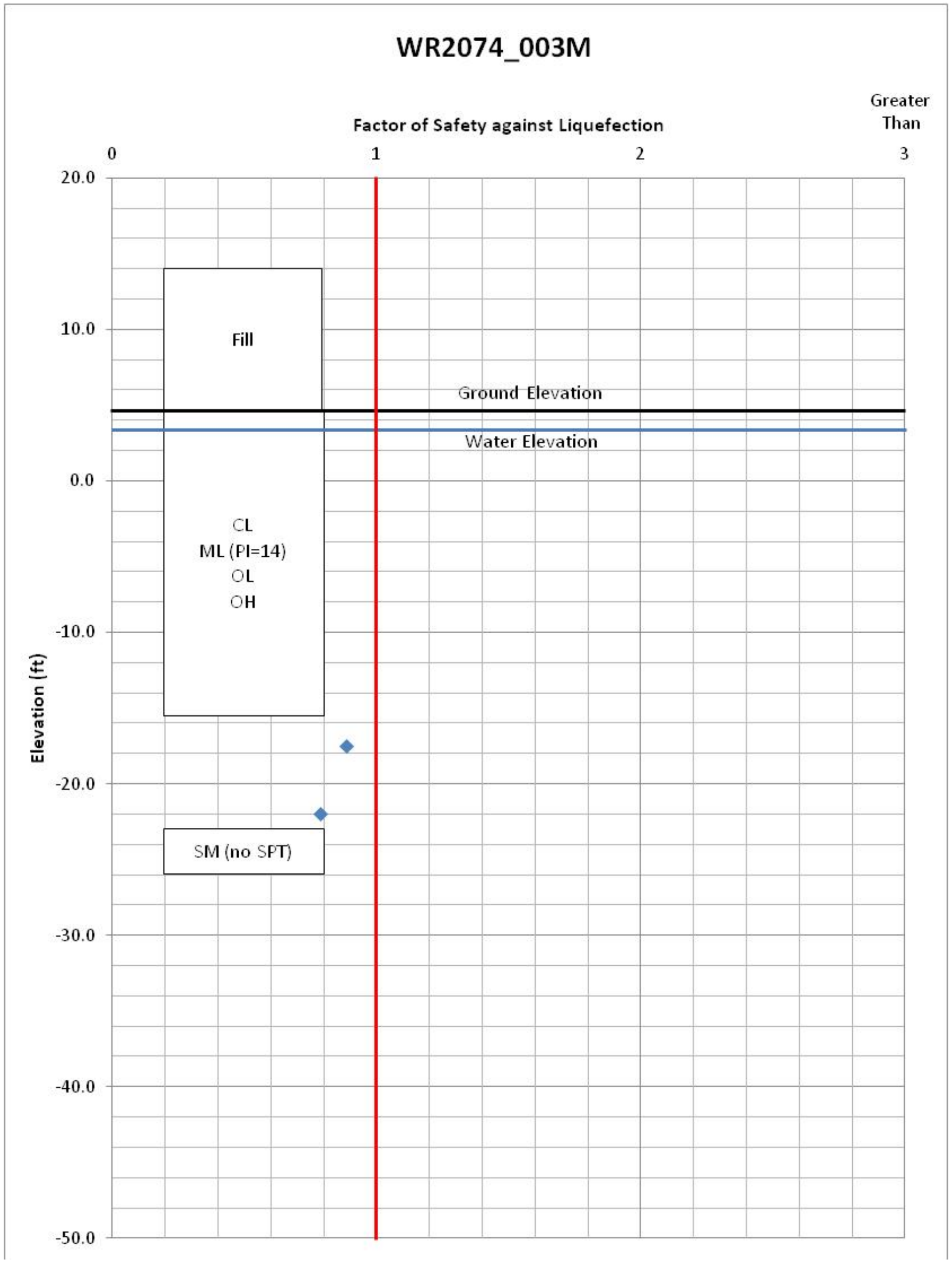
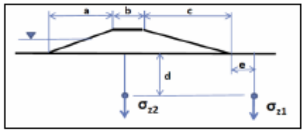


Fig. C-46. Brookside, Station 117+51

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	5/31/2013
Study Area:	Brookside	**Checked by:**		**Date:**	
River Section:	118+02				
Boring Number:	WR2074_009B				

Input Parameters					
Embankment Crest Elevation (ft)	14.6 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	7.1 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	0.0 ft	Hammer Efficiency	79	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	1.1 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	70.1 ft
Crest Width, b (ft)	15.8 ft
Landside/Downstream Slope, c (ft)	48.9 ft
Dist. of Boring from Levee Toe [1] (ft)	-56.8 ft
Embankment Height, H (ft)	7.5 ft

Boring WR2074_008B
Boring on the crest
SPT Ground Elevation Used in Analysis
14.60 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
36.0	-21.4	10	SM	19		120	125	4262.7	2927.4	735.7	3532.5	2128.5	0.85	1	1	1.00	11.2	3.43	1.07	15.4	0.16	0.88	0.19	1.00	0.76	1.00	1.30
41.0	-26.4	11	SP	4		120	125	4850.6	3203.2	698.6	4157.5	2441.5	0.81	1	1	1.00	11.8	0.00	1.00	11.8	0.13	0.84	0.19	1.00	0.75	0.97	1.00
46.0	-31.4	6	SP-SM	10		120	125	5440.1	3480.8	663.1	4782.5	2754.5	0.78	1	1	1.00	6.2	0.87	1.02	7.2	0.09	0.80	0.18	1.00	0.80	0.95	0.70

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

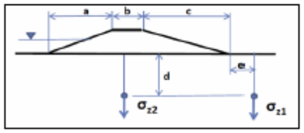
[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	7/23/2013
Study Area:	Brookside	**Checked by:**		**Date:**	
Levee Station:	133+44				
Boring Number:	WR2074_010B				

Input Parameters					
Embankment Crest Elevation (ft)	15.2 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	-0.6 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-0.8 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	-0.6 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	67.9 ft
Crest Width, b (ft)	15.2 ft
Landside/Downstream Slope, c (ft)	41.1 ft
Dist. of Boring from Levee Toe [1] (ft)	-48.7 ft
Embankment Height, H (ft)	15.8 ft

Boring WR2074_010B
Boring on the crest
SPT Ground Elevation Used in Analysis
15.20 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
41.0	-25.8	24	SM	34		120	125	4716.4	3156.4	1561.4	3156.0	1583.5	0.82	1	1	1.00	25.2	4.93	1.19	34.9	2.00	0.84	0.22	1.00	0.64	1.00	3.00
48.5	-33.3	16	SM	19		120	125	5526.5	3498.5	1434.0	4093.5	2053.0	0.78	1	1	1.00	16.0	3.43	1.07	20.6	0.22	0.78	0.20	1.00	0.71	1.00	1.65
56.0	-40.8	21	SM	21		120	125	6347.2	3851.2	1317.2	5031.0	2522.5	0.74	1	1	1.00	20.0	3.78	1.09	25.5	0.30	0.72	0.19	1.00	0.68	0.94	2.30
61.0	-45.8	22	ML	65		120	125	6900.9	4342.5	1245.9	5656.0	2835.5	0.70	1	1	1.00	19.7	5.00	1.20	28.6	0.39	0.68	0.18	1.00	0.68	0.91	3.00

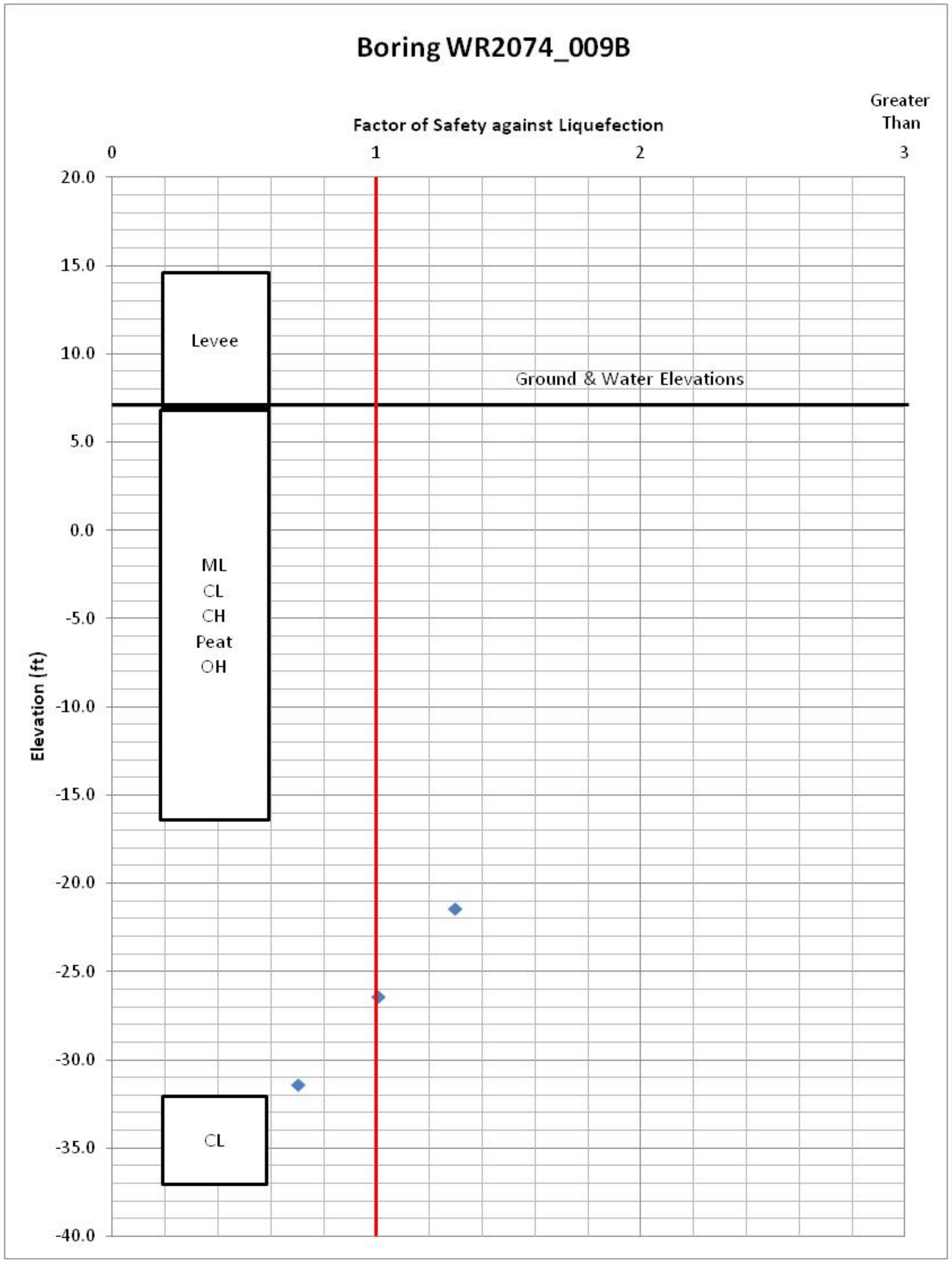


Fig. C-47. Brookside, Station 118+02

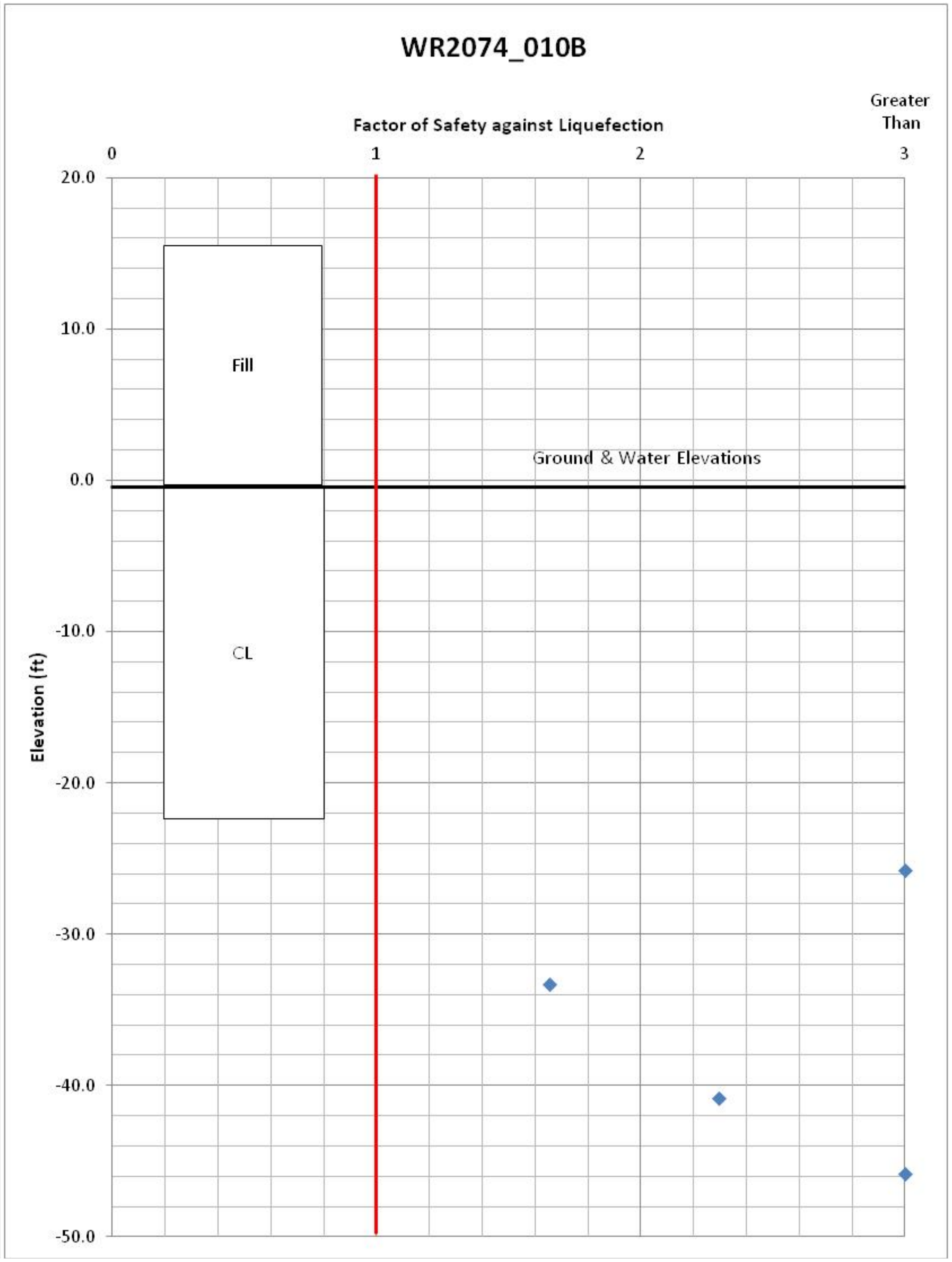


Fig. C-48. Brookside, Station 133+44

LIQUERFACTION TRIGGERING ANALYSIS

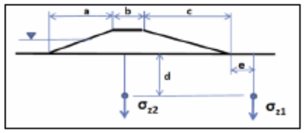
Project: Lower San Joaquin
Study Area: Brookside
River Section: 133+82
Boring Number: WR2074_007B

Prepared by: Vlad Perlea
Checked by:

Date: 5/31/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	15.2 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	5.5 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	5.2 ft	Hammer Efficiency	79	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	5.5 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	41.7 ft
Crest Width, b (ft)	15.2 ft
Landside/Downstream Slope, c (ft)	25.2 ft
Dist. of Boring from Levee Toe [1] (ft)	-32.8 ft
Embankment Height, H (ft)	9.7 ft

Boring WR2074_007B

Boring on the crest
SPT Ground Elevation Used in Analysis
15.20 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
26.5	-11.3	8	SC	20		120	125	3095.9	2066.3	997.4	2100.0	1051.7	1.01	1	1	1.00	10.7	3.61	1.08	15.1	0.16	0.94	0.24	1.00	0.76	1.00	0.99
31.5	-16.3	23	SM	49		120	125	3643.8	2302.2	920.3	2725.0	1364.7	0.96	1	1	1.00	29.0	5.00	1.20	39.8	2.00	0.92	0.24	1.00	0.60	1.00	3.00
36.5	-21.3	8	SC	20		120	125	4196.2	2542.6	847.7	3350.0	1677.7	0.91	1	1	1.00	9.6	3.61	1.08	14.0	0.15	0.88	0.23	1.00	0.77	1.00	0.99

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

LIQUERFACTION TRIGGERING ANALYSIS

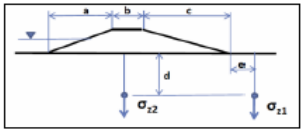
Project: Lower San Joaquin
Study Area: Brookside
Levee Station: 160+48
Boring Number: WR2074_011B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters

Embankment Crest Elevation (ft)	17.6 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	0.6 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-0.8 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.6 ft			120.0 pcf	



Surcharge Information

Waterside/Upstream Slope, a (ft)	61.2 ft
Crest Width, b (ft)	20.5 ft
Landside/Downstream Slope, c (ft)	35.7 ft
Dist. of Boring from Levee Toe [1] (ft)	-46.0 ft
Embankment Height, H (ft)	17.0 ft

Boring WR2074_011B

Boring on the crest
SPT Ground Elevation Used in Analysis
17.60 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
44.5	-26.9	13	SM	47		120	125	5099.6	3471.0	1669.1	3437.5	1721.5	0.78	1	1	1.00	13.0	5.00	1.20	20.6	0.22	0.81	0.21	1.00	0.74	1.00	1.59
47.0	-29.4	42	SW-SM	12		120	125	5364.7	3580.1	1621.7	3750.0	1878.0	0.77	1	1	1.00	41.4	1.55	1.03	44.3	2.00	0.79	0.21	1.00	0.60	1.00	3.00
49.5	-31.9	33	SW-SM	12		120	125	5630.9	3690.2	1575.4	4062.5	2034.5	0.76	1	1	1.00	32.1	1.55	1.03	34.6	2.00	0.77	0.20	1.00	0.60	1.00	3.00
52.0	-34.4	25	SW-SM	12		120	125	5898.2	3801.6	1530.2	4375.0	2191.0	0.75	1	1	1.00	23.9	1.55	1.03	26.2	0.32	0.75	0.19	1.00	0.65	0.99	2.43
54.5	-36.9	20	SW-SM	12		120	125	6166.9	3914.3	1486.4	4687.5	2347.5	0.74	1	1	1.00	18.9	1.55	1.03	21.0	0.23	0.73	0.19	1.00	0.69	0.97	1.75

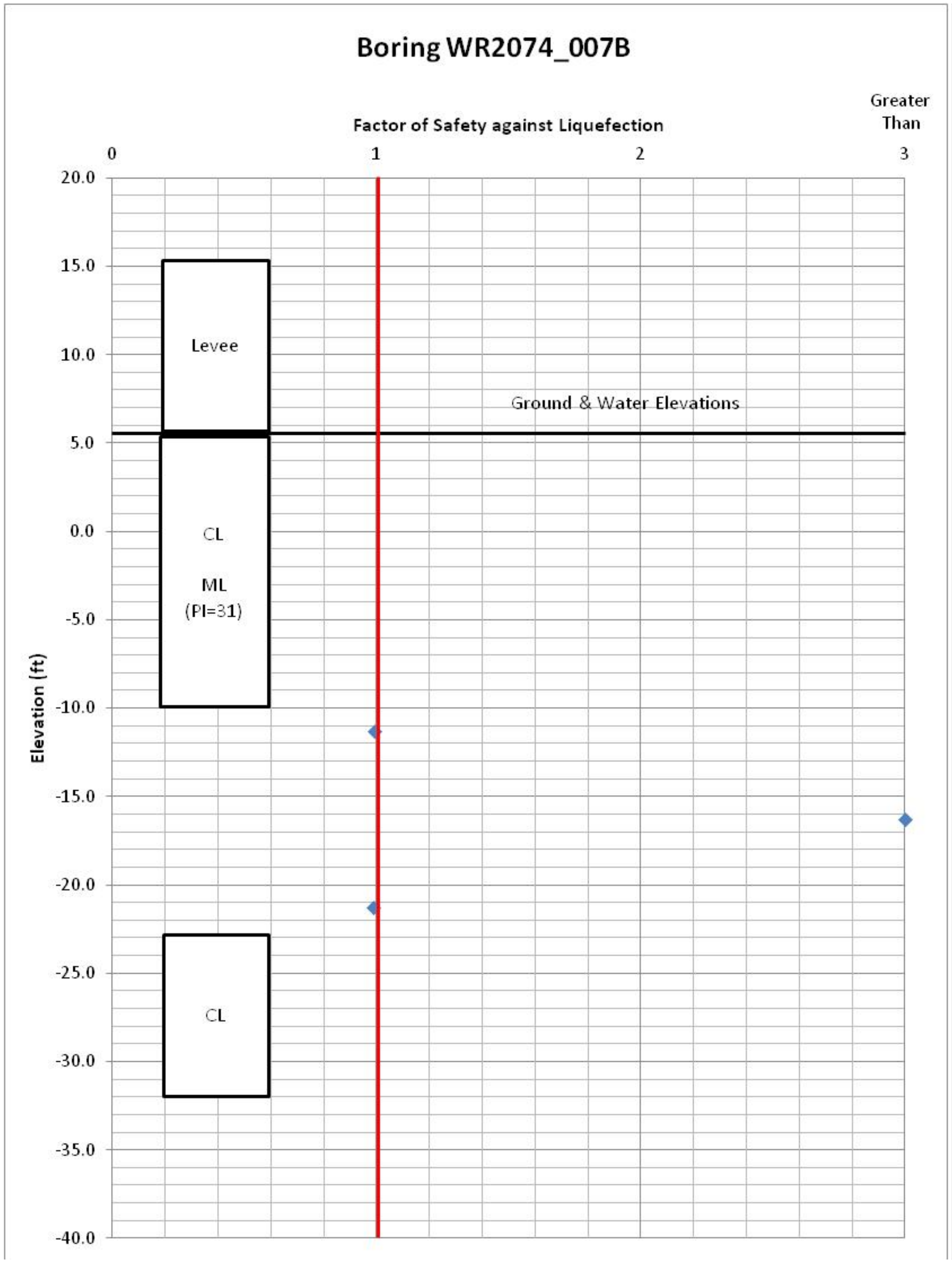


Fig. C-49. Brookside, Station 133+82

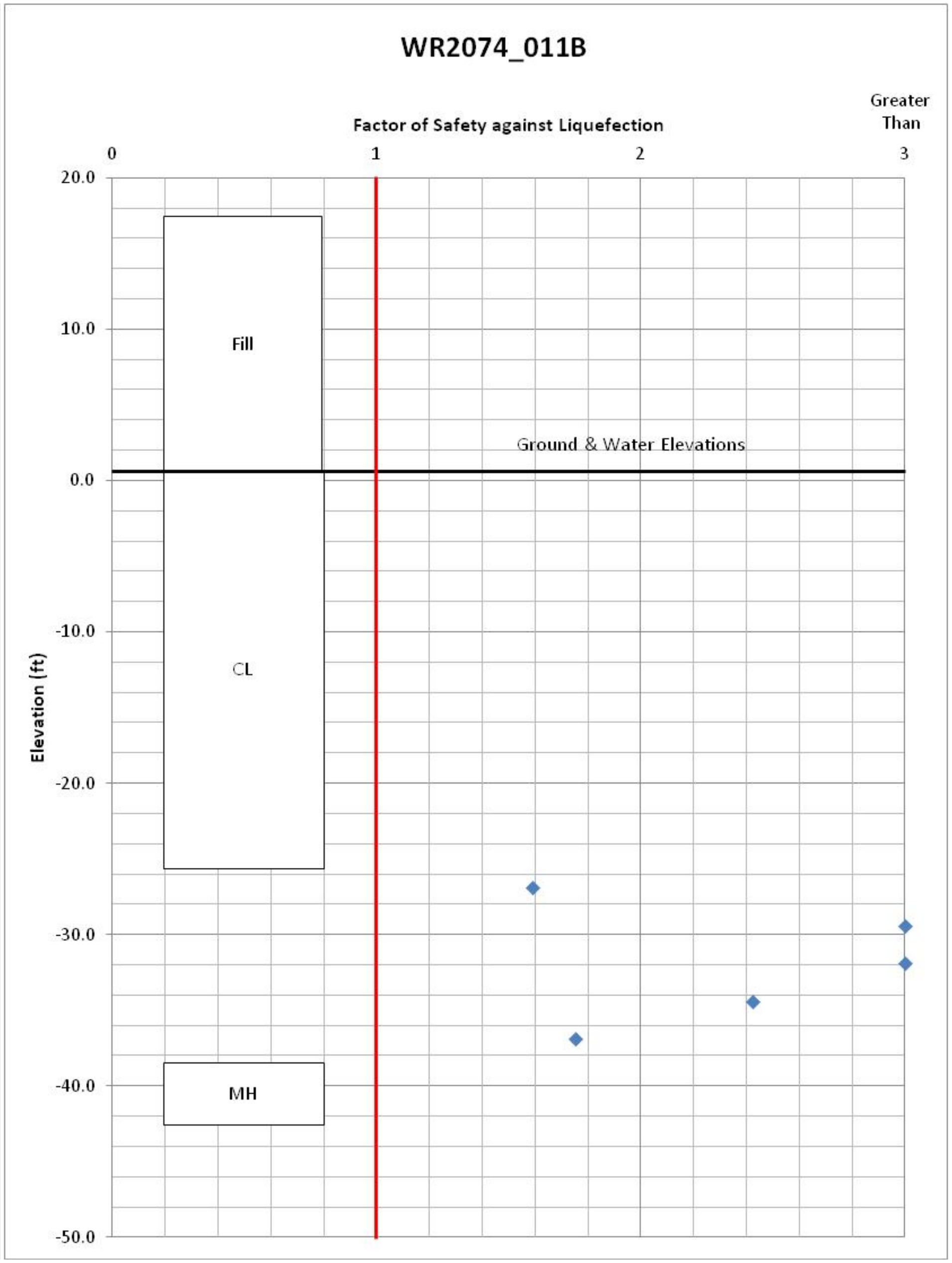
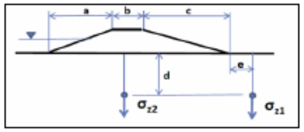


Fig. C-50. Brookside, Station 160+48

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	5/31/2013
Study Area:	Brookside	**Checked by:**		**Date:**	
River Section:	185+70				
Boring Number:	WR2074_008B				

Input Parameters					
Embankment Crest Elevation (ft)	17.6 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	0.8 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	0.0 ft	Hammer Efficiency	79	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.8 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	55.4 ft
Crest Width, b (ft)	15.8 ft
Landside/Downstream Slope, c (ft)	38.6 ft
Dist. of Boring from Levee Toe [1] (ft)	-46.5 ft
Embankment Height, H (ft)	16.8 ft

Boring	WR2074_008B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
17.60 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
26.0	-8.4	9	CL	56	Clay	120	125	3097.1	2572.9	1951.1	1150.0	575.9	0.91	1	1	1.00	n.a.	5.00	1.20	n.a.	2.00	0.94	0.24	1.00	0.60	1.00	#N/A
41.0	-23.4	13	SM	41		120	125	4678.0	3217.9	1657.0	3025.0	1514.9	0.81	1	1	1.00	13.9	5.00	1.20	21.7	0.24	0.84	0.22	1.00	0.73	1.00	1.63
46.0	-28.4	15	SP-SM	9		120	125	5202.8	3580.4	1556.8	3650.0	1827.9	0.77	1	1	1.00	15.2	0.56	1.02	16.0	0.17	0.80	0.21	1.00	0.72	1.00	1.23
51.0	-33.4	14	ML	80		120	125	5733.0	4110.6	1462.0	4275.0	2140.9	0.72	1	1	1.00	13.2	5.00	1.20	20.9	0.23	0.76	0.20	1.00	0.74	1.00	1.72
61.0	-43.4	24	SM	45		120	125	6813.1	5190.7	1292.1	5525.0	2766.9	0.64	1	1	1.00	20.2	5.00	1.20	29.2	0.42	0.68	0.18	1.00	0.68	0.92	3.00
66.0	-48.4	26	SP-SM	8		120	125	7363.2	5740.8	1217.2	6150.0	3079.9	0.61	1	1	1.00	20.8	0.30	1.01	21.3	0.23	0.64	0.17	1.00	0.67	0.88	1.87

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

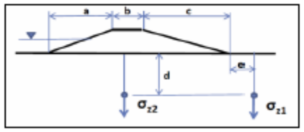
[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

LIQUERFACTION TRIGGERING ANALYSIS

Project:	Lower San Joaquin	**Prepared by:**	Vlad Perlea	**Date:**	7/23/2013
Study Area:	Brookside	**Checked by:**		**Date:**	
Levee Station:	217+77				
Boring Number:	WR2074_012B				

Input Parameters					
Embankment Crest Elevation (ft)	13.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	0.9 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.6 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	0.9 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	50.0 ft
Crest Width, b (ft)	33.0 ft
Landside/Downstream Slope, c (ft)	41.3 ft
Dist. of Boring from Levee Toe [1] (ft)	-57.8 ft
Embankment Height, H (ft)	12.5 ft

Boring	WR2074_012B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.40 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
38.5	-25.1	15	SM	39		120	125	4563.4	3159.4	1330.9	3250.0	1627.6	0.82	1	1	1.00	15.8	5.00	1.20	23.9	0.27	0.86	0.22	1.00	0.71	1.00	1.83
41.0	-27.6	23	SP-SM	7		120	125	4846.0	3286.0	1301.0	3562.5	1784.1	0.80	1	1	1.00	23.7	0.12	1.01	24.0	0.27	0.84	0.22	1.00	0.65	1.00	1.88

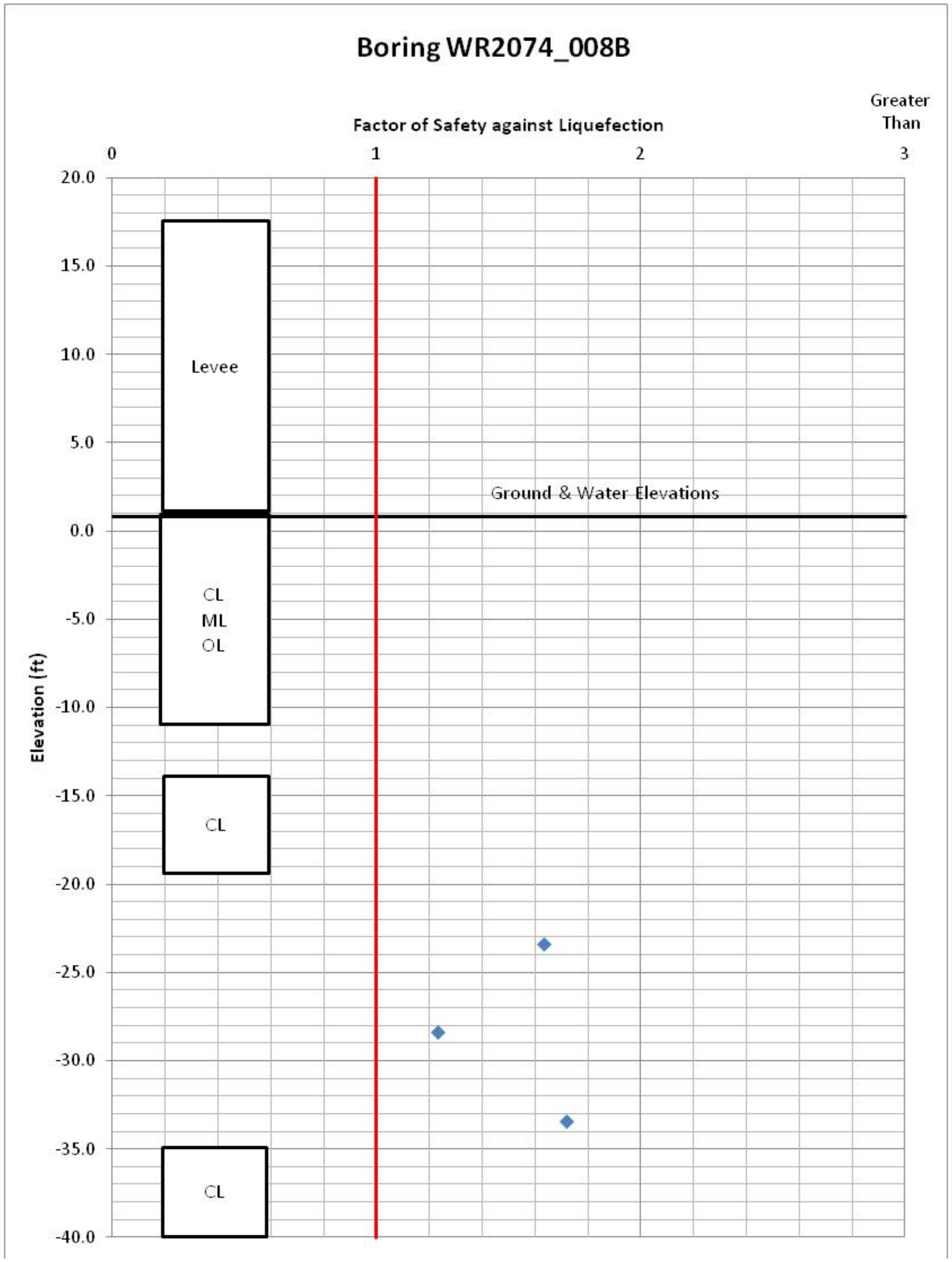


Fig. C-51. Brookside, Station 185+70

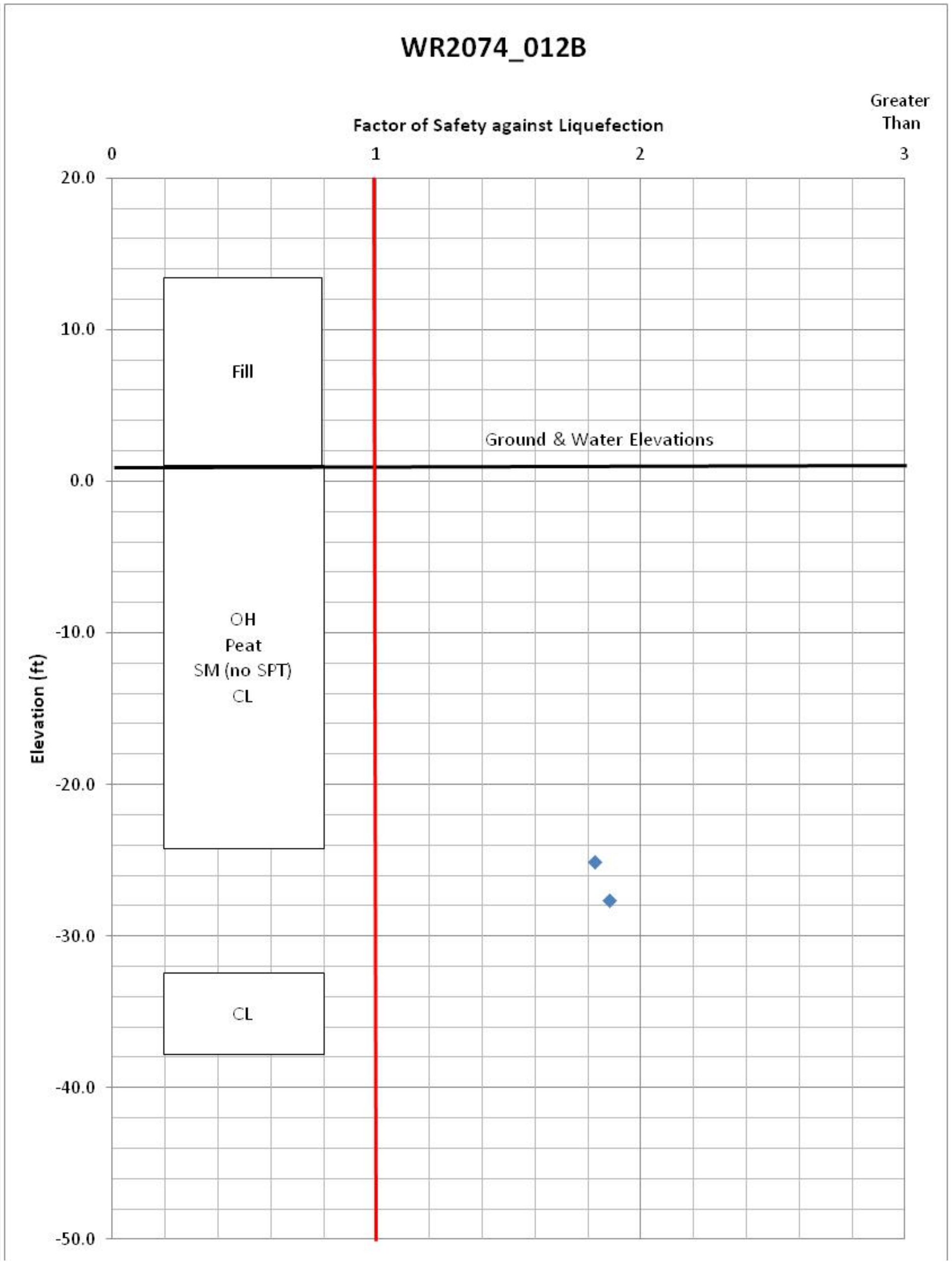


Fig. C-52. Brookside, Station 217+77

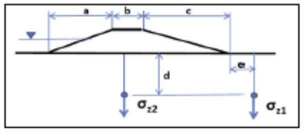
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Brookside
Levee Station: 247+31
Boring Number: WR2074_013B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.9 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	-1.1 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-1.1 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	-1.1 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	49.5 ft
Crest Width, b (ft)	17.0 ft
Landside/Downstream Slope, c (ft)	37.5 ft
Dist. of Boring from Levee Toe [1] (ft)	-46.0 ft
Embankment Height, H (ft)	15.0 ft

Boring	WR2074_013B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.90 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
31.0	-17.1	25	SM	14		120	125	3631.1	2632.7	1631.1	2000.0	1001.6	0.90	1	1	1.00	28.8	2.20	1.04	32.2	2.00	0.92	0.24	1.00	0.60	1.00	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

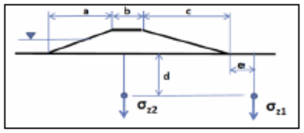
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Brookside
Levee Station: 248+41
Boring Number: WR2074_005M

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.9 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	2.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.1 ft	Hammer Efficiency	79	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	2.4 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	48.3 ft
Crest Width, b (ft)	20.0 ft
Landside/Downstream Slope, c (ft)	23.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-33.0 ft
Embankment Height, H (ft)	11.5 ft

Boring	WR2074_005M
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.90 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
21.0	-7.1	16	SP-SM	11		120	125	2496.9	2184.9	1331.9	1187.5	594.7	0.98	1	0.95	1.00	19.7	1.21	1.03	21.4	0.23	0.95	0.25	1.00	0.68	1.00	1.42
26.0	-12.1	27	SM	27		120	125	3052.5	2428.5	1262.5	1812.5	907.7	0.93	1	1	1.00	33.2	4.48	1.13	42.0	2.00	0.94	0.24	1.00	0.60	1.00	3.00
31.5	-17.6	16	SP-SM	6		120	125	3651.0	2683.8	1173.5	2500.0	1252.0	0.89	1	1	1.00	18.7	0.03	1.00	18.8	0.20	0.92	0.24	1.00	0.69	1.00	1.27
41.5	-27.6	17	SM	46		120	125	4742.7	3432.3	1015.2	3750.0	1878.0	0.79	1	1	1.00	17.6	5.00	1.20	26.1	0.32	0.84	0.22	1.00	0.70	1.00	2.18
46.0	-32.1	21	SM	13		120	125	5241.0	3930.6	951.0	4312.5	2159.7	0.73	1	1	1.00	20.3	1.89	1.04	22.9	0.26	0.80	0.21	1.00	0.67	0.99	1.84

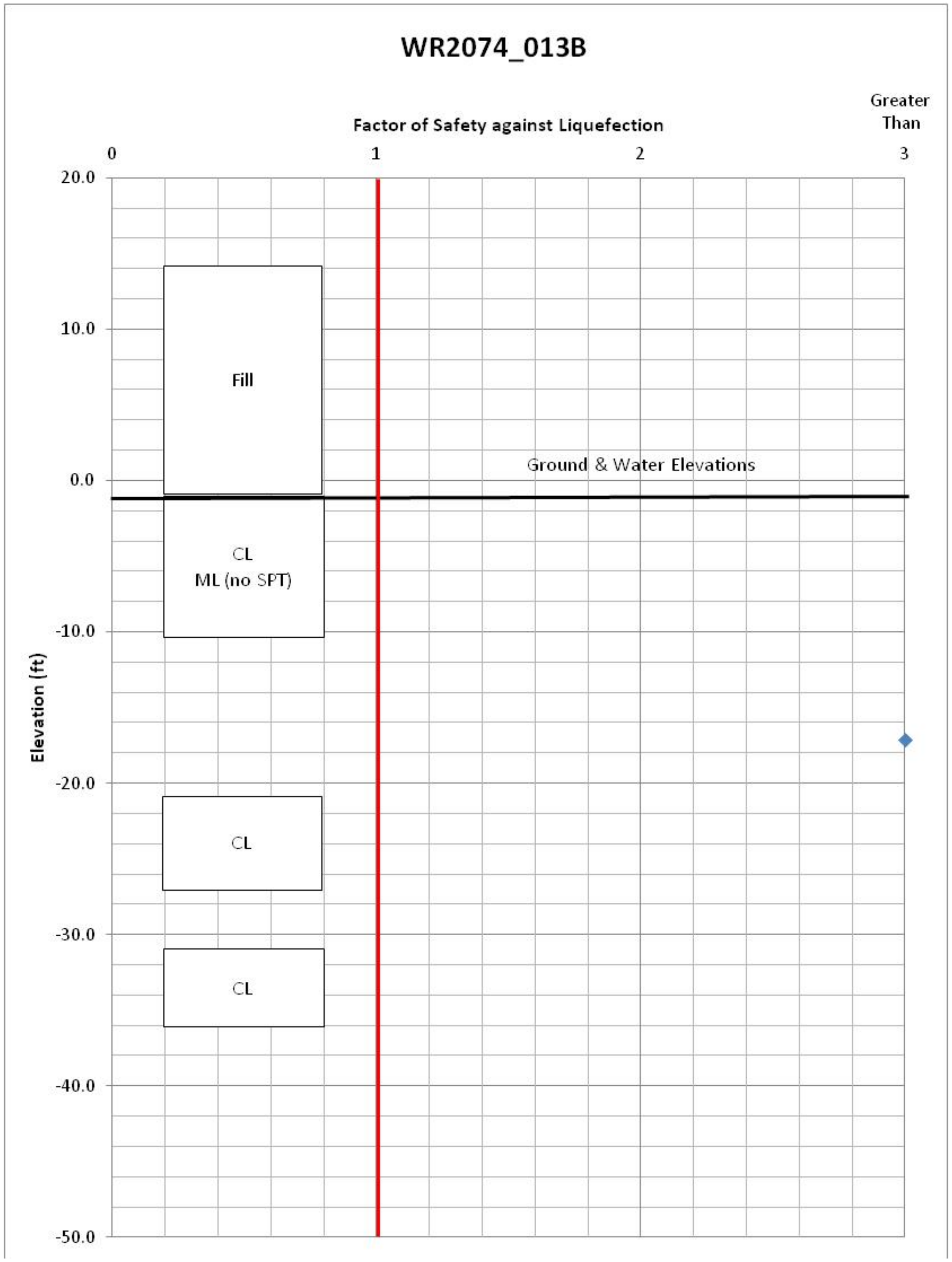


Fig. C-53. Brookside, Station 247+31

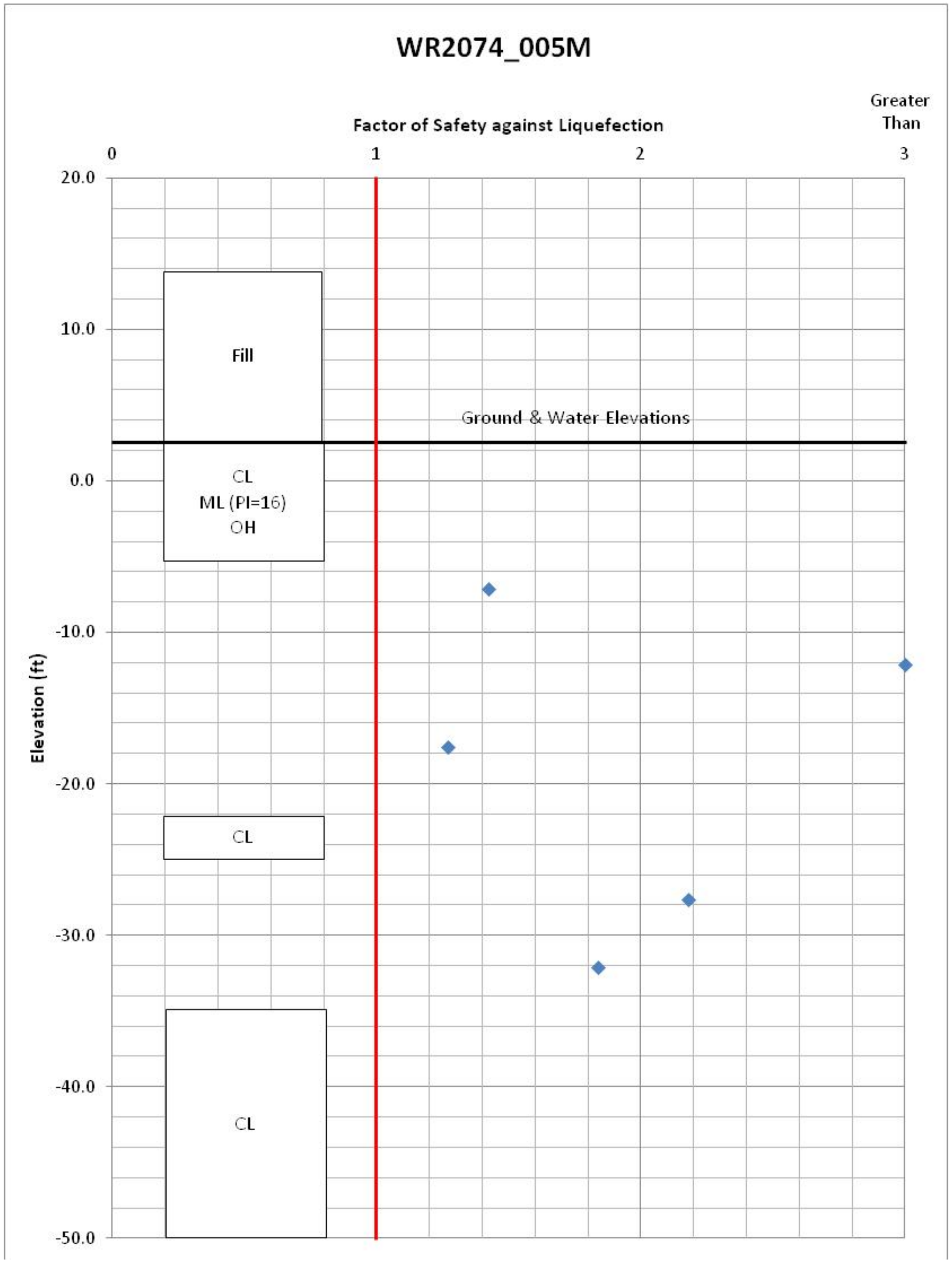


Fig. C-54. Brookside, Station 248+41

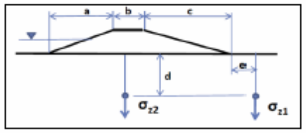
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 5+23
Boring Number: WR1608_002B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	5.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	5.4 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	26.4 ft
Crest Width, b (ft)	9.0 ft
Landside/Downstream Slope, c (ft)	23.2 ft
Dist. of Boring from Levee Toe [1] (ft)	-27.7 ft
Embankment Height, H (ft)	8.0 ft

Boring	WR1608_002B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.40 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
36.5	-23.1	46	SW-SM	5		120	125	4084.8	2768.1	559.3	3562.5	1784.1	0.87	1	1	1.00	51.6	0.00	1.00	51.6	2.00	0.88	0.23	1.00	0.60	1.00	3.00

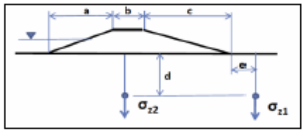
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 43+57
Boring Number: WR1608_002M

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.3 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	10.1 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	84	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.3 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	31.7 ft
Crest Width, b (ft)	16.0 ft
Landside/Downstream Slope, c (ft)	38.4 ft
Dist. of Boring from Levee Toe [1] (ft)	5.0 ft
Embankment Height, H (ft)	10.1 ft

Boring	WR1608_002M
Boring on waterside or landside field	
SPT Ground Elevation Used in Analysis	
3.30 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
16.5	-13.2	18	SM	16		120	125	2131.3	1432.4	95.3	2062.5	1032.9	1.22	1	0.95	1.00	29.1	2.77	1.05	33.4	2.00	0.96	0.25	1.00	0.60	1.00	3.00
21.0	-17.7	7	SP-SM	27		120	125	2727.5	1747.8	129.0	2625.0	1314.6	1.10	1	0.95	1.00	10.2	4.48	1.13	16.1	0.17	0.95	0.25	1.00	0.77	1.00	1.04
26.5	-23.2	8	SP-SM	8		120	125	3451.6	2422.0	165.6	3312.5	1658.9	0.93	1	1	1.00	10.5	0.30	1.01	10.9	0.12	0.94	0.24	1.00	0.77	1.00	0.75

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

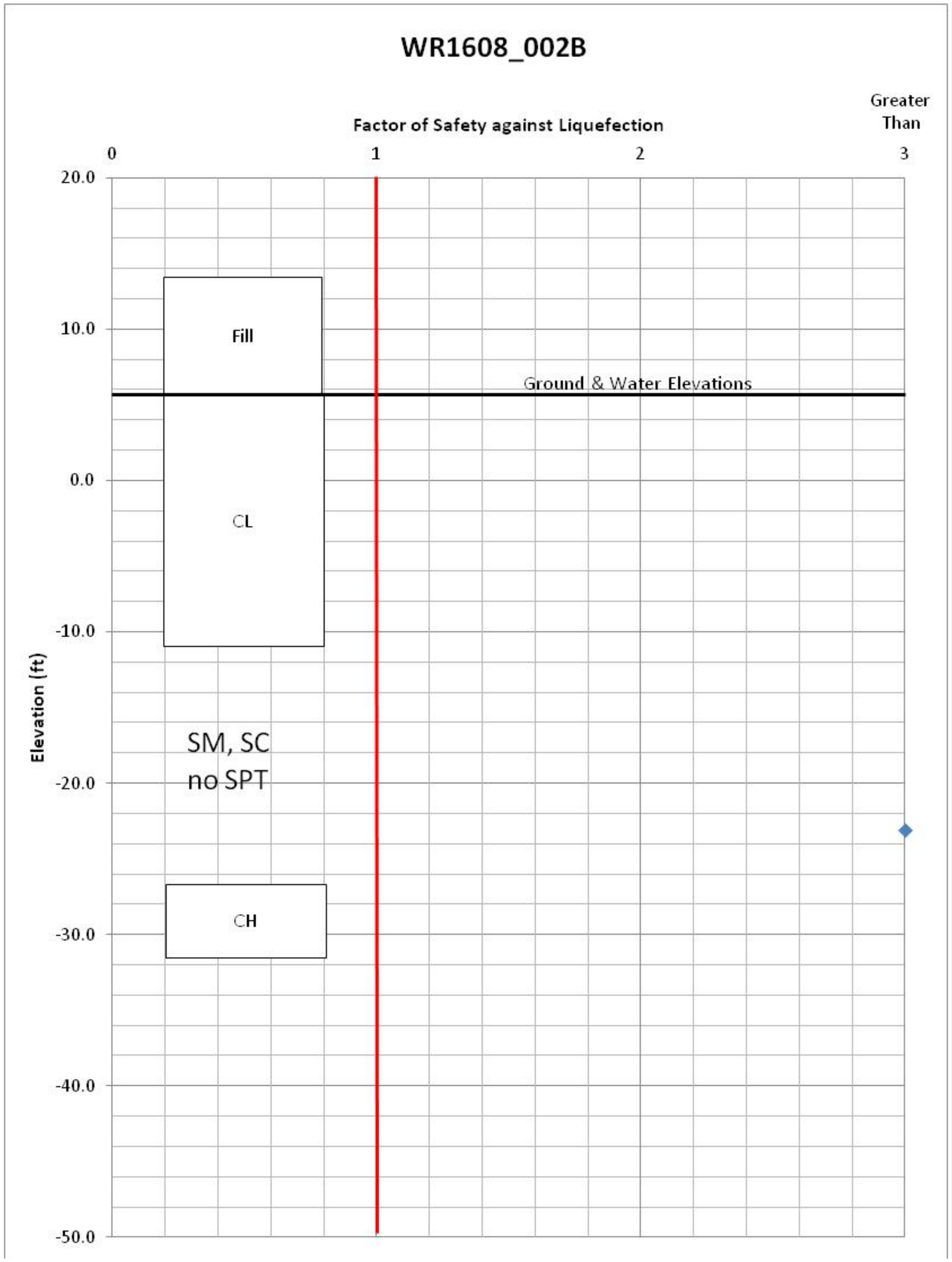


Fig. C-55. Lincoln Village, Station 5+23

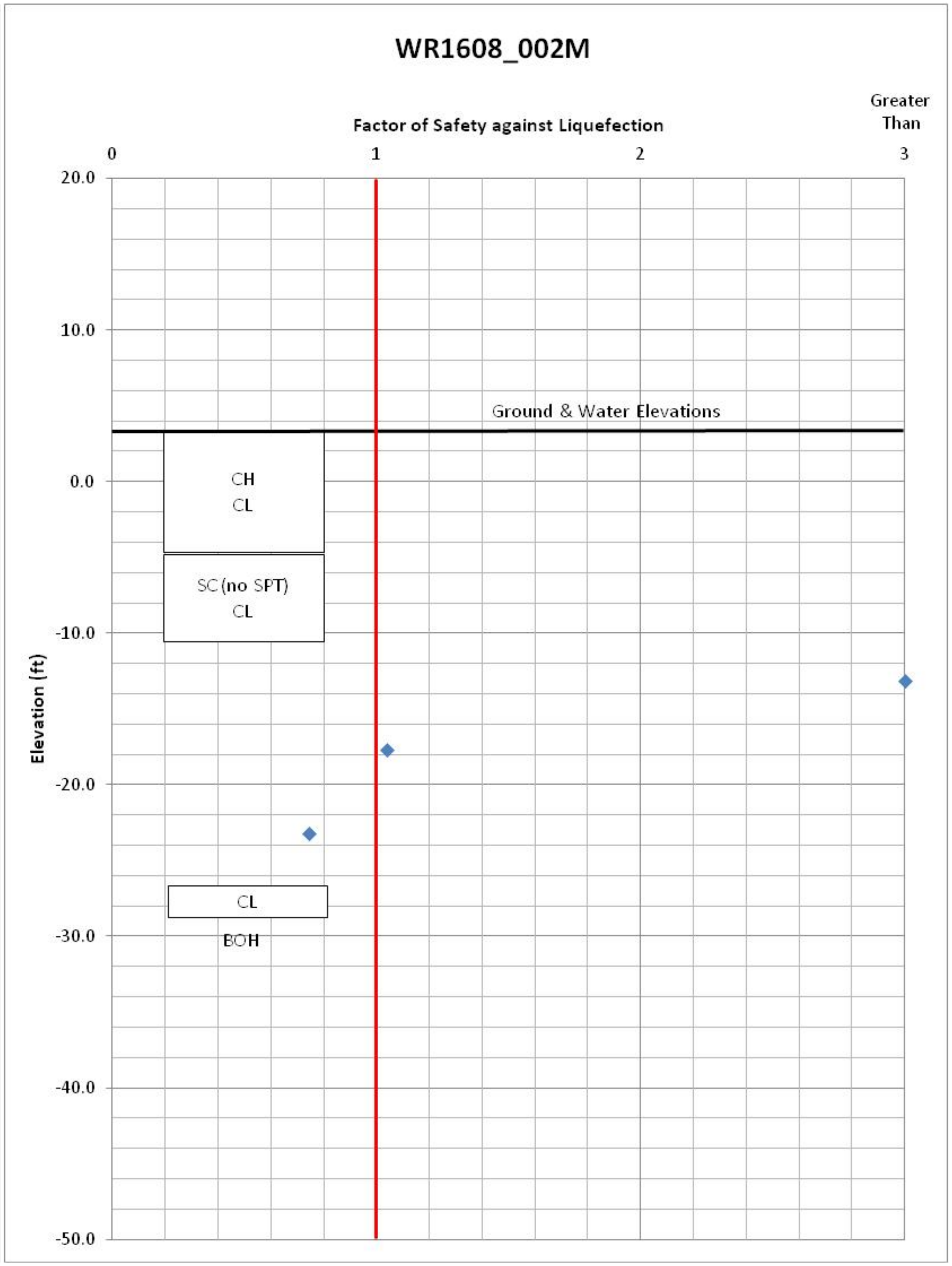


Fig. C-56. Lincoln Village, Station 43+00

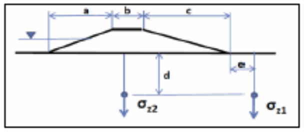
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 43+58
Boring Number: WR1608_001M

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.3 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.3 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	84	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.3 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	33.0 ft
Crest Width, b (ft)	16.0 ft
Landside/Downstream Slope, c (ft)	40.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-48.0 ft
Embankment Height, H (ft)	10.0 ft

Boring	WR1608_001M
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.30 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
31.0	-17.7	7	SW-SM	31		120	125	3588.8	2609.1	990.3	2625.0	1314.6	0.90	1	1	1.00	8.8	4.77	1.16	15.0	0.16	0.92	0.24	1.00	0.78	1.00	1.01
36.5	-23.2	13	SW-SM	7		120	125	4198.4	2875.5	912.4	3312.5	1658.9	0.86	1	1	1.00	15.6	0.12	1.01	15.9	0.17	0.88	0.23	1.00	0.71	1.00	1.11

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

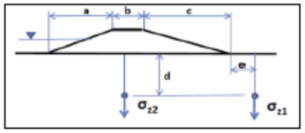
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 50+79
Boring Number: WR1608_004B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	5.4 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	5.4 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	26.4 ft
Crest Width, b (ft)	9.0 ft
Landside/Downstream Slope, c (ft)	20.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-24.5 ft
Embankment Height, H (ft)	8.0 ft

Boring	WR1608_004B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.40 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
24.0	-10.6	30	SP	4		120	125	2692.2	2155.6	729.2	2000.0	1001.6	0.99	1	0.95	1.00	36.5	0.00	1.00	36.5	2.00	0.94	0.25	1.00	0.60	1.00	3.00
26.5	-13.1	28	SP	4		120	125	2961.4	2268.8	685.9	2312.5	1158.1	0.97	1	1	1.00	34.7	0.00	1.00	34.7	2.00	0.94	0.24	1.00	0.60	1.00	3.00
29.0	-15.6	26	SP	4		120	125	3233.6	2384.9	645.6	2625.0	1314.6	0.94	1	1	1.00	31.2	0.00	1.00	31.2	2.00	0.93	0.24	1.00	0.60	1.00	3.00
32.0	-18.6	19	SM	28		120	125	3564.1	2528.2	601.1	3000.0	1502.4	0.91	1	1	1.00	22.5	4.56	1.14	30.2	2.00	0.91	0.24	1.00	0.66	1.00	3.00
34.5	-21.1	14	SM	28		120	125	3842.8	2650.9	567.3	3312.5	1658.9	0.89	1	1	1.00	16.4	4.56	1.14	23.2	0.26	0.89	0.23	1.00	0.71	1.00	1.69
37.0	-23.6	15	SP-SM	7		120	125	4124.2	2776.4	536.2	3625.0	1815.4	0.87	1	1	1.00	16.6	0.12	1.01	16.8	0.18	0.87	0.23	1.00	0.70	1.00	1.19
39.5	-26.1	13	SP-SM	7		120	125	4408.3	2910.7	507.8	3937.5	1971.9	0.85	1	1	1.00	13.8	0.12	1.01	14.0	0.15	0.85	0.22	1.00	0.73	1.00	1.02

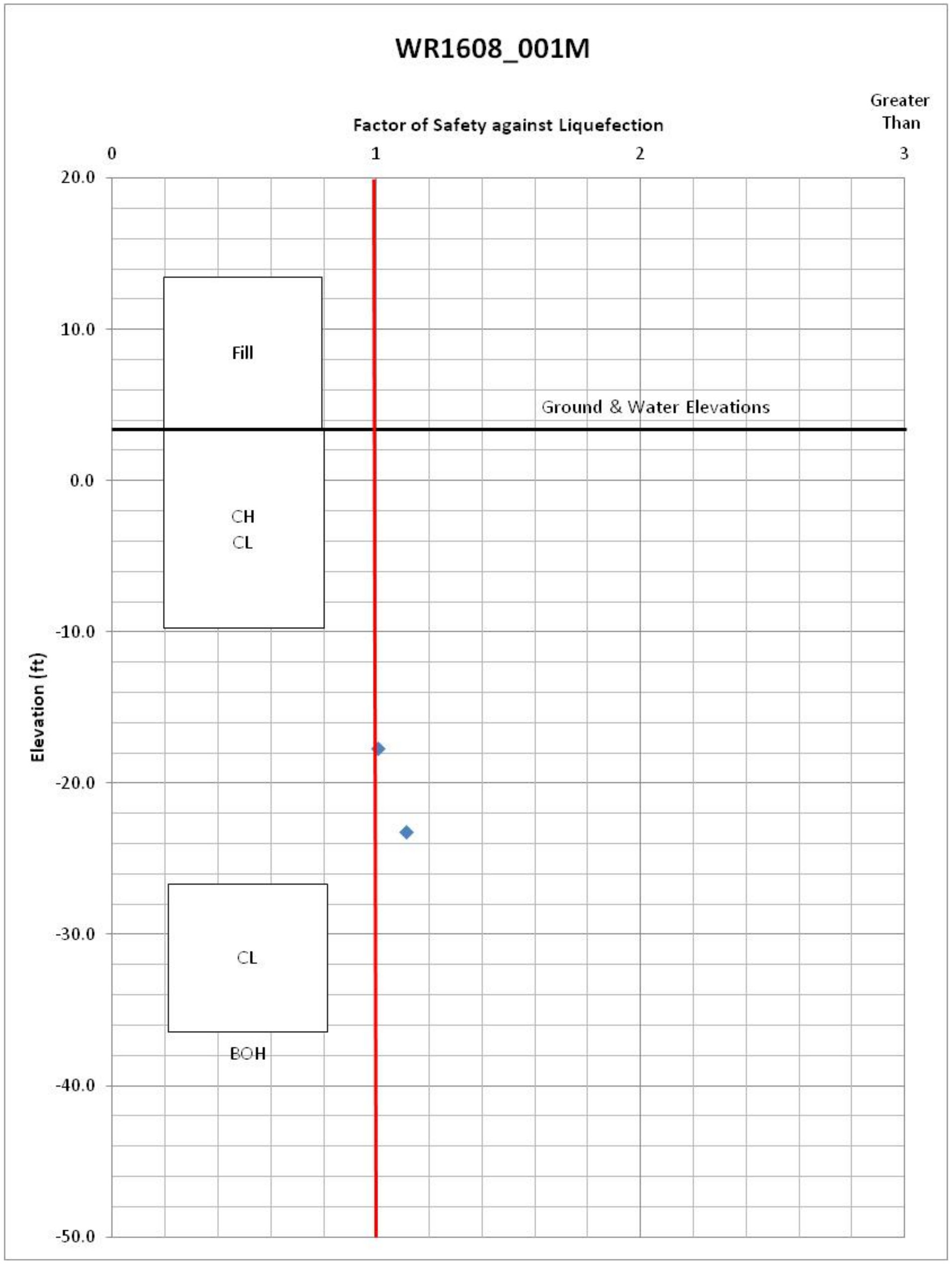


Fig. C-57. Lincoln Village, Station 43+58

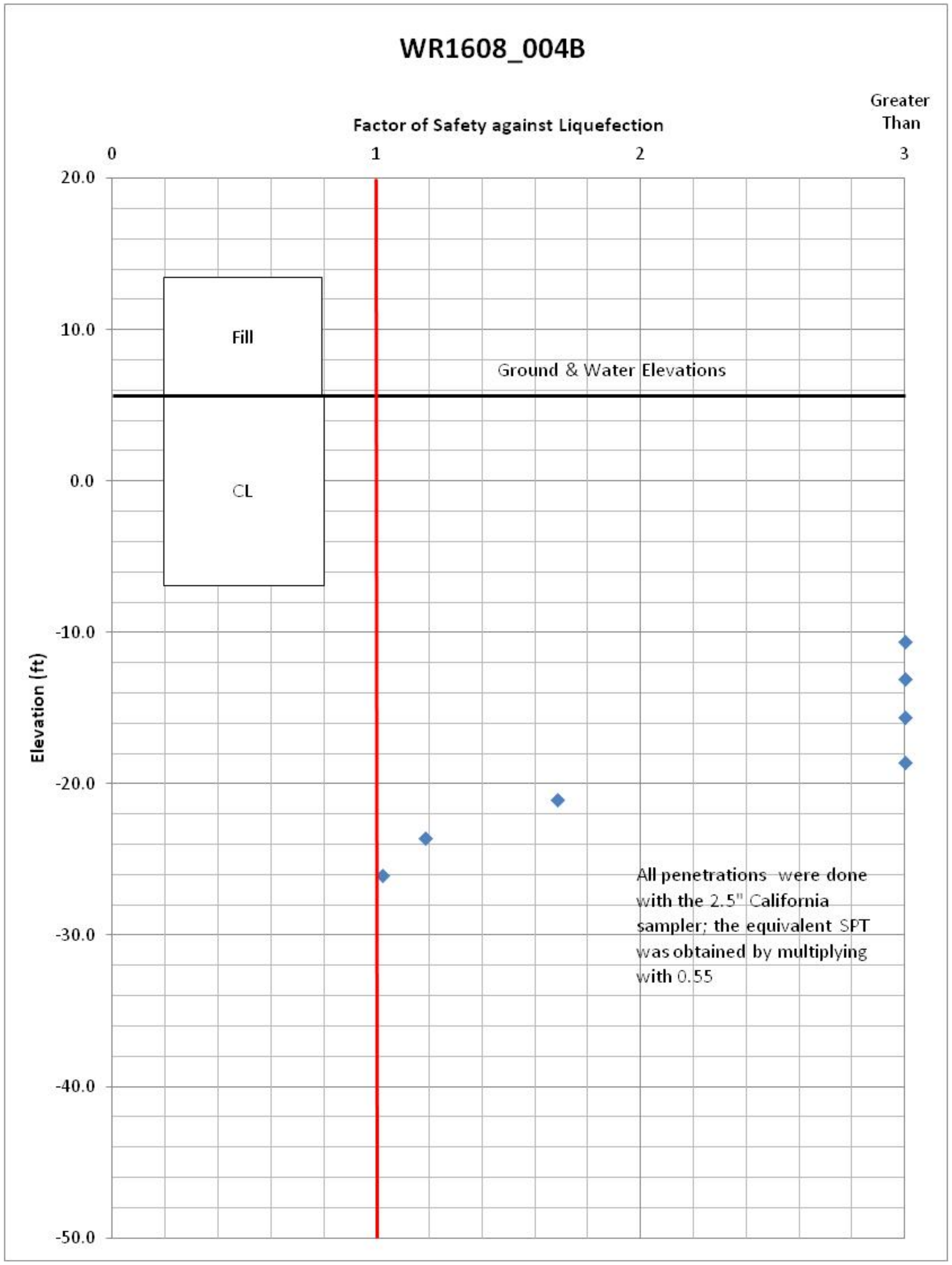


Fig. C-58. Lincoln Village, Station 50+79

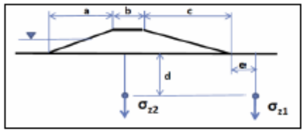
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 89+65
Boring Number: WR1608_004M

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.5 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	5.7 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	84	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	5.7 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	25.5 ft
Crest Width, b (ft)	22.0 ft
Landside/Downstream Slope, c (ft)	34.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-45.0 ft
Embankment Height, H (ft)	7.8 ft

Boring	WR1608_004M
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.50 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
26.0	-12.5	15	SC	17		120	125	3054.7	2399.5	818.2	2275.0	1139.3	0.94	1	1	1.00	19.7	3.01	1.06	23.9	0.27	0.94	0.24	1.00	0.68	1.00	1.67

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

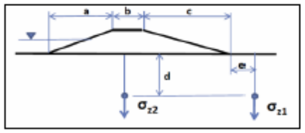
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 89+67
Boring Number: WR1608_003M

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.3 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	4.8 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	84	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.8 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	25.5 ft
Crest Width, b (ft)	22.0 ft
Landside/Downstream Slope, c (ft)	34.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-45.0 ft
Embankment Height, H (ft)	8.5 ft

Boring	WR1608_003M
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.30 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
26.0	-12.7	19	SC	42		120	125	3053.8	2386.1	900.3	2187.5	1095.5	0.94	1	1	1.00	25.0	5.00	1.20	35.1	2.00	0.94	0.24	1.00	0.64	1.00	3.00

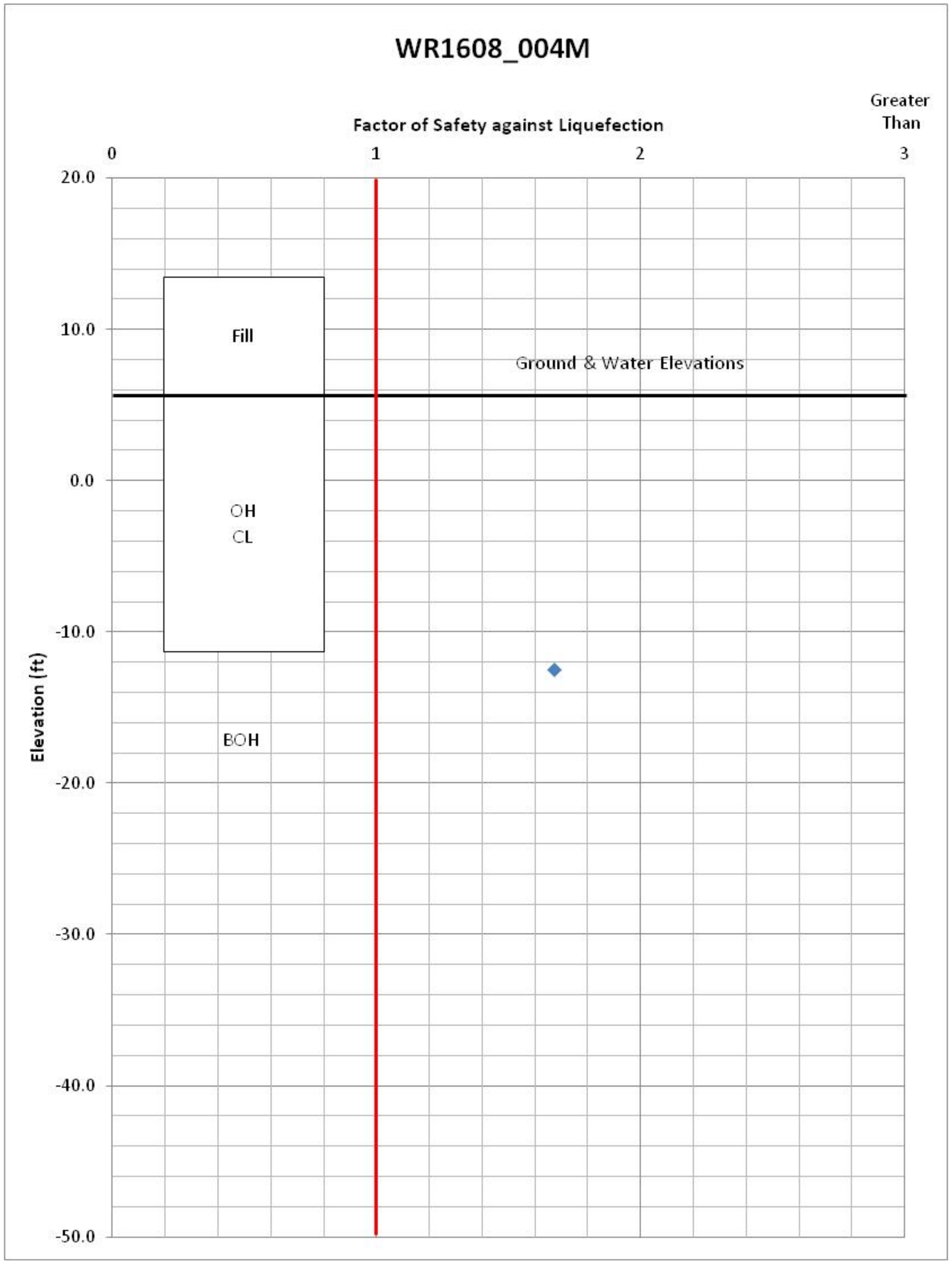


Fig. C-59. Lincoln Village, Station 89+65

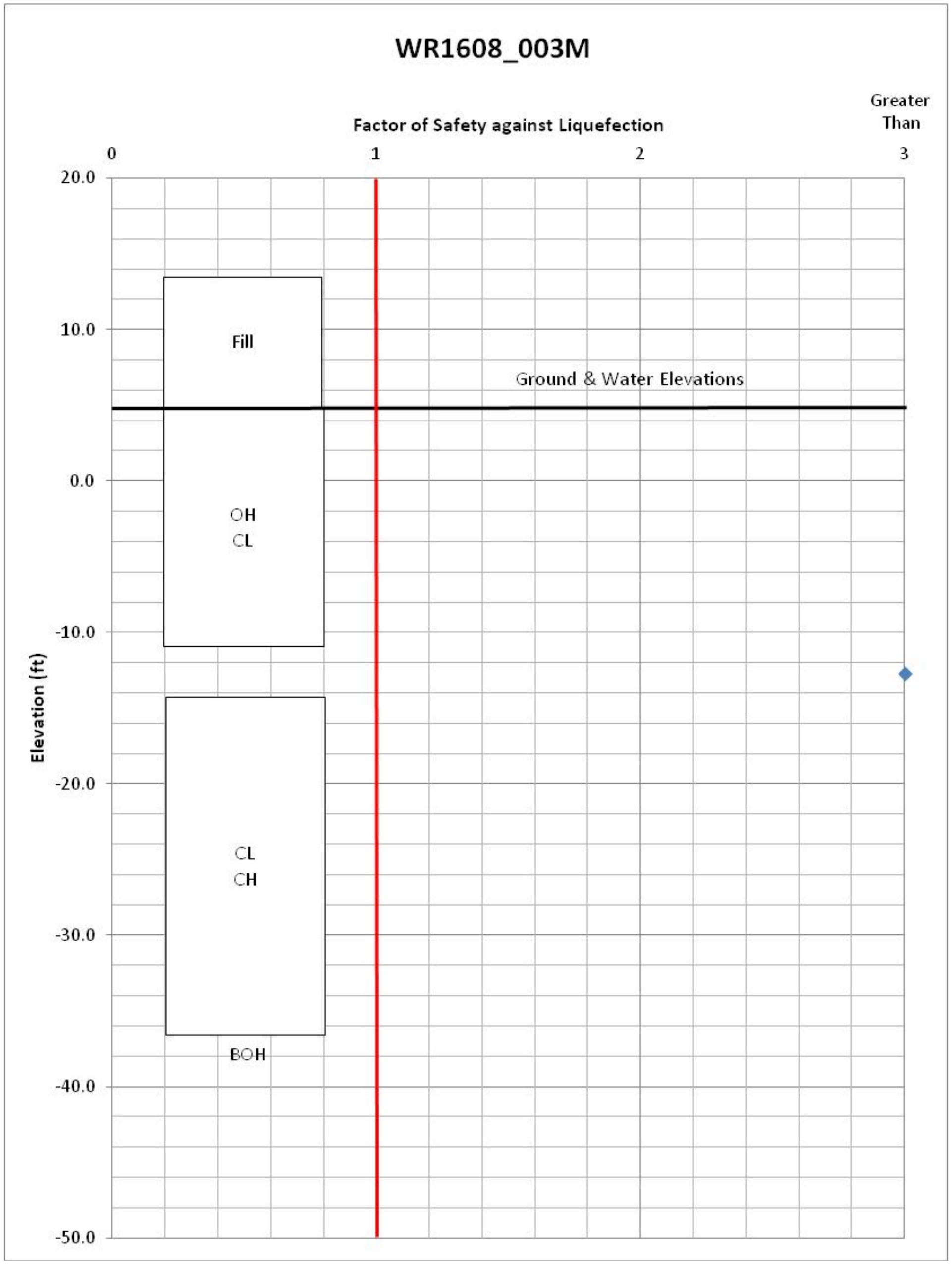


Fig. C-60. Lincoln Village, Station 89+67

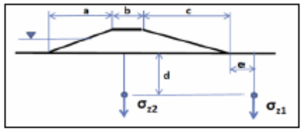
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 109+90
Boring Number: WR1608_008B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.0 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	1.0 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	1.0 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	39.6 ft
Crest Width, b (ft)	60.0 ft
Landside/Downstream Slope, c (ft)	30.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-60.0 ft
Embankment Height, H (ft)	12.0 ft

Boring	WR1608_008B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.00 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
27.0	-14.0	10	SP-SM	10		120	125	3277.9	2529.1	1417.9	1875.0	939.0	0.91	1	1	1.00	12.3	0.87	1.02	13.4	0.14	0.94	0.24	1.00	0.75	1.00	0.89
29.5	-16.5	25	ML	60		120	125	3579.3	2674.5	1406.8	2187.5	1095.5	0.89	1	1	1.00	28.5	5.00	1.20	39.2	2.00	0.93	0.24	1.00	0.60	1.00	3.00
33.5	-20.5	20	SM	33		120	125	4056.7	2902.3	1384.2	2687.5	1345.9	0.85	1	1	1.00	21.9	4.88	1.18	30.7	2.00	0.90	0.23	1.00	0.66	1.00	3.00
37.5	-24.5	45	SP-SM	11		120	125	4528.7	3124.7	1356.2	3187.5	1596.3	0.82	1	1	1.00	47.5	1.21	1.03	50.0	2.00	0.87	0.23	1.00	0.60	1.00	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

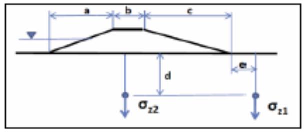
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 150+00
Boring Number: WR1608_013B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	12.7 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.2 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.2 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	31.4 ft
Crest Width, b (ft)	8.0 ft
Landside/Downstream Slope, c (ft)	23.8 ft
Dist. of Boring from Levee Toe [1] (ft)	-27.8 ft
Embankment Height, H (ft)	9.5 ft

Boring	WR1608_013B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
12.70 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
23.0	-10.3	16	SP-SM	16		120	125	2598.0	2080.1	936.5	1687.5	845.1	1.01	1	0.95	1.00	19.6	2.77	1.05	23.4	0.26	0.95	0.25	1.00	0.68	1.00	1.61
28.5	-15.8	20	SP-SM	7		120	125	3179.1	2318.0	830.1	2375.0	1189.4	0.96	1	1	1.00	25.0	0.12	1.01	25.3	0.30	0.93	0.24	1.00	0.64	1.00	1.84
31.0	-18.3	15	SP-SM	7		120	125	3447.4	2430.3	785.9	2687.5	1345.9	0.93	1	1	1.00	18.4	0.12	1.01	18.7	0.20	0.92	0.24	1.00	0.69	1.00	1.25
33.5	-20.8	18	SP-SM	4		120	125	3718.6	2545.5	744.6	3000.0	1502.4	0.91	1	1	1.00	20.6	0.00	1.00	20.6	0.22	0.90	0.23	1.00	0.67	1.00	1.43

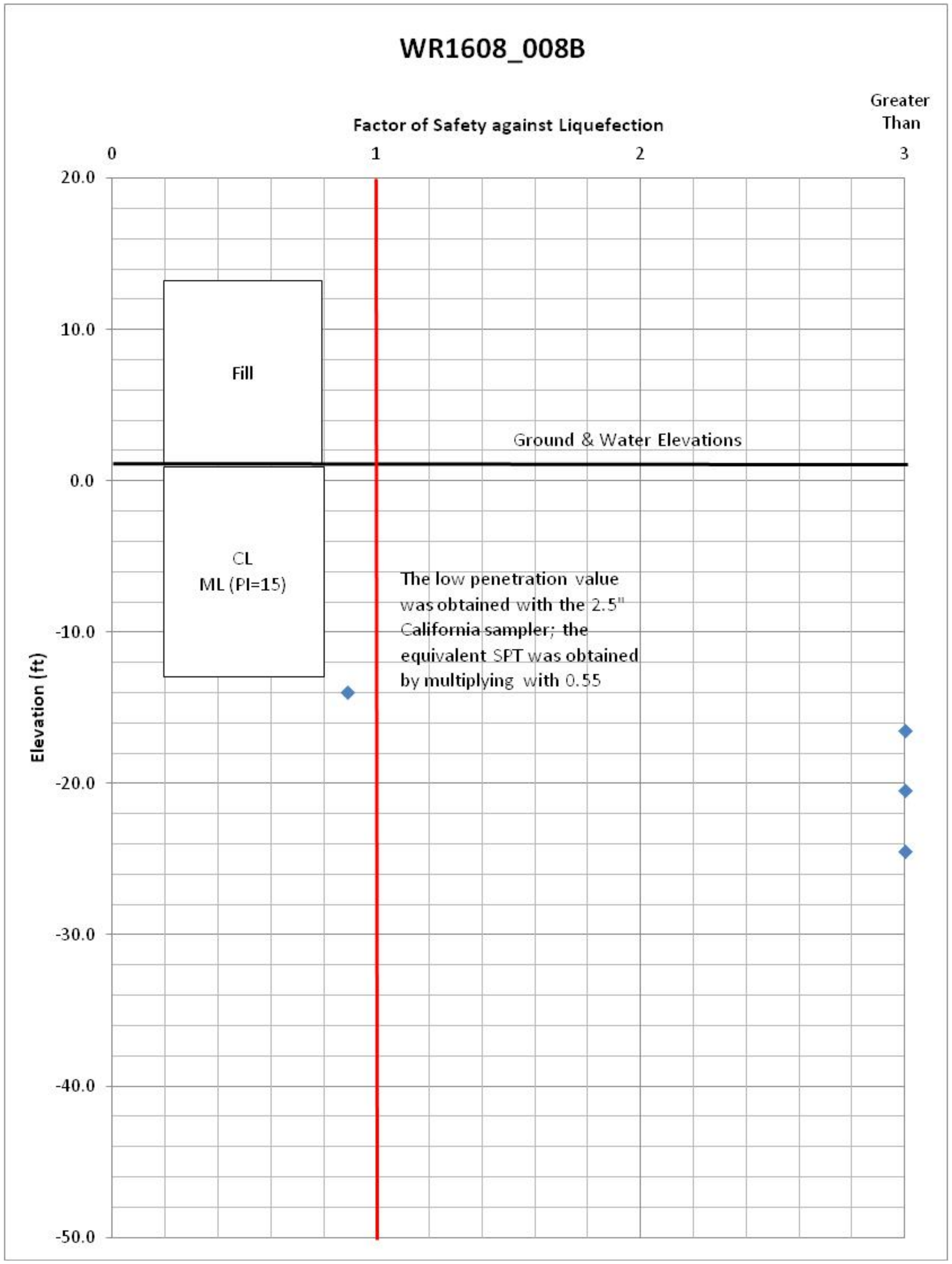


Fig. C-61. Lincoln Village, Station 109+90

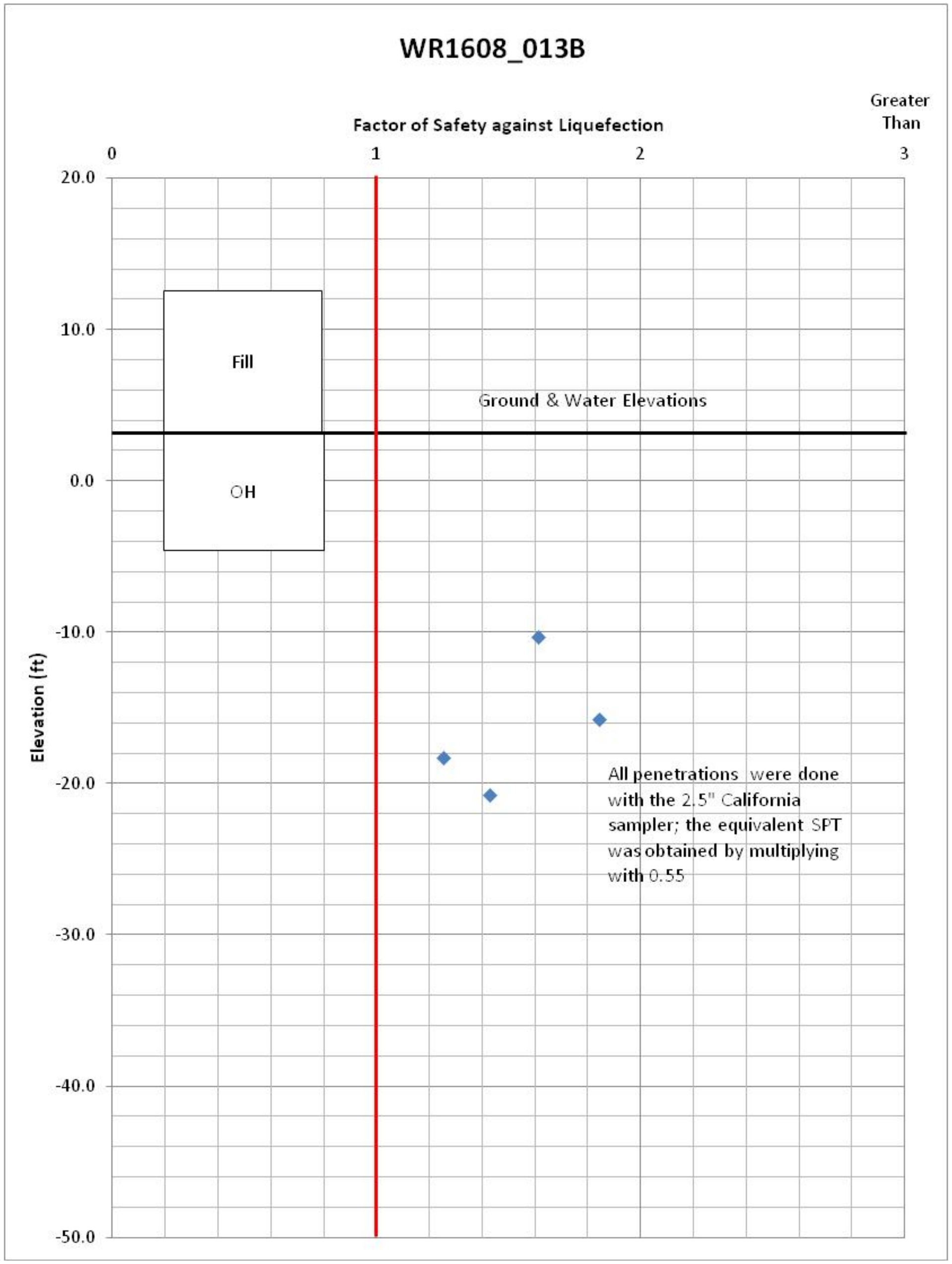


Fig. C-62. Lincoln Village, Station 150+00

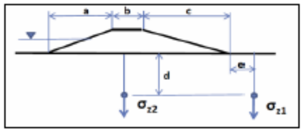
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 159+20
Boring Number: WR1608_001B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.1 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.1 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	84	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.1 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	25.0 ft
Crest Width, b (ft)	9.0 ft
Landside/Downstream Slope, c (ft)	50.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-54.5 ft
Embankment Height, H (ft)	10.0 ft

Boring	WR1608_001B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.05 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
31.0	-18.0	17	SM	15		120	125	3510.4	2515.1	910.6	2628.4	1314.9	0.92	1	1	1.00	21.8	2.50	1.05	25.4	0.30	0.92	0.24	1.00	0.66	1.00	1.88
36.5	-23.5	14	SM	39		120	125	4115.7	2777.3	828.5	3315.9	1659.2	0.87	1	1	1.00	17.1	5.00	1.20	25.5	0.30	0.88	0.23	1.00	0.70	1.00	1.99
41.5	-28.5	13	SP-SM	12		120	125	4674.6	3024.1	762.4	3940.9	1972.2	0.84	1	1	1.00	15.2	1.55	1.03	17.3	0.18	0.84	0.22	1.00	0.72	1.00	1.27

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

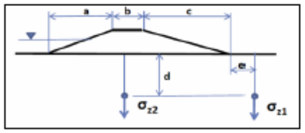
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 159+41
Boring Number: WR1608_009B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	4.1 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.1 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	28.1 ft
Crest Width, b (ft)	14.0 ft
Landside/Downstream Slope, c (ft)	37.4 ft
Dist. of Boring from Levee Toe [1] (ft)	-44.4 ft
Embankment Height, H (ft)	9.4 ft

Boring	WR1608_009B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.40 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao&Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
33.5	-20.1	12	ML	63		120	125	3833.4	2703.9	844.9	3022.1	1512.0	0.88	1	1	1.00	13.1	5.00	1.20	20.7	0.22	0.90	0.23	1.00	0.74	1.00	1.43
36.0	-22.6	13	ML	63		120	125	4110.9	2825.4	809.9	3334.6	1668.5	0.87	1	1	1.00	14.7	5.00	1.20	22.6	0.25	0.88	0.23	1.00	0.72	1.00	1.64
38.5	-25.1	12	ML	63		120	125	4390.0	2948.5	776.5	3647.1	1825.0	0.85	1	1	1.00	12.5	5.00	1.20	20.0	0.22	0.86	0.22	1.00	0.74	1.00	1.45
41.0	-27.6	15	SM	11		120	125	4670.8	3073.3	744.8	3959.6	1981.5	0.83	1	1	1.00	15.8	1.21	1.03	17.4	0.19	0.84	0.22	1.00	0.71	1.00	1.27
43.5	-30.1	17	SM	13		120	125	4953.3	3199.8	714.8	4272.1	2138.0	0.81	1	1	1.00	17.2	1.89	1.04	19.7	0.21	0.82	0.21	1.00	0.70	1.00	1.49

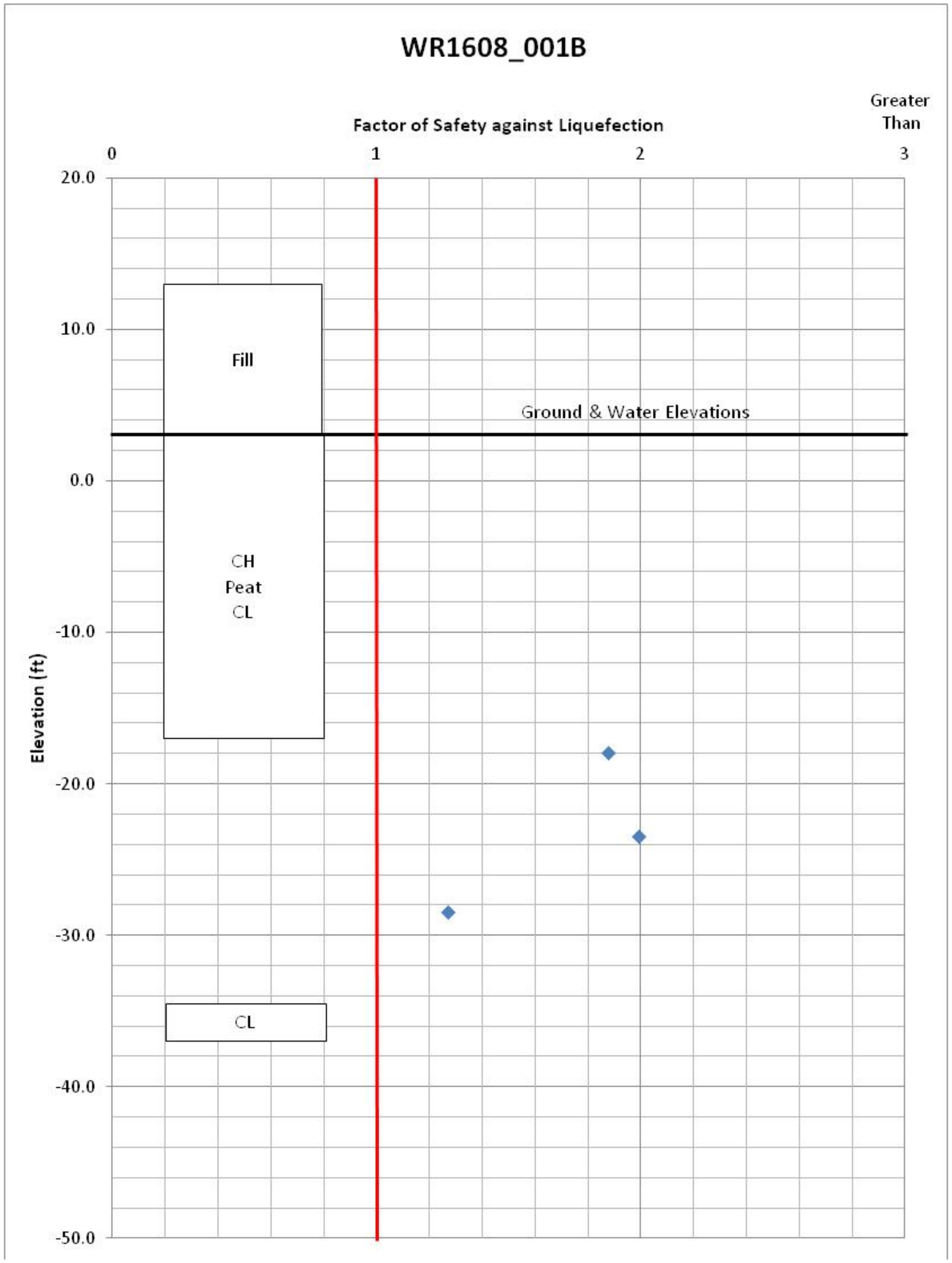
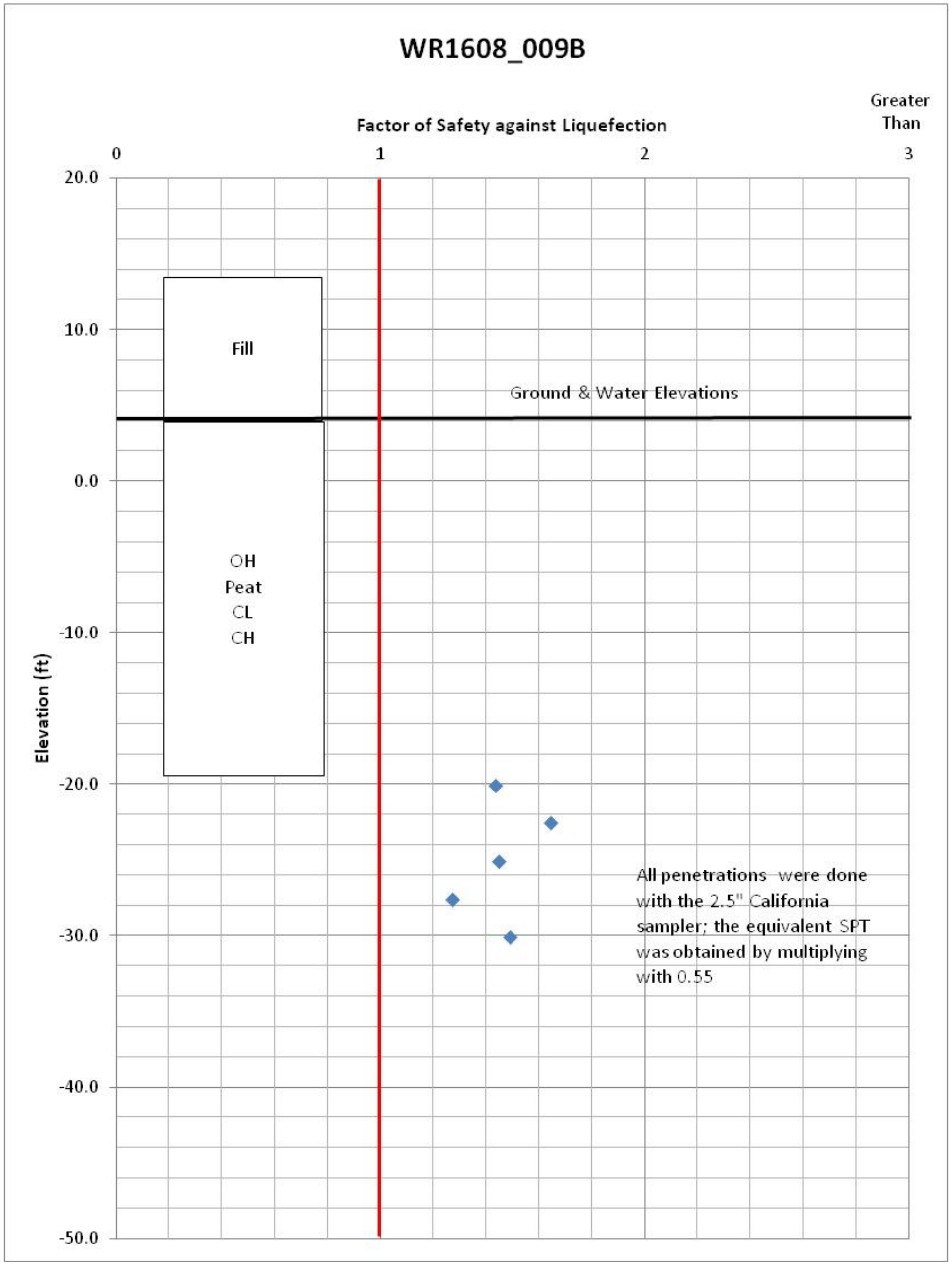


Fig. C-63. Lincoln Village, Station 159+20



All penetrations were done with the 2.5" California sampler; the equivalent SPT was obtained by multiplying with 0.55

Fig. C-64. Lincoln Village, Station 159+41

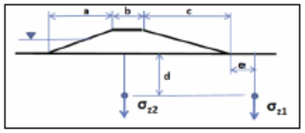
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 159+48
Boring Number: WR1608_010B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.4 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.7 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	9.7 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.7 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	29.1 ft
Crest Width, b (ft)	9.0 ft
Landside/Downstream Slope, c (ft)	38.8 ft
Dist. of Boring from Levee Toe [1] (ft)	5.0 ft
Embankment Height, H (ft)	9.7 ft

Boring WR1608_010B
Boring on waterside or landside field
SPT Ground Elevation Used in Analysis
3.70 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
21.0	-17.3	8	SP-SM	10		120	125	2717.2	1762.5	120.7	2625.0	1314.6	1.10	1	0.95	1.00	10.7	0.87	1.02	11.8	0.13	0.95	0.25	1.00	0.76	1.00	0.79
24.0	-20.3	11	SM	23		120	125	3111.1	1969.2	139.6	3000.0	1502.4	1.04	1	0.95	1.00	13.9	4.06	1.10	19.4	0.21	0.94	0.25	1.00	0.73	1.00	1.27
30.0	-26.3	34	SM	12		120	125	3893.7	2583.3	172.2	3750.0	1878.0	0.91	1	1	1.00	39.5	1.55	1.03	42.3	2.00	0.93	0.24	1.00	0.60	1.00	3.00
33.0	-29.3	31	SM	8		120	125	4282.3	2971.9	185.8	4125.0	2065.8	0.84	1	1	1.00	33.6	0.30	1.01	34.3	2.00	0.91	0.23	1.00	0.60	1.00	3.00
36.0	-32.3	26	SM	8		120	125	4669.2	3358.8	197.7	4500.0	2253.6	0.79	1	1	1.00	26.5	0.30	1.01	27.1	0.34	0.88	0.23	1.00	0.63	0.98	2.19

NOTE
[1] "e" is the distance from landside toe, positive downstream and negative going upstream.
[2] Soil description may be used to estimate fines content where lab testing is not available.
Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.
Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.
[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.
[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for liner (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

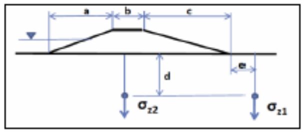
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 164+99
Boring Number: WR1608_011B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.6 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	3.6 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	77	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	3.6 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	33.0 ft
Crest Width, b (ft)	14.0 ft
Landside/Downstream Slope, c (ft)	29.0 ft
Dist. of Boring from Levee Toe [1] (ft)	-36.0 ft
Embankment Height, H (ft)	10.0 ft

Boring WR1608_011B
Boring on the crest
SPT Ground Elevation Used in Analysis
13.60 ft

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR[3]	K_α	f parameter	K_σ	FS against Liquefaction
24.5	-10.9	18	ML	38		120	125	2836.1	2280.8	1051.6	1812.5	907.7	0.96	1	0.95	1.00	21.3	5.00	1.20	30.6	2.00	0.94	0.24	1.00	0.67	1.00	3.00
27.0	-13.4	8	ML	38		120	125	3106.2	2394.8	1009.2	2125.0	1064.2	0.94	1	1	1.00	10.0	5.00	1.20	16.9	0.18	0.94	0.24	1.00	0.77	1.00	1.11
29.5	-15.9	11	ML	70		120	125	3376.5	2509.1	967.0	2437.5	1220.7	0.92	1	1	1.00	13.0	5.00	1.20	20.6	0.22	0.93	0.24	1.00	0.74	1.00	1.38
32.0	-18.4	13	ML	35		120	125	3647.8	2624.5	925.8	2750.0	1377.2	0.90	1	1	1.00	15.2	5.00	1.20	23.3	0.26	0.91	0.24	1.00	0.72	1.00	1.65
34.5	-20.9	23	ML	35		120	125	3920.6	2741.2	886.1	3062.5	1533.7	0.88	1	1	1.00	26.0	5.00	1.20	36.3	2.00	0.89	0.23	1.00	0.63	1.00	3.00
37.0	-23.4	20	SP-SM	10		120	125	4195.1	2859.8	848.1	3375.0	1690.2	0.86	1	1	1.00	21.9	0.87	1.02	23.2	0.26	0.87	0.23	1.00	0.66	1.00	1.72
40.0	-26.4	20	SP-SM	8		120	125	4527.0	3004.5	805.0	3750.0	1878.0	0.84	1	1	1.00	21.9	0.30	1.01	22.5	0.25	0.85	0.22	1.00	0.66	1.00	1.70
42.0	-28.4	4	ML	90		120	125	4749.8	3221.0	777.8	4000.0	2003.2	0.81	1	1	1.00	4.0	5.00	1.20	9.8	0.11	0.83	0.22	1.00	0.80	1.00	0.77
44.5	-30.9	19	SP	6		120	125	5030.1	3501.3	745.6	4312.5	2159.7	0.78	1	1	1.00	19.2	0.03	1.00	19.3	0.21	0.81	0.21	1.00	0.68	0.99	1.47
47.0	-33.4	15	SP	6		120	125	5312.2	3783.4	715.2	4625.0	2316.2	0.75	1	1	1.00	14.8	0.03	1.00	14.9	0.16	0.79	0.21	1.00	0.72	0.98	1.13
50.0	-36.4	21	SP	6		120	125	5653.1	4124.3	681.1	5000.0	2504.0	0.72	1	1	1.00	19.7	0.03	1.00	19.8	0.21	0.77	0.20	1.00	0.68	0.95	1.52

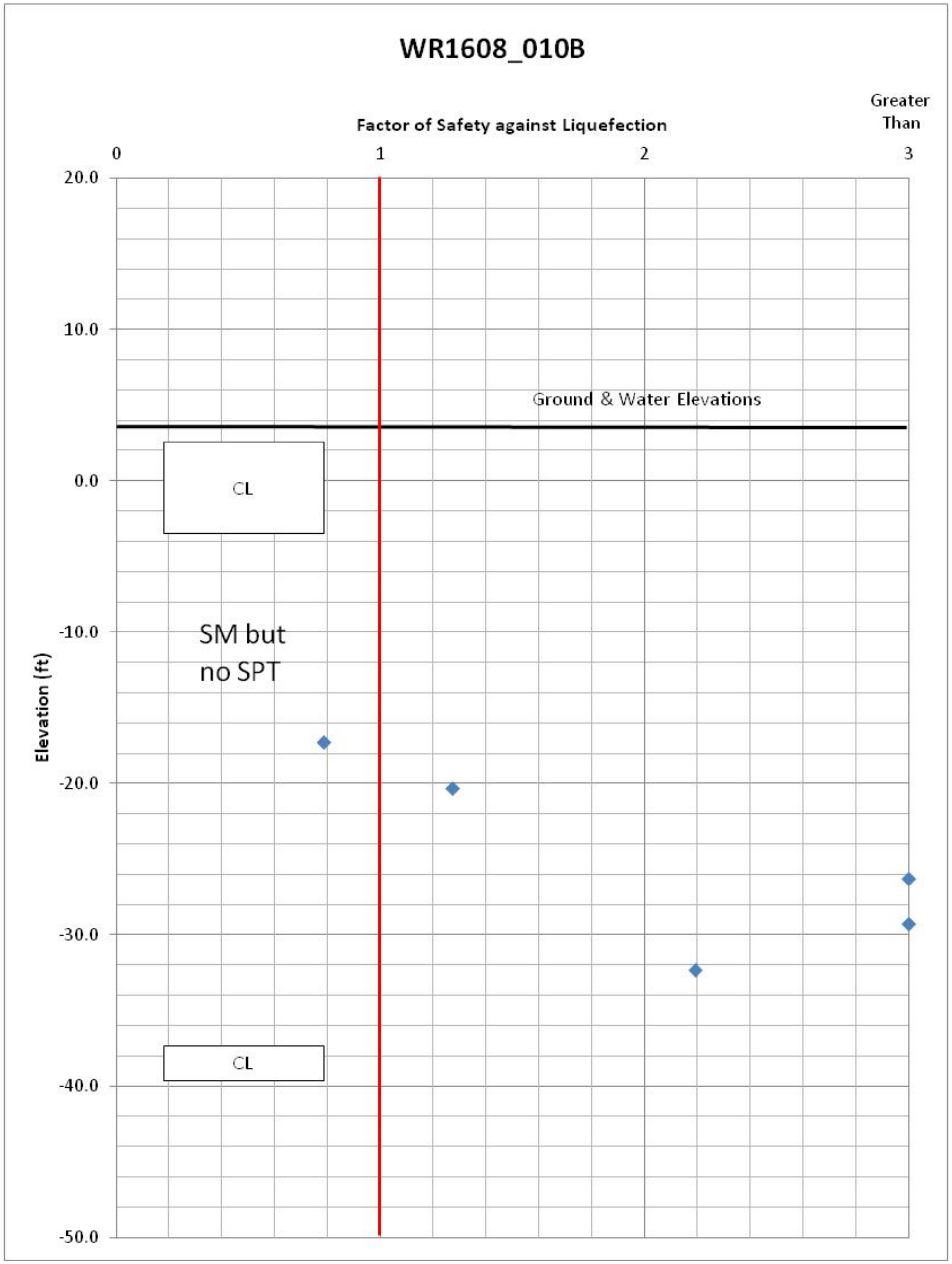
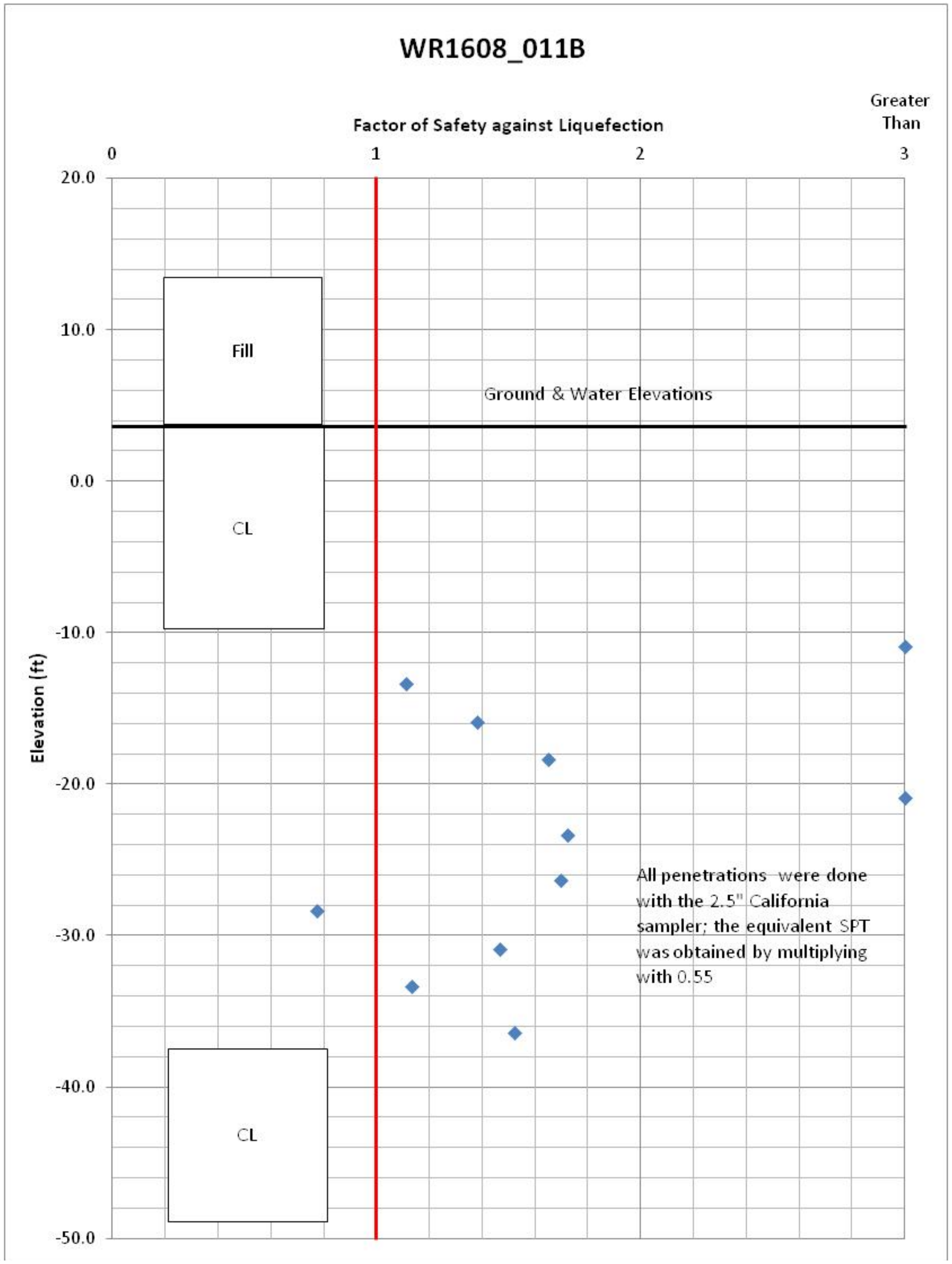


Fig. C-65. Lincoln Village, Station 159+48



All penetrations were done with the 2.5" California sampler; the equivalent SPT was obtained by multiplying with 0.55

Fig. C-66. Lincoln Village, Station 164+99

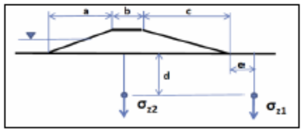
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 142+28
Boring Number: WR1608_005M

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	12.7 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	4.9 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	84	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	4.9 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	25.7 ft
Crest Width, b (ft)	12.0 ft
Landside/Downstream Slope, c (ft)	25.7 ft
Dist. of Boring from Levee Toe [1] (ft)	-31.7 ft
Embankment Height, H (ft)	7.8 ft

Boring	WR1608_005M
Boring on the crest	
SPT Ground Elevation Used in Analysis	
12.70 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
26.0	-13.3	11	SC	21		120	125	2967.9	2262.8	727.4	2275.0	1139.3	0.97	1	1	1.00	14.9	3.78	1.09	20.0	0.21	0.94	0.24	1.00	0.72	1.00	1.32
31.0	-18.3	8	ML	92		120	125	3520.7	2503.6	655.2	2900.0	1452.3	0.92	1	1	1.00	10.3	5.00	1.20	17.4	0.18	0.92	0.24	1.00	0.77	1.00	1.16
41.0	-28.3	11	SM	14		120	125	4651.2	3028.8	535.7	4150.0	2078.3	0.84	1	1	1.00	12.9	2.20	1.04	15.6	0.17	0.84	0.22	1.00	0.74	1.00	1.14
46.0	-33.3	49	GP	5		120	125	5228.3	3605.9	487.8	4775.0	2391.3	0.77	1	1	1.00	52.6	0.00	1.00	52.6	2.00	0.80	0.21	1.00	0.60	0.95	3.00

NOTE

[1] "e" is the distance from landside toe, positive downstream and negative going upstream.

[2] Soil description may be used to estimate fines content where lab testing is not available.

Based on Youd et. Al., "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Worshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

Surcharge from embankment calculation is presented in Poulos & Davis (1978) which based on Boussinesq formulas for stresses generated by infinite length trapezoidal loading on elastic half-space.

[3] CSR is calculated without consideration of the influence of embankment to reflect free-field condition consistent with the PGA used.

[4] It is conservative to answer "No" if unsure about sampling method; answering "Yes" implies that sampler has room for linter (1.5-inch inside diameter) but the liner is not inserted.

Updated April 2013

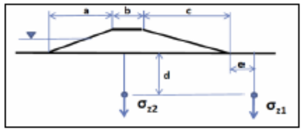
LIQUERFACTION TRIGGERING ANALYSIS

Project: Lower San Joaquin
Study Area: Lincoln Village
Levee Station: 201+51
Boring Number: WCNBFM_001B

Prepared by: Vlad Perlea
Checked by:

Date: 7/23/2013
Date:

Input Parameters					
Embankment Crest Elevation (ft)	13.0 ft	Rod Length Above GS. (ft)	7	Magnitude, M	6.4
Base Elevation (ft)	6.6 ft	Sampler without Liner? (Y/N)	n	PGA (g's)	0.2
Height below Crest of Embankment (ft)	0.0 ft	Borehole Dia. (inch)	4.5		
Groundwater Elevation during Drilling (ft)	-2.0 ft	Hammer Efficiency	84	Assumed Embankment UW (pcf)	
Groundwater Elevation for Analysis (ft)	6.6 ft			120.0 pcf	



Surcharge Information	
Waterside/Upstream Slope, a (ft)	12.9 ft
Crest Width, b (ft)	8.0 ft
Landside/Downstream Slope, c (ft)	14.2 ft
Dist. of Boring from Levee Toe [1] (ft)	-18.2 ft
Embankment Height, H (ft)	6.5 ft

Boring	WCNBFM_001B
Boring on the crest	
SPT Ground Elevation Used in Analysis	
13.00 ft	

Depth (ft)	Elevation (ft)	Field Blow Count, N	USCS Soil Type/Description [2]	Fines Content (%<#200)	Flag for Analysis "Clay" or "Unsaturated"	Wet Unit Weight (pcf)	Saturated Unit Weight (pcf)	Total Overburden Pressure during Drilling (psf)	Effective Overburden Pressure during Drilling (psf)	Surcharge Influence during Drilling (psf)	Total Overburden Pressure for Analysis (psf)	Effective Overburden Pressure for Analysis (psf)	Overburden Correction Factor, C_N [Liao&Whitman]	C_B	C_R	C_S	$N_{1,60}$ [Liao& Whitman]	Alpha	Beta	$(N_{1,60})_{cs}$ [Liao&Whitman]	$CRR_{7.5}$	r_d	CSR^3	K_α	f parameter	K_σ	FS against Liquefaction
16.0	-3.0	9	SP-SM	34		120	125	1780.1	1717.7	629.1	1197.1	598.1	1.11	1	0.95	1.00	13.3	4.93	1.19	20.7	0.22	0.96	0.25	1.00	0.74	1.00	1.34
21.0	-8.0	14	SP-SM	17		120	125	2299.6	1925.2	523.6	1822.1	911.1	1.05	1	0.95	1.00	19.5	3.01	1.06	23.7	0.27	0.95	0.25	1.00	0.68	1.00	1.63
26.0	-13.0	13	SP-SM	17		120	125	2840.1	2153.7	439.1	2447.1	1224.1	0.99	1	1	1.00	18.0	3.01	1.06	22.1	0.24	0.94	0.24	1.00	0.69	1.00	1.50
31.0	-18.0	7	SP-SM	18		120	125	3399.9	2401.5	373.9	3072.1	1537.1	0.94	1	1	1.00	9.2	3.23	1.07	13.0	0.14	0.92	0.24	1.00	0.78	1.00	0.88
36.0	-23.0	8	SP-SM	10		120	125	3974.6	2976.2	323.6	3697.1	1850.1	0.84	1	1	1.00	9.4	0.87	1.02	10.5	0.12	0.88	0.23	1.00	0.78	1.00	0.77
41.0	-28.0	31	SW-SM	7		120	125	4560.2	3561.8	284.2	4322.1	2163.1	0.77	1	1	1.00	33.5	0.12	1.01	33.9	2.00	0.84	0.22	1.00	0.60	0.99	3.00

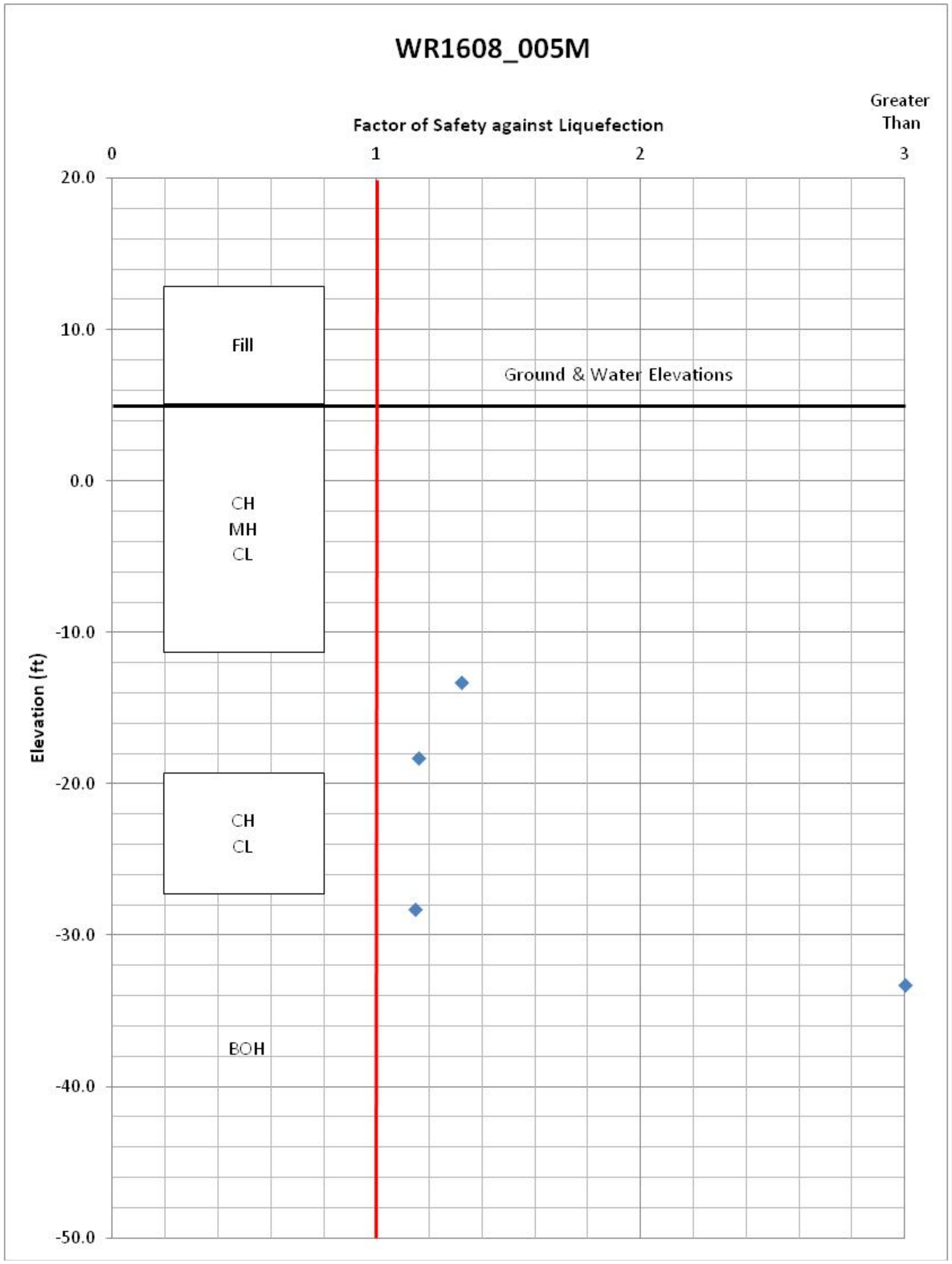


Fig. C-67. Lincoln Village, Station 142+28

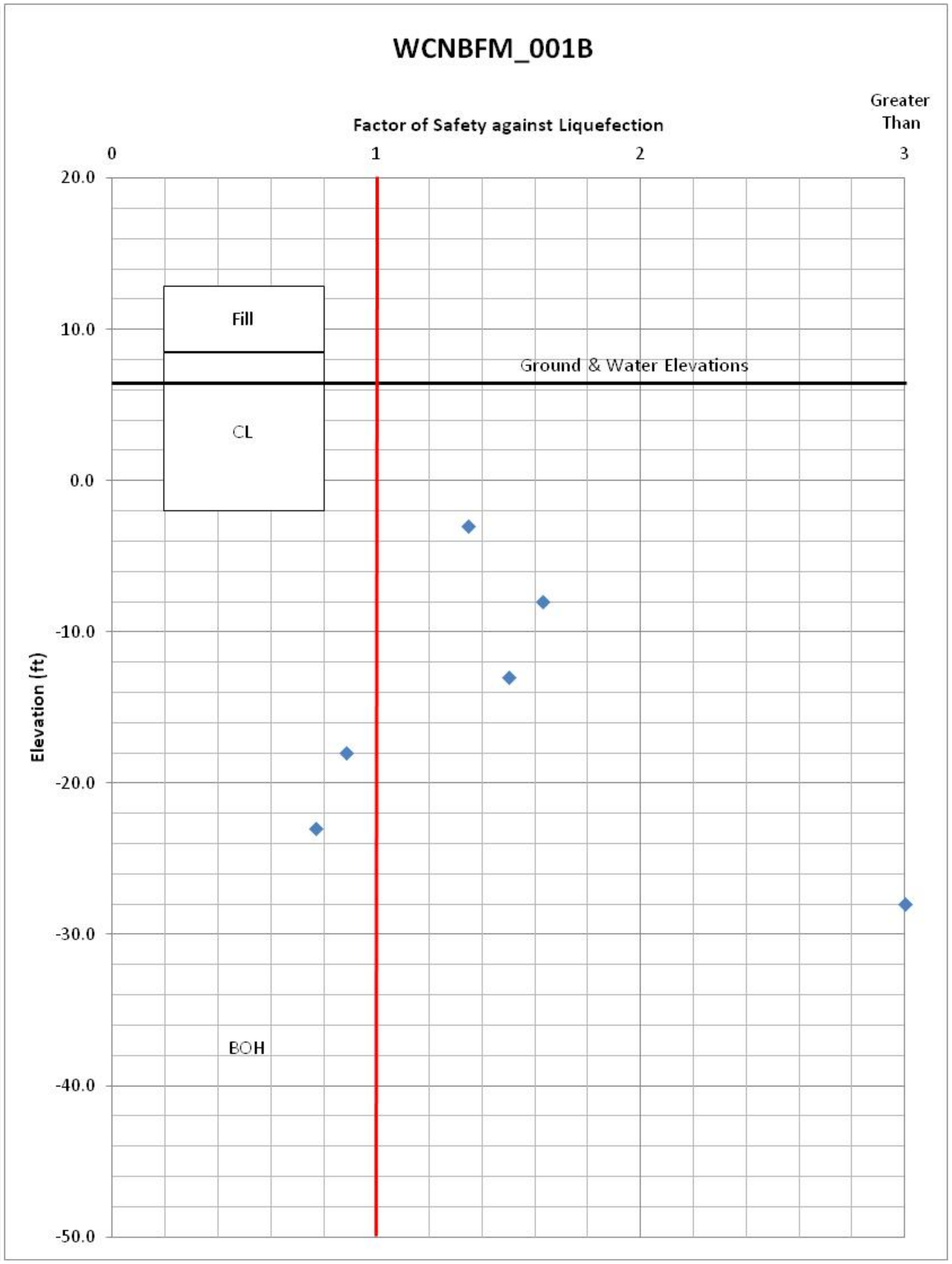


Fig. C-68. Lincoln Village, Station 201+51

Appendix D

<u>Selected Boring Logs</u>

DATE STARTED **2/6/07**	DATE COMPLETED **2/8/07**	GROUND ELEVATION **29.4 ft**	ELEVATION BASIS **Andregg Survey**	TOTAL DEPTH OF BORING **101.5 ft**	
DRILLING CONTRACTOR **Westex**		DRILLER'S NAME **Chris Minor**	HELPER'S NAME **Boyd Dortsch**	TOTAL DEPTH OF FILL **18 ft**	
DRILLING METHOD **0'-26.5' HSA, 26.5'-101.5' Rotary**		DRILL RIG MAKE AND MODEL **CME 550**		CONSULTANT COMPANY **Fugro West, Inc.**	
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) **4 3/8 inches**		DRILLING ROD TYPE AND DIAMETER **HQ core 94mm, NWJ 67mm**		FIELD LOGGER **Spyridon Giannakos**	
☒ VERTICAL	☐ INCLINED	CASING TYPE, DIAMETER, INSTALLATION DEPTH **10" HSA, 26.5'**		FIELD LOG REVIEWER **Duston Marlow**	
SAMPLER TYPE(S) **SPT(1.375"), MC(2"), Punch Core(2.25"), Shelby Tube(3")**		HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP **140 lb CME Automatic Hammer/ 30-inch drop**		HAMMER EFFICIENCY **72%**	
BOREHOLE BACKFILL OR COMPLETION **cement grout to ground surface**		GROUNDWATER READING:	DURING DRILLING **24 ft**	AFTER DRILLING (DATE-TIME) **Not Measured**	

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		CLAYEY GRAVEL (GC); dense; brown (10YR 5/3); dry; medium to coarse sand; fine to coarse gravel; (FILL).	☒	1	83	12 14 17	31	37						S01C_000_000S, S01B_000_001S, S01A_001_001S
	1		SANDY SILT (ML); dense; brown (10YR 5/3); dry; low plasticity, low dry strength, slow dilatancy, low toughness fines; (FILL).												
	2 3		SILTY SAND (SM); dense; dark yellowish brown (10YR 4/4); dry; fine to medium sand; (FILL).												
25	4 5		SANDY SILT (ML); brown (10YR 4/3); dry; low plasticity, low dry strength, slow dilatancy, low toughness fines; with clay mottling (FILL).												
	6		CLAYEY SAND (SC); brown (7.5YR 5/4); dry; 55% fine to medium sand; 45% fines; trace organics (FILL).	■	2	83	5 8 10	18			12			45	S02B_006_006M, S02A_006_007M
	7		Poorly Graded SAND with Silt (SP-SM); medium dense; pale yellow (2.5Y 8/2); dry; 95% medium to coarse sand; 5% fines; (FILL).	☒	3	83	4 6 7	13	16		2			5	S03B_007_007S, S03A_007_008S
20	8 9 10		SANDY SILT (ML); brown (10YR 4/3); moist; low plasticity, low dry strength, slow dilatancy, low toughness fines; (FILL).												
	11 12		Poorly Graded SAND (SP); loose; very pale brown (10YR 8/2); 98% fine to medium sand; 2% fines; (FILL).	☒	4	78	WOH 2 3	5	6		3			2	S04B_010_010S, S04A_010_011S
	13		LEAN CLAY (CL); very dark grayish brown (10YR 3/2); dry; low to medium dry strength, no to slow dilatancy, low toughness fines; (FILL).	▌	5	90					30	44	22	88	S05A_013_015T 3" Shelby 0 psi
15	14		SILT (ML); brown (10YR 4/3); moist; 88% low dry strength, slow dilatancy, low toughness fines; 12% sand; oxidized (FILL).												
	15 16 17		SANDY SILT (ML); loose; dark yellowish brown (10YR 4/4); dry; 50% fine sand; 50% fines; trace mica (FILL). (BASE OF FILL).	☒	6	61	2 3 4	7	8		13			50	S06A_015_016S
10	18 19 20		SILTY SAND (SM); medium dense; brown (10YR 5/3); moist; 83% fine to medium sand; 17% fines; with white mottling (NATIVE).												

Final Report Version 9/30/2008

Borehole Location: Crest of Levee
Coordinates: North 2,122,291.98 East 6,324,796.46
Levee Station or Milepost: STA: 1553+82.13 Offset: 3.24 feet Left
GPS: Latitude 37.82064 Longitude -121.32006
Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_069B

Sheet 1 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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				REMARKS
											Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	
	20				7	100	3 5 7	12			9			17	S07B_021_021M, S07A_021_022M
	21		81% sand; 19% fines; very pale brown (10YR 8/3) below 21.5'.		8	83	3 5 7	12	14		11			19	S08A_022_023S
∇ 5	23 24		Poorly Graded SAND with Silt (SP-SM); medium dense; light yellowish brown (10YR 6/4); wet; 94% medium sand; 6% fines.												
	25 26		Olive (5Y 5/3) from 26.0' to 30.5'.		9	67	3 8 8	16	19		25			6	S09A_025_026S
0	27 28 29				10	67									S10A_027_028P Switch to Rotary
	30 31		Dark greenish gray (10G 4/1) below 30.5'.		11	44	5 6 7	13	16						S11B_030_030S, S11A_030_031S
-5	32 33 34					12									No Sample Taken
	35 36		SILT with Sand (ML); medium dense; olive gray (5Y 4/2); moist; low plasticity, low to medium dry strength, slow dilatancy, low toughness fines. LEAN CLAY with Sand (CL); very stiff; olive gray (5Y 5/2); moist; medium dry strength, slow dilatancy, low toughness fines; trace sand, oxidized, trace organics, white mottling.		12	83	3 4 5	9	11	1.0P 1.8P					S12B_035_036S, S12A_036_036S
-10	37 38 39		SANDY SILT (ML); medium dense; gray (5Y 5/1); moist; low plasticity, low dry strength, slow dilatancy, low toughness fines; oxidized, trace organics.		13	67				2.5P	29	45	28		S13A_037_038P
	40 41 42		Dark grayish brown (2.5Y 4/2) mottled with red, medium plasticity below 40.0'.		14	60					29	24	1		S14A_040_042T 3" Shelby 100 psi
	43				15	72	7 6 8	14	17	2.0P 4.5P					S15A_043_044S
-15	44 45		SILT (ML); medium dense; brown (10YR 4/3); moist; low		16	100									S16A_045_045P

Final Report Version 9/30/2008

Borehole Location: Crest of Levee
Coordinates: North 2,122,291.98 East 6,324,796.46
Levee Station or Milepost: STA: 1553+82.13 Offset: 3.24 feet Left
GPS: Latitude 37.82064 Longitude -121.32006
Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_069B

Sheet 2 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations
Program

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
	45 46		plasticity, low to medium dry strength, slow dilatancy, low toughness fines; trace mica, trace organics, oxidized. SILTY SAND (SM); medium dense; olive brown (2.5Y 4/3); moist; fine to medium sand; trace mica.	☒	17	89	2 6 11	17	20						S17B_045_046S, S17A_046_047S
-20	47 48 49		CLAYEY SAND (SC); gray (5Y 5/1); 75% fine to medium sand; 25% fines; trace mica.	▮	18	57					20			25	S18A_048_048P
	50 51		SILTY SAND (SM); dense; olive brown (2.5Y 4/4); moist; 74% fine sand; 26% fines; trace mica.	☒	19	61	12 15 15	30	36						S19B_050_051S, S19A_051_051S
-25	52 53 54		Oxidized from 52.5' to 53.0'.	▮	20	81					21			26	S20A_052_053P
	55 56		Poorly Graded SAND (SP); very dense; olive (5Y 4/3); moist; fine to medium sand; trace mica.	☒	21	56	17 25 33	58	70						S21B_055_055S, S21A_055_056S
-30	57 58 59		Well-Graded SAND (SW); olive gray (5Y 4/2); moist; fine to coarse sand; trace mica. SILTY SAND (SM); very dense; olive gray (5Y 4/2); moist; 73% fine sand; 27% fines; trace mica, gray mottling.	▮	22	60					21			27	S22A_059_060P
	60 61			☒	23	61	19 25 33	58	70						S23A_060_061S
-35	62 63 64		Poorly Graded SAND with Silt (SP-SM); olive gray (5Y 4/2); 89% fine to coarse sand; 11% fines; trace mica.	▮	24	100					25			11	S24A_062_063P
	65 66 67		LEAN CLAY with Sand (CL); stiff; greenish gray (10G 5/1); moist; high dry strength, no to slow dilatancy, medium toughness fines; oxidized.	▮	NR	0									No Recovery
	68			☒	25	100	6 7 9	16	19	2.0P	31	40	24		S25A_068_069S
-40	69 70			▮	26	67									S26A_069_070P

Final Report Version 9/30/2008

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County: San Joaquin

LOG OF BORING
WR0017_069B

Sheet 3 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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				REMARKS
											Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	
	70 71		LEAN CLAY (CL); very stiff; greenish gray (10G 5/1); dry; medium plasticity, high dry strength, no to slow dilatancy, medium toughness fines; oxidized.		27	100	6 8 8	16	19	3.8P					S27A_070_072S
-45	72 73 74		3' layer of silty sand (SM). SILTY SAND (SM); olive gray (5Y 4/2); moist; 87% fine to coarse sand; 13% fines; polygenic coarse sand.		28	100					17			13	S28A_074_075P
	75 76		Poorly Graded SAND with Silt (SP-SM); dense; light yellowish brown (2.5Y 6/3); moist; fine to medium sand. LEAN CLAY (CL); olive (5Y 4/3); moist; medium plasticity, medium to high dry strength, no to slow dilatancy, medium toughness fines; oxidized, trace organics.		29	61	23 23 18	41	49						S29B_075_076S, S29A_076_076S
-50	77 78 79		SANDY SILT (ML); olive brown (2.5Y 4/3); moist; low plasticity, medium to high dry strength, no to slow dilatancy, medium toughness fines; trace organics, trace mica.		30	100									S30A_077_078P
	80 81 82		CLAYEY SAND (SC); olive brown (2.5Y 4/3); moist; fine sand; trace mica. LEAN CLAY with Sand (CL); light olive brown (2.5Y 5/3); moist; medium to high dry strength, slow dilatancy, low toughness fines; trace mica, trace organics.		31	90					26	42	28		S31A_080_083S 3" Shelby 0 psi
	83				NR	0	7 8 11	19	23						No Recovery
-55	84		SILTY CLAYEY SAND (SC-SM); dense; light olive brown (2.5Y 5/3); moist; 62% sand; 38% low to medium dry strength, slow dilatancy, low toughness fines; trace mica, oxidized.		32	100									S32A_084_085P
	85 86				33	61	8 11 15	26	31	1.0P	26	29	7	38	S33A_085_086S
-60	87 88 89		SILTY SAND (SM); medium dense; olive gray (5Y 4/2); moist; 53% fine sand; 47% fines; trace mica, oxidized.		34	57									
	90 91		Trace organics below 90.5'.		35	61	9 10 14	24	29		22			47	S35B_090_091S, S35A_091_091S
-65	92 93 94 95		SILT (ML); olive brown (2.5Y 4/3); moist; medium plasticity, medium to high dry strength, slow dilatancy, low toughness fines; trace mica, oxidized.		NR	0									No Recovery

Final Report Version 9/30/2008

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County: San Joaquin

LOG OF BORING
WR0017_069B

Sheet 4 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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				REMARKS
											Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	
	95														
	96		LEAN CLAY with Sand (CL); medium stiff; gray (5Y 5/1); moist; medium to high dry strength, no to slow dilatancy, medium to high toughness fines; trace mica, oxidized.		36	100	WOH 4 7	11	13	0.8P					S36B_095_095S, S36A_095_097S
	97 98 99		Silty sand lens at 97.5'. Very stiff to hard below 98.0'.		37	86				1.8P 3.0T 4.5P	38	43	23		S37A_097_098P
-70	100 101		CLAYEY SAND (SC); medium dense; dark grayish brown (2.5Y 4/2); moist; low plasticity, medium to high dry strength, slow dilatancy, medium toughness fines; fine to medium sand; trace oxidation.		38	67	9 10 12	22	26		16			48	S38B_100_101S, S38A_101_101S
			SILTY SAND (SM); medium dense; dark grayish brown (2.5Y 4/2); moist; 52% fine to coarse sand; 48% fines; trace oxidation.												
	102 103		Borehole terminated at 101.5 feet. Backfilled with cement grout..												
-75	104 105														
	106 107 108														
-80	109 110														
	111 112 113														
-85	114 115														
	116 117 118														
-90	119 120														

Final Report Version 9/30/2008

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LOG OF BORING
WR0017_069B

Sheet 5 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

DATE STARTED 2/9/07	DATE COMPLETED 2/12/07	GROUND ELEVATION 29.9 ft	ELEVATION BASIS Andregg Survey	TOTAL DEPTH OF BORING 101.5 ft
DRILLING CONTRACTOR Westex		DRILLER'S NAME Chris Minor	HELPER'S NAME Boyd Dortsch	TOTAL DEPTH OF FILL 20 ft
DRILLING METHOD 0'-26.5' HSA, 26.5'-101.5' Rotary		DRILL RIG MAKE AND MODEL CME 555		CONSULTANT COMPANY Fugro West, Inc.
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 4 3/8 inches		DRILLING ROD TYPE AND DIAMETER HQ core 94mm, NWJ 67mm		FIELD LOGGER J. Anderson/S. Giannakos
☒ VERTICAL ☐ INCLINED		CASING TYPE, DIAMETER, INSTALLATION DEPTH 10" HSA, 26.5'		FIELD LOG REVIEWER Duston Marlow
SAMPLER TYPE(S) SPT(1.375"), MC(2"), Punch Core(2.25"), Shelby Tube(3")		HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP 140 lb CME Automatic Hammer/ 30-inch drop		HAMMER EFFICIENCY 72%
BOREHOLE BACKFILL OR COMPLETION cement grout to ground surface		GROUNDWATER READING: DURING DRILLING Not Measured		AFTER DRILLING (DATE-TIME) 25.5 ft on 2/12/07 11:00AM

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				REMARKS
											Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	
	0		CLAYEY GRAVEL (GC); dense; light olive brown (2.5Y 5/3); dry; medium to coarse sand; fine to coarse gravel; base rock (FILL).		1	61	19 15 15	30	36						S01B_000_001S, S01A_001_001S
	1		LEAN CLAY with Sand (CL); very dark grayish brown (10YR 3/2); moist; medium plasticity, medium to high dry strength, no to slow dilatancy, medium toughness fines; (FILL).												
	4		Poorly Graded SAND (SP); medium dense; brown (10YR 4/3); dry; fine to medium sand; trace mica (FILL).												
25	5				2	61	6 7 5	12	14						S02B_005_006S, S02A_006_006S
	6		SANDY SILT (ML); loose to medium dense; very dark grayish brown (2.5Y 3/2); moist; 65% medium dry strength, slow dilatancy, medium toughness fines; 35% sand; trace mica (FILL). Dark yellowish brown (10YR 4/4), fine to medium sand from 7.5' to 8.0'. Dark grayish brown (10YR 4/2), slow to rapid dilatancy below 8.0'.												
	7				3	93					19	27	2	65	S03A_008_010T 3" Shelby 0 psi
20	10				4	44	3 3 3	6	7						S04A_010_011S
	12		LEAN CLAY (CL); dark grayish brown (10YR 4/2); dry; medium dry strength, slow dilatancy, low toughness fines; trace mica (FILL).												
	13		LEAN CLAY with Sand (CL); very dark grayish brown (2.5Y 3/2); moist; medium plasticity, medium to high dry strength, no to slow dilatancy, low toughness fines; trace mica, oxidized (FILL).		5	90					32	43	20		S05A_013_015T 3" Shelby 0 psi
15	15				6	56	3 3 3	6	7						S06A_015_016S
10	20		(BASE OF FILL).												

Final Report Version 9/30/2008

Borehole Location: Crest of Levee
Coordinates: North 2,120,457.89 East 6,325,060.90
Levee Station or Milepost: STA: 1595+33.28 Offset: 4.31 feet Right
GPS: Latitude 37.81561 Longitude -121.31911
Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_074B

Sheet 1 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

Elevation, feet	Depth, feet	FIELD CLASSIFICATION OF MATERIALS (Description)	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 21	Poorly Graded SAND with Silt (SP-SM); loose; dark grayish brown (10YR 4/2); 88% fine to medium sand; 12% fines; trace mica, oxidized. Dark brown (10YR 3/3) below 21.0'.	7	94	3 4 6	10			11				S07C_020_021M, S07B_021_021M, S07A_021_022M
	22		8	72	4 3 4	7	8		9			12	S08A_022_023S
	23 24	SANDY SILT (ML); dark gray (2.5Y 4/1); moist; medium plasticity, medium to high dry strength, no to slow dilatancy, medium toughness fines; with clay, trace mica, oxidized.											
5 ▼	25 26	Poorly Graded SAND with Silt (SP-SM); loose; dark grayish brown (2.5Y 4/2); moist; 89% fine to medium sand; 11% fines; oxidized, trace mica.	9	83	1 2 3	5	6		35			11	S09B_025_026S, S09A_026_026S
	27 28 29	Dark gray below 28.5'.		14									No Sample Taken. Switch to Rotary
0	30 31	Medium dense below 30.0'.	10	39	4 5 5	10	12						S10A_030_031S
	32 33 34	CLAYEY SAND (SC); medium dense; dark greenish gray (10Y 4/1); wet; 86% fine to medium sand; 14% fines; trace mica.	11	29									S11A_031_032P
-5	35 36		12	50	5 6 7	13	16		31			14	S12A_035_036S
	37 38 39		13	24									S13A_036_037P
-10	40 41	Greenish gray (5GY 5/1) below 41.0'.	NR	0									No Recovery Hydraulically Advanced SPT Sampler
	42		14	33	4 5 7	12	14						S14A_042_042S
	43 44	87% sand; 13% fines.	15	38					29			13	S15A_043_044P
-15	45												

Final Report Version 9/30/2008

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LOG OF BORING
WR0017_074B

Sheet 2 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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
	45 46				16	22	10 8 8	16							S16A_045_046M
	47		2" of medium to coarse sand at 46.5'. Well-Graded SAND with Clay (SW-SC); medium dense to dense; dark greenish gray (5GY 4/1); wet; 89% sand; 11% fines; trace mica.		17	44	4 5 6	11	13						S17B_047_047S, S17A_047_047S no sand size description
	48 49				18	50					28			11	S18A_048_049P
-20	50 51		Well-Graded SAND (SW); dense; greenish gray (10Y 5/1); wet.		19	56	15 20 21	41	49						S19B_050_051S, S19A_051_051S
	52 53 54		CLAYEY SAND (SC); dense; dark greenish gray (10GY 4/1); wet; 82% fine to coarse sand; 18% fines.		20	50					14			18	S20A_051_052P
-25	55 56		87% sand; 13% fines; light greenish gray (10Y 8/1), fine to medium sand from 55.0' to 59.0'.		21	67	14 31 29	60			19			13	S21B_055_056M, S21A_056_056M
	57				22	28	5 9 21	30	36						S22A_057_057S
	58 59		Greenish gray (10Y 6/1), fine to coarse sand below 59.0'.		23	100									S23A_058_059P
-30	60 61		87% sand; 13% fines.		24	50	14 19 20	39	47		20			13	S24A_060_061S
	62 63 64		SILT with Sand (ML); light olive gray (5Y 6/2); moist; low plasticity, low dry strength, slow dilatancy, low toughness fines; trace mica.		NR	0									No Recovery
-35	65 66		LEAN CLAY with Sand (CL); stiff to very stiff; olive gray (5Y 5/2); moist; high dry strength, no dilatancy, low toughness fines; oxidized.		25	72	5 6 7	13	16	1.0P 1.8P	28	39	25		S25B_065_065S, S25A_065_066S
-40	67 68 69 70		Greenish gray (10Y 5/1), medium toughness below 67.5'. 1" silty fine to medium sand lens at 67.8'.		26	88				3.0P 2.5T					S26A_068_069P

Final Report Version 9/30/2008

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LOG OF BORING
WR0017_074B
Sheet 3 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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 71 72				NR	0									No Recovery 3" Shelby 0 psi
	73				27	100	6 8 10	18	22	2.3P					S27A_073_074S
	74		Grayish brown (2.5Y 5/2), low to medium toughness, trace organics and mica below 74.0'.		28	100				1.8P	27	49	34		S28A_074_075P
-45	75 76 77				29	83									S29A_075_077T 3" Shelby
	78		LEAN CLAY (CL); olive gray (5Y 5/2); moist; high dry strength, no dilatancy, low toughness fines; oxidized.		30	100	0 1 7	8	10	0.1P	26	41	28		S30A_078_079S
	79				31	100				0.5P 3.5T					S31A_079_080P
-50	80				32	100	0 4 5	9	11	0.8P					S32B_080_081S
	81 82		SANDY LEAN CLAY (CL); stiff; olive gray (5Y 5/2); moist; 52% medium dry strength, no to slow dilatancy, low toughness fines; 48% sand; oxidized.								26	32	19	52	S33A_082_083P
	83 84		SANDY SILT (ML); greenish gray (10Y 6/1); moist; low plasticity, low dry strength, slow dilatancy, low toughness fines; oxidized, trace mica. Dark greenish gray (5GY 4/1) below 84.5'.		33	100				0.1P					
-55	85 86		LEAN CLAY (CL); soft to medium stiff; dark greenish gray (5GY 4/1); moist; low plasticity, medium dry strength, no to slow dilatancy, low toughness fines; trace mica. SANDY SILT (ML); dark greenish gray (5GY 4/1); moist; low plasticity, low to medium dry strength, slow dilatancy, low toughness fines; trace mica.		34	83	0 4 14	18	22	0.6P 0.3P					S34C_085_086S, S34B_086_086S, S34A_086_086S
	87 88 89		Well-Graded SAND with Silt (SW-SM); medium dense; dark greenish gray (5GY 4/1); fine to coarse sand. FAT CLAY (CH); soft; greenish gray (10Y 5/1); wet; medium to high plasticity, no dry strength, no dilatancy, low toughness fines.			52				0.3P					No Sample Taken
-60	90 91 92		SANDY LEAN CLAY (CL); olive gray (5Y 5/2); moist; low dry strength, slow dilatancy, low toughness fines; with sand, oxidized.		35	90					30	60	43		S35A_090_093T 3" Shelby
	93		LEAN CLAY (CL); medium stiff to stiff; light olive gray (5Y 6/2); moist; low plasticity, high dry strength, no dilatancy, medium toughness fines; oxidized, trace mica.		36	83	6 6 7	13	16	1.5P					S36B_093_093S, S36A_093_094S
-65	94 95					100									No Sample Taken

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LOG OF BORING
WR0017_074B

Sheet 4 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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				REMARKS
											Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	
	95 96				37	100	0 4 8	12	14	0.8P					S37A_095_097S
	97 98 99		SANDY SILT (ML); very dense; grayish brown (2.5Y 5/2); moist; 67% low dry strength, slow dilatancy, low toughness fines; 33% sand; oxidized, trace mica.		38	71				1.0P 0.8P	30	33	9	67	S38A_098_099P
-70	100 101				39	94	14 24 30	54	65	2.5P					S39A_100_102S
	102		Borehole terminated at 101.5 feet. Backfilled with cement grout..												
	103														
	104														
-75	105														
	106														
	107														
	108														
	109														
-80	110														
	111														
	112														
	113														
	114														
-85	115														
	116														
	117														
	118														
	119														
-90	120														

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LOG OF BORING
WR0017_074B
Sheet 5 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

DATE STARTED
12/15/06

DATE COMPLETED
12/21/06

GROUND ELEVATION
22.9 ft

ELEVATION BASIS
Andregg Survey

TOTAL DEPTH OF BORING
126.5 ft

DRILLING CONTRACTOR
Westex

DRILLER'S NAME
Chris Minor

HELPER'S NAME
Boyd Dortsch

TOTAL DEPTH OF FILL
15 ft

DRILLING METHOD
0'-25' HSA, 25'-126.5' Rotary

DRILL RIG MAKE AND MODEL
CME 550

CONSULTANT COMPANY
Fugro West, Inc.

DRILL BIT SIZE AND TYPE (HOLE DIAMETER)
4 3/8 inches

DRILLING ROD TYPE AND DIAMETER
HQ core 94mm, NWJ 67mm

FIELD LOGGER
Spyridon Giannakos

☒ VERTICAL ☐ INCLINED

CASING TYPE, DIAMETER, INSTALLATION DEPTH
HSA, 10", 25'

FIELD LOG REVIEWER
Duston Marlow

SAMPLER TYPE(S)
SPT(1.375"), Punch Core(2.25"), Shelby Tube(3")

HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP
Automatic CME 140 lb, 30-inch drop

HAMMER EFFICIENCY
72%

BOREHOLE BACKFILL OR COMPLETION
cement grout to ground surface

GROUNDWATER READING: DURING DRILLING
19 ft

AFTER DRILLING (DATE-TIME)
31 ft on 12/19/06 8:00AM

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				REMARKS
											Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	
	0		CLAYEY GRAVEL (GC); loose; brown (7.5YR 4/4); dry to moist; medium to coarse sand; fine to coarse gravel; (FILL).		1	100	3 3 3	6	7						S01A_000_002S
	1		LEAN CLAY (CL); brown (7.5YR 4/4); moist; medium plasticity, low dry strength, slow dilatancy, medium toughness fines; some sand (FILL).												
	2														
20	3														
	4														
	5				2	56	6 4 3	7	8		12	22	5		S02B_005_006S, S02A_006_006S
	6		SILTY CLAYEY SAND (SC-SM); loose; dark reddish brown (5YR 3/4); fine to medium sand; (FILL).												
	7														
15	8														
	9														
	10		CLAYEY SAND (SC); loose; yellowish brown (10YR 5/4); moist; 84% fine to medium sand; 16% fines; (FILL).		3	72					5				S03A_010_013T 3" Shelby 300 psi
	11														
	12														
10	13				4	100	3 2 4	6	7		7			16	S04A_013_015S
	14		(BASE OF FILL).												
	15		SILTY SAND (SM); dark grayish brown (10YR 4/2); moist; 86% fine sand; 14% fines; (NATIVE).		5	80					26			14	S05_A_015_018T 3" Shelby 300 psi
	16														
	17														
5	18		SANDY LEAN CLAY (CL); dark reddish brown (5YR 3/2); moist; low plasticity, low dry strength, no to slow dilatancy, low toughness fines; trace mica.		6	100	2 2 4	6	7						S06A_018_019S
▽	19		Wet at 19.0'. CLAYEY SAND (SC); loose; dark reddish brown (5YR		7	77					26	32	12		S07A_019_021T 3" Shelby
	20														

Final Report Version 9/30/2008

Borehole Location: Crest of Levee
Coordinates: North 2,152,579.89 East 6,323,939.91
Levee Station or Milepost: STA: 1151+05.61 Offset: 11.19 feet Left
GPS: Latitude 37.90375 Longitude -121.32397
Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_019B

Sheet 1 of 6

Engineering Support Services
Urban Levee Geotechnical Evaluations
Program

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				REMARKS
											Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	
	20 21		3/2); moist; low dry strength, no dilatancy, low toughness fines. 6" silty sand slough at 21.5'.		7	77					26	32	12		300 psi
0	22 23 24		Poorly Graded SAND with Clay (SP-SC); loose to medium dense; dark gray (10YR 4/1); wet; 94% fine sand; 6% fines; micaceous.		8	100	2 4 4	8	10		28			6	S08B_022_022S, S08A_022_023S
	25 26		LEAN CLAY with Sand (CL); stiff; reddish gray (5YR 5/2); moist; low dry strength, low toughness fines.		9	89	2 4 5	9	11	4.3P	31	35	13		S09_025_027S Switch to Rotary
-5	27 28 29				10	81									S10A_028_029P
▼	30 31		SANDY SILT (ML); medium dense; dark reddish brown (5YR 3/2); wet; some iron oxide mottling, micaceous.		11	100	5 7 9	16	19		28	26	4		S11A_030_032S
-10	32 33 34				12	45									S12A_032_033P
	35 36		2" medium sand lens at 35.5'.		13	72	5 11 7	18	22						S13A_035_036S
-15	37 38 39		LEAN CLAY with Sand (CL); stiff to very stiff; dark reddish gray (5YR 4/2); moist to wet; medium dry strength, no dilatancy, medium toughness fines; micaceous.		14	90				2.3P	25	45	31		S14A_038_039P
	40 41		Stiff from 40.0' to 43.0'.		15	100	3 5 5	10	12	1.8P					S15A_040_042S
-20	42 43 44 45		1" to 2" subangular gravel lens at 41.5'.		16	100				3.3P					S16A_042_043P

Final Report Version 9/30/2008

Borehole Location: Crest of Levee
Coordinates: North 2,152,579.89 East 6,323,939.91
Levee Station or Milepost: STA: 1151+05.61 Offset: 11.19 feet Left
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Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_019B
Sheet 2 of 6

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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
	45		White mottling at 45.0'.												S17A_045_047S
	46				17	100	6 9 10	19	23						
	47														S18A_050_050P
-25	48				18	14									
	49														
	50														S19B_050_051S, S19A_051_052S
	51		SILTY SAND (SM); dense; dark reddish brown (5YR 3/3); moist; 70% fine sand; 30% fines; some brown and black mottling.		19	100	7 13 16	29	35						
	52										24			26	S20A_052_053P
-30	53		Light olive gray (5Y 5/2), fine to medium sand at 53.0'.		20	76									
	54														
	55		Medium to coarse sand at 55.0'.												S21A_056_057S
	56		LEAN CLAY (CL); very stiff; brown (7.5YR 4/2); moist; medium to high plasticity, medium dry strength, no dilatancy, medium toughness fines; micaceous.		21	100	6 9 8	17	20	2.8P					
	57														S22A_057_058P
-35	58				22	100				2.5P					
	59														
	60		SANDY LEAN CLAY (CL); medium stiff; (5GY 3/1) (4/4); moist; low dry strength, slow dilatancy, low toughness fines; fine sand.												S23A_060_062S
	61				23	100	0 0 2	2	2	0.8P	33	34	20		
	62														S24A_062_063P
-40	63		CLAYEY SAND (SC); dense; dark grayish brown (10YR 4/2); moist to wet; fine to medium sand; micaceous.		24	81									
	64														
	65														S25B_065_066S, S25A_066_067S
	66		Dark greenish gray (5G 4/1); 66% sand; 34% fines; dark greenish gray (5G 4/1) below 66.0'.		25	89	6 15 17	32	38						
	67										27			34	S26A_067_068P
-45	68				26	76									
	69														
	70														

Final Report Version 9/30/2008

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LOG OF BORING
WR0017_019B

Sheet 3 of 6

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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		LEAN CLAY with Sand (CL); very stiff; dark greenish gray (5G 4/1); dry to moist; no dilatancy, medium toughness fines; some iron oxide mottling.		27	100	14 13 16	29	35	2.5P					S27B_070_071S, S27A_071_072S
	71														
	72														S28A_073_074P
-50	73		Decrease in stiffness, trace fine sand from 73.0'.		28	100									
	74									1.0P					
	75		Hard at 75.0'.		29	100	6 10 11	21	25	4.3P	23	37	24		S29A_075_077S
	76														
	77														S30A_077_078P
-55	78		Very stiff at 78.0'.		30	100									
	79														
	80		Reddish brown (5YR 4/4) mottled with iron oxide staining at 80.0'.		31	100	12 16 18	34	41	3.0P					S31A_080_082S
	81														
	82		Dark greenish gray (5BG 4/1) at 82.0'.							3.5P					S32A_082_083P
-60	83				32	100									
	84														
	85		SILTY SAND (SM); dense; dark greenish gray (5G 4/1); wet; 67% fine sand; 33% fines; micaceous.		33	100	8 12 16	28	34		33			33	S33A_085_087S
	86														S34A_086_087P
	87														
-65	88				34	31									
	89														
	90		SANDY SILT (ML); loose; dark olive gray (5Y 3/2); moist to wet; high plasticity, low dry strength, no dilatancy, low toughness fines; micaceous.		35	100	0 0 8	8	10	0.3P					S35A_090_092S
	91														S36A_094_095P
	92														
-70	93		2" medium to coarse sand lens at 93.5'.		36	71									
	94		SANDY LEAN CLAY (CL); very stiff; very dark greenish gray (10GY 3/1); dry; 57% medium dry strength, no								16			57	
	95														

Final Report Version 9/30/2008

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GPS: Latitude 37.90375 Longitude -121.32397
Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_019B

Sheet 4 of 6

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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
	95–96.5		dilatancy, medium toughness fines; 43% fine sand; micaceous. FAT CLAY with Sand (CH); very stiff; dark greenish gray (5G 4/1); dry to moist; medium dry strength, no dilatancy, medium toughness fines; white mottling.	☒	37	100	8 12 15	27	32	3.7P					S37A_095_097S
-75 (at 98)	96.5–100		Hard from 97.0' to 100.0'.	▮	38	100				4.5+P					S38A_097_098P
	100–101.5		Trace fine sand below 101.0'.	☒	39	100	10 15 19	34	41	3.3P	29	53	38		S39A_100_102S
-80 (at 103)	101.5–105		6" silt lens at 102.5'. Hard below 103.5'.	▮	40	100				4.5+P					S40A_102_103P
	105–106.5		SILTY SAND (SM); very dark greenish gray (10Y 3/1); moist to wet; 80% fine sand; 20% fines.	☒	41	100	8 10 14	24	29						S41B_106_106S, S41A_106_107S
-85 (at 108)	106.5–110		Dark gray (10YR 4/1), fine to medium sand, micaceous below 107.0'.	▮	42	90					20			20	S42A_107_108P
	110–111.5		CLAYEY SAND (SC); very dense; dark gray (2.5Y 4/1); wet; 82% sand; 18% fines.	☒	43	100	22 32 29	61	73		21			18	S43A_110_112S
-90 (at 113)	111.5–115		LEAN CLAY (CL); olive gray (5Y 5/2); moist; medium to high dry strength, no dilatancy, high toughness fines; iron oxide mottling.	▮	44	57				4.0P					S44A_113_114P
	115–116.5		SILT (ML); medium dense; light gray (5Y 7/2); moist; low plasticity fines; fine sand; trace sand. LEAN CLAY with Sand (CL); stiff; bluish gray (5B 5/1); dry; medium dry strength, no dilatancy, high toughness fines; some iron oxide staining, interlayered with lenses of soft silt.	☒	45	67	8 10 12	22	26						S45A_115_116S
-95 (at 118)	116.5–120			▮	46	100				1.5P					S46A_118_119P

Final Report Version 9/30/2008

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Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_019B

Sheet 5 of 6

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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
	120	▨	Medium stiff from 120.0' to 123.5'.												S47A_120_122S
	121	▨		☒	47	100	1 3 4	7	8	0.8P	34	39	23		
	122	▨		█											S48A_123_124P
-100	123	▨		█	48	100				2.5P					
	124	▨	Very stiff below 123.5'. White mottling at 124.0'.	█											
	125	▨													No Recovery
	126	▨		☒	NR	0	4 8 12	20	24						
	127		Borehole terminated at 126.5 feet. Backfilled with cement grout..												
-105	128														
	129														
	130														
	131														
	132														
-110	133														
	134														
	135														
	136														
	137														
-115	138														
	139														
	140														
	141														
	142														
-120	143														
	144														
	145														

Final Report Version 9/30/2008

Borehole Location: Crest of Levee
Coordinates: North 2,152,579.89 East 6,323,939.91
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Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_019B
Sheet 6 of 6

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

DATE STARTED 12/13/06 / DATE COMPLETED 12/15/06	GROUND ELEVATION 22.8 ft / ELEVATION BASIS Andregg Survey	TOTAL DEPTH OF BORING 101.5 ft
DRILLING CONTRACTOR Westex	DRILLER'S NAME Chris Minor / HELPER'S NAME Boyd Dortsch	TOTAL DEPTH OF FILL 15 ft
DRILLING METHOD 0'-25' HSA, 25'-101.5' Rotary	DRILL RIG MAKE AND MODEL CME 550	CONSULTANT COMPANY Fugro West, Inc.
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 4 3/8 inches	DRILLING ROD TYPE AND DIAMETER HQ core 94mm, NWJ 67mm	FIELD LOGGER Spyridon Giannakos
☒ VERTICAL ☐ INCLINED	CASING TYPE, DIAMETER, INSTALLATION DEPTH HSA, 10", 25'	FIELD LOG REVIEWER Duston Marlow
SAMPLER TYPE(S) SPT(1.375'), Punch Core(2.25"), Shelby Tube(3')	HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP Automatic CME 140 lb, 30-inch drop	HAMMER EFFICIENCY 72%
BOREHOLE BACKFILL OR COMPLETION cement grout to ground surface	GROUNDWATER READING: DURING DRILLING 20 ft	AFTER DRILLING (DATE-TIME) Not Measured

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		CLAYEY GRAVEL (GC); brown (7.5YR 4/4); medium to coarse sand; fine to coarse gravel; well graded gravel (FILL).		1	44	9 5 8	13	16						S01B_000_001S, S01A_001_001S
	1		SANDY LEAN CLAY (CL); brown (7.5YR 4/3); dry; low dry strength, slow dilatancy, low to medium toughness fines; trace gravel and organics (FILL).												
	2														
20	3														
	4														
	5		63% fines; 37% sand; with orange-brown mottling, micaceous below 5.0'.		2	39	3 4 9	13	16		16	32	17	63	S02A_005_006S
	6														
	7		LEAN CLAY with Sand (CL); reddish brown (5YR 4/4); moist; 75% low dry strength, slow dilatancy, low toughness fines; 25% fine sand; some iron oxide staining (FILL).												S03A_007_009T 3" Shelby 0 psi
15	8				3	50					22	32	14	75	
	9														
	10		With approximately 0.5 mm lenses of silty sand, some clay, medium brown (5YR 3/4) to dusty brown (5YR 2/2) at 10.0'.		4	67	3 5 4	9	11						S04A_010_011S
	11														
	12														
10	13														
	14		(BASE OF FILL).												
	15		FAT CLAY with Sand (CH); medium stiff; dark yellowish brown (10YR 4/4); moist; low dry strength, slow dilatancy, low toughness fines; micaceous (NATIVE).												S05A_015_017T 3" Shelby 300 psi
	16				5	87					31				
	17														
5	18				6	100	0 3 3	6	7	1.0P	43	53	30		S06A_018_019S
	19		Dusty brown (5YR 2/2), some iron oxide staining below 19.0'.												
▽	20														

Final Report Version 9/30/2008

Borehole Location: Crest of Levee
Coordinates: North 2,148,895.80 East 6,322,760.53
Levee Station or Milepost: STA: 1191+43.18 Offset: 8.34 feet Left
GPS: Latitude 37.89359 Longitude -121.32796
Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_024B

Sheet 1 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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														S07A_020_023T 3" Shelby 300 psi
	21		SANDY LEAN CLAY (CL); soft; dark olive gray (5Y 3/2); moist; 69% no dilatancy, low toughness fines; 31% fine sand.		7	100									
	22														
0	23		Lenses of iron oxide staining, fine grained sand at 22.5'.		8	67	2 3 3	6	7	0.3P	25	29	16	69	S08A_023_024S
	24														
	25														
	26		SILTY SAND (SM); loose; dark olive gray (5Y 3/2); wet; fine sand; trace mica.		9	100	2 2 4	6	7						S09B_025_026S, S09A_025_027S Switch to Rotary
	27		SILT (ML); olive gray (5Y 5/2); moist; low plasticity, low dry strength, low toughness fines; some iron oxide staning, trace mica.							4.5P					S10A_028_029P
-5	28		LEAN CLAY (CL); stiff; olive gray (5Y 4/2); moist; medium plasticity, medium dry strength, slow dilatancy, medium toughness fines.		10	100				2.0P					
	29		SANDY LEAN CLAY (CL); very stiff; dark grayish brown (10YR 4/2); medium dry strength, slow dilatancy, medium toughness fines; trace fine sand and mica.												
	30														S11A_030_032S
	31		SILT (ML); reddish brown (5YR 4/4); wet; fine to medium sand; with clay lenses.		11	100	6 9 5	14	17	2.5P	31	38	19		
	32														S12A_033_034P
-10	33		Some iron oxide staining at 32.5'. Sand and silt lenses at 33.0'.		12	71				2.5P	28			90	
	34		LEAN CLAY (CL); reddish brown (5YR 4/4); moist; 90% medium plasticity, medium dry strength, medium toughness fines; 10% sand.												
	35														S13A_035_037S
	36		CLAYEY SAND (SC); medium dense; dark yellowish brown (10YR 4/4); 72% fine to medium sand; 28% fines; poorly graded, trace clay.		13	100	6 7 9	16	19						
	37										25			28	S14A_037_038P
-15	38				14	64									
	39														
	40														S15A_040_042S
	41		Loose at 40.5'.		15	100	3 1 2	3	4	2.5P					
	42														S16A_043_044P
-20	43		SANDY LEAN CLAY (CL); reddish gray (5YR 5/2); low plasticity, medium dry strength, medium toughness fines; fine to medium sand.		16	100									
	44														
	45														

Final Report Version 9/30/2008

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GPS: Latitude 37.89359 Longitude -121.32796
Channel / River Name / Feature: San Joaquin River
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LOG OF BORING
WR0017_024B

Sheet 2 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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
	45		CLAYEY SAND (SC); dense; yellowish brown (10YR 5/4); 73% fine to medium sand; 27% fines.	☒	17	44	6 12 19	31	37		20			27	S17A_045_047S
-25	47 48 49			▮	18	81									S18A_048_049P
	50 51		FAT CLAY with Sand (CH); stiff to very stiff; yellow (10YR 8/6); low dry strength, no dilatancy, medium toughness fines; pockets of black organics and iron oxide stained fine sand.	☒	19	100	1 4 6	10	12	2.5P 3.5P	31	54	41		S19A_050_052S
-30	52 53 54		Stiff from 53.0' to 57.0'.	▮	20	100				1.8P 1.3P 4.2T					S20A_053_054P
	55 56		Dark yellowish brown, micaceous at 55.0'.	☒	21	100	6 9 12	21	25	1.3P					S21A_056_057S
-35	57 58 59		Interlayered fine to medium sand from 57.0' to 58.5' (1" to 4" in thickness).	▮	22	100				2.5P 4.0T					S22A_058_059P
	60 61		SILTY SAND (SM); dense; dark reddish brown (5YR 3/2); wet; rounded to subrounded gravel; 83% fine to coarse sand; 17% fines; micaceous.	☒	23	100	8 19 22	41	49		18			17	S23A_060_062S
-40	62 63 64		Increase in coarse sand at 64.0'.	▮	24	86									S24A_063_064P Driller's Note (DN): Hard drilling below 62.0'
	65 66		Grayish brown (10YR 5/2), very dense below 65.0'. Dark yellowish brown below 66.0'.	☒	25	44	17 30 32	62	74						S25A_065_066S
-45	67 68 69 70		3" poorly-graded sand lens, medium to coarse sand, dark yellowish orange (10YR 2/2) at 68.5'.	▮	26	100									S26A_066_067P

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Sheet 3 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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 71		86% sand; 14% fines; dark greenish gray (10Y 4/1), fine to medium sand below 70.0'.		27	83	9 24 22	46	55		28			14	S27A_073_074S
-50	72 73 74				28	95									S28A_073_074P
	75 76		Trace coarse sand at 75.0'.		29	89	18 25 24	49	59						S29A_075_077S
-55	77 78 79				30	71									S30A_078_079P
	80 81		Dense from 80.0' to 85.0'.		31	89	19 23 15	38	46						S31A_080_082S
-60	82 83 84				32	48									S32A_082_083P
	85 86				33	100	9 21 23	44	53						S33A_085_087S
-65	87 88 89		6" well-graded sand, fine to coarse sand, fine to coarse gravel at 87.5'. LEAN CLAY (CL); very stiff; dry to moist; high plasticity, high dry strength, no dilatancy, high toughness fines; micaceous. CLAYEY SAND (SC); medium dense to dense; very dark gray (10YR 3/1); 61% fine to medium sand; 39% fines.		34	100									S34A_088_089P
	90 91				35	100	9 11 14	25	30		16			39	S35A_090_092S
-70	92 93 94 95				36	81									S36A_093_094P

Final Report Version 9/30/2008

Borehole Location: Crest of Levee

Coordinates: North 2,148,895.80 East 6,322,760.53

Levee Station or Milepost: STA: 1191+43.18 Offset: 8.34 feet Left

GPS: Latitude 37.89359 Longitude -121.32796

Channel / River Name / Feature: San Joaquin River

County: San Joaquin

LOG OF BORING
WR0017_024B

Sheet 4 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

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				REMARKS
											Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	
	95		<u>SILT</u> (ML); very dense; very dark gray (10YR 3/1); dry to moist; low plasticity fines.	☒	37	100	12 21 27	48	58						S37A_095_097S
	96		<u>LEAN CLAY</u> (CL); dark gray (10YR 4/1); dry to moist; medium plasticity, medium dry strength, no to slow dilatancy, medium toughness fines.	■	38	100									S38B_097_098P, S38A_098_099P
-75	98		<u>Poorly Graded SAND with Silt</u> (SP-SM); dark grayish brown (10YR 4/2); wet; fine to medium sand.												
	100		<u>LEAN CLAY</u> (CL); dark gray (10YR 4/1); low plasticity, low dry strength, no dilatancy, low toughness fines; micaceous, white lineations.	☒	39	100	12 26 21	47	56						S39A_100_101S
	101.5		Borehole terminated at 101.5 feet. Backfilled with cement grout..												

Final Report Version 9/30/2008

Borehole Location: Crest of Levee
Coordinates: North 2,148,895.80 East 6,322,760.53
Levee Station or Milepost: STA: 1191+43.18 Offset: 8.34 feet Left
GPS: Latitude 37.89359 Longitude -121.32796
Channel / River Name / Feature: San Joaquin River
County: San Joaquin

LOG OF BORING
WR0017_024B

Sheet 5 of 5

Engineering Support Services
Urban Levee Geotechnical Evaluations Program

DATE STARTED 10/19/10	**DATE COMPLETED** 10/19/10	**GROUND ELEVATION** 22.36 ft	**ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 73.5 ft
DRILLING CONTRACTOR Pitcher		**DRILLER'S NAME** James Musich	**HELPER'S NAME** William Stewart	**TOTAL DEPTH OF FILL** 14.5 ft
DRILLING METHOD HSA and Mud Rotary		**DRILL RIG MAKE AND MODEL** CME-55, PD 56		**CONSULTANT COMPANY** URS Corporation
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 10" Auger, 4.875" Drag bit, 4.25 HQ bit		**DRILLING ROD TYPE AND DIAMETER** 3-1/2" HQ, 2-5/8" N, 10" HSA		**FIELD LOGGER** M. Palmer
☒ **VERTICAL** ☐ **INCLINED**		**CASING TYPE, DIAMETER, INSTALLATION DEPTH** 5.5 OD x 5" ID Steel to 15'		**FIELD LOG REVIEWER** M. Palmer
SAMPLER TYPE(S) SPT, 2.5" ID Punch Core, 3" Osterberg		**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** CME Autohammer, 140 lbs/30-inch		**HAMMER EFFICIENCY** 80%
BOREHOLE BACKFILL OR COMPLETION Cement-bentonite grout		**GROUNDWATER READING:**	**DURING DRILLING** Not noted	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Asphalt Concrete Road.												0-17.5' HSA with center plug
			AB Road Base.												
	1	▨	[LEVEE FILL] SANDY LEAN CLAY (CL); olive brown (2.5Y 4/3); moist; 70% low to medium plasticity, high dry strength, no dilatancy fines; 30% fine sand; micaceous.												
20	3			☒	S01A	17	1 2 3 [5]	7							S01A_003_004S
	4														4-5' HSA with center plug
	5			▮	S02A	87				24	34	8		UW	S02A_005_007T 3" Osterberg Piston sample 150 psi
	6		[LEVEE FILL] SILT with Sand (ML); black (10YR 2/1); moist; 75% high dry strength, no to slow dilatancy fines; 25% fine sand.												
15	8	▨	[LEVEE FILL] SANDY LEAN CLAY (CL); dark olive brown (2.5Y 3/3); 60% low plasticity, high dry strength, slow dilatancy fines; 40% fine to coarse sand; no reaction with HCl; orange and black mottling; micaceous.	☒	S03B S03A	44	1 3 2 [5]	7							S03B_007_008S S03A_008_009S
	9														9-10' HSA with center plug
	10			▮	S04A	83				16	NP	NP	63	UW	S04A_010_012T 3" Osterberg Piston sample 200 psi
10	12		[LEVEE FILL] SANDY SILT (ML); loose; olive brown (2.5Y 4/3); moist; 63% low dry strength, rapid dilatancy fines; 37% fine to coarse sand; weak reaction with HCl; micaceous, some laminations.	☒	S05A	50	2 2 2 [4]	5					63	HD	S05A_013_014S
	14														14-15' with center plug
	14.5 ←FILL		SANDY SILT (ML); loose; olive brown (2.5Y 4/3); moist; 51% low dry strength, rapid dilatancy fines; 49% fine to coarse sand; strong reaction with HCl; micaceous.												
	15			▮	S06A	100				14 18	 18	 1	 51	UW UW HD	S06A_015_018T 3" Osterberg Piston sample 100 psi After SPT, pull augers and set 5.5" x 5.0" steel casing to 15', then cleanout and advance with 4-7/8 drag bit to 20'.
5	17.5		At 17.5 feet 54% fines; 46% sand.	☒	S07A	67	2 2 3 [5]	7					54	HD	S07A_018_019S
	19			⧗											19' - 20' Mud Rotary drag bit
	20														

Final Report Version 2/22/2011

Borehole Location: Levee Crest **County:** San Joaquin	**LOG OF BORING**
Coordinates: Northing: 2,157,195.76 **Easting:** 6,329,451.55	**WR0404_041B**
Latitude: 37.91655 **Longitude:** -121.30500	**Sheet 1 of 4**
Levee Station or Milepost: 1175+01 **Levee Mile:**	
Levee Segment	**Engineering Support Services Urban Levee Geotechnical Evaluations Program**
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II	
Channel / River Name / Feature: French Camp Slough	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
0	20 21 22		Well-Graded SAND with Silt (SW-SM); loose; olive brown (2.5Y 4/3); wet; 92% fine to medium sand; 8% no plasticity fines; no reaction with HCl; micaceous.		S08A	0									3" Osterberg Piston sample 300 psi Sample fell out of tube into mud tank. Sand.
	23				S09A	50	2 2 2 [4]	5					8	HD	S09A_023_024S 22.5-73.5"101 geobarrel
	24 25 26				S10A	33									25' - 27' NR
-5	27 28		LEAN CLAY (CL); stiff; grayish brown (2.5Y 5/2); moist; 90% high dry strength, no dilatancy fines; 10% fine sand; variably strong reaction with HCl.		S11A	72	2 5 6 [11]	15	1.5P	25	39	20			S11A_027_028S
	29 30 31		Sand in cuttings indicate SILTY SAND (SM).		S12A	14									29' - 30' NR
-10	32 33		LEAN CLAY (CL); stiff; light olive brown (2.5Y 5/3); moist; 90% high dry strength, no dilatancy fines; 10% fine to medium sand; weak reaction with HCl; scattered orange and black mottling.		S13A	100	0 2 3 [5]	7	1.0P	26	39	18			S13A_032_033S
	34				S14A	100			1.0P						
	35 36				S15A	100			1.0P 1.0P						
-15	37 38		LEAN CLAY with Sand (CL); very stiff; light olive brown (2.5Y 5/3) grades to olive brown (2.5Y 4/3); moist; 80% high dry strength, no dilatancy fines; 20% fine to medium sand; no reaction with HCl; orange iron oxide mottling throughout; blocky texture.		S16A	94	6 8 10 [18]	24		23	40	19			S16A_037_038S
	39 40 41		FAT CLAY (CH); very stiff; olive brown (2.5Y 4/3); moist; 90% high plasticity, very high dry strength, no dilatancy fines; 10% fine to medium sand; black mottling throughout, micaceous.		S17A	95			2.25P 3.0P 2.75P						
-20	42 43		At 41.9 feet 1-inch thick black medium sand lens.		S18A	50	4 9 9 [18]	24	2.5P	29					S18A_042_043S
	44 45		At 44 feet grayish green (5G 4/2).		S19A	100									

Final Report Version 2/22/2011

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,157,195.76 **Easting:** 6,329,451.55
Latitude: 37.91655 **Longitude:** -121.30500
Levee Station or Milepost: 1175+01 **Levee Mile:**
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: French Camp Slough

LOG OF BORING
WR0404_041B

Sheet 2 of 4

Engineering Support Services Urban Levee Geotechnical Evaluations Program

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45 46		LEAN CLAY with Sand (CL); medium stiff; dark greenish gray (5G 4/1); moist; 80% high dry strength, no to slow dilatancy fines; 20% fine sand; weak reaction with HCl; trace brown organic fibers.		S19A	100									
-25	47 48		At 48' very stiff.		S20A	83	1 6 9 [15]	20	0.5P 3.5P	28					S20A_047_048S
	49 50 51				S21A	21			3.75P						49.75-52' NR Sample blocked off in shoe.
-30	52 53		At 52.5 feet up to 20% calcium carbonate precipitation throughout; strong reaction with HCl.		S22A	100	3 8 9 [17]	23		24	41	22			S22A_052_053S
	54 55 56		SANDY SILT (ML); dense; dark greenish gray (5G 4/1); moist; 55% low plasticity, high dry strength, slow to rapid dilatancy fines; 45% fine sand; no reaction with HCl; micaceous.		S23A	86									
-35	57 58				S24A	78	5 11 16 [27]	36							S24A_057_058S
	59 60 61		SILTY SAND (SM); very dense; dark greenish gray (5G 4/1); moist; 76% fine sand; 24% no plasticity fines; no reaction with HCl.		S25A	29									59.5-62' NR
-40	62 63				S26A	67	13 25 32 [57]	76					24		S26A_062_063S
	64 65 66				S27A	43									
-45	67 68		FAT CLAY (CH); very stiff; dark greenish gray (5G 4/1); moist; 90% medium to high plasticity, very high dry strength, no dilatancy fines; 10% fine sand; strong reaction with HCl; white calcium carbonate mottling throughout.		S28A	56	7 8 12 [20]	27							S28A_067_068S
	69 70				S29A	95			2.25P						

Final Report Version 2/22/2011

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,157,195.76 **Easting:** 6,329,451.55
Latitude: 37.91655 **Longitude:** -121.30500
Levee Station or Milepost: 1175+01 **Levee Mile:**
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: French Camp Slough

LOG OF BORING
WR0404_041B
Sheet 3 of 4

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DWR LEVEE UNIU SOIL LOG REV1: RD404.GPJ; DWR OFFICIAL LIBRARY 12222010.GLB; 2/21/11

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA					REMARKS
										Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	
	70 71	▨	SANDY LEAN CLAY (CL); very stiff; dark greenish gray (5G 4/1); moist; 60% medium plasticity, high dry strength, no dilatancy fines; 40% fine to coarse sand; strong reaction with HCl; scattered thin seams of Clayey Sand (SC).		S29A	95			2.25P 2.25P						
-50	72 73	▨		☒	S30A	67	8 19 27 [46]	61							S30A_072_073S
	74 75 76 77														
-55	78 79 80 81 82														
-60	83 84 85 86 87														
-65	88 89 90 91 92														
-70	93 94 95														

Bottom of boring 73.5'.
Backfilled by tremmie to bottom of boring with approximately 50 gallons grout mix consisting of 35 gallons of water, 6-47lbs sacks of portland cement and 15 lb bentonite to within 2 feet of surface, 1/2 sack Holeplug to within 1-1/2 feet of surface then levee cuttings and finished with AB.

Final Report Version 2/22/2011

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,157,195.76 **Easting:** 6,329,451.55
Latitude: 37.91655 **Longitude:** -121.30500
Levee Station or Milepost: 1175+01 **Levee Mile:**
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: French Camp Slough

LOG OF BORING
WR0404_041B
Sheet 4 of 4

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DATE STARTED 10/6/11 **DATE COMPLETED** 10/6/11	**GROUND ELEVATION** 19.5 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 51.5 ft
DRILLING CONTRACTOR Gregg Drilling & Testing, Inc.	**DRILLER'S NAME** Angel Salazar **HELPER'S NAME** Martin Soto	**TOTAL DEPTH OF FILL** 11 ft
DRILLING METHOD Hand Auger/HSA/Mud Rotary	**DRILL RIG MAKE AND MODEL** Mobile B-80 (D-21)	**CONSULTANT COMPANY** URS Corporation
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 6" Carbide tooth auger, 4-7/8" drag bit	**DRILLING ROD TYPE AND DIAMETER** 2-1/2" NWJ	**FIELD LOGGER** M. Palmer
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** 6-5/8" O.D. Steel to 10'	**FIELD LOG REVIEWER** R. Nixon
SAMPLER TYPE(S) Bag, Dames&Moore (2.5"x20"), Osterberg (3"x36"), SPT(1.375")	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** Marl, automatic, 140 lbs / 30-inch drop	**HAMMER EFFICIENCY** 85%
BOREHOLE BACKFILL OR COMPLETION Cement-bentonite grout	**GROUNDWATER READING: DURING DRILLING** Not encountered due to drilling method	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA					REMARKS
										Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	
	0 1		[LEVEE FILL] SANDY LEAN CLAY (CL); yellowish brown (10YR 5/6); moist; 55% high dry strength, slow dilatancy fines; 45% fine sand; no reaction with HCl.												Hand Auger to 6' HSA to 5'
	2 3 4				S01A					14	31	10	55		S01A_002_004B
15			[LEVEE FILL] LEAN CLAY with Sand (CL); very stiff; dark grayish brown (2.5Y 4/2); moist; 85% low plasticity, high dry strength, no to slow dilatancy fines; 15% fine to medium sand; no reaction with HCl; reddish-orange iron oxide staining throughout; micaceous.												
	5 6 7				S02A	72			3.0P	19	39	22		UW	S02A_005_008T Osterberg 400 psi
	8														Advance with 6" HSA.
	9				S03A	91			3.9P	19	39	15	70	UW	S03A_009_010T Dames & Moore 250 psi
10	10		[LEVEE FILL] LEAN CLAY with Sand (CL); very stiff; olive (5Y 5/3); moist; 70% high dry strength, no to slow dilatancy fines; 30% fine to medium sand.												Set casing to 10'. Clean out and advanced to with 4-7/8" drag bit, switched to Mud Rotary.
←FILL	11 12 13		FAT CLAY (CH); dark grayish brown (2.5Y 4/2); 90% high plasticity, very high dry strength, no dilatancy fines; 10% fine sand; weak reaction with HCl.		S04A	63				24 24	55	40		UW UW CCRS	S04A_011_014T Osterberg 500 psi
5	14 15 16		FAT CLAY with organics (CH); very dark gray (5Y 3/1); moist; 88% high dry strength, no dilatancy fines; 12% organic matter; carbonized organic matter (fine gravel size); slight organic odor; slight spongy feel.		S05A	89									S05A_015_016T Dames & Moore 350 psi
0	17 18 19 20		At 19 feet medium stiff to stiff.		S06A	67			1.0P	78 43 45	58 73	33 49		UW OC SG UW DS UW CCRS	S06A_017_020T Osterberg 350 psi

Draft 3 After All Lab Data Added 7/25/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,180,127.61 **Easting:** 6,319,568.23
Latitude: 37.97928 **Longitude:** -121.33997
Levee Station or Milepost: 6565+02 **Levee Mile:** 22.4
Levee Segment Reach L
Survey Method: GPS **Coord. System:** State Plane
Channel / River Name / Feature: Calaveras River

LOG OF BORING
WR1614_018B
Sheet 1 of 3

Levee Evaluations

DWR LEVEE UNU SOIL LOG REV1: SJAFCA-20091208.GPJ; DWR OFFICIAL LIBRARY 10092012.GLB; 2/26/13

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA					REMARKS
										Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	
	20 21 22 23		SILT with organics (ML); soft; very dark gray (5Y 3/1); moist; 95% slow dilatancy fines; 5% fine grained brown and black organics; slight organic odor; micaceous.		S07A	84			0.5P	35	43	16		UW	S07A_021_022T Dames & Moore 180 psi
	24		ELASTIC SILT with organics (MH); soft; very dark gray (5Y 3/1); moist; 90% fines; 10% black fibrous organics; slight organic odor; micaceous.		S08A	100				98 157	145	91		UW CD UW OC	S08A_023_026T Osterberg 320 psi
-5	25 26		ORGANIC ELASTIC SILT (OH); very stiff; very dark gray (10YR 3/1); moist; 70% fines; organic odor; fibrous; 30% organic material.						2.4P	170 190 188	300 278	178 174		UW UW DS UW CCRS	
	27 28 29		ELASTIC SILT with organics (MH); very dark gray (5Y 3/1); moist; 90% low plasticity, medium to high dry strength, rapid dilatancy fines; 10% fine grained organics; slight organic odor; trace shell fragments at bottom of sample.		S09A	100				163	140	65		UW	S09A_027_029T Dames & Moore 380 psi
-10	30 31 32		At 29 feet 89% low plasticity, medium dry strength, rapid dilatancy fines; 6% organic material; 5% fine to medium sand; strong reaction with HCl; shell fragments, spongy texture.		S10A	100			0.4P	132 160 145	125 127	41 56		UW OC SG UW CCRS UW DS	S10A_030_032T Osterberg 300 psi
	33 34		At 32.5 feet medium stiff; dark greenish gray (5GY 4/1); 95% low plasticity, medium to high dry strength, rapid dilatancy fines; 5% fine sand; no reaction with HCl; trace mica; scattered brown, woody fragments.		S11A	89			0.6P						S11A_033_035T Dames & Moore 500 psi
-15	35 36 37		LEAN to FAT CLAY with organics (CL/CH); dark greenish gray (5GY 4/1); moist; 5% organics. At 36.5 trace shells variably scattered shells have strong reaction with HCl.		S12A	100				65 94 27	94 29	60 14		UW OC UW CCRS UW CCRS	S12A_036_038T Osterberg 520 psi Lost 3" sample out of tube.
	38 39		Poorly Graded SAND with Silt (SP-SM); black (N 2.5/); wet; 90% fine to medium sand; 10% no plasticity fines; no reaction with HCl; trace brown woody fibrous fragments.		S13A	100									S13A_039_041T Dames & Moore 100 psi
-20	40 41 42		At 40.5 feet very loose.		S14A	100	2 1 1 [2]	3							S14A_041_042S
-25	43 44 45		ELASTIC SILT with Sand (MH); dark greenish gray (5GY 4/1); moist; 95% low plasticity, medium to high dry strength, rapid dilatancy fines; 5% fine to medium sand; no reaction with HCl; trace brown woody fibrous fragments.		S15A	100									S15A_043_046T Osterberg 500 psi

Draft 3 After All Lab Data Added 7/25/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,180,127.61 **Easting:** 6,319,568.23
Latitude: 37.97928 **Longitude:** -121.33997
Levee Station or Milepost: 6565+02 **Levee Mile:** 22.4
Levee Segment Reach L
Survey Method: GPS **Coord. System:** State Plane
Channel / River Name / Feature: Calaveras River

LOG OF BORING
WR1614_018B
Sheet 2 of 3

Levee Evaluations

DWR LEVEE UNU SOIL LOG REV1; SJAFCA-20091208.GPJ; DWR OFFICIAL LIBRARY 10092012.GLB; 2/26/13

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45			▮	S15A	100			0.5P	62	68	27	80	UW	
	46		At 45.5 feet soft.												
	47	▨	FAT CLAY (CH); dark greenish gray (5GY 4/1); moist; 87% fines; 13% sand.	▮	S16A	100			0.25P	60	56	26	87	UW	S16A_047_048T Dames & Moore 220 psi
	48	▨													
	49	▨	At 49 feet slight organic odor.	▮											S17A_049_052T Osterberg 400 psi
-30	50	▨		▮	S17A	100									
	51		Poorly Graded SAND (SP); very dark gray (N 3/); wet; 96% no plasticity fines; 4% fine to coarse sand; trace fine gravel, organics.	▮						21			4	UW	
	52		Total Depth Drilled 51.5 feet												
	53		Borehole backfilled with 80 gallons of cement bentonite grout consisting of 15 bags (47 lbs) of Type II-V Portland cement, 35 pounds of bentonite and approximately 60 gallons of water.												
	54														
-35	55														
	56														
	57														
	58														
	59														
-40	60														
	61														
	62														
	63														
	64														
-45	65														
	66														
	67														
	68														
	69														
-50	70														

Draft 3 After All Lab Data Added 7/25/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,180,127.61 **Easting:** 6,319,568.23
Latitude: 37.97928 **Longitude:** -121.33997
Levee Station or Milepost: 6565+02 **Levee Mile:** 22.4
Levee Segment Reach L
Survey Method: GPS **Coord. System:** State Plane
Channel / River Name / Feature: Calaveras River

LOG OF BORING
WR1614_018B
Sheet 3 of 3

Levee Evaluations

DWR LEVEE UNIJ SOIL LOG REV1: SJAFCA-20091208.GPJ DWR OFFICIAL LIBRARY 10092012.GLB 2/26/13

DATE STARTED 11/3/11
DATE COMPLETED 11/3/11
GROUND ELEVATION 15.4 ft
ELEVATION DATUM NAVD 88
TOTAL DEPTH OF BORING 31.0 ft
DRILLING CONTRACTOR Gregg Drilling & Testing, Inc.
DRILLER'S NAME Luis Torres
HELPER'S NAME Rob Ramirez
TOTAL DEPTH OF FILL 0 ft
DRILLING METHOD Hand Auger/Mud Rotary
DRILL RIG MAKE AND MODEL Mobile B-53 (D-26)
CONSULTANT COMPANY URS Corporation
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 4-5/8" drag bit
DRILLING ROD TYPE AND DIAMETER 2-1/2" NWJ, 4" HWJ
FIELD LOGGER P. Crispell
☒ **VERTICAL** ☐ **INCLINED**
CASING TYPE, DIAMETER, INSTALLATION DEPTH 8" LCS to 12'
FIELD LOG REVIEWER M. Turner
SAMPLER TYPE(S) PCore(2.5"), SPT(1.375")
HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP Marl, automatic, 140 lbs / 30-inch drop
HAMMER EFFICIENCY 77%
BOREHOLE BACKFILL OR COMPLETION Cement-bentonite grout
GROUNDWATER READING: **DURING DRILLING** **AFTER DRILLING (DATE-TIME)** Not encountered due to drilling method

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
15	0	⁙	<u>SILTY SAND</u> (SM); brown (7.5YR 5/4); moist; 60% fine sand; 40% low plasticity, low dry strength, slow dilatancy, low toughness fines.												Hand auger to 5'
	1														
	2														
	3														
	4														
10	5		At 5 feet very dense.	☒	S01A	33	14 21 22 [43]	55		24	46	8	40		S01A_005_007S
	6		At 6.5 feet hard pan.												
	7			▮	S02A	93									
	8														
	9														
5	10		Gradational change.												
		⁚	<u>SILT with Sand</u> (ML); loose; brown (7.5YR 4/3); wet; 81% low dry strength, slow dilatancy, low toughness fines; 19% fine sand; indurated.												
	11			☒	S03A	72	2 3 5 [8]	10		43	46	11	81		S03A_011_013S
	12														
	13	▨	<u>LEAN CLAY with Sand</u> (CL); brown (7.5YR 4/3); moist; 85% fines; 15% fine sand.	▮	S04A	64			0.9P	42	41	20			S04A_014_015P
	14														
0	15														
	16	▥	<u>ELASTIC SILT</u> (MH); medium stiff; dark brown (10YR 3/3); moist; 100% high dry strength, no dilatancy, low toughness fines.	☒	S05A	78	0 3 5 [8]	10		45	50	13			S05A_016_018S
	17														
	18	▨	<u>FAT CLAY</u> (CH); dark brown (10YR 3/3); moist; 100% high plasticity, very high dry strength, no dilatancy, high toughness fines.	▮	S06A	57									
	19														
	20														

Draft 3 After All Lab Data Added 12/31/2012

Borehole Location: Landside Levee Toe **County:** San Joaquin
Coordinates: Northing: 2,182,117.89 **Easting:** 6,328,852.24
Latitude: 37.98497 **Longitude:** -121.30782
Levee Station or Milepost: 6669+40 **Levee Mile:** 20.4
Levee Segment Reach O
Survey Method: GPS **Coord. System:** State Plane
Channel / River Name / Feature: Calaveras River

LOG OF BORING
WR1614_019B

Sheet 1 of 2

Levee Evaluations

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA					REMARKS
										Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	
-5	20	▨		▮	S06A	57									
	21	▨	At 21 feet very dark grayish brown (10YR 3/2).	☒	S07B S07A	89	6 6 8 [14]	18							S07B_021_022S S07A_022_023S
	22		SANDY SILT (ML); medium dense; dark grayish brown (10YR 4/2); moist; 60% low plasticity fines; 40% fine sand.												
	23		At 23 feet 75% fines; 25% sand.	▮											S08B_023_024P
	24	▨	LEAN CLAY with Sand (CL); very dark grayish brown (10YR 3/2); moist; 78% medium dry strength, no dilatancy, medium toughness fines; 22% fine sand.	▮	S08A	76									S08A_024_025P
-10	25	▨	At 25.5 feet medium stiff.						0.7P	30	34	14	78		
	26		SANDY SILT (ML); very dark grayish brown (10YR 3/2); moist; 53% fines; 47% sand.	☒	S09A	100	0 0 0 [0]	0		38	35	6	53		S09A_026_028S
	27														
	28			▮											
	29		At 29 feet 54% fines; 46% sand.		S10A	57									
	30								0.6P	29	37	12	54		S10A_029_030P
-15	31														

Total Depth Drilled 31 feet

Borehole backfilled with 50 gallons of cement bentonite grout consisting of 8 bags (47 lbs) of Type II-V Portland cement, 20 pounds of bentonite and approximately 40 gallons of water.

Elevation, feet	Depth, feet
	32
	33
	34
-20	35
	36
	37
	38
	39
-25	40
	41
	42
	43
	44
	45

Draft 3 After All Lab Data Added 12/31/2012

Borehole Location: Landside Levee Toe **County:** San Joaquin
Coordinates: Northing: 2,182,117.89 **Easting:** 6,328,852.24
Latitude: 37.98497 **Longitude:** -121.30782
Levee Station or Milepost: 6669+40 **Levee Mile:** 20.4
Levee Segment Reach O
Survey Method: GPS **Coord. System:** State Plane
Channel / River Name / Feature: Calaveras River

LOG OF BORING
WR1614_019B
Sheet 2 of 2

Levee Evaluations

DWR LEVEE UNU SOIL LOG REV1: SJAFCA-20091208.GPJ; DWR OFFICIAL LIBRARY 10092012.GLB; 2/14/13

DATE STARTED 8/20/10	**DATE COMPLETED** 8/20/10	**GROUND ELEVATION** 14.00 ft	**ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 40.0 ft
DRILLING CONTRACTOR Neil O. Anderson		**DRILLER'S NAME** Mike Young	**HELPER'S NAME** Sean McNeil	**TOTAL DEPTH OF FILL** 9.5 ft
DRILLING METHOD HSA/Rotary Wash		**DRILL RIG MAKE AND MODEL** CME 75		**CONSULTANT COMPANY** Kleinfelder
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 10" HSA, 4-7/8" Drag Bit		**DRILLING ROD TYPE AND DIAMETER** NWJ 2-5/8"		**FIELD LOGGER** G. Lenehan
☒ **VERTICAL** ☐ **INCLINED**		**CASING TYPE, DIAMETER, INSTALLATION DEPTH** HSA 10" OD, 15 ft		**FIELD LOG REVIEWER** G. Lenehan
SAMPLER TYPE(S) SPT (1.375"), PC (2.5")		**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** CME Auto Hammer 140 lbs/30-inch drop		**HAMMER EFFICIENCY** 79%
BOREHOLE BACKFILL OR COMPLETION Grout		**GROUNDWATER READING: DURING DRILLING** Not Measured Due to Drilling Method		**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		SANDY SILT (ML); very stiff; yellowish brown (10YR 5/4); dry; 55% low dry strength, slow dilatancy, low toughness fines; 45% fine to medium sand; strong reaction with HCl; [Levee Fill]. At 1.0 foot, 1 inch lens of silty gravel (GM).		S01A	75	9 10 11 [21]	28	2.25P		39	13			S01A_000_002S S01A_000_002S Hollow-Stem Auger to 22 feet
10	2		GRAVELLY LEAN CLAY with Sand (CL); brown (10YR 4/3); moist; 60% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 20% fine, subrounded gravel; 20% fine to medium sand; strong reaction with HCl; [Levee Fill].		S02A	44									S02A_002_005P S02A_002_005P
	5		SANDY LEAN CLAY (CL); very stiff; very dark grayish brown (10YR 3/2); 70% high dry strength, no dilatancy, medium toughness fines; 30% fine sand; [Levee Fill].		S03A	75	1 2 2 [4]	5	2.0P	16	37	13			S03A_005_007S S03A_005_007S
	6		SILTY SAND (SM); dark yellowish brown (10YR 4/4); moist; 76% fine to medium sand; 24% fines; [Levee Fill].												
5	7				S04A	39			0.75P				24	PA	S04A_007_010P S04A_007_010P
←FILL	9.5		LEAN CLAY (CL); medium stiff; very dark grayish brown (10YR 3/2); moist; 90% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 10% fine sand; with organics.												
	10				S05A	67								SG	S05A_010_012T S05A_010_012T SG = 2.80
	12		At 12.0 feet, 5 inch lens of sandy lean clay (CL). SANDY SILT (ML); very soft; very dark grayish brown (10YR 3/2); moist; 70% low dry strength, slow dilatancy, low toughness fines; 30% fine sand.		S06A	100			0P	37	40	14		OC	S06A_012_015P S06A_012_015P OC = 4.6%
0	14		SANDY SILT (ML); dark yellowish brown (10YR 4/6); moist; 70% low plasticity, low dry strength, slow dilatancy, low toughness fines; 30% fine sand.												
	15		ORGANIC SILT with Sand (OL); soft; black (N 2.5/); moist; 85% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; 15% fine sand.		S07A	100	0 0 0 [0]	0	0.25P	41 62				OC	S07A_015_017S S07A_015_017S OC = 14.6%
	16.5		LEAN CLAY with Sand (CL); medium stiff; black (10YR 2/1); moist; 80% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 20% fine sand.												
	17				S08A	100			0.5P					OC	S08A_017_020P S08A_017_020P OC = 12.2%
	18		SILT (ML); black (N 2.5/); moist; 90% no plasticity, low dry strength, slow to rapid dilatancy, low toughness fines; 10% fine sand; with organics.						0.5P						
-5	19		ORGANIC SILT with Sand (OH); medium stiff; black (N 2.5/); moist; 80% medium dry strength, slow dilatancy,						0.5P	71	60	21			
	20														

Draft 3 After All Lab Data Added 5/16/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,178,670.55 **Easting:** 6,310,266.10
Latitude: 37.97505 **Longitude:** -121.37220
Levee Station or Milepost: 117+51 **Levee Mile:**
Levee Segment Brookside
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: San Joaquin River

LOG OF BORING

WR2074_003M

Sheet 1 of 2

Engineering Support Services Urban Levee Geotechnical Evaluations Program

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20 21 22		medium toughness fines; 20% fine sand.		S09A	100								SG	S09A_020_022T S09A_020_022T SG = 2.62
-10	23 24 25		At 22.0 feet, 6 inch lens of sandy lean clay (CL). SANDY ORGANIC SILT (OH); medium stiff; black (7.5YR 2.5/1); moist; 70% medium dry strength, slow dilatancy, medium toughness fines; 30% fine sand.		S10A	100			0.5P 0.5P	145	65	7		OC	S10A_022_025P Switch to Rotary Wash S10A_022_025P OC = 23.7%
	26 27		LEAN CLAY with Sand (CL); very soft; very dark greenish gray (10BG 3/1); wet; 80% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 20% fine sand; with organics.		S11A	100	0 0 0 [0]	0	0P	89					S11A_025_027S S11A_025_027S
-15	28 29 30		LEAN CLAY (CL); stiff; very dark greenish gray (10BG 3/1); wet; 93% high dry strength, no dilatancy, medium toughness fines; 7% fine sand.		S12A	44			1.25P		44	20	93		S12A_027_030P S12A_027_030P
	31 32		SILTY SAND (SM); loose; very dark greenish gray (10BG 3/1); wet; 75% fine to medium sand; 25% fines.		S13A	100	1 3 3 [6]	8		32					S13A_030_032S S13A_030_032S
-20	33 34 35		SILT with Sand (ML); very dark greenish gray (10BG 3/1); wet; 74% low plasticity, low dry strength, slow dilatancy, low toughness fines; 26% fine sand. At 33.5 feet, 6 inch lens of poorly graded sand with silt (SP-SM).		S14A	89							74		S14A_032_035P S14A_032_035P
	36 37		Poorly Graded SAND with Silt (SP-SM); medium dense; bluish black (5B 2.5/1); wet; 90% fine to medium sand; 10% fines.		S15A	100	2 4 4 [8]	11							S15A_035_037S Vibrating wire piezometer installed at 35 feet S15A_035_037S
-25	38 39 40		CLAYEY SAND (SC); greenish black (5GY 2.5/1); wet; 69% fine to medium sand; 31% fines. SILTY SAND (SM); very dark greenish gray (10BG 3/1); wet; 75% fine to medium sand; 25% fines. At 38.5 feet, 4 inch lens of poorly graded sand with silt (SP-SM).		S16A	86					28	9	31		S16A_037_040P S16A_037_040P
-30	41 42 43 44 45		Total depth drilled 40 feet. Boring backfilled with neat cement grout: 2 bags (94 lb.) Portland Cement 20 lbs. of bentonite 50 gallons of water												

Draft 3 After All Lab Data Added 5/16/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,178,670.55 **Easting:** 6,310,266.10
Latitude: 37.97505 **Longitude:** -121.37220
Levee Station or Milepost: 117+51 **Levee Mile:**
Levee Segment Brookside
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: San Joaquin River

LOG OF BORING
WR2074_003M
Sheet 2 of 2

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DATE STARTED 10/14/11 **DATE COMPLETED** 10/14/11	**GROUND ELEVATION** 14.60 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 51.5 ft
DRILLING CONTRACTOR Pitcher Drilling Inc.	**DRILLER'S NAME** James Musich **HELPER'S NAME** Malakai Fakalolo	**TOTAL DEPTH OF FILL** 7.5 ft
DRILLING METHOD HSA/Rotary Wash	**DRILL RIG MAKE AND MODEL** CME 55	**CONSULTANT COMPANY** Kleinfelder
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 8" HSA, 3-7/8" Drag Bit	**DRILLING ROD TYPE AND DIAMETER** NWJ 2-5/8"	**FIELD LOGGER** M. Luna
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** HSA, 10" OD, 15 ft	**FIELD LOG REVIEWER** M. Briseno
SAMPLER TYPE(S) StdCal(2.5"), SPT (1.375"), DM (2.5")	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** CME Auto Hammer 140 lbs/30-inch drop	**HAMMER EFFICIENCY** 77%
BOREHOLE BACKFILL OR COMPLETION Grout	**GROUNDWATER READING: DURING DRILLING** Not Measured Due to Drilling Method	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0 1		LEAN CLAY (CL); reddish gray (10R 5/1); moist; 100% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; [Levee fill].	NSD											Hand Auger to 5 feet
	2 3				S01A										S01A_002_004B
10	4			NSD											
	5 6		FAT CLAY (CH); very stiff; dark brown (10YR 3/3); moist; 85% high dry strength, no dilatancy, high toughness fines; 15% fine to coarse, subangular sand; [Levee fill].		S02A	61			2.5P	38 36	71	52		UW UW	S02A_005_007T Switch to Hollow-Stem Auger D&M pushed with 250 psi
←FILL	7			NSD											
	8		SILT (ML); dark brown (10YR 3/3); moist; 100% low plasticity, low dry strength, slow to rapid dilatancy, low toughness fines.		S03A	100			1.5P 0.75P	24				UW	S03A_007_009T D&M pushed with 300 psi
5	9		Below 9.0 feet, very dark grayish brown (2.5Y 3/2); 4 inch lens of poorly graded sand (SP); trace of organics (<5%).	NSD											
	10 11		LEAN CLAY (CL); soft; very dark gray (10YR 3/1); moist; 100% medium dry strength, no dilatancy, medium toughness fines. Below 11.25 feet, dark grayish brown (10YR 4/2);.		S04A	97			0.75P 0.25P	35 49	 49	 25		UW UW	S04A_010_012T D&M pushed with 250 psi Switched to mud rotary
	12			NSD											
	13		Below 12.5 feet, medium stiff.		S05A	97			0.50P 0.60P	37 39 39	 43 42	 20 20		UW UW UW	S05A_012_014T D&M pushed with 200 psi
0	14			NSD											
	15 16		FAT CLAY (CH); medium stiff; greenish black (5BG 2.5/1); moist; 95% high dry strength, no dilatancy, high toughness fines; 5% fine sand.		S06A	100			0.75P 0.75P	49 40 46	 51 54	 25 31		UW UW UW	S06A_015_017T Switch to Rotary Wash D&M pushed with 275 psi
	17		FAT CLAY (CH); stiff; black (10YR 2/1); moist; 100% high dry strength, no dilatancy, high toughness fines; with organics.	NSD											
	18		At 18.4 feet, lense of ELASTIC SILT(MH).		S07A	100			1.25P 0.75P	68 66 69 65 72	85 97 88 92	58 59 49 55		UW UW UW UW UW	S07A_017_019T D&M pushed with 300 psi
	19		Below 19.0 feet, medium stiff.	NSD											
-5	20				S08A	100			0.5P						S08A_020_022T

Draft 3 After All Lab Data Added 5/16/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,178,721.48 **Easting:** 6,310,263.88
Latitude: 37.97518 **Longitude:** -121.37221
Levee Station or Milepost: 118+02 **Levee Mile:**
Levee Segment Brookside
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Tenmile Slough

LOG OF BORING
WR2074_009B

Sheet 1 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20 21				S08A	100			0.75P	108 75	102	63		UW UW	D&M pushed with 200 psi
	22			NSD											
	23 24		ORGANIC ELASTIC SILT (OH); stiff; black (10YR 2/1); moist; 100% medium dry strength, slow dilatancy, medium toughness fines.		S09A	100			0.5P 1.0P	108 81	96	52		UW OC	S09A_022_024T D&M pushed with 300 psi OC = 8.7%
-10			PEAT (PT); black (10YR 2/1); wet.	NSD											
	25 26				S10A	100			1.0P 0.75P	217 102 93	97 84	56 45		UW UW UW	S10A_025_027T D&M pushed with 250 psi
	27		ORGANIC ELASTIC SILT (OH); medium stiff; black (10YR 2/1); moist; 100% medium dry strength, slow dilatancy, medium toughness fines.	NSD											
	28 29		LEAN CLAY (CL); medium stiff; dark greenish gray (10GY 4/1); 100% medium dry strength, no dilatancy fines.		S11A	100			0.75P 1.75P	38 34 30	48 49	31 31		UW UW UW	S11A_027_029T D&M pushed with 300 psi
-15			Below 29.0 feet, stiff.	NSD											
	30 31		Below 30.0 feet, medium stiff.		S12A	100			0.75P 3.5P	27	27	8		UW	S12A_030_032T D&M pushed with 300 psi
	32		SANDY SILT (ML); dark greenish gray (10GY 4/1); 70% low plasticity, low dry strength, slow to rapid dilatancy, low to medium toughness fines; 30% fine sand.	NSD											
	33 34		SILTY SAND (SM); dark greenish gray (10GY 4/1); 81% fine sand; 19% fines.		S13B S13A	72	3 4 5 [9]			29 30			19 19	UW HD PA UW HD PA	S13B_033_034C S13A_034-034C
-20				NSD											
	35 36		35.0 to 36.5 feet, medium dense.		S14A	56	2 4 6 [10]	13							S14A_035_037S
	37			NSD											
	38 39		Poorly Graded SAND (SP); greenish gray (10GY 5/1); wet; 96% fine to medium sand; 4% fines.		S15B S15A	89	6 8 7 [15]			23			4	UW PA	S15B_038_039C S15A_039_039C
-25				NSD											
	40 41		40.0 to 41.5 feet, medium dense.		S16A	67	1 4 7 [11]	14							S16A_040_042S
	42			NSD											
	43 44		Poorly Graded SAND with Silt (SP-SM); greenish gray (10GY 5/1); moist; 90% sand; 10% fines. At 43.5 feet, 6 inch lens of LEAN CLAY (CL).		S17B S17A		2 5 6 [11]			34			10	UW HD PA	S17B_043_044C S17A_044_044C
-30	45			NSD											

Draft 3 After All Lab Data Added 5/16/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: **Northing:** 2,178,721.48 **Easting:** 6,310,263.88
Latitude: 37.97518 **Longitude:** -121.37221
Levee Station or Milepost: 118+02 **Levee Mile:**
Levee Segment Brookside
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Tenmile Slough

LOG OF BORING
WR2074_009B
Sheet 2 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA					REMARKS
										Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	
	45 46		Below 45.0 feet, loose.	╳	S18A	61	3 4 2 [6]	8							S18A_045_047S
	47		SANDY LEAN CLAY (CL); very stiff; dark greenish gray (10GY 4/1); 70% medium dry strength, no dilatancy, medium toughness fines; 30% fine sand.	NSD											
	48			▌	S19A	97			3.0P 4.5P	21	40	21		UW	S19A_047_049T D&M pushed with 300 psi
-35	49		Below 49.0 feet, hard.	NSD											
	50 51		LEAN CLAY (CL); hard; dark greenish gray (10GY 4/1); 100% medium plasticity, medium dry strength, no dilatancy, medium toughness fines.	▌	S20A	64			4.5P						S20A_050_052T D&M pushed with 300 psi
	52		Total depth drilled 51.5 feet. Boring backfilled with neat cement grout: 8 bags (47 lb.) Portland Cement 32 gallons of water												
	53														
-40	54														
	55														
	56														
	57														
	58														
-45	59														
	60														
	61														
	62														
	63														
-50	64														
	65														
	66														
	67														
	68														
-55	69														
	70														

Draft 3 After All Lab Data Added 5/16/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,178,721.48 **Easting:** 6,310,263.88
Latitude: 37.97518 **Longitude:** -121.37221
Levee Station or Milepost: 118+02 **Levee Mile:**
Levee Segment Brookside
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Tenmile Slough

LOG OF BORING
WR2074_009B
Sheet 3 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DATE STARTED 8/16/10	**DATE COMPLETED** 8/17/10	**GROUND ELEVATION** 15.18 ft	**ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 50.0 ft
DRILLING CONTRACTOR Neil O. Anderson		**DRILLER'S NAME** Mike Young	**HELPER'S NAME** Sean McNeil	**TOTAL DEPTH OF FILL** 13.5 ft
DRILLING METHOD HSA/Rotary Wash		**DRILL RIG MAKE AND MODEL** CME 75		**CONSULTANT COMPANY** Kleinfelder
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 10" HSA, 4-7/8" Drag Bit		**DRILLING ROD TYPE AND DIAMETER** NWJ 2-5/8"		**FIELD LOGGER** G. Lenehan
☒ **VERTICAL**	☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** HSA 10" OD		**FIELD LOG REVIEWER** G. Lenehan
SAMPLER TYPE(S) SPT (1.375"), PC (2.5")		**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** CME Auto Hammer 140 lbs/30-inch drop		**HAMMER EFFICIENCY** 79%
BOREHOLE BACKFILL OR COMPLETION Grout		**GROUNDWATER READING:**	**DURING DRILLING** Not Measured Due to Drilling Method	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
15	0–2		SAND AND GRAVEL at surface [Levee Fill]. LEAN CLAY with Sand (CL); very stiff; very dark gray (7.5YR 3/1); moist; 75% medium plasticity, high dry strength, no dilatancy, medium toughness fines; 25% fine sand; weak reaction with HCl; [Levee Fill].		S01A	100	6 7 7 [14]	18	2.75P						S01A_000_002S Hollow-Stem Auger to 15 feet
	2–5		Below 2.0 feet, black (5YR 2.5/1. FAT CLAY (CH); hard; very dark grayish brown (10YR 3/2); moist; 87% high dry strength, no dilatancy, high toughness fines; 13% fine sand; [Levee Fill].		S02A	100			4.5P		52	25	87		S02A_002_005P
10	5–7		Below 5.0 feet, very stiff; black (2.5Y 2.5/1).		S03A	100	3 5 8 [13]	17	2.25P	18					S03A_005_007S
	7–10		LEAN CLAY (CL); hard; very dark greenish gray (5GY 3/1); moist; 90% medium dry strength, no dilatancy, medium toughness fines; 10% fine sand; [Levee Fill]. At 9.5 feet, 6 inch lens of clayey sand (SC).		S04A	100					30	16			S04A_007_010P
5	10–12		Below 10.5 feet, very dark greenish gray (10Y 3/1).		S05A	100	3 5 6 [11]	14	4.5P	16					S05A_010_012S
←FILL	12–15		Below 12.0 feet, very stiff. LEAN CLAY with Sand (CL); very stiff; dark greenish gray (10Y 4/1); moist; 75% high dry strength, no dilatancy, medium toughness fines; 25% fine sand.		S06A	100			3.5P 3.5P						S06A_012_015P
0	15–17		Below 16.0 feet, black (N 1.5/).		S07A	100	3 6 9 [15]	20	3.75P	21	32	13			S07A_015_017S Switch to Rotary Wash
	17–20		LEAN CLAY with Sand soft; dark greenish gray (10Y 4/1); moist; 75% high dry strength, no dilatancy, medium toughness fines; 25% fine sand; with organics. At 18.0 feet, wet. Below 19.5 feet, very stiff.		S08A	53			0.5P 3.5P	30	37	16		OC	S08A_017_020P OC = 7.2%

Draft 3 After All Lab Data Added 5/16/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: **Northing:** 2,179,929.44 **Easting:** 6,311,172.33
Latitude: 37.97853 **Longitude:** -121.36909
Levee Station or Milepost: 133+82 **Levee Mile:**
Levee Segment Brookside
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Tenmile Slough

LOG OF BORING
WR2074_007B

Sheet 1 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
-5	20				S09A	67								SG	S09A_020_022T SG = 2.55
	22		ELASTIC SILT (MH); medium stiff; greenish black (10Y 2.5/1); wet; 100% low dry strength, no dilatancy, low toughness fines; with organics.		S10A	69				82	77	31		OC	S10A_022_025P OC = 13.4%
	24		Below 24.0 feet, moist.						0.5P						
-10	25		CLAYEY SAND (SC); medium dense; dark bluish gray (5B 4/1); moist; 70% fine to medium sand; 30% fines.		S11A	100	2 3 5 [8]	11	1.5P	28				HD	S11A_025_027S
	27		SILT with Sand (ML); dark greenish gray (5BG 4/1); moist; 78% low dry strength, slow dilatancy, low toughness fines; 22% fine sand.		S12A	72			2.0P		32	7	78		S12A_027_030P
-15	30				S13A	100	7 10 13 [23]	30		25					S13A_030_032S
	31		SILTY SAND (SM); medium dense; very dark greenish gray (10BG 3/1); moist; 51% fine sand; 49% fines.												
	32		Below 32.0 feet, very dark greenish gray (5BG 3/1).		S14A	83							49	PA	S14A_032_035P
-20	35				S15A	88	2 3 5 [8]	11		25	29	12			S15A_035_037S
	36		CLAYEY SAND (SC); medium dense; very dark greenish gray (5BG 3/1); moist; 80% fine sand; 20% fines.												
	37				S16A	89							53		S16A_037_040P
	38		SANDY SILT (ML); very dark greenish gray (5BG 3/1); moist; 53% low plasticity, low to medium dry strength, no to slow dilatancy, low toughness fines; 47% fine sand.												
-25	40		40.0 to 41.5 feet, medium dense.		S17A	92	5 8 9 [17]	22		29					S17A_040_042S
	42		Below 42.0 feet, 67% fines; 33% sand.		S18A	89							67		S18A_042_045P
	45														

Draft 3 After All Lab Data Added 5/16/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,179,929.44 **Easting:** 6,311,172.33
Latitude: 37.97853 **Longitude:** -121.36909
Levee Station or Milepost: 133+82 **Levee Mile:**
Levee Segment Brookside
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Tenmile Slough

LOG OF BORING
WR2074_007B
Sheet 2 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
-30	45 46 47		Below 45.0 feet, very loose; very dark greenish gray (5BG 3/1).		S19A	100	1 1 2 [3]	4		33					S19A_045_047S
	47 48 49 50		SILTY SAND (SM); greenish black (5GY 2.5/1); wet; 79% fine to medium sand; 21% fines.		S20A	89							21	PA	S20A_047_050P
-35	50 51 52 53 54														
-40	55 56 57 58 59														
-45	60 61 62 63 64														
-50	65 66 67 68 69 70														

Total depth drilled 50 feet.
Boring backfilled with neat cement grout:
7 bags (47 lb.) Portland Cement
50 gallons of water

Draft 3 After All Lab Data Added 5/16/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,179,929.44 **Easting:** 6,311,172.33
Latitude: 37.97853 **Longitude:** -121.36909
Levee Station or Milepost: 133+82 **Levee Mile:**
Levee Segment Brookside
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Tenmile Slough

LOG OF BORING

WR2074_007B

Sheet 3 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DWR LEVEE UNU SOIL LOG REV1; BROOKSIDE BORINGS.GPJ; DWR OFFICIAL LIBRARY 02232012.GLB; 6/5/12

DATE STARTED 2/6/09	**DATE COMPLETED** 2/6/09	**GROUND ELEVATION** 3.27 ft	**ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 32.0 ft
DRILLING CONTRACTOR Neil O Anderson		**DRILLER'S NAME** James Young	**HELPER'S NAME** Sean McNeil	**TOTAL DEPTH OF FILL** 8 ft
DRILLING METHOD HSA/Rotary Wash		**DRILL RIG MAKE AND MODEL** CME 75		**CONSULTANT COMPANY** Kleinfelder
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 10" HSA, 5" Punch Core		**DRILLING ROD TYPE AND DIAMETER** NWJ 2-5/8 OD; PC 3" ID, 3-1/2 OD		**FIELD LOGGER** M. Shubert
☒ **VERTICAL** ☐ **INCLINED**		**CASING TYPE, DIAMETER, INSTALLATION DEPTH** HSA: 10" O.D./6" I.D. Case to 5'		**FIELD LOG REVIEWER** A. Killinger
SAMPLER TYPE(S) SPT 2" O.D./1-3/8" I.D., 2-1/2" Punch Core		**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** CME Auto Hammer, 140 lbs / 30-inch drop		**HAMMER EFFICIENCY** 84%
BOREHOLE BACKFILL OR COMPLETION Grout		**GROUNDWATER READING:**	**DURING DRILLING** 7 ft	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	CLASSIFICATION OF MATERIALS (Description)	Sample Number	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS AND PIEZOMETER INSTALLATION NOTES
	0	CLAYEY SAND (SC); dark brown (7.5YR 3/2); moist; 40% fines; 60% fine sand; [Fill].										S01A_000_005P
	1											
	2	Poorly Graded GRAVEL with Clay and Sand (GP-GC); brown (10YR 4/3); moist; 10% fines; 60% fine, subrounded gravel; 30% fine to coarse, angular to subangular sand; strong reaction with HCl; [Fill].	S01A									
0	3	FAT CLAY with Sand (CH); very stiff; black (5YR 2.5/1); moist; 84% high dry strength, no dilatancy, high toughness fines; 16% fine sand; [Fill].										
	4					3.5P	17	57	39	84	HD	
	5	LEAN CLAY with Sand (CL); yellowish red (5YR 5/6); moist; 80% medium dry strength, no dilatancy, medium toughness fines; 20% fine sand; [Fill].		5 11								S02A_005_007S Switched to mud rotary OC = 2.6%
	6		S02A	15 [26]	36		19	38	21		OC	
FILL	7 ▽											S03A_007_010P
-5	8	CLAYEY SAND (SC); yellowish red (5YR 5/6); moist; 34% fines; 66% fine to medium sand.	S03A							34	PA	
	9											
	10			6 9		3.0P						S04A_010_012S
	11	LEAN CLAY (CL); very stiff; grayish green (5G 5/2); moist; 85% medium dry strength, slow dilatancy, medium toughness fines; 15% fine sand.	S04A	10 [19]	27	4.5P	23	37	20			
	12											S05A_012_015P
-10	13		S05A					38	19			
	14	SILTY SAND (SM); medium dense; reddish brown (5YR 5/4); wet; 73-84% fine sand; 16-27% fines.										
	15			7 8								S06A_015_017S
	16		S06A	10 [18]	25					16	PA	
	17											S07A_017_020P SG = 2.74
-15	18		S07A							24	PA SG	
	19											
	20											

Final Report Version 10/29/2009

Borehole Location: Levee Toe (Landside) **County:** San Joaquin
Coordinates: Northing: 2,192,612.86 **Easting:** 6,312,861.86
Latitude: 38.01330 **Longitude:** -121.36358
Levee Station or Milepost: 43+00 **Levee Mile:**
Levee Segment Lincoln Village
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Fivemile Slough

LOG OF BORING
WR1608_002M

Sheet 1 of 2

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DWR LEVEE UAU SOIL + PIEZ LOG REV1; LINCOLN VILLAGE BORINGS.GPJ; DWR OFFICIAL LIBRARY 02232012.GLB; 6/26/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA					Piezometer Installation Schematic	REMARKS AND PIEZOMETER INSTALLATION NOTES
									Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests		
	20 21 22		At 20 feet, loose.		S08A	2 3 4 [7]	10					27			S08A_020_022S
-20	22 23 24 25				S09A										S09A_022_025P
	25 26 27		<u>Poorly Graded SAND with Silt</u> (SP-SM); medium dense; reddish brown (5YR 4/3); wet; 8% fines; 92% fine sand.		S10A	3 4 4 [8]	11					8			S10A_025_027S Vibrating wire piezometer installed at 24 feet
-25	27 28 29 30				S11A										S11A_027_030P
	30 31 32		<u>LEAN CLAY with Sand</u> (CL); dark bluish gray (10B 4/1); moist; 80% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; 20% fine sand.		S12A	3 4 5 [9]	13								S12A_030_032S
-30 -35 -40	33 34 35 36 37 38 39 40 41 42 43 44 45		Total Depth Drilled 32 Feet. Boring backfilled with neat cement grout.												

Final Report Version 10/29/2009

Borehole Location: Levee Toe (Landside) **County:** San Joaquin
Coordinates: Northing: 2,192,612.86 **Easting:** 6,312,861.86
Latitude: 38.01330 **Longitude:** -121.36358
Levee Station or Milepost: 43+00 **Levee Mile:**
Levee Segment Lincoln Village
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Fivemile Slough

LOG OF BORING
WR1608_002M

Sheet 2 of 2

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DATE STARTED 11/1/11 **DATE COMPLETED** 11/1/11	**GROUND ELEVATION** 13.00 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 40.0 ft
DRILLING CONTRACTOR Pitcher Drilling Inc.	**DRILLER'S NAME** James Musich **HELPER'S NAME** Malakai Fakalolo	**TOTAL DEPTH OF FILL** 12 ft
DRILLING METHOD HSA/Rotary Wash	**DRILL RIG MAKE AND MODEL** CME 55	**CONSULTANT COMPANY** Kleinfelder
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 8" HSA, 3-7/8" Drag Bit	**DRILLING ROD TYPE AND DIAMETER** NWJ 2-5/8"	**FIELD LOGGER** G. Lenehan
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** HSA, 10" OD, 15 ft.	**FIELD LOG REVIEWER** M. Briseno
SAMPLER TYPE(S) StdCal(2.5"), SPT (1.375"), DM (2.5")	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** CME Auto Hammer, 140 lbs / 30-inch drop	**HAMMER EFFICIENCY** 77%
BOREHOLE BACKFILL OR COMPLETION Grout	**GROUNDWATER READING: DURING DRILLING** Not Measured Due to Drilling Method	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % <#200	Other Lab Tests	REMARKS
	0		Asphalt concrete - 3 inches. Aggregate base - 4 inches. LEAN CLAY (CL); hard; black (2.5Y 2.5/1); moist; 90% high dry strength, no dilatancy, medium toughness fines; [Levee Fill].												
	1			NSD											Hand Auger to 4 feet
	2				S01A										S01A_002_003B
10	3			NSD											
	4				S02A	61			>4.5P	22	40	20		UW	S02A_004_006T Switch to hollow-stem auger at 4 ft. D&M pushed with 450 psi
	5														
	6			NSD											
	7														
5	8				S03A	72			>4.5P						S03A_008_010T D&M pushed with 450 psi
	9														
	10			NSD											
FILL	11		Below 11.0 feet, stiff.		S04A	89			1.25P 1.5P						S04A_011_013T D&M pushed with 350 psi
	12		LEAN CLAY (CL); stiff; black (2.5Y 2.5/1); moist; 100% high dry strength, no dilatancy, medium toughness fines.												
0	13			NSD											
	14				S05A	61			3.25P	22	40	26		UW OC	S05A_014_016T D&M pushed with 300 psi OC = 4.2% Began rotary wash at 15 ft.
	15		Below 15.0 feet, very stiff; olive brown (2.5Y 4/4).												
	16			NSD											
	17		LEAN CLAY (CL); very stiff; dark greenish gray (10GY 4/1); moist; 90% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 10% fine sand.		S06A	67			2.0P						S06A_017_019T D&M pushed with 300 psi
-5	18														
	19			NSD											
	20														

Final Report Version 5/25/2012

Borehole Location: Levee Crest **County:** San Joaquin **Coordinates: Northing:** 2,187,777.13 **Easting:** 6,311,545.68 **Latitude:** 38.00012 **Longitude:** -121.36798 **Levee Station or Milepost:** 109+90 **Levee Mile:** **Levee Segment** Lincoln Village **Survey Method:** Ground Survey **Coord. System:** CA State Plane Zone III **Channel / River Name / Feature:** Fourteenmile Slough	**LOG OF BORING** **WR1608_008B** **Sheet 1 of 2** **Engineering Support Services Urban Levee Geotechnical Evaluations Program**

DWR LEVEE UNU SOIL LOGREV1; LINCOLN VILLAGE BORINGS.GPJ; DWR OFFICIAL LIBRARY 02232012.GLB; 6/26/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20 21				S07A	50			2.75P						S07A_020_022T D&M pushed with 250 psi
	22		SANDY LEAN CLAY (CL); medium stiff; dark greenish gray (10GY 4/1); moist; 53% medium dry strength, no dilatancy, medium toughness fines; 47% fine sand.	NSD											
-10	23				S08A	100			0.5P	24	31	15	53	UW	S08A_023_025T D&M pushed with 350 psi
	24 25		SANDY SILT (ML); very dark greenish gray (5GY 3/1); moist; 60% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 40% fine sand.	NSD											
	26 27		Poorly Graded SAND with Silt (SP-SM); dark greenish gray (10GY 4/1); wet; 90% fine to medium sand; 10% fines.		S09B S09A	78	6 9 10			25			10	UW HD PA PE	S09B_026_027C K = 5.7E-04 cm/sec S09A_027_028C
-15	28			NSD			[19]								
	29		SILT (ML); dense; very dark greenish gray (10GY 3/1); moist; 100% low plasticity, low dry strength, slow dilatancy, low toughness fines.		S10A	72	3 11 14	32							S010A_028_030S
	30			NSD			[25]								
	31		SILTY SAND (SM); dark greenish gray (10GY 4/1); wet; 67% fine to medium sand; 33% fines.		S11B S11A	83	5 9 9			18			33	UW HD PA PE	S11B_031_032C K = 2.6E-06 cm/sec S11A_032_032C
	32			NSD			[18]								
-20	33		32.5 to 34.0 feet, medium dense.		S12A	78	4 9 11	26							S12A_032_034S
	34			NSD			[20]								
	35		Poorly Graded SAND with Silt (SP-SM); dark greenish gray (10GY 4/1); wet; 89% fine to medium sand; 11% fines.		S13B S13A	78	9 13 17			20			11	UW	S13B_035_036C S13A_036_036C
	36			NSD			[30]								
	37		36.5 to 38.0 feet, very dense.		S14A	56	13 24 21	58							S14A_036_038S
-25	38			NSD			[45]								
	39		SILTY SAND (SM); dark greenish gray (10GY 4/1); wet; 84% fine to medium sand; 16% fines.		S15B S15A	78	17 27 29			16			16	UW	S15B_039_040C S15A_040_040C
	40						[56]								
	41 42		Total Depth Drilled 40 Feet. Boring backfilled with neat cement grout: 8 bags (94 lb.) Portland Cement 30 gallons of water												
-30	43 44 45														

Final Report Version 5/25/2012

Borehole Location: Levee Crest
County: San Joaquin
Coordinates: Northing: 2,187,777.13
Easting: 6,311,545.68
Latitude: 38.00012
Longitude: -121.36798
Levee Station or Milepost: 109+90
Levee Mile:
Levee Segment Lincoln Village
Survey Method: Ground Survey
Coord. System: CA State Plane Zone III
Channel / River Name / Feature: Fourteenmile Slough

LOG OF BORING
WR1608_008B
Sheet 2 of 2

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DATE STARTED 11/15/11 **DATE COMPLETED** 11/15/11	**GROUND ELEVATION** 2.40 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 41.5 ft
DRILLING CONTRACTOR Pitcher Drilling Inc.	**DRILLER'S NAME** James Musich **HELPER'S NAME** Malakai Fakalolo	**TOTAL DEPTH OF FILL** 0 ft
DRILLING METHOD Rotary Wash	**DRILL RIG MAKE AND MODEL** CME 55	**CONSULTANT COMPANY** Kleinfelder
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 3-7/8" Drag Bit	**DRILLING ROD TYPE AND DIAMETER** NWJ 2-5/8"	**FIELD LOGGER** G. Lenehan
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** HSA, 10" OD, 15 ft.	**FIELD LOG REVIEWER** M. Briseno
SAMPLER TYPE(S) StdCal(2.5"), SPT (1.375"), DM (2.5")	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** CME Auto Hammer, 140 lbs / 30-inch drop	**HAMMER EFFICIENCY** 77%
BOREHOLE BACKFILL OR COMPLETION Grout	**GROUNDWATER READING: DURING DRILLING** Not Measured Due to Drilling Method **AFTER DRILLING (DATE-TIME)**	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Asphalt concrete - 3 inches. Aggregate base - 6 inches.	NSC											
	1		SANDY LEAN CLAY (CL); black (10YR 2/1); moist; 70% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 30% fine sand.		S01A										S01A_002_003B Hand Auger to 5 feet
0	2 3			NSC											
	4		LEAN CLAY (CL); stiff; dark greenish gray (5GY 4/1); moist; 60% high dry strength, no dilatancy, medium toughness fines; 40% fine sand.												
	5				S02A	100			1.5P	28	40	25		UW	S02A_005_007T Switch to hollow-stem auger at 5 ft. D&M pushed with 300 psi
	6		SILTY SAND (SM); dark greenish gray (5GY 4/1); moist; 54% fine sand; 46% fines.												
-5	7			NSC											
	8 9				S03A	94				29			46	UW	S03A_008_010T D&M pushed with 200 psi
	10			NSC											
	11		At 11.0 feet, 6 inch lens of Poorly Graded SAND With SILT (SP-SM).		S04A	89				31			11 19	UW HD PA PE	S04A_011_013T D&M pushed with 100 psi K = 1.0E-03 cm/sec
-10	12		SILTY SAND (SM); dark greenish gray (5GY 4/1); wet; 81% fine sand; 19% fines.												
	13			NSC											
	14 15				S05A	89									S05A_014_016T D&M pushed with 300 psi
	16			NSC											
-15	17 18		Poorly Graded SAND with Silt (SP-SM); dark greenish gray (5GY 4/1); wet; 90% fine to medium sand; 10% fines.		S06B S06A	83	4 9 10 [19]						10		S06B_017_018C S06A_018_019C
	19 20			NSC											

Final Report Version 5/25/2012

Borehole Location: Levee Toe (Landside)	**County:** San Joaquin
Coordinates: Northing: 2,185,861.52	**Easting:** 6,315,344.23
Latitude: 37.99479	**Longitude:** -121.35477
Levee Station or Milepost: 159+48	**Levee Mile:**
Levee Segment Lincoln Village	
Survey Method: Ground Survey	**Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Fourteenmile Slough	

LOG OF BORING
WR1608_010B

Sheet 1 of 2

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DWR LEVEE UNU SOIL LOG REV1; LINCOLN VILLAGE BORINGS.GPJ; DWR OFFICIAL LIBRARY 02232012.GLB; 6/26/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20		Below 20.0 feet, loose.		S07A	67	4 5 3 [8]	10							S07A_020_022S
-20	21 22			NSD											
	23 24		SILTY SAND (SM); medium dense; greenish black (5GY 2.5/1); wet; 77% fine sand; 23% fines.		S08A	72	3 5 6 [11]	14					23		S08A_023_025S
	25			NSD											
-25	26 27		Below 26.0 feet, 88% fine sand; 12% fines.		S09B S09A	83	1 7 18 [25]			24			12	UW HD PA PE	S09B_026_027C K = 5.8E-04 cm/sec S09A_027_028C
	28			NSD											
	29 30		29.0 to 30.5 feet, dense.		S10A	78	6 18 16 [34]	44							S10A_029_031S
	31			NSD											
-30	32 33		Poorly Graded SAND with Silt and Gravel (SP-SM); dense; very dark greenish gray (10GY 3/1); moist; 70% fine to coarse, subrounded sand; 22% fine, subrounded gravel; 8% fines.		S11A	39	10 14 17 [31]	40							S11A_032_034S
	34			NSD											
	35 36		Below 35.0 feet, medium dense.		S12A	44	7 11 15 [26]	33					8	PA	S12A_035_037S
-35	37 38 39			NSD											
	40 41		SANDY LEAN CLAY (CL); greenish black (10GY 2.5/1); moist; 58% medium dry strength, no dilatancy, medium toughness fines; 42% fine sand.		S13B S13A	100	3 3 8 [11]			30	29	8	58	UW	S13B_040_041C S13A_041_042C
-40	42 43 44 45		Total Depth Drilled 41.5 Feet. Boring backfilled with neat cement grout: 8 bags (94 lb.) Portland Cement 30 gallons of water												

Final Report Version 5/25/2012

Borehole Location: Levee Toe (Landside)
County: San Joaquin
Coordinates: Northing: 2,185,861.52
Easting: 6,315,344.23
Latitude: 37.99479
Longitude: -121.35477
Levee Station or Milepost: 159+48
Levee Mile:
Levee Segment Lincoln Village
Survey Method: Ground Survey
Coord. System: CA State Plane Zone III
Channel / River Name / Feature: Fourteenmile Slough

LOG OF BORING
WR1608_010B

Sheet 2 of 2

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DWR LEVEE UNU SOIL LOG REV1; LINCOLN VILLAGE BORINGS.GPJ; DWR OFFICIAL LIBRARY 02232012.GLB; 6/26/12

DATE STARTED 9/2/11 **DATE COMPLETED** 9/2/11	**GROUND ELEVATION** 13.60 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 62.5 ft
DRILLING CONTRACTOR Pitcher Drilling Inc.	**DRILLER'S NAME** James Musich **HELPER'S NAME** Malakai Fakalolo	**TOTAL DEPTH OF FILL** 10 ft
DRILLING METHOD HSA/Rotary Wash	**DRILL RIG MAKE AND MODEL** CME 55	**CONSULTANT COMPANY** Kleinfelder
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 10" HSA, 4-7/8" Drag Bit	**DRILLING ROD TYPE AND DIAMETER** NWJ 2-5/8"	**FIELD LOGGER** G. Lenehan
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** HSA, 10" OD, 15 ft.	**FIELD LOG REVIEWER** M. Briseno
SAMPLER TYPE(S) StdCal(2.5"), DM (2.5"), OST (3")	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** CME Auto Hammer, 140 lbs / 30-inch drop	**HAMMER EFFICIENCY** 77%
BOREHOLE BACKFILL OR COMPLETION Grout	**GROUNDWATER READING: DURING DRILLING** Not Measured Due to Drilling Method **AFTER DRILLING (DATE-TIME)**	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Asphalt concrete - 3 inches.												
			Aggregate base - 4 inches.												
	1		SANDY LEAN CLAY (CL); stiff; dark yellowish brown (10YR 3/4); moist; 65% medium plasticity, high dry strength, no dilatancy, medium toughness fines; 35% fine sand; [Levee Fill].	NSD											Hand Auger to 4 feet
	2														
	3														
10	4				S01A	78			0.80T						S01A_004_006T D&M pushed with 450 psi Switch to hollow-stem auger at 5 ft.
	5		Below 5.0 feet, black (10YR 3/1).												
	6			NSD											
	7		LEAN CLAY (CL); stiff; olive brown (2.5Y 4/3); moist; 90% high dry strength, no dilatancy, medium toughness fines; 10% fine sand; [Levee Fill].		S02A	63			0.50T	23	40	24		UW	S02A_006_009T Osterberg pushed with 350 psi
	8														
5	9			NSD											
←FILL	10		LEAN CLAY (CL); stiff; olive brown (2.5Y 4/3); moist; 90% medium to high plasticity, high dry strength, no dilatancy, medium toughness fines; 10% fine sand.		S03A	100			0.60T						S03A_010_012T D&M pushed with 300 psi
	11														
	12			NSD											
	13		ORGANIC ELASTIC SILT (OH); medium stiff; black (5Y 2.5/1); moist; 90% medium dry strength, no dilatancy, low toughness fines; 10% fine sand.		S04A	100			0.27T	100	98	38		UW	S04A_013_016T Osterberg pushed with 250 psi
0	14														
	15														Began rotary wash at 15 ft.
	16			NSD											
	17		SANDY LEAN CLAY (CL); stiff; dark greenish gray (5GY 4/1); moist; 70% medium plasticity, medium dry strength, no dilatancy, medium toughness fines; 30% fine sand.		S05A	100			0.60T						S05A_017_019T D&M pushed with 400 psi
	18														
-5	19			NSD											
					S06A	83									S06A_019_022T
	20														

Final Report Version 5/25/2012

Borehole Location: Levee Crest County: San Joaquin
Coordinates: Northing: 2,186,047.82 Easting: 6,315,822.39
Latitude: 37.99545 Longitude: -121.35315
Levee Station or Milepost: 164+99 Levee Mile:
Levee Segment Lincoln Village
Survey Method: Ground Survey Coord. System: CA State Plane Zone III
Channel / River Name / Feature: Fourteenmile Slough

LOG OF BORING
WR1608_011B

Sheet 1 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DWR LEVEE UANU SOIL LOG REV1; LINCOLN VILLAGE BORINGS.GPJ; DWR OFFICIAL LIBRARY 02232012.GLB; 6/4/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA					REMARKS
										Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	
	20 21 22				S06A	83			0.60T						Osterberg pushed with 600 psi
	22 23			NSD											
-10	24 25		SANDY SILT (ML); dark greenish gray (5GY 4/1); moist; 62% low dry strength, slow dilatancy, low toughness fines; 38% fine sand.		S07B S07A	89	10 15 18 [33]			20	21	3	38	UW	S07B_024_025C S07A_025_025C
	25 26			NSD											
	26 27				S08B S08A	89	6 5 10 [15]								S08B_026_027C S08A_026_027C
	28			NSD											
-15	29 30		SANDY SILTY CLAY (CL-ML); dark greenish gray (5GY 4/1); moist; 70% low dry strength, low toughness fines; 30% fine sand.		S09B S09A	72	5 7 13 [20]			25	28	6		UW	S09B_029_030C S09A_030_030C
	30 31			NSD											
	31 32		SILTY SAND (SM); dark greenish gray (5GY 4/1); wet; 65% fine to medium sand; 35% fines. At 32.0 feet, 6 inch lens of sandy silt (ML), fine sand.		S10B S10A	89	7 6 18 [24]						35		S10B_031_032C S10A_032_033C
	33			NSD											
-20	34 35		Below 34.5 feet, greenish black (5GY 2.5/1).		S11B S11A	78	11 20 22 [42]								S11B_034_035C S11A_035_035C
	35 36			NSD											
	36 37		Poorly Graded SAND with Silt (SP-SM); dark greenish gray (5GY 4/1); wet; 90% fine to medium sand; 10% fines.		S12B S12A	89	20 19 17 [36]			13			10	UW PA	S12B_036_037C S12A_036_037C
	38			NSD											
-25	39 40		Below 39.0 feet, 92% fine to medium sand; 8% fines.		S13B S13A	89	11 18 19 [37]			15			8	PA UW	S13B_039_040C S13A_030_040C
	40 41			NSD											
	41 42		SILT (ML); greenish black (5GY 2.5/1); wet; 90% no to low plasticity, low dry strength, slow to rapid dilatancy, low toughness fines; 10% fine sand.		S14B S14A	78	7 4 3 [7]								S14B_041_042C S14A_042_043C
	43			NSD											
-30	44 45		Poorly Graded SAND with Silt (SP-SM); greenish black (5GY 2.5/1); wet; 94% fine to medium sand; 6% fines.		S15B S15A	72	9 15 20			15			6	UW PA	S15B_044_045C S15A_045_045C

Final Report Version 5/25/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,186,047.82 **Easting:** 6,315,822.39
Latitude: 37.99545 **Longitude:** -121.35315
Levee Station or Milepost: 164+99 **Levee Mile:**
Levee Segment Lincoln Village
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Fourteenmile Slough

LOG OF BORING
WR1608_011B
Sheet 2 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DWR LEVEE UNU SOIL LOGREV1 LINCOLN VILLAGEBORINGS.GPJ DWR OFFICIAL LIBRARY 022012.GLB 6/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA					REMARKS
										Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	
	45			NSD			[35]								
	46 47		Below 46.0 feet, fine to coarse, subangular sand.		S16B S16A	78	13 13 15								S16B_046_047C S16A_047_048C
-35	48		At 48.5 feet, 4 inch lens of silty sand (SM).	NSD			[28]								
	49 50				S17A	67	12 20 19								S17A_049_050C
				NSD			[39]								
	51 52		LEAN CLAY with Sand (CL); dark greenish gray (5GY 4/1); wet; 83% medium dry strength, no dilatancy, medium toughness fines; 17% fine sand.		S18B S18A	89	14 17 20			26	46	27	83	UW	S18B_051_052C S18A_052_053C
	53			NSD			[37]								
-40	54 55		Below 54.0 feet, 75% fines, 25% sand.		S19B S19A	78	14 18 20								S19B_054_055C S19A_055_055C
-45	56 57 58 59			NSD			[38]								
	60 61		Below 60.0 feet, 80% fines, 20% sand.		S20B S20A	89	17 30 41								S20B_060_061C S20A_061_062C
	62			NSD			[71]								
-50 -55	63 64 65 66 67 68 69 70		Total Depth Drilled 62.5 Feet. Boring backfilled with neat cement grout: 8 bags (94 lb.) Portland Cement 32 gallons of water												

Final Report Version 5/25/2012

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,186,047.82 **Easting:** 6,315,822.39
Latitude: 37.99545 **Longitude:** -121.35315
Levee Station or Milepost: 164+99 **Levee Mile:**
Levee Segment Lincoln Village
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Fourteenmile Slough

LOG OF BORING
WR1608_011B
Sheet 3 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DATE STARTED 5/14/09 **DATE COMPLETED** 5/14/09	**GROUND ELEVATION** 12.99 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 50.0 ft
DRILLING CONTRACTOR Neil O Anderson	**DRILLER'S NAME** James Young **HELPER'S NAME** Sean McNeil	**TOTAL DEPTH OF FILL** 15 ft
DRILLING METHOD HSA/Rotary Wash	**DRILL RIG MAKE AND MODEL** CME 75	**CONSULTANT COMPANY** Kleinfelder
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 10" HSA, 5" Punch Core	**DRILLING ROD TYPE AND DIAMETER** NWJ 2-5/8 OD/PC 3" ID, 3-1/2 OD	**FIELD LOGGER** M. Shubert
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** HSA: 10" O.D./6" I.D. Case to 15'	**FIELD LOG REVIEWER** A. Killinger
SAMPLER TYPE(S) SPT 2" O.D./1-3/8" I.D., 2-1/2" PC	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** CME Auto Hammer, 140 lbs / 30-inch drop	**HAMMER EFFICIENCY** 84%
BOREHOLE BACKFILL OR COMPLETION Grout	**GROUNDWATER READING:** **DURING DRILLING** 17.5 ft	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		LEAN CLAY with Sand (CL); dusky red (2.5YR 3/2); moist; 76% low to medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; 24% fine sand; [Levee Fill].		S01A	43				12			76	OC SG	S01A_000_005P OC = 13.2% SG = 2.75
10	3		ORGANIC LEAN CLAY (OL); very stiff; black (10YR 2/1); moist; 100% medium dry strength, no dilatancy, medium toughness fines; strong reaction with HCl; [Levee Fill].						3.0P						
	5				S02A	100	2 4 4 [8]	11		23	43	27			S02A_005_007S
5	7		ORGANIC LEAN CLAY (OL); hard; black (10YR 2/1); moist; 100% medium dry strength, no dilatancy, medium toughness fines; [Levee Fill].		S03A	50			4.5P	17				OC	S03A_007_010P OC = 15.4%
	10				S04A	83			4.5P	20			100	HD SG	S04A_010_012T SG = 2.78
0	12		LEAN CLAY (CL); very stiff; weak red (2.5YR 4/2); moist; 100% medium dry strength, no dilatancy, medium toughness fines; [Levee Fill].		S05A	36			2.5P 2.5P		34	16			S05A_012_015P
FILL	15		SILTY SAND (SM); medium dense; weak red (2.5YR 4/2); moist; 66-83% fine sand; 17-34% fines.		S06A	100	3 4 5 [9]	13		26			34		S06A_015_017S Switched to mud rotary
-5	17				S07A	39									S07A_017_020P
	20														

Final Report Version 10/29/2009

Borehole Location: Levee Crest County: San Joaquin
Coordinates: Northing: 2,187,482.16 Easting: 6,318,764.23
Latitude: 37.99946 Longitude: -121.34299
Levee Station or Milepost: 201+51 Levee Mile:
Levee Segment Lincoln Village
Survey Method: Ground Survey Coord. System: CA State Plane Zone III
Channel / River Name / Feature: Fourteenmile Slough

LOG OF BORING
WCNBFM_001B

Sheet 1 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DWR LEVEE UNU SOIL LOG REV'L LINCOLN VILLAGE BORINGS.GPJ; DWR OFFICIAL LIBRARY 02232012.GLB; 6/6/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA					REMARKS
										Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	
	20 21				S08A	100	5 7 7 [14]	20							S08A_020_022S
-10	22 23 24				S09A	39									S09A_022_025P
	25 26				S10A	100	5 6 7 [13]	18		25			17	PA SG	S10A_025_027S SG = 2.75
-15	27 28 29				S11A	44									S11A_027_030P
	30 31		At 30 feet, loose, 6% fine, subrounded gravel, 76% fine to coarse, subrounded sand, 18% fines.		S12A	100	4 3 4 [7]	10					18	PA	S12A_030_032S
-20	32 33 34		Poorly Graded SAND with Silt (SP-SM); medium dense; weak red (2.5YR 4/2); wet; 90-94% fine sand; 6-10% fines.		S13A	58			0.5P	17			6		S13A_032_035P
	35 36				S14A	100	3 4 4 [8]	11					10	PA	S14A_035_037S
-25	37 38 39				S15A	81									S15A_037_040P
	40 41		Well-Graded SAND with Silt and Gravel (SW-SM); dense; weak red (2.5YR 4/2); moist; 7% fines; 58% fine to coarse, subrounded sand; 35% fine, subrounded to rounded gravel.		S16A	100	11 12 19 [31]	43					7	PA SG	S16A_040_042S SG = 2.68
-30	42 43 44 45				S17A	33									S17A_042_045P

Final Report Version 10/29/2009

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,187,482.16 **Easting:** 6,318,764.23
Latitude: 37.99946 **Longitude:** -121.34299
Levee Station or Milepost: 201+51 **Levee Mile:**
Levee Segment Lincoln Village
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Fourteenmile Slough

LOG OF BORING
WCNBFM_001B

Sheet 2 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45 46 47	▨	<u>LEAN CLAY</u> (CL); very stiff; very dark greenish gray (10BG 3/1); moist; 100% medium dry strength, slow dilatancy, low toughness fines.	☒	S18A	100	4 6 7 [13]	18	2.5P	28	32	13			S18A_045_047S
-35	47 48 49 50	▨	<u>CLAYEY SAND</u> (SC); very dark greenish gray (10BG 3/1); moist; 40% fines; 60% fine sand.	▮	S19A	56									S19A_047_050P

Total Depth Drilled 50 Feet.
Boring backfilled with neat cement grout,

Elevation, feet	Depth, feet
	51
	52
-40	53
	54
	55
	56
	57
-45	58
	59
	60
	61
	62
-50	63
	64
	65
	66
	67
-55	68
	69
	70

Final Report Version 10/29/2009

Borehole Location: Levee Crest **County:** San Joaquin
Coordinates: Northing: 2,187,482.16 **Easting:** 6,318,764.23
Latitude: 37.99946 **Longitude:** -121.34299
Levee Station or Milepost: 201+51 **Levee Mile:**
Levee Segment Lincoln Village
Survey Method: Ground Survey **Coord. System:** CA State Plane Zone III
Channel / River Name / Feature: Fourteenmile Slough

LOG OF BORING
WCNBFM_001B

Sheet 3 of 3

Engineering Support Services Urban Levee Geotechnical Evaluations Program

DWR LEVEE UNU SOIL LOG REV1 LINCOLN VILLAGE BORINGS.GPJ DWR OFFICIAL LIBRARY 02232012.GLB 6/5/12

Appendix E

Sensitivity Analysis with Respect to Coincident Water Elevation

General.

The influence on the liquefaction assessment results of the assumed coincident water elevation (CWE) was determined significant:

- Primarily, due to the relative location of potentially liquefiable layers with respect to CWE. If these layers are above CWE they should be considered non-saturated and, therefore, non-liquefiable.
- Secondly, CWE has a major impact on the ratio between the total vertical stress and the effective vertical stress at the depth analyzed for liquefaction. The cyclic stress ratio (CSR) varies in direct proportionality with this ratio:

$$CSR = 0.65 \left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{v0}}{\sigma'_{v0}}\right) r_d$$

as well as the factor of safety against liquefaction:

$$FS_{liq} = (CRR_{7.5}/CSR) \cdot MSF \cdot K_{\sigma} \cdot K_{\alpha}$$

Because the stress ratio can roughly vary between 1.0 and 2.0, FS_{liq} may vary between a maximum value when CWE is exactly at the depth of evaluation and half of that when CWE is at the ground surface. In other words, FS_{liq} may be calculated as 1.6 for a low CWE, but can drop below 1.0 if a higher CWE is justified.

The draft ETL "Guidelines for Seismic Evaluation of Levees" includes the following recommendation with respect to CWE selection:

> "The highest of the following three levels should be used to determine the coincident water level for combining with a 100-year return period or a less frequent seismic event (e.g., 200-year or 500-year):
>
> - The median annual water level. This should be the higher of the river level or the groundwater level.
> - The typical seasonal water level. For levees where the impact of failure would be low, the typical seasonal water level should be the average water level during the wettest month of the year, and is preferably a 10-year average (e.g., February for California's Central Valley levees). For levees where the impact of failure might be severe, 84th percentile of seasonal water level should be considered as the typical seasonal water level.
> - The mean high tide elevation, for levees affected by tides. In these cases, consideration should be given to the predicted sea level rise expected in the decades ahead.
>
> If the coincident water level is at or below the landside levee toe, then the material within the levee embankment does not need to be evaluated for liquefaction susceptibility. Potentially liquefiable materials in the levee embankment or foundation should be

evaluated for liquefaction, if these materials are saturated under the analyzed coincident or analysis water level."

With this study, when information was available, the coincident water level was assumed to be the maximum level in a year without flood event. If this was not available, a conservative assumption of a water level at the ground surface was considered (i.e. unsaturated material in levee and saturated material – therefore potentially liquefiable – in the entire foundation soil).

Example No.1: Boring WR0017_002B – Crest of levee.

This boring is located in Unit RD 17 at Station 1007+42. The liquefaction triggering evaluation at this location is presented in Figure C-9. There are two relatively low SPT blowcounts that may potentially correspond to liquefaction: at elevations 9.2 and -30.8. The ground surface elevation is 12.7 and the top of levee at elevation 20.2. Figure E-1 show the variation of FS_{liq} with the assumed CWE at the two elevations where liquefiability was suspected.

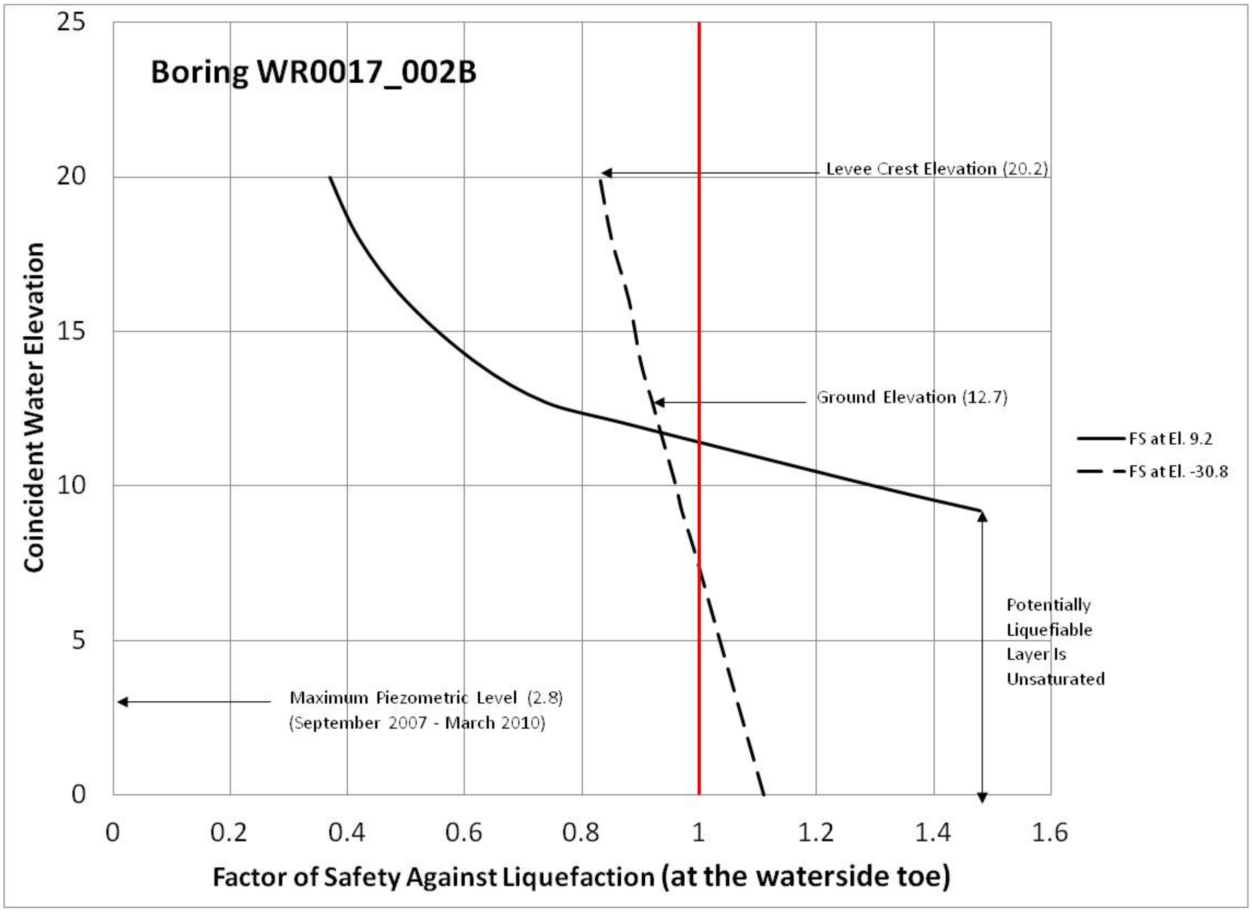


Figure E-1. Variation of FS_{liq} with the assumed CWE at the two elevations in boring WR0017_002B.

The effect of CWE on the calculated FS_{liq} is very important with the shallower potentially liquefiable layer:

- if CWE < 9.2, the layer is non-saturated and, therefore, non-liquefiable;
- for CWE = 9.2, FS_{liq} = 1.48, still non-liquefiable, although saturated;
- with higher CWE, FS_{liq} significantly decreases;
- it becomes FS_{liq} = 0.74 with CWE = 12.7, the ground surface elevation;
- and FS_{liq} = 0.37 with CWE = 20.0, close to top of the levee.

The deeper potentially liquefiable layer is less affected by the CWE selection, but still significantly:

- FS_{liq} = 1.11 for CWE = 0.0;
- FS_{liq} = 0.99 for CWE = 8.0;
- FS_{liq} = 0.92 for CWE = 12.7, the ground surface elevation;
- FS_{liq} = 0.83 for CWE = 20.0, close to top of the levee;

There is a piezometer (WR0017_001M) installed at Station 1048+84, close to the location of interest. Readings were available between September 2007 and March 2010. The maximum ground water level within this interval was 2.8. Assuming CWE = 2.8, it resulted FS_{liq} = 1.07 for the deeper layer; the shallower layer was determined to be well above CWE and, therefore, non-saturated.

Consequently, the location of Boring WR0017_002B was considered non-liquefiable. It is noted that the conservative assumption of water at the ground surface (CWE = 12.7) would imply the conclusion that both two layers were liquefiable.

Example No. 2: Boring WR0017_007B – Crest of levee.

This boring is located in Unit RD 17 at Station 1048+79. The liquefaction triggering evaluation at this location is presented in Figure C-10. There are two relatively low SPT blowcounts that may potentially correspond to liquefaction: at elevations -0.8 and -4.3, probably within the same geologic unit. The ground surface elevation is 8.7 and the top of levee at elevation 21.7. Figure E-2 show the variation of FS_{liq} with the assumed CWE at the two elevations where liquefiability was suspected.

The evaluated location is practically the same where piezometer readings were available: piezometer WR0017_001M installed at Station 1048+84 showed the maximum ground water level within a 2.5-year interval of 2.8. With CWE = 2.8 it resulted FS_{liq} of the order of 1.8 to 2.0 at the potentially liquefiable elevations.

It is noted that considering CWE at the ground surface elevation would still correspond to FS_{liq} in excess of 1.0 at both evaluated depths. Because CWE was credibly defined, this location was not considered seismically vulnerable.

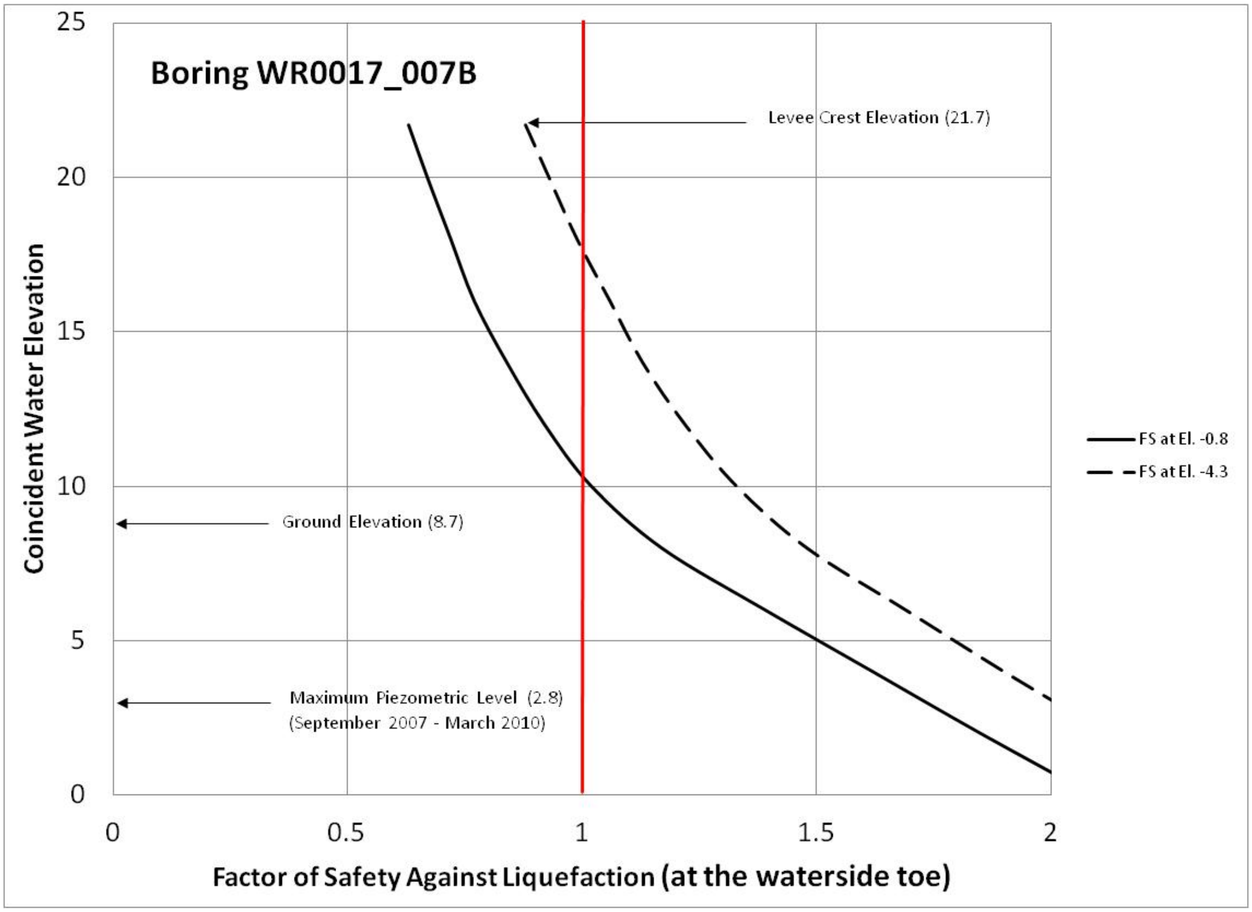


Figure E-2. Variation of FS_{liq} with the assumed CWE at the two elevations in boring WR0017_007B.

<u>Example No. 3</u>: Boring WR0017_041B – Crest of levee.

This boring is located in Unit RD 17 at Station 1330+01. The liquefaction triggering evaluation at this location is presented in Figure C-16. Five depths where SPT blowcounts were available have been examined in detail: 8.2 (not shown in Figure C-16, being in the unsaturated zone), 4.7, -0.3, -5.3, and -10.3. The ground surface elevation is 14.2 and the top of levee at elevation 25.7. Figure E-3 shows the variation of FS_{liq} with the assumed CWE at these five elevations.

The multi-annual maximum piezometric level (no flood events between September 2007 and March 2010) was available in Piezometers WR0017_005M & 006M at Station 1301+04 (maximum water elevation 4.8) and WR0017_ 008M & 009M at Station 1417+01 (maximum water elevation 5.5). The interpolated CWE = 5.0 was considered for Station 1330+01.

From Figure E-3 it is evident that no liquefaction is expected at any depth, with FS_{liq} of at least 1.4. If the CWE at ground elevation had been conservatively assumed, liquefaction would have been predicted at two shallower depths. Assuming all evaluated depths within the same geologic unit, variable CWE would correspond to different thickness of liquefiable layer, as shown in Figure E-4.

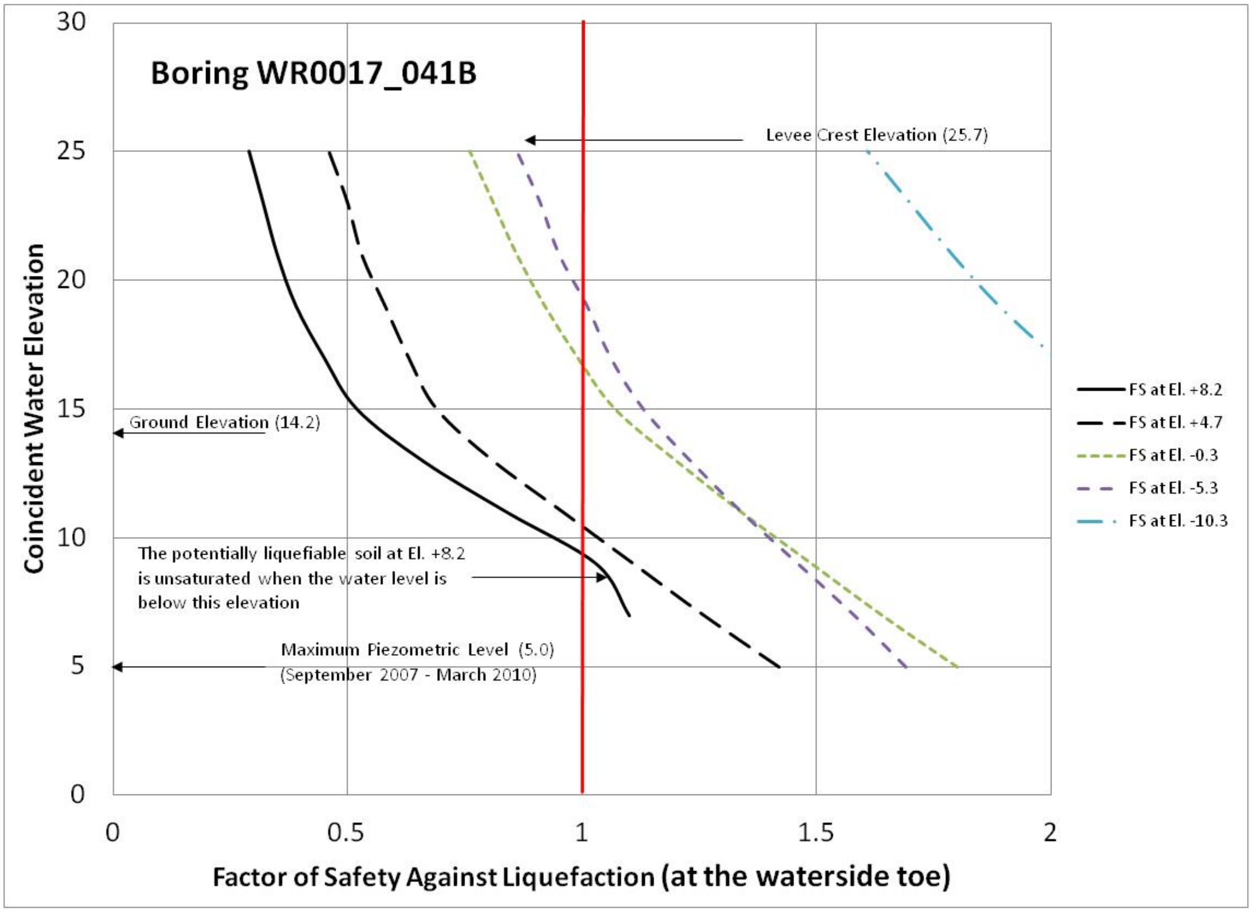


Figure E-3. Variation of FS_{liq} with the assumed CWE at the two elevations in boring WR0017_041B.

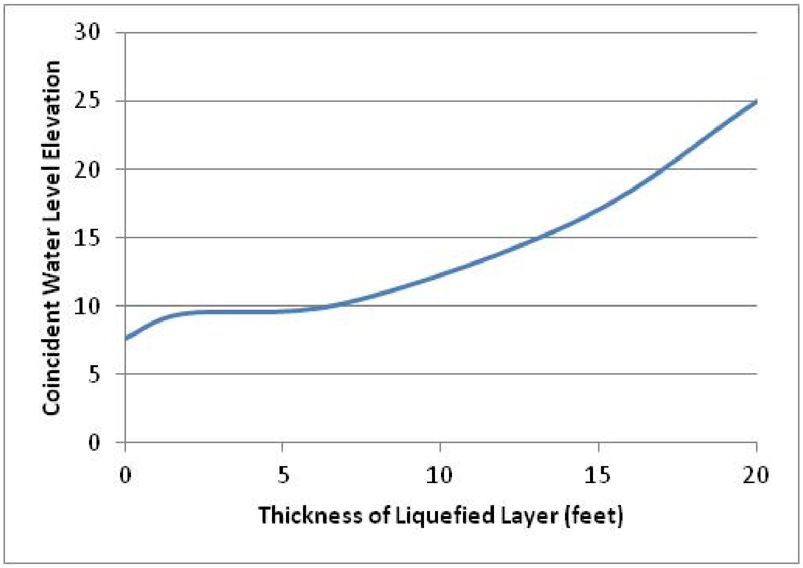


Figure E-4. Effect of assumed CWE on the thickness of layer determined as liquefiable at Boring WR0017_041B location.

<u>Example No. 4</u>: Boring WR0017_047B – Crest of levee.

This boring is located in Unit RD 17 at Station 1377+73. The liquefaction triggering evaluation at this location is presented in Figure C-17. Eight depths located probably within the same geologic unit have been examined in detail. The ground surface elevation is 14.2 and the top of levee at elevation 27.2. Figure E-5 shows the variation of FS_{liq} with the assumed CWE at these eight elevations.

The multi-annual maximum piezometric level (no flood events between September 2007 and March 2010) was available in Piezometers WR0017_005M & 006M at Station 1301+04 (maximum water elevation 4.8) and WR0017_ 008M & 009M at Station 1417+01 (maximum water elevation 5.5). The interpolated CWE = 5.3 was considered for Station 1377+73.

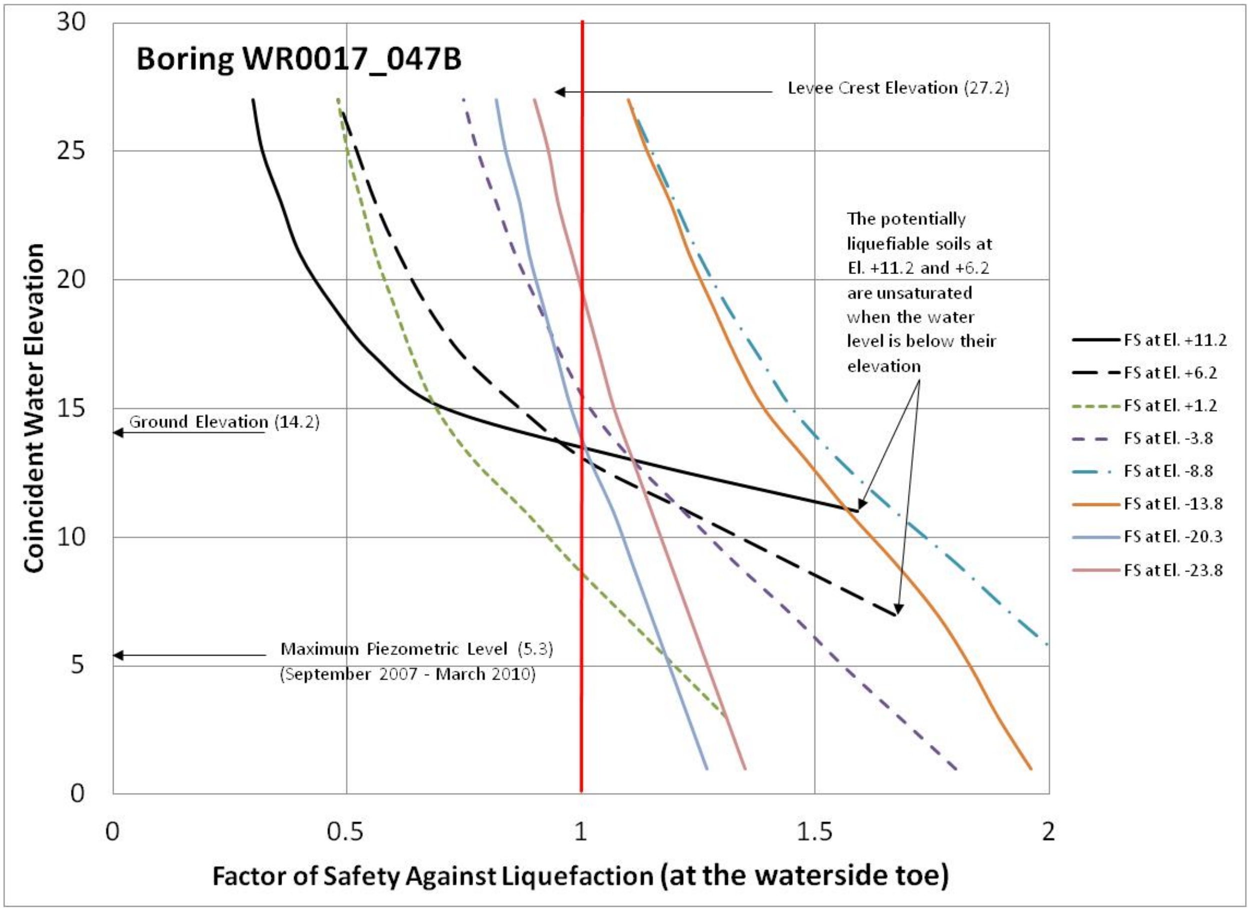


Figure E-5. Variation of FS_{liq} with the assumed CWE at the two elevations in boring WR0017_047B.

No liquefaction was predicted at this location when CWE = 5.3 was considered. However, if CWE = 14.2 (ground surface elevation) were conservatively assumed, a potential liquefiable layer of about 15 feet in thickness would have been assumed.

<u>Example No. 5</u>: Boring WR0017_102B – Crest of levee.

This boring is located in Unit RD 17 at Station 1825+94. The liquefaction triggering evaluation at this location is presented in Figure C-8. Six depths located probably within the same geologic unit have been examined in detail. The ground surface elevation is 14.0 and the top of levee at elevation 34.5. Figure E-6 shows the variation of FS_{liq} with the assumed CWE at these eight elevations.

The multi-annual maximum piezometric level (no flood events between September 2007 and March 2010) was available in Piezometers WR0017_022M & 023M at Station 1784+89 equal to 6.8, which was assumed CWE for Station 1825+94 too.

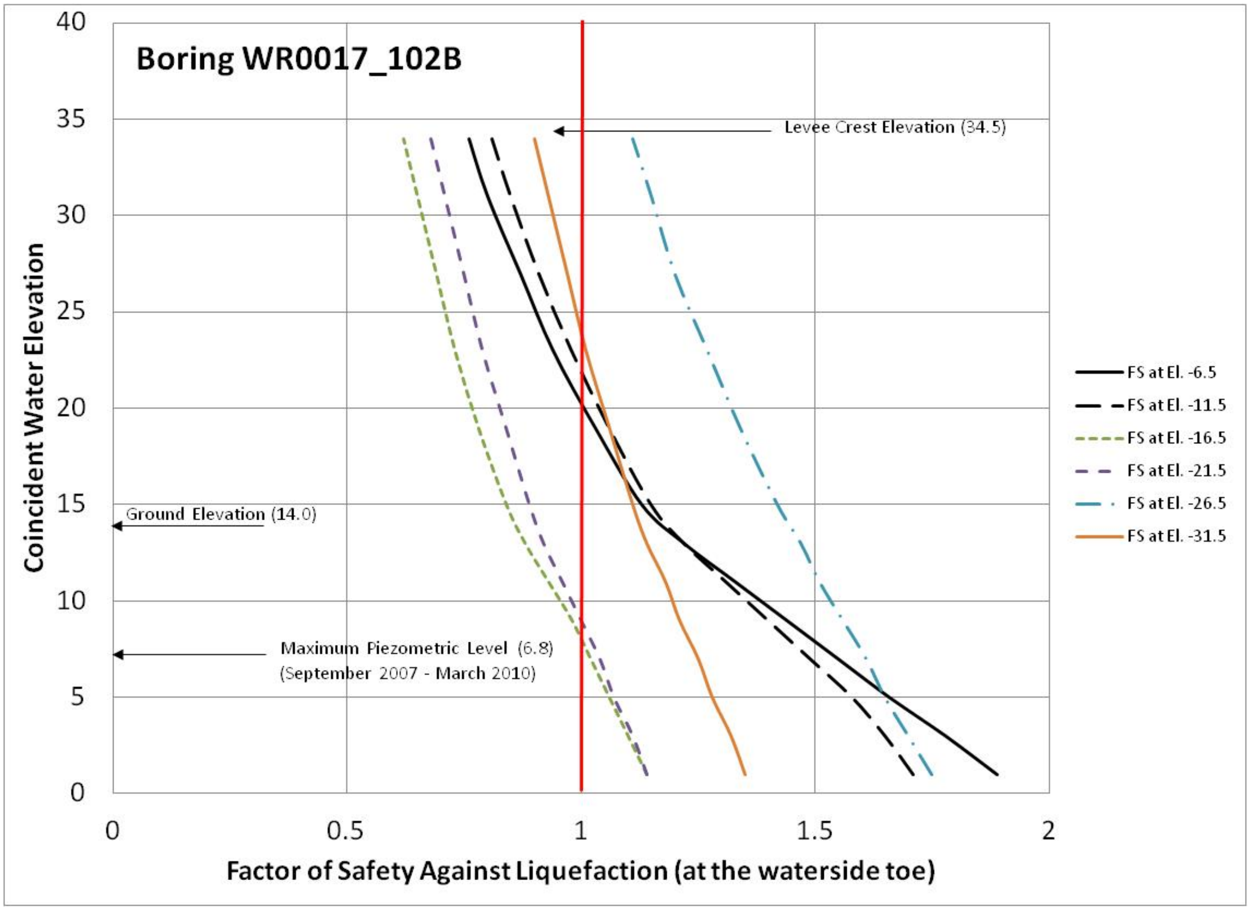


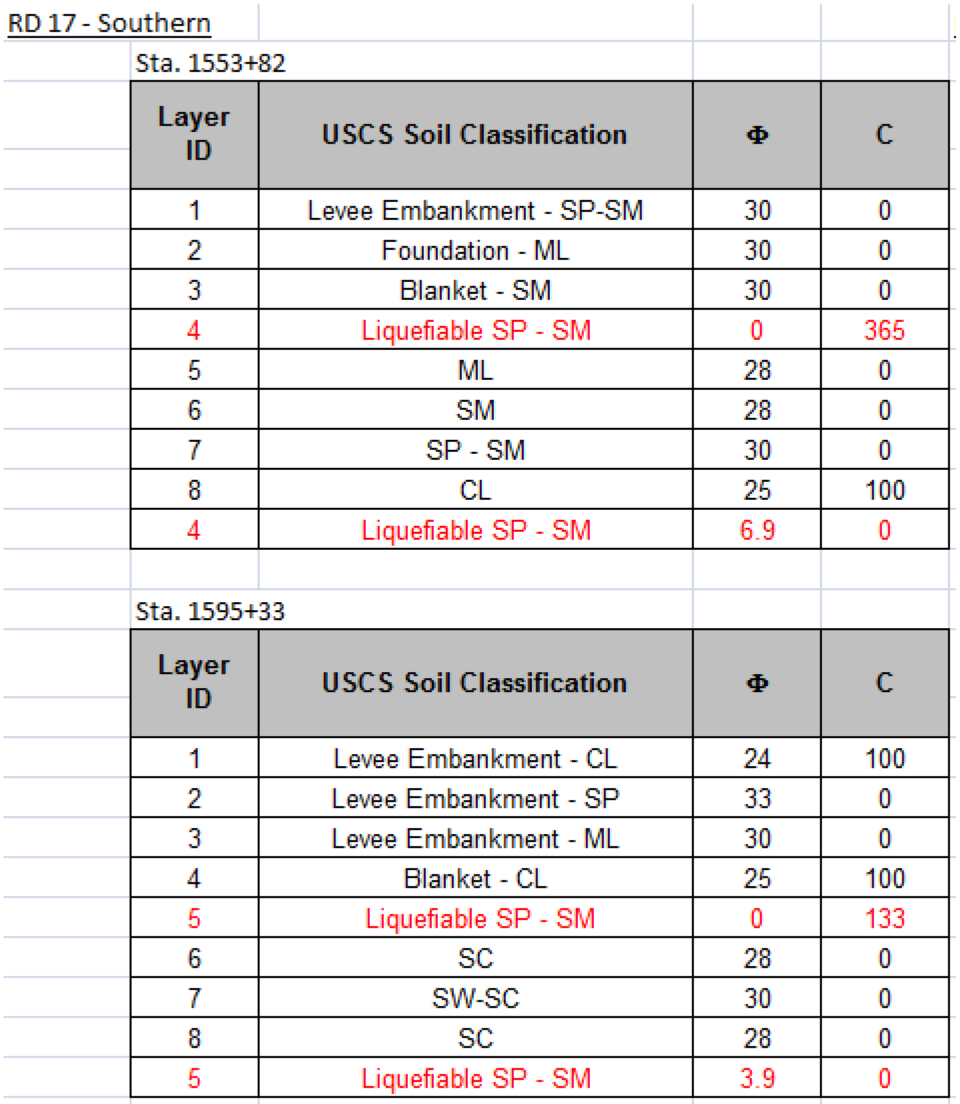
Figure E-6. Variation of FS_{liq} with the assumed CWE at the two elevations in boring WR0017_102B.

For CWE = 6.8 no liquefaction was predicted at this location. It is noted however, that the factor of safety against liquefaction in a 10-foot layer (approximately between elevations -14.0 and -24.0) was of the order of 1.02 – 1.05. With CWE as low as elevation 9.0 (5 feet below the ground surface elevation) liquefaction of this layer would have been predicted.

Appendix F

UTEXAS4 Post-Earthquake Stability Analyses

SOIL PARAMETERS – Post-liquefaction residual strength is shown in red.



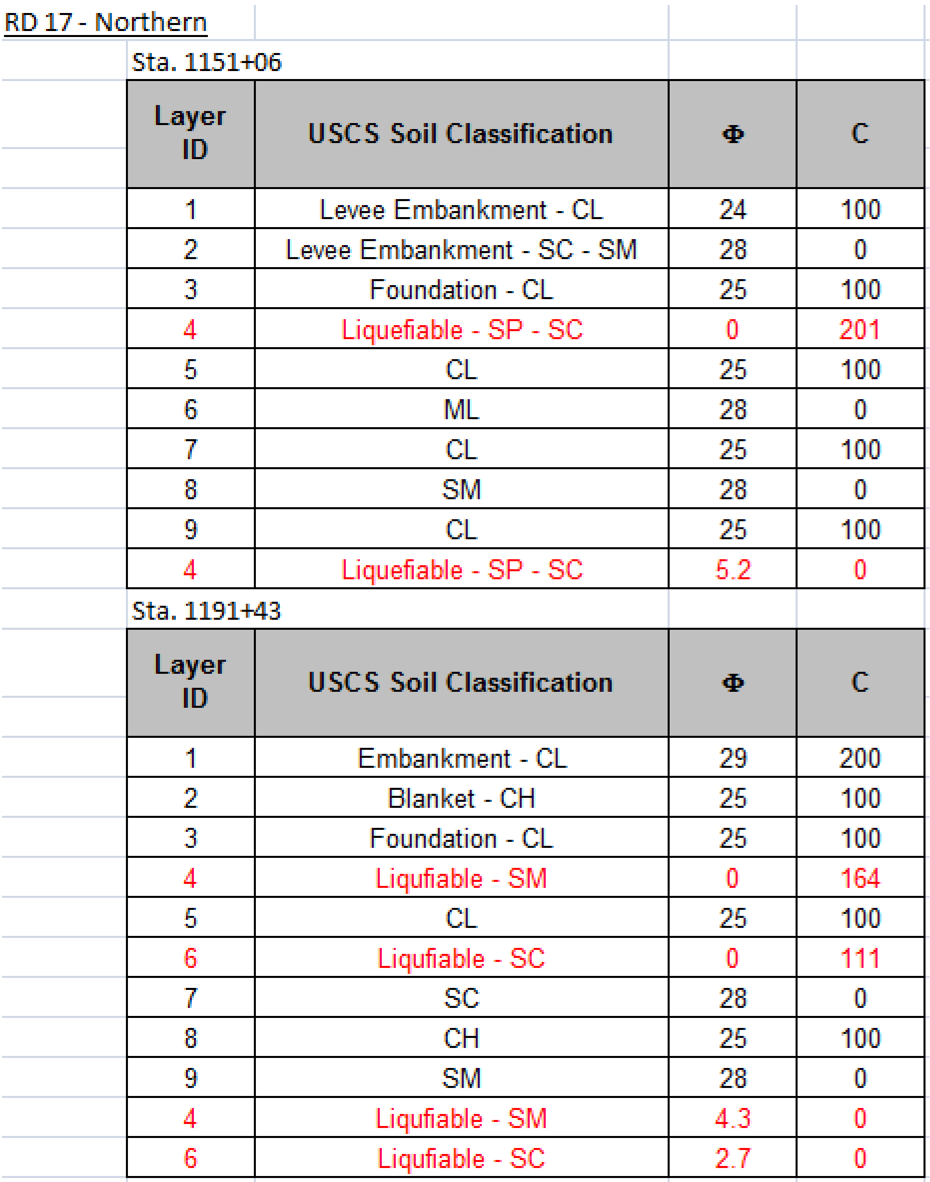
RD 17 - Southern

Sta. 1553+82

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - SP-SM	30	0
2	Foundation - ML	30	0
3	Blanket - SM	30	0
4	Liquefiable SP - SM	0	365
5	ML	28	0
6	SM	28	0
7	SP - SM	30	0
8	CL	25	100
4	Liquefiable SP - SM	6.9	0

Sta. 1595+33

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - CL	24	100
2	Levee Embankment - SP	33	0
3	Levee Embankment - ML	30	0
4	Blanket - CL	25	100
5	Liquefiable SP - SM	0	133
6	SC	28	0
7	SW-SC	30	0
8	SC	28	0
5	Liquefiable SP - SM	3.9	0



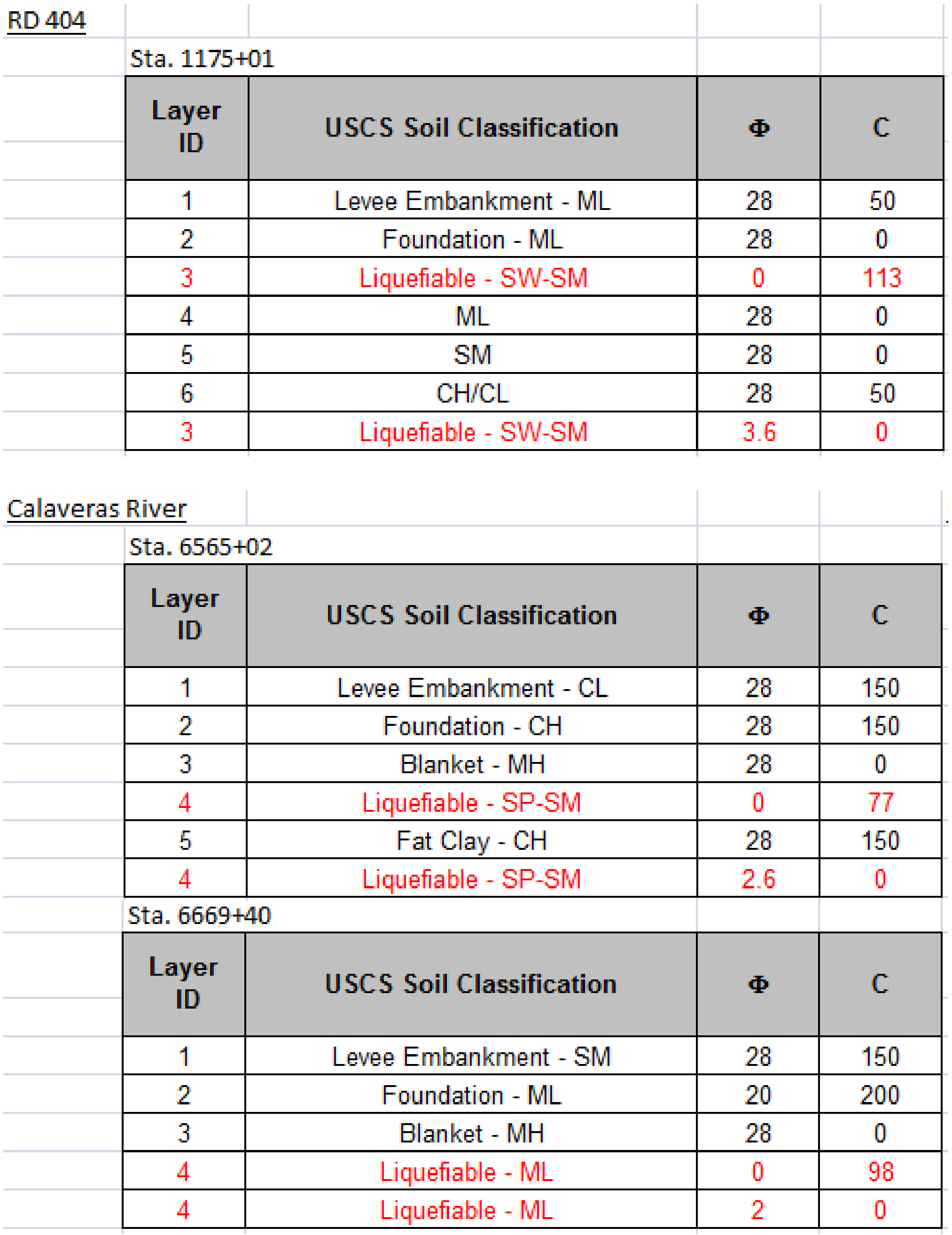
RD 17 - Northern

Sta. 1151+06

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - CL	24	100
2	Levee Embankment - SC - SM	28	0
3	Foundation - CL	25	100
4	Liquefiable - SP - SC	0	201
5	CL	25	100
6	ML	28	0
7	CL	25	100
8	SM	28	0
9	CL	25	100
4	Liquefiable - SP - SC	5.2	0

Sta. 1191+43

Layer ID	USCS Soil Classification	Φ	C
1	Embankment - CL	29	200
2	Blanket - CH	25	100
3	Foundation - CL	25	100
4	Liqufiable - SM	0	164
5	CL	25	100
6	Liqufiable - SC	0	111
7	SC	28	0
8	CH	25	100
9	SM	28	0
4	Liqufiable - SM	4.3	0
6	Liqufiable - SC	2.7	0



RD 404

Sta. 1175+01

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - ML	28	50
2	Foundation - ML	28	0
3	Liquefiable - SW-SM	0	113
4	ML	28	0
5	SM	28	0
6	CH/CL	28	50
3	Liquefiable - SW-SM	3.6	0

Calaveras River

Sta. 6565+02

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - CL	28	150
2	Foundation - CH	28	150
3	Blanket - MH	28	0
4	Liquefiable - SP-SM	0	77
5	Fat Clay - CH	28	150
4	Liquefiable - SP-SM	2.6	0

Sta. 6669+40

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - SM	28	150
2	Foundation - ML	20	200
3	Blanket - MH	28	0
4	Liquefiable - ML	0	98
4	Liquefiable - ML	2	0

Brookside

Sta. 117+51

Layer ID	USCS Soil Classification	Φ	C
1	Sandy Lean Clay - CL	22	100
2	Silty Sand - SM	28	0
3	Lean Clay - CL	22	100
4	Sandy Silt with Organic Layers - ML	28	0
5	Sandy Lean Clay - CL	22	100
6	Liquefiable Silty Sand - SM	0	189
7	Silt with Sand - ML	28	0
6	Liquefiable Silty Sand - SM	4	0

Sta. 118+02

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - CL	28	50
2	Foundation - ML	28	0
3	Blanket - CH	20	200
4	Organic Silt - OH	20	50
5	Lean Clay - CL	20	100
6	Silty Sand - SM	28	0
7	Poorly Graded Sand - SP	0	151
8	Poorly Graded Sand with Silt - SP-SM	0	151
9	Lean Clay - CL	20	100
7	Poorly Graded Sand - SP	4.3	0
8	Poorly Graded Sand with Silt - SP-SM	4.3	0

Sta. 133+82

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - CL	25	150
2	Clayey Sand - SC	0	242
3	Silt with Sand - ML	28	0
4	Silty Sand - SM	28	0
5	Clayey Sand - SC	28	0
6	Silty Sand - SM	28	0
2	Clayey Sand - SC	5.1	0

Lincoln Village

Sta. 43+57

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - CL	22	100
2	Clayey Sand - SC	28	0
3	Lean Clay - CL	22	100
4	Poorly Graded Sand with Silt - SP-SM	0	201
4	Poorly Graded Sand with Silt - SP-SM	4.7	0

Sta. 109+90

Layer ID	USCS Soil Classification	Φ	C
1	Sandy Lean Clay - CL	22	100
2	Sandy Silt - ML	28	0
3	Poorly Graded Sand with Silt - SP-SM	0	282
4	Silty Sand - SM	28	0
5	Poorly Graded Sand with Silt - SP-SM	30	0
3	Poorly Graded Sand with Silt - SP-SM	6.0	0

Sta. 164+99

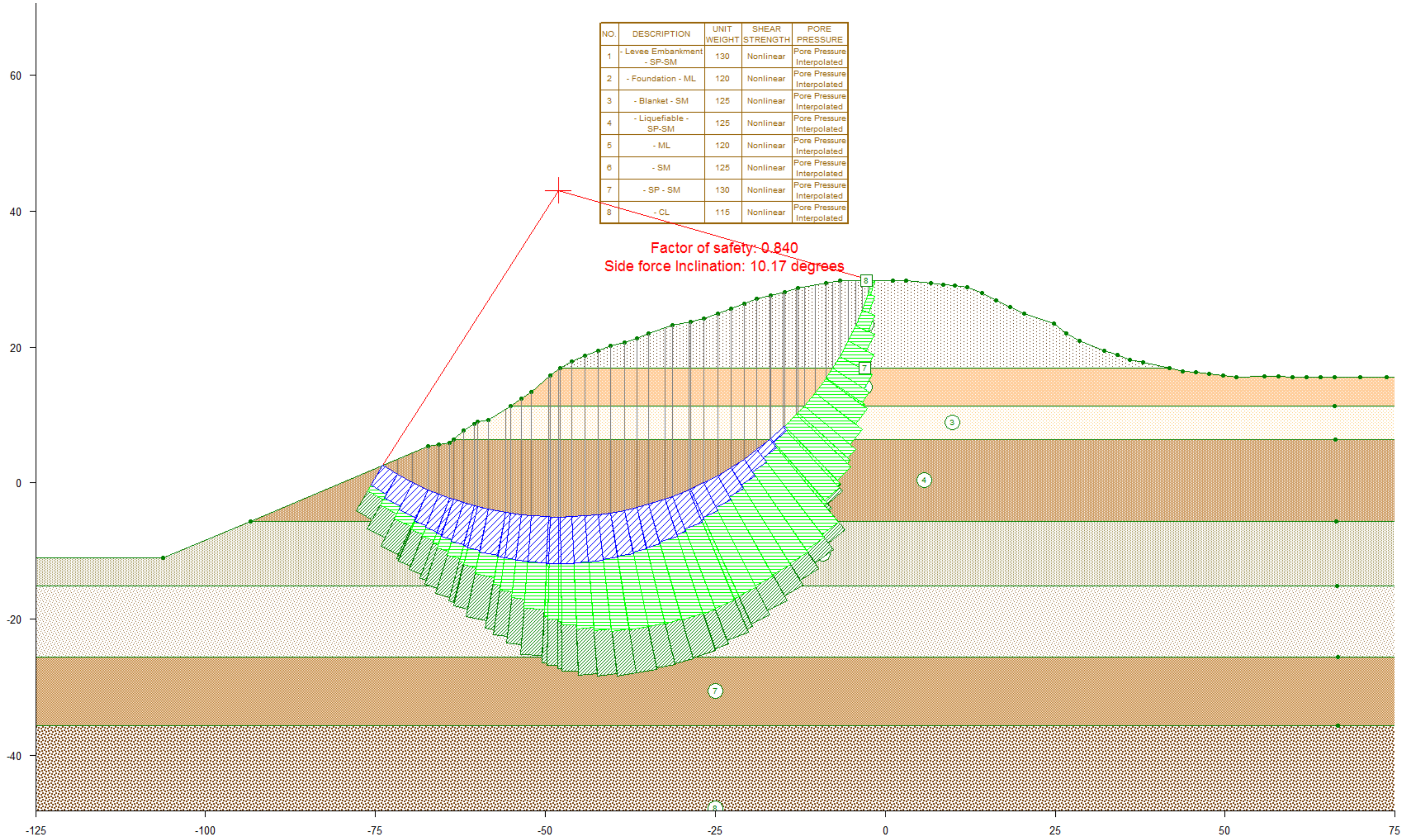
Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - CL	22	100
2	Lean Clay - CL	22	100
3	Organic Elastic Silt - OH	30	75
4	Sandy Lean Clay - CL	22	100
5	Silty Sand - SM	28	0
6	Poorly Graded Sand with Silt - SP-SM	30	0
7	Silt - ML	0	224
7	Silt - ML	3.4	0

Sta. 159+48

Layer ID	USCS Soil Classification	Φ	C
1	Sandy Lean Clay - CL	22	100
2	Silty Sand - SM	28	0
3	Poorly Graded Sand with Silt SP-SM	0	207
4	Silty Sand - SM	28	0
5	Poorly Graded Sand with Silt SP-SM	30	0
6	Sandy Lean Clay - CL	22	100
3	Poorly Graded Sand with Silt SP-SM	5.1	0

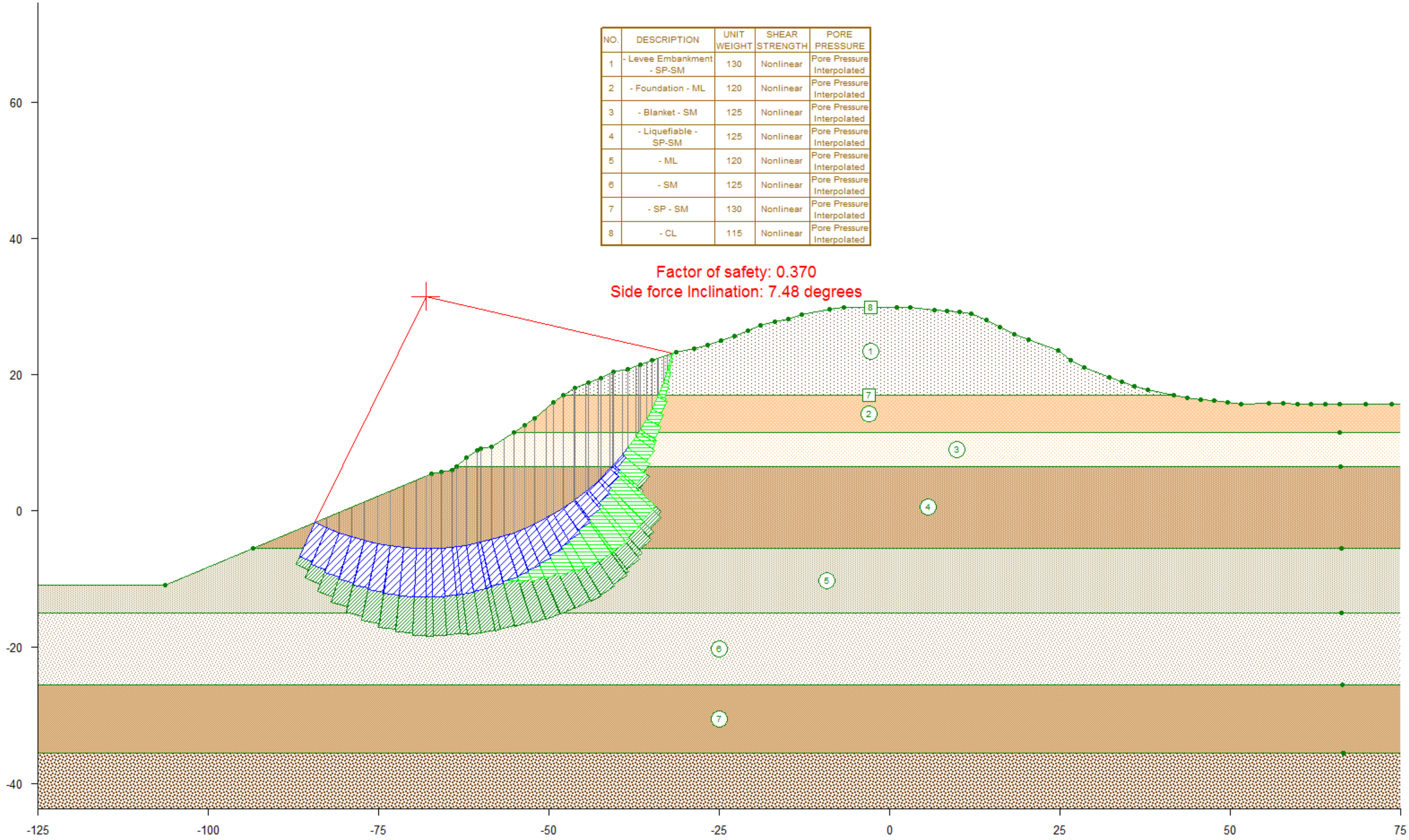
Sta. 201+51

Layer ID	USCS Soil Classification	Φ	C
1	Levee Embankment - CL	22	100
2	Silty Sand - SM	28	0
3	Poorly Graded Sand with Silt - SP-SM	0	201
4	Well Graded Sand with Silt&Gravel - SW-SM	30	0
3	Poorly Graded Sand with Silt - SP-SM	4.7	0



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SP-SM	130	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Blanket - SM	125	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	125	Nonlinear	Pore Pressure Interpolated
5	- ML	120	Nonlinear	Pore Pressure Interpolated
6	- SM	125	Nonlinear	Pore Pressure Interpolated
7	- SP - SM	130	Nonlinear	Pore Pressure Interpolated
8	- CL	115	Nonlinear	Pore Pressure Interpolated

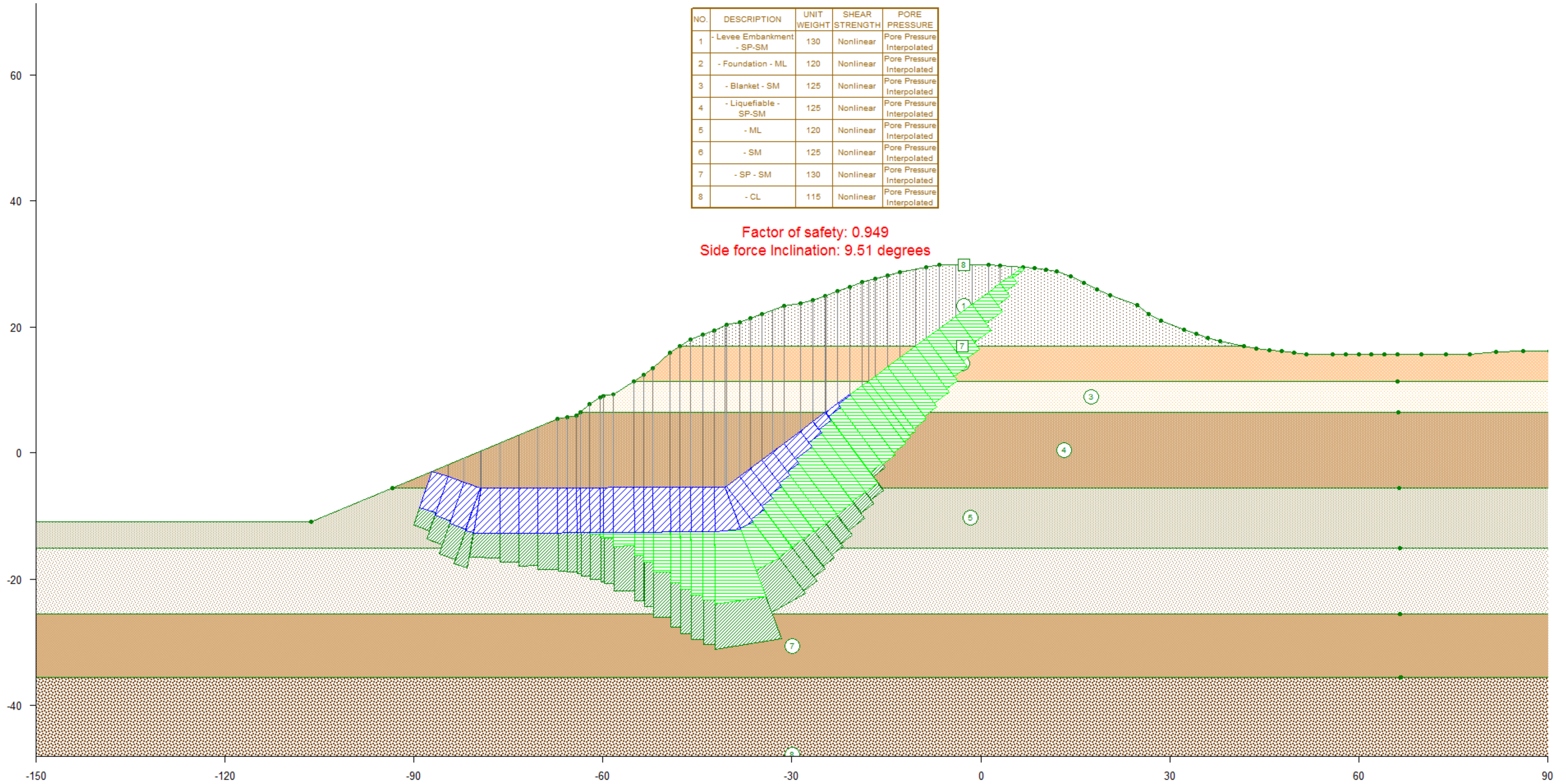
Fig F-1(a). RD 17 Southern, Station 1553+82 – Waterside – Option 1: Circular (Sr = 365 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SP-SM	130	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Blanket - SM	125	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	125	Nonlinear	Pore Pressure Interpolated
5	- ML	120	Nonlinear	Pore Pressure Interpolated
6	- SM	125	Nonlinear	Pore Pressure Interpolated
7	- SP - SM	130	Nonlinear	Pore Pressure Interpolated
8	- CL	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 0.370
Side force Inclination: 7.48 degrees

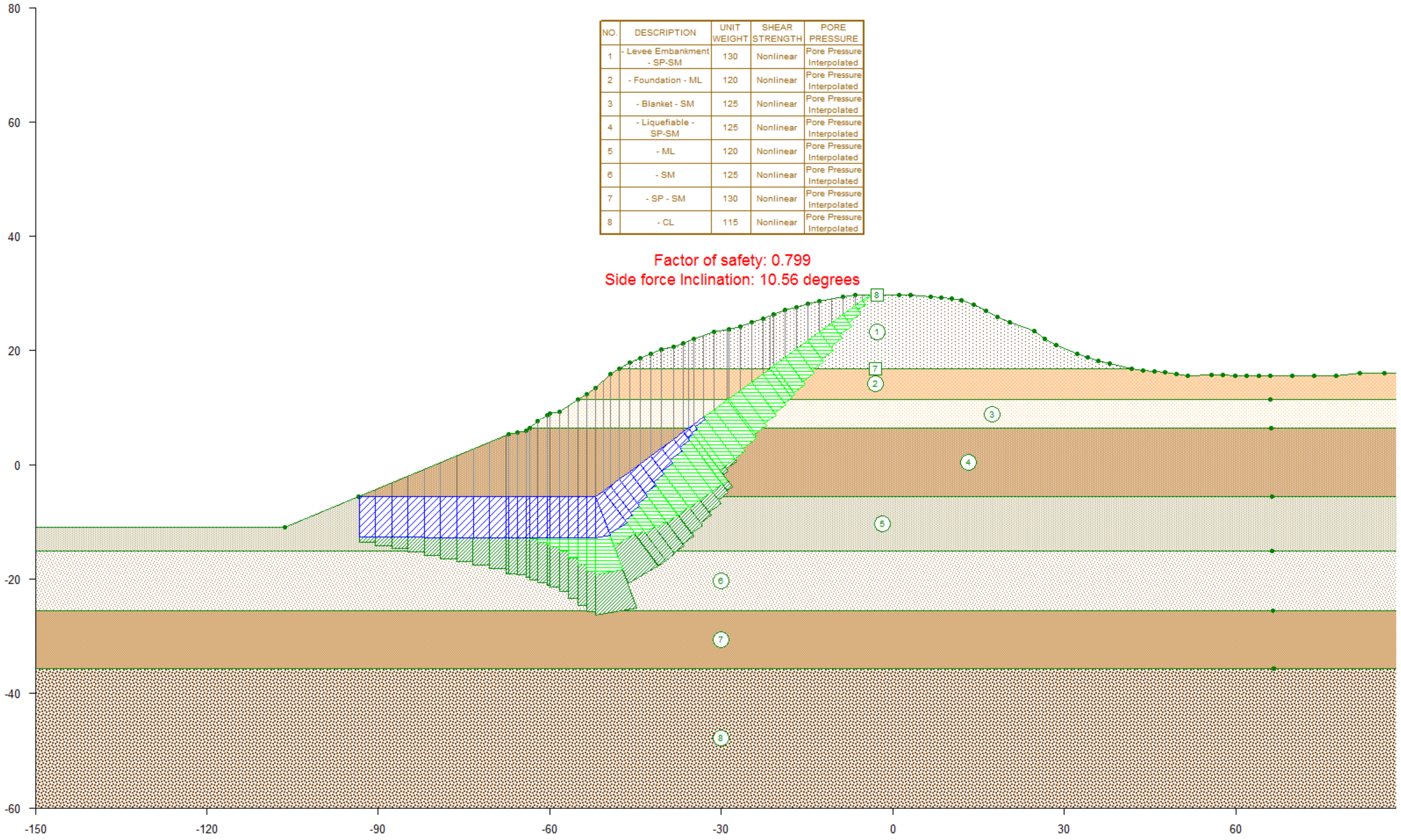
Fig F-1(b). RD 17 Station 1553+82 – Waterside – Option 1: Circular (PHI = 6.9 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SP-SM	130	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Blanket - SM	125	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	125	Nonlinear	Pore Pressure Interpolated
5	- ML	120	Nonlinear	Pore Pressure Interpolated
6	- SM	125	Nonlinear	Pore Pressure Interpolated
7	- SP - SM	130	Nonlinear	Pore Pressure Interpolated
8	- CL	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 0.949
Side force Inclination: 9.51 degrees

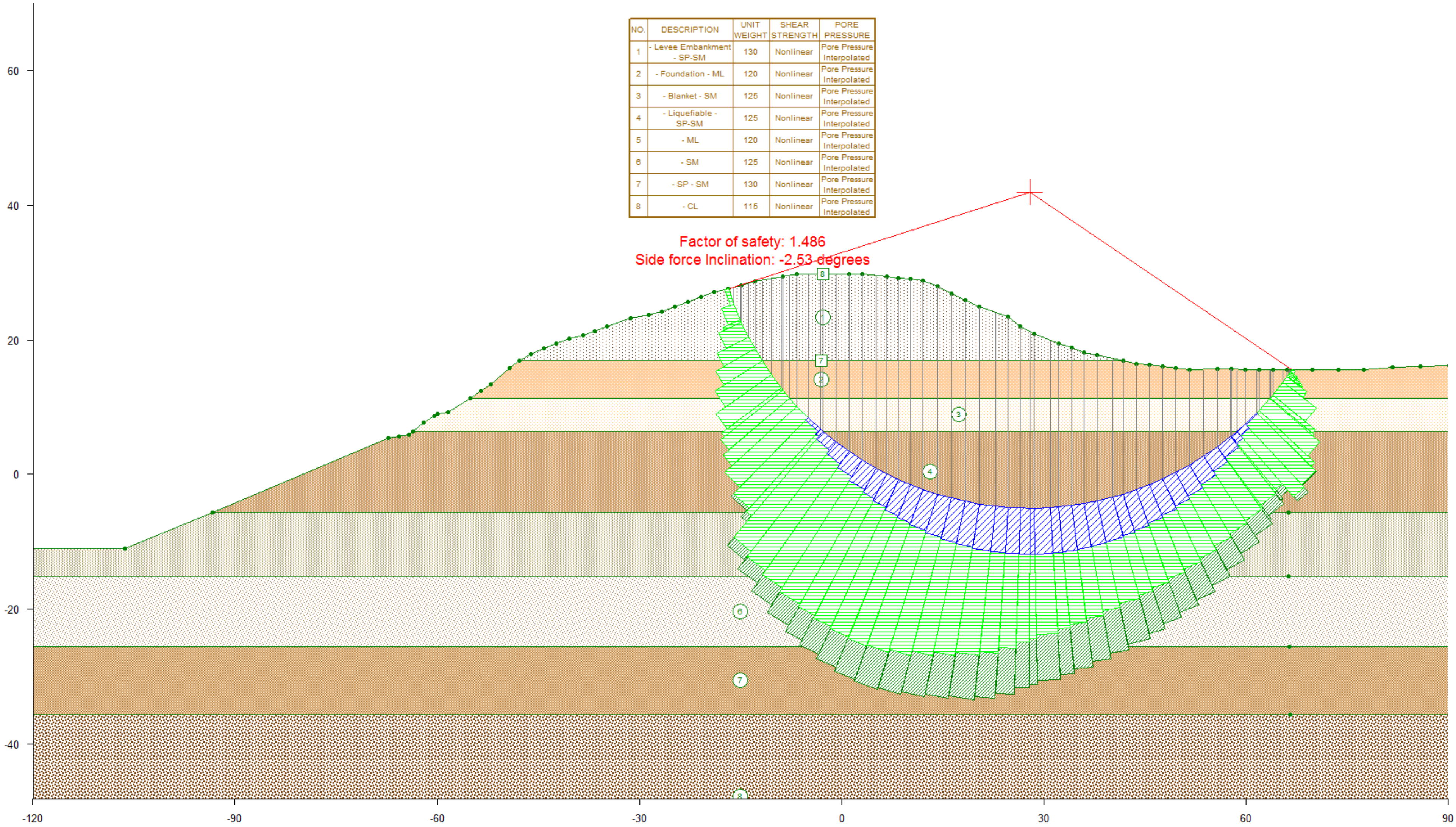
Fig F-2(a). RD 17 Southern, Station 1553+82 – Waterside – Option 2: Wedges (Sr = 365 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SP-SM	130	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Blanket - SM	125	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	125	Nonlinear	Pore Pressure Interpolated
5	- ML	120	Nonlinear	Pore Pressure Interpolated
6	- SM	125	Nonlinear	Pore Pressure Interpolated
7	- SP - SM	130	Nonlinear	Pore Pressure Interpolated
8	- CL	115	Nonlinear	Pore Pressure Interpolated

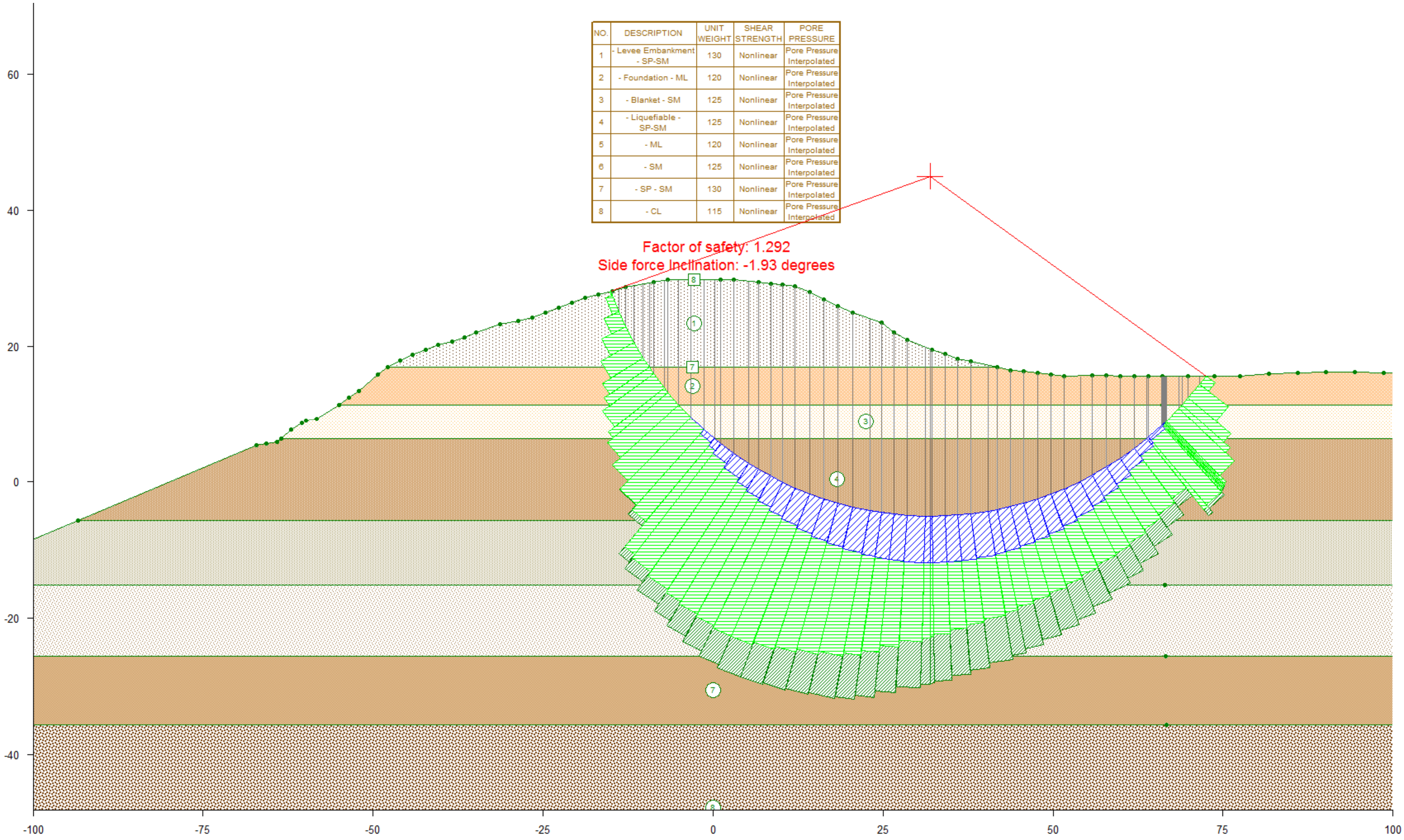
Factor of safety: 0.799
Side force Inclination: 10.56 degrees

Fig F-2(b). RD 17 Station 1553+82 – Waterside – Option 2: Wedges (PHI = 6.9 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SP-SM	130	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Blanket - SM	125	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	125	Nonlinear	Pore Pressure Interpolated
5	- ML	120	Nonlinear	Pore Pressure Interpolated
6	- SM	125	Nonlinear	Pore Pressure Interpolated
7	- SP - SM	130	Nonlinear	Pore Pressure Interpolated
8	- CL	115	Nonlinear	Pore Pressure Interpolated

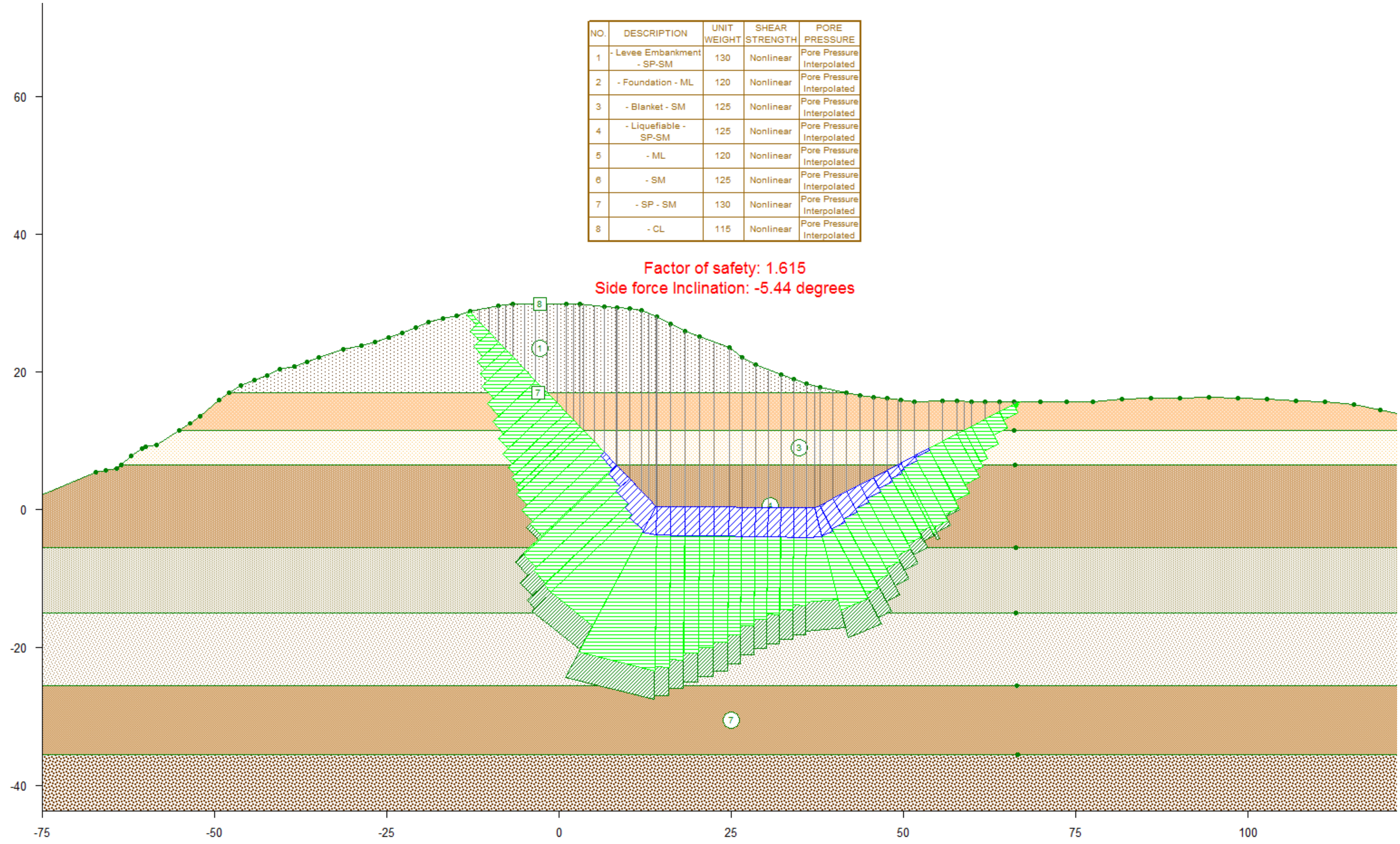
Fig F-3(a). RD 17 Southern, Station 1553+82 – Landside – Option 3: Circular (Sr = 365 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SP-SM	130	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Blanket - SM	125	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	125	Nonlinear	Pore Pressure Interpolated
5	- ML	120	Nonlinear	Pore Pressure Interpolated
6	- SM	125	Nonlinear	Pore Pressure Interpolated
7	- SP - SM	130	Nonlinear	Pore Pressure Interpolated
8	- CL	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.292
Side force Inclination: -1.93 degrees

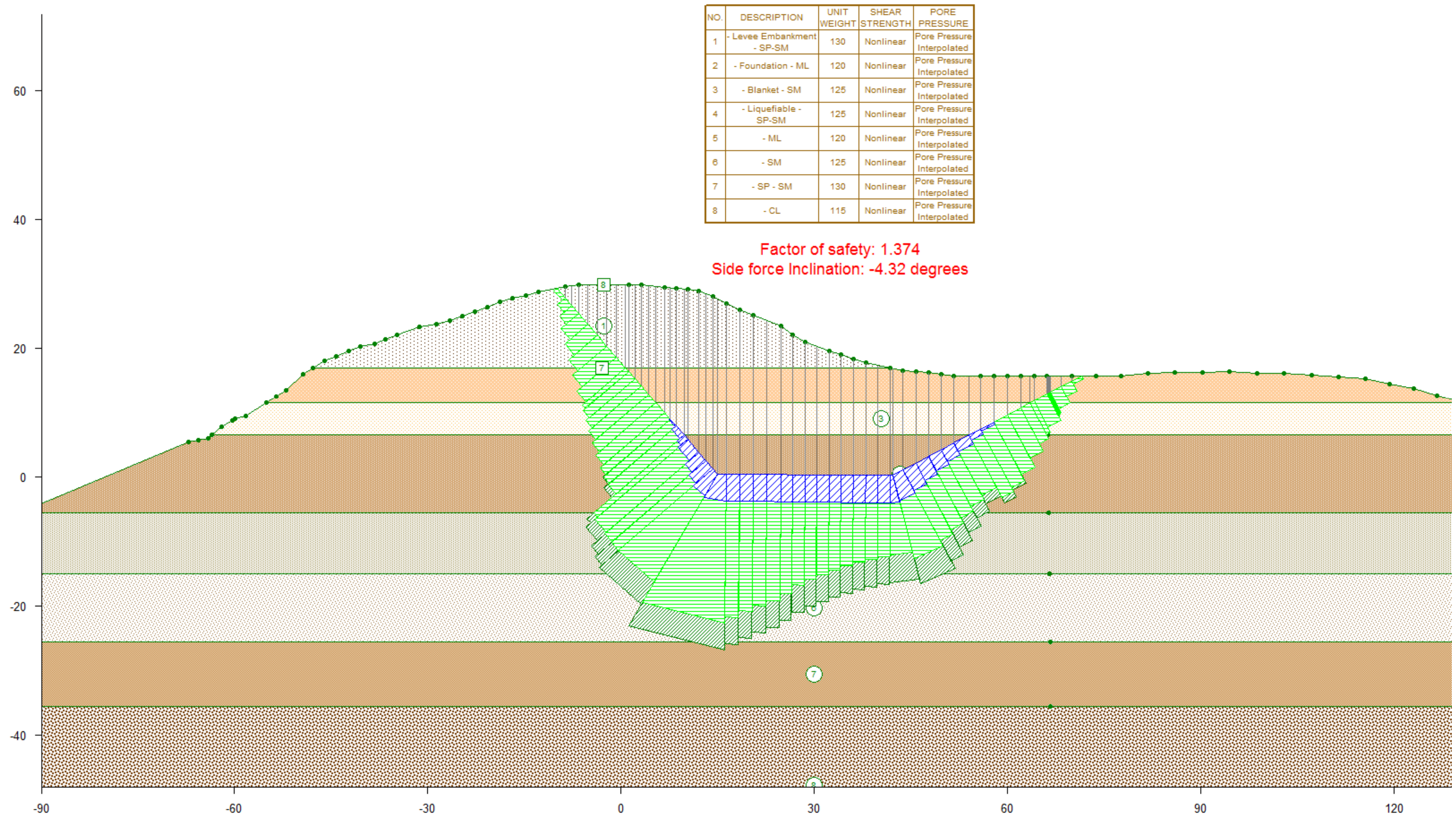
Fig F-3(b). RD 17 Station 1553+82 – Landside – Option 3: Circular (PHI = 6.9 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SP-SM	130	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Blanket - SM	125	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	125	Nonlinear	Pore Pressure Interpolated
5	- ML	120	Nonlinear	Pore Pressure Interpolated
6	- SM	125	Nonlinear	Pore Pressure Interpolated
7	- SP - SM	130	Nonlinear	Pore Pressure Interpolated
8	- CL	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.615
Side force Inclination: -5.44 degrees

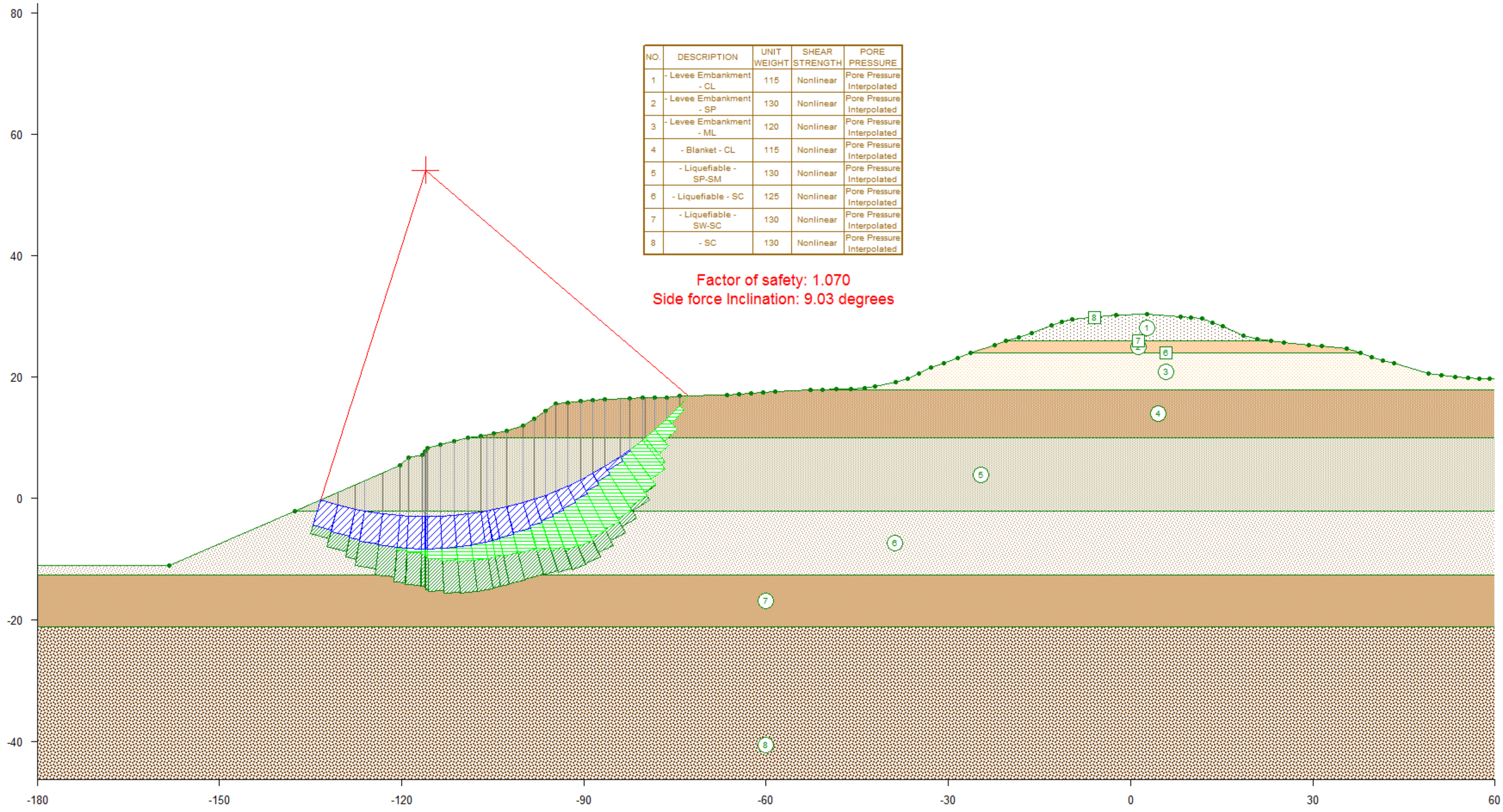
Fig F-4(a). RD 17 Southern, Station 1553+82 – Landside – Option 4: Wedge (Sr = 365 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SP-SM	130	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Blanket - SM	125	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	125	Nonlinear	Pore Pressure Interpolated
5	- ML	120	Nonlinear	Pore Pressure Interpolated
6	- SM	125	Nonlinear	Pore Pressure Interpolated
7	- SP - SM	130	Nonlinear	Pore Pressure Interpolated
8	- CL	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.374
Side force Inclination: -4.32 degrees

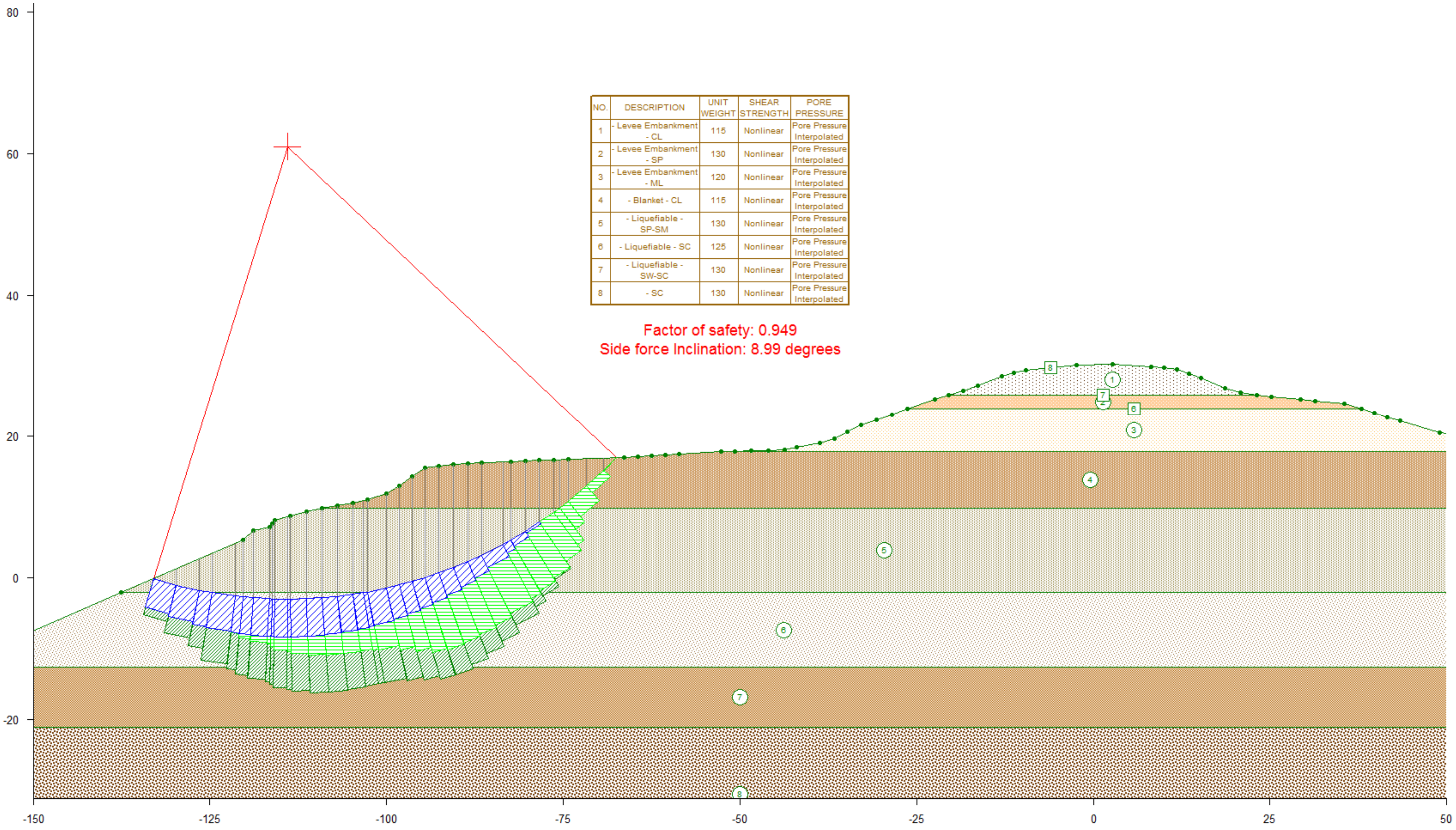
Fig F-4(b). RD 17 Station 1553+82 – Landside – Option 4: Wedge (PHI = 6.9 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SP	130	Nonlinear	Pore Pressure Interpolated
3	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
4	- Blanket - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Liquefiable - SP-SM	130	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable - SW-SC	130	Nonlinear	Pore Pressure Interpolated
8	- SC	130	Nonlinear	Pore Pressure Interpolated

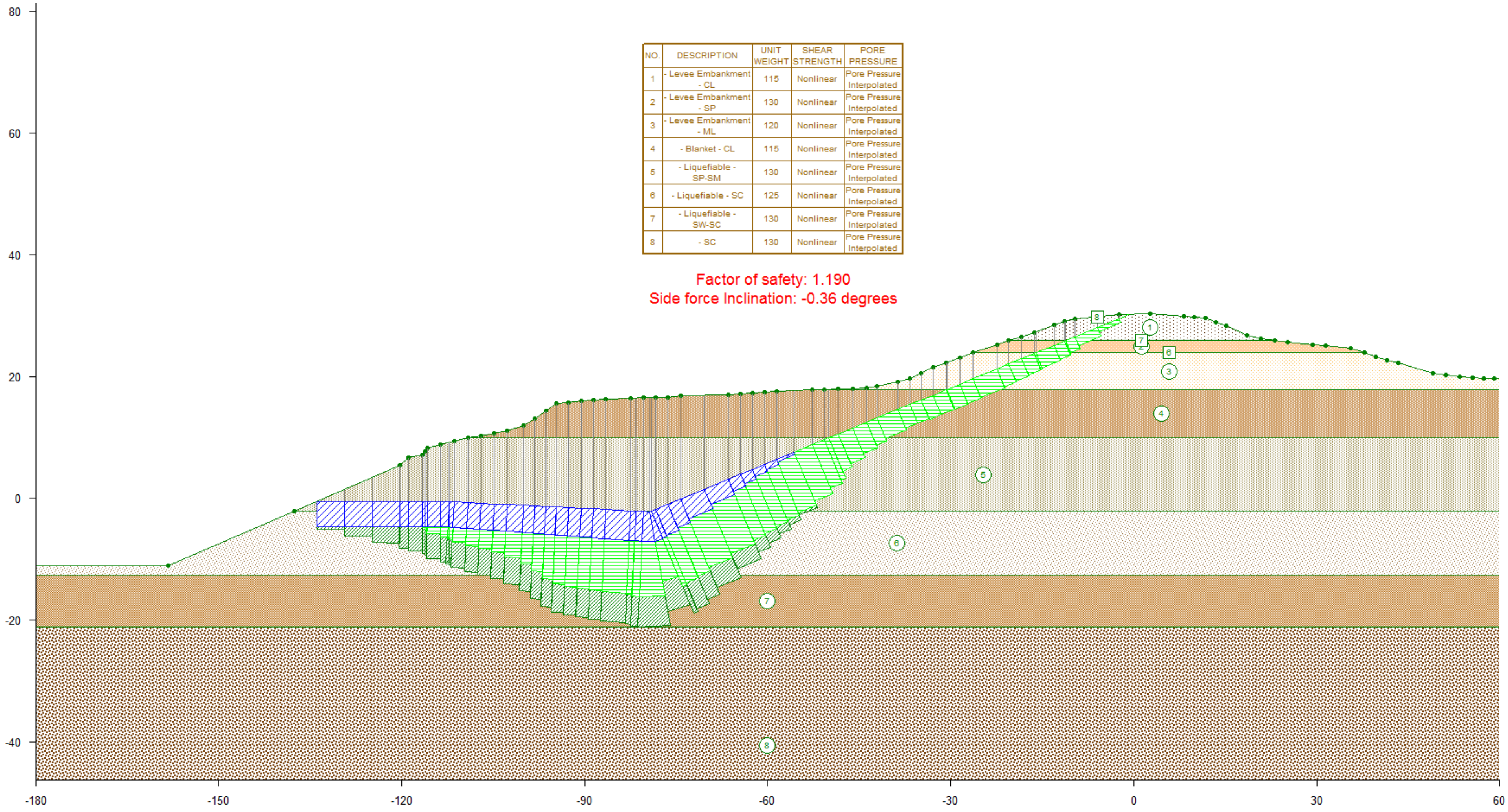
Factor of safety: 1.070
Side force Inclination: 9.03 degrees

Fig F-5(a). RD 17 Southern, Station 1595+33 – Waterside – Option 1: Circular (Sr = 133 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SP	130	Nonlinear	Pore Pressure Interpolated
3	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
4	- Blanket - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Liquefiable - SP-SM	130	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable - SW-SC	130	Nonlinear	Pore Pressure Interpolated
8	- SC	130	Nonlinear	Pore Pressure Interpolated

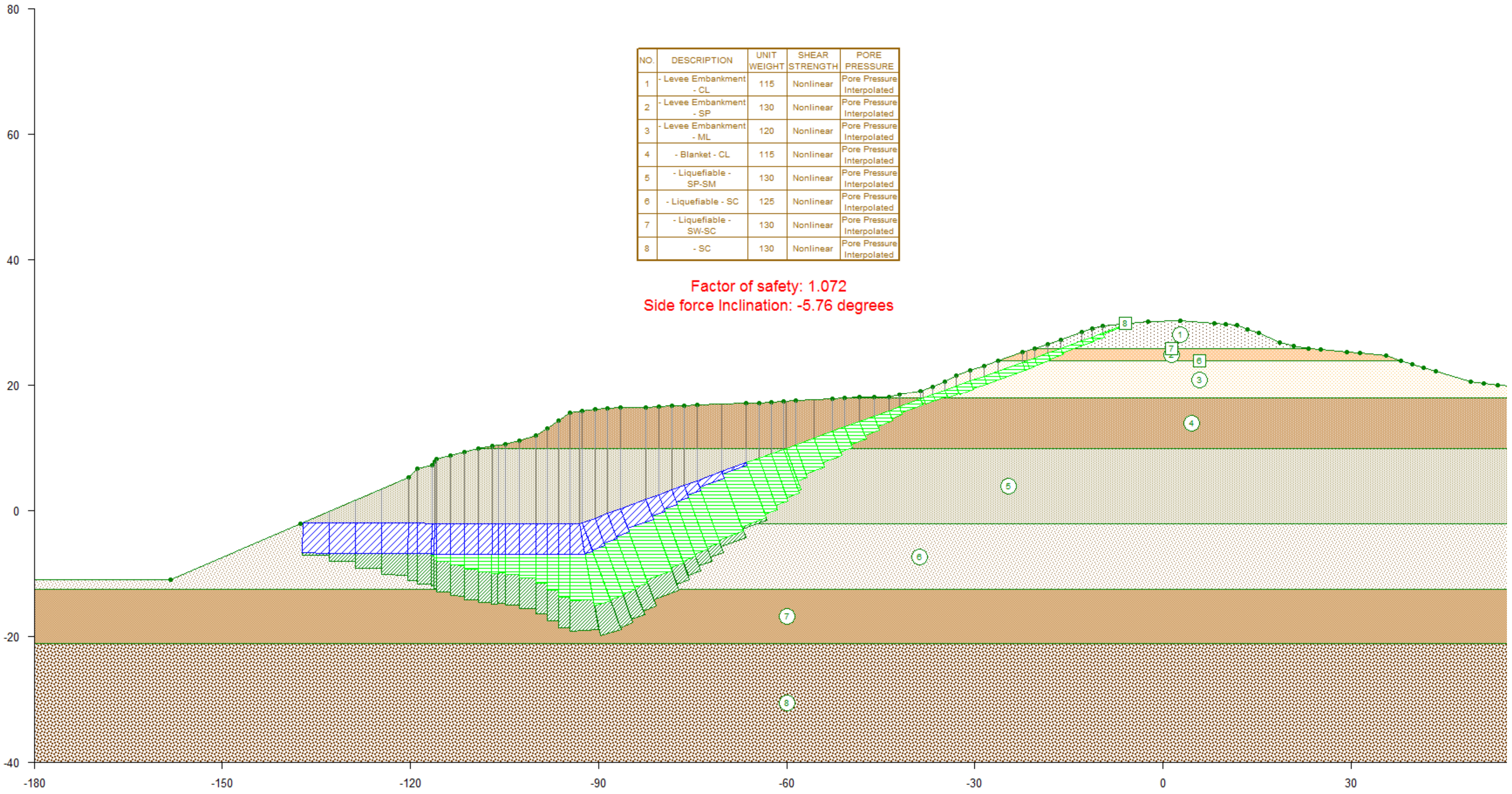
Fig F-5(b). RD 17 Station 1595+33 – Waterside – Option 1: Circular (PHI = 3.9 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SP	130	Nonlinear	Pore Pressure Interpolated
3	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
4	- Blanket - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Liquefiable - SP-SM	130	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable - SW-SC	130	Nonlinear	Pore Pressure Interpolated
8	- SC	130	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.190
Side force Inclination: -0.36 degrees

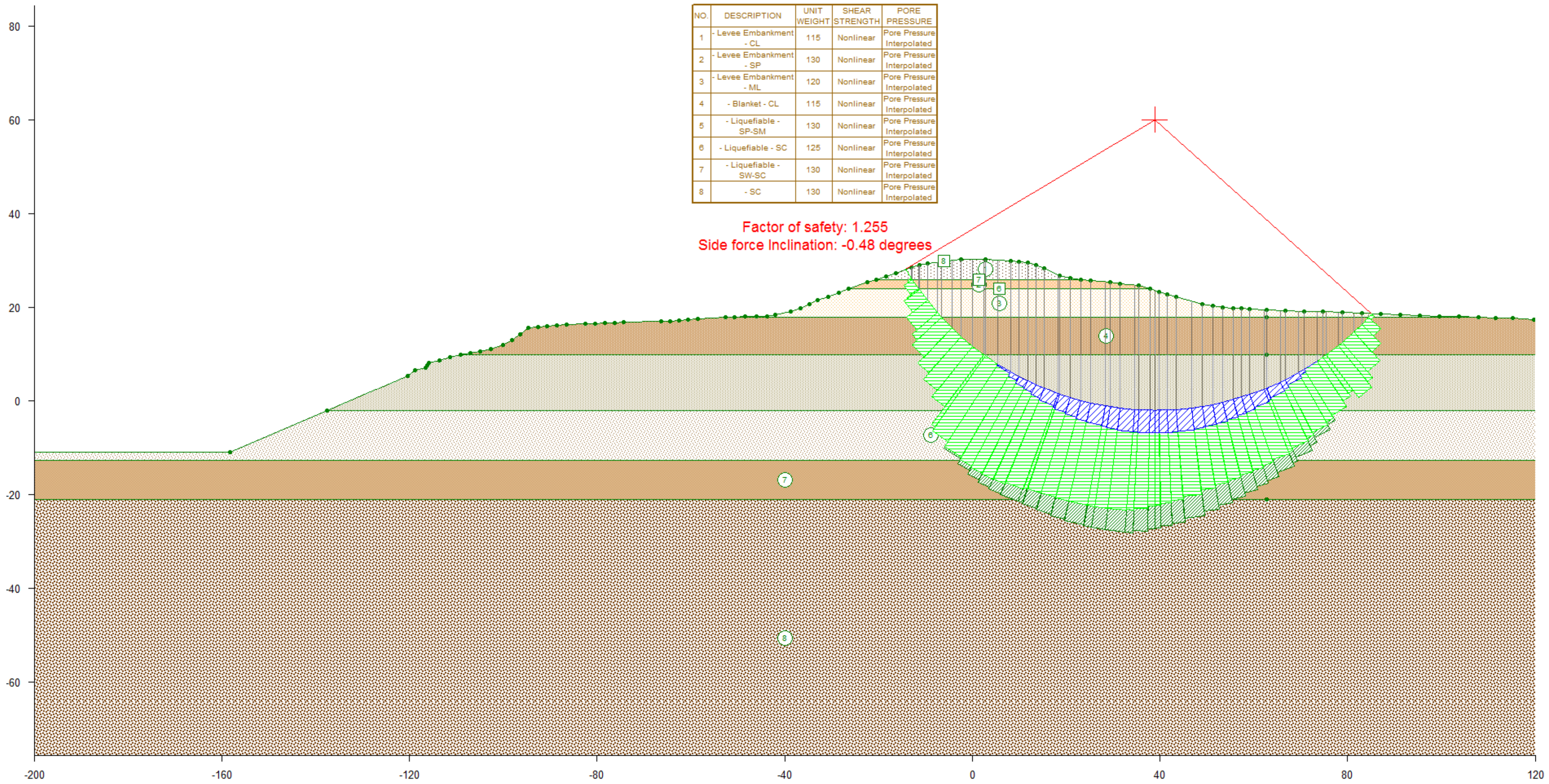
Fig F-6(a). RD 17 Southern, Station 1595+33 – Waterside – Option 2: Wedges (Sr = 133 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SP	130	Nonlinear	Pore Pressure Interpolated
3	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
4	- Blanket - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Liquefiable - SP-SM	130	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable - SW-SC	130	Nonlinear	Pore Pressure Interpolated
8	- SC	130	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.072
Side force Inclination: -5.76 degrees

Fig F-6(b). RD 17 Station 1595+33 – Waterside – Option 2: Wedges (PHI = 3.9 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SP	130	Nonlinear	Pore Pressure Interpolated
3	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
4	- Blanket - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Liquefiable - SP-SM	130	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable - SW-SC	130	Nonlinear	Pore Pressure Interpolated
8	- SC	130	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.255
Side force Inclination: -0.48 degrees

Fig F-7(a). RD 17 Southern, Station 1595+33 – Landside – Option 3: Circular (Sr = 133 psf in liquefiable material)

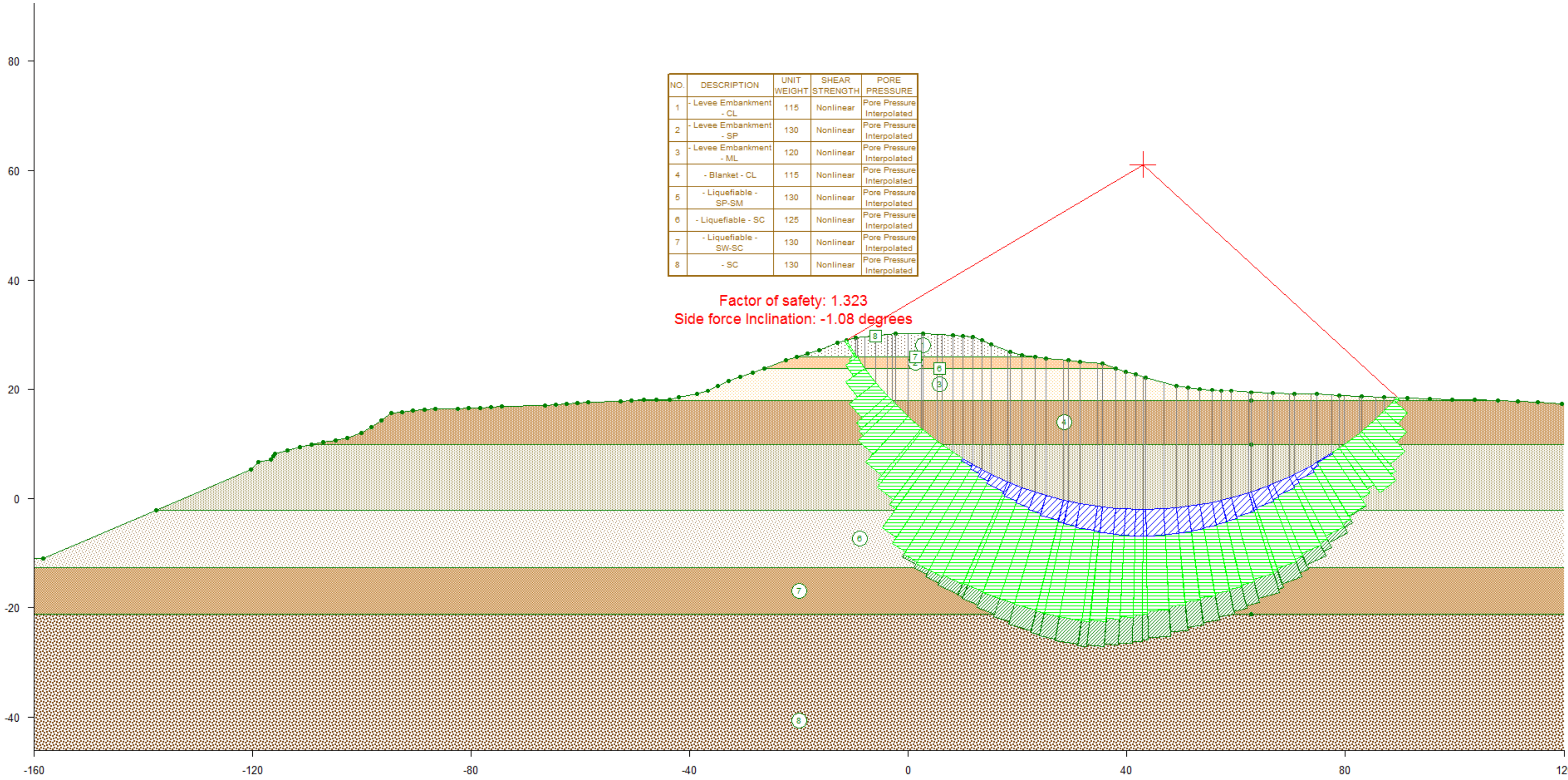
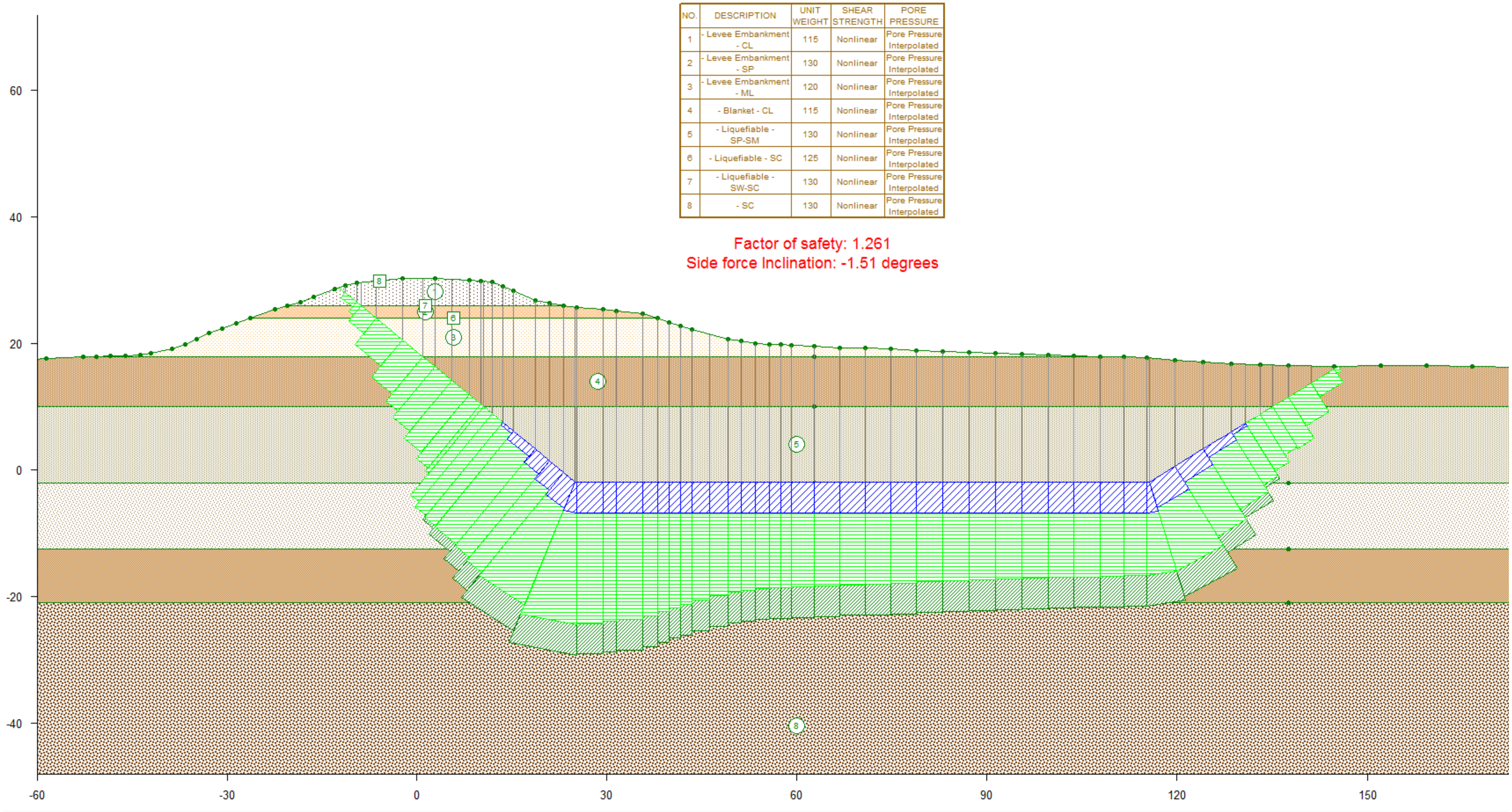
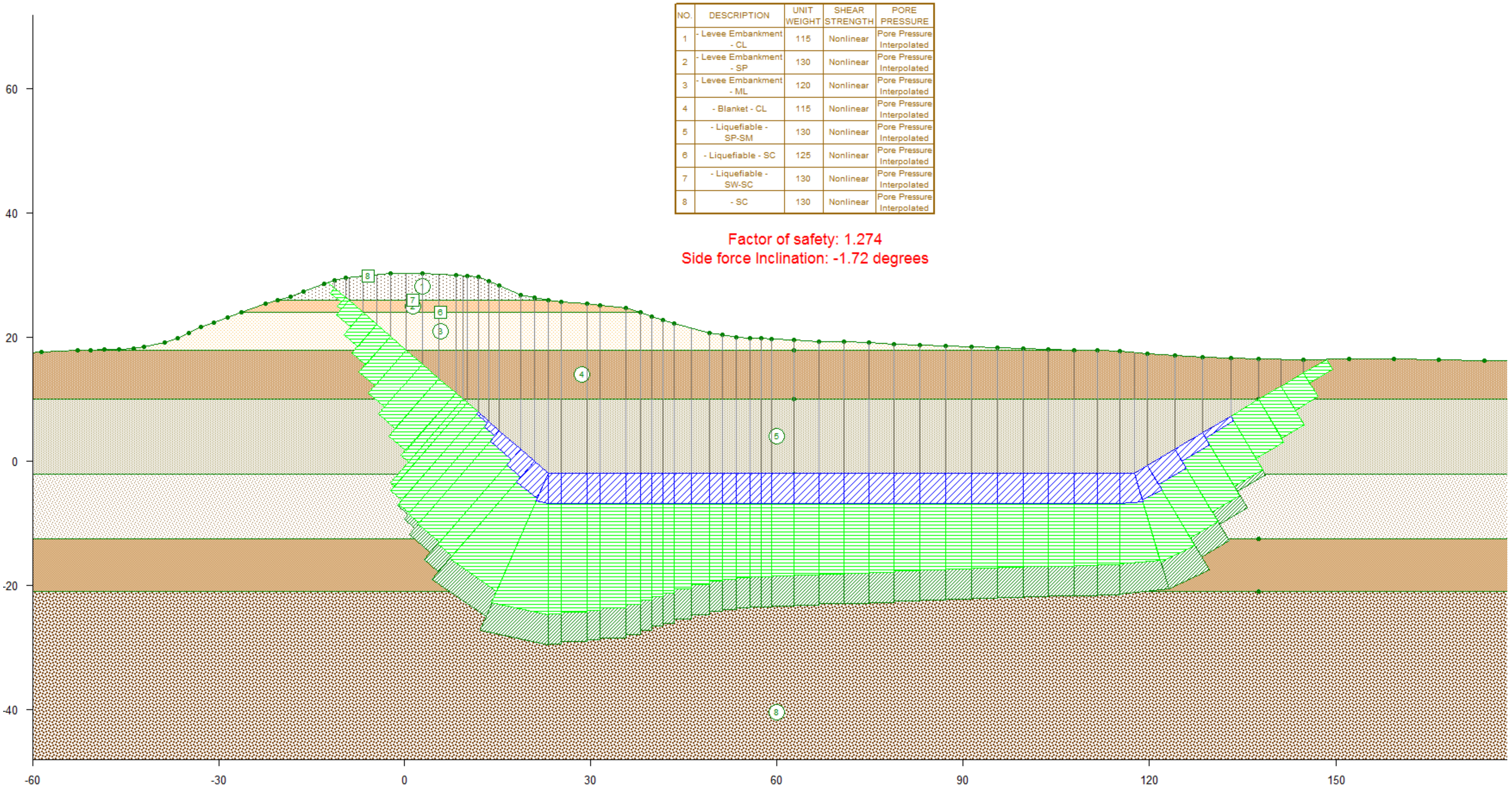


Fig F-(7). RD 17 Station 1595+33 – Landside – Option 3: Circular (PHI = 3.9 in liquefiable material)



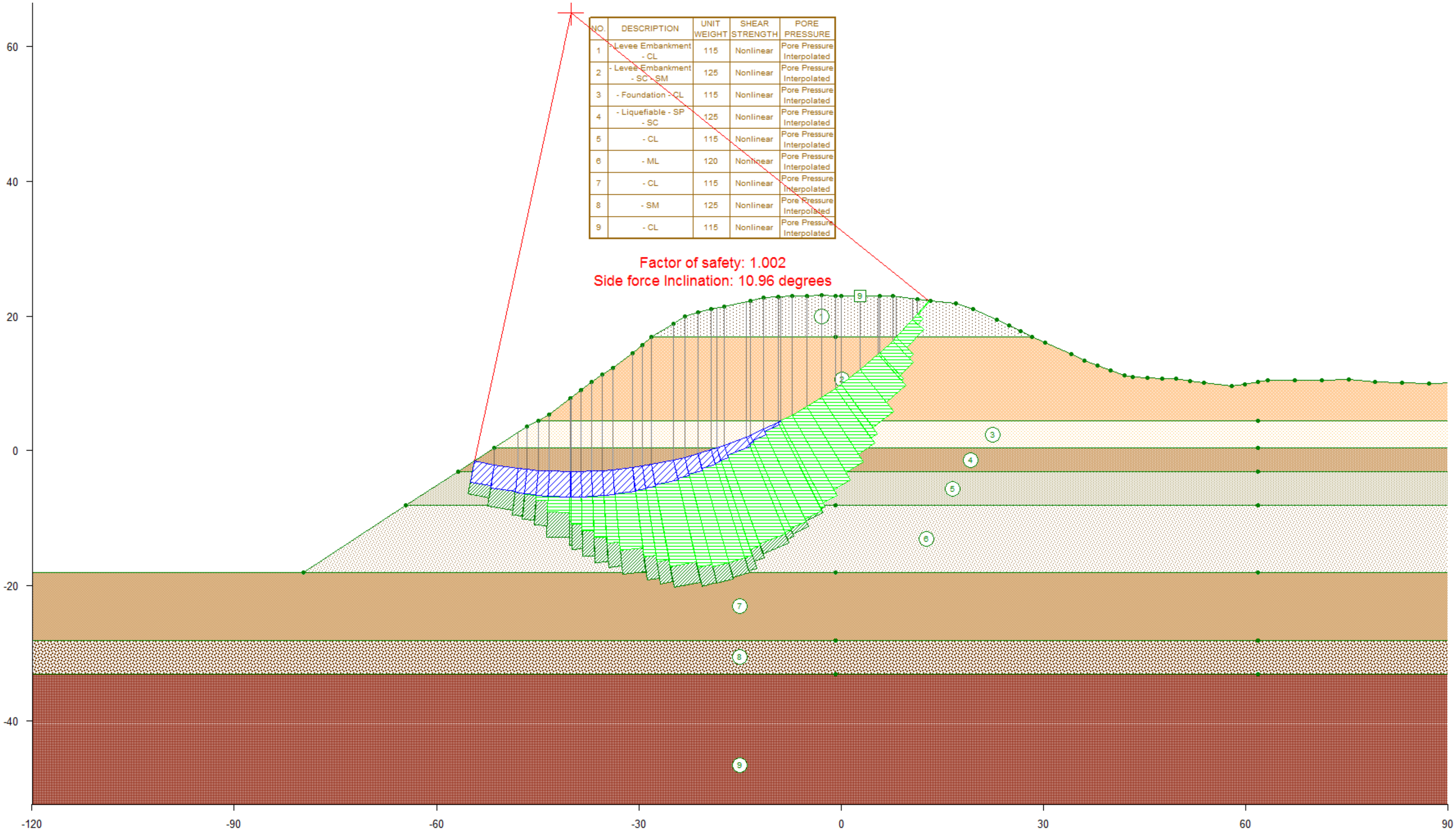
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SP	130	Nonlinear	Pore Pressure Interpolated
3	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
4	- Blanket - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Liquefiable - SP-SM	130	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable - SW-SC	130	Nonlinear	Pore Pressure Interpolated
8	- SC	130	Nonlinear	Pore Pressure Interpolated

Fig F-8(a). RD 17 Southern, Station 1595+33 – Landside – Option 4: Wedge (Sr = 133 psf in liquefiable material)



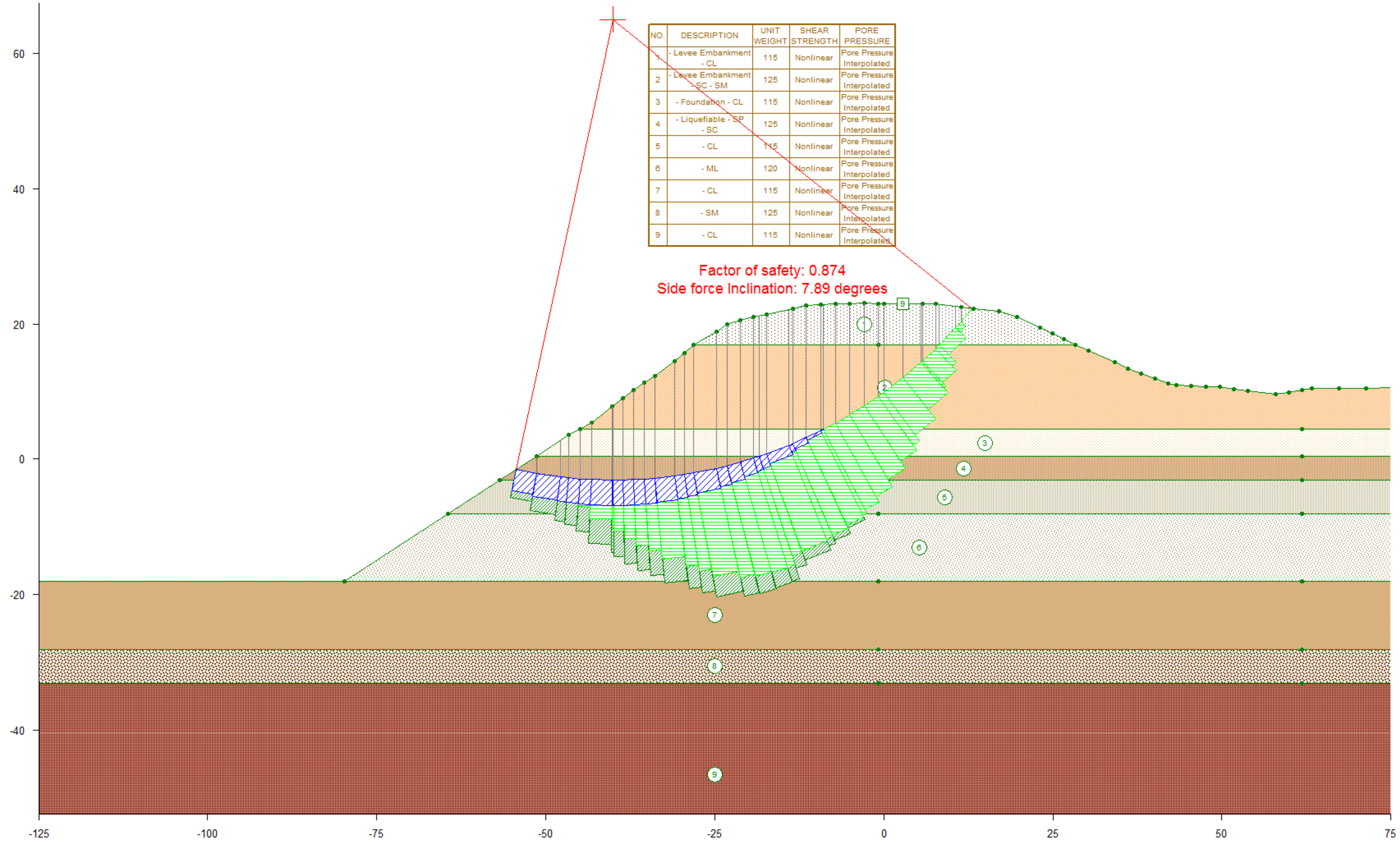
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SP	130	Nonlinear	Pore Pressure Interpolated
3	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
4	- Blanket - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Liquefiable - SP-SM	130	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable - SW-SC	130	Nonlinear	Pore Pressure Interpolated
8	- SC	130	Nonlinear	Pore Pressure Interpolated

Fig F-8(b). RD 17 Station 1595+33 – Landside – Option 4: Wedge (PHI = 3.9 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SC - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP - SC	125	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- ML	120	Nonlinear	Pore Pressure Interpolated
7	- CL	115	Nonlinear	Pore Pressure Interpolated
8	- SM	125	Nonlinear	Pore Pressure Interpolated
9	- CL	115	Nonlinear	Pore Pressure Interpolated

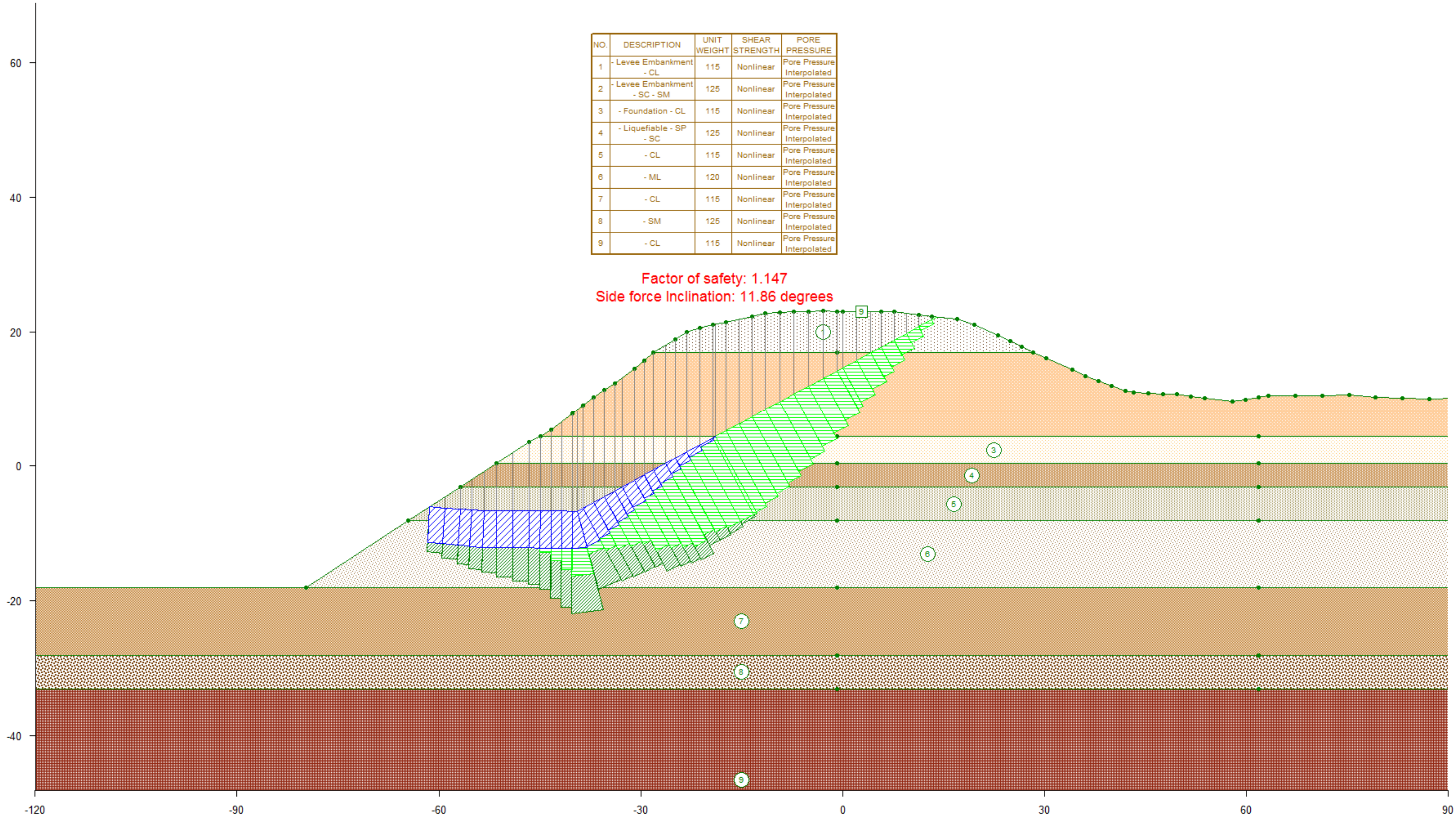
Fig F-9(a). RD 17 Northern, Station 1151+06 – Waterside – Option 1: Circular (Sr = 201 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SC - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP - SC	125	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- ML	120	Nonlinear	Pore Pressure Interpolated
7	- CL	115	Nonlinear	Pore Pressure Interpolated
8	- SM	125	Nonlinear	Pore Pressure Interpolated
9	- CL	115	Nonlinear	Pore Pressure Interpolated

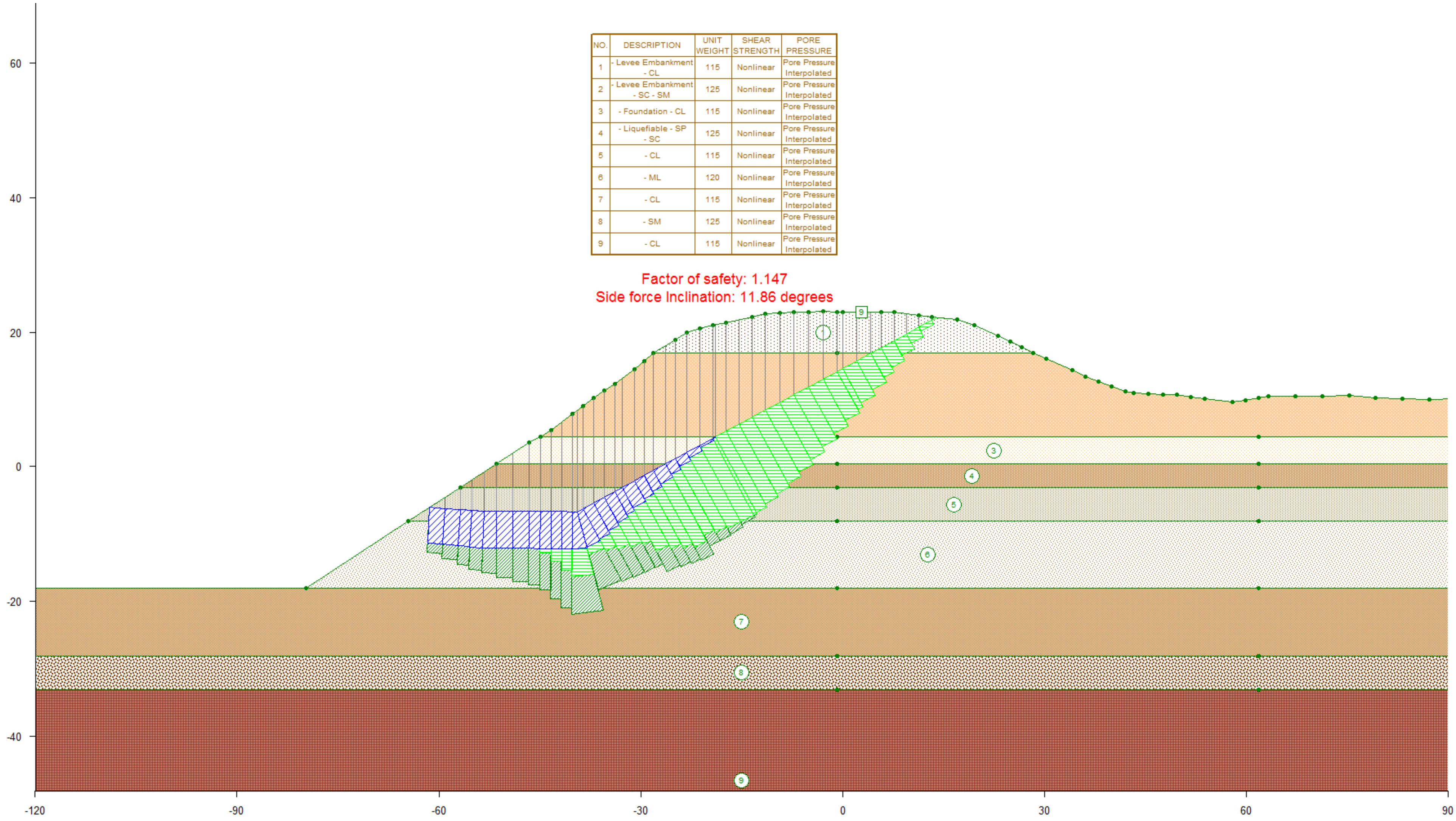
Factor of safety: 0.874
Side force Inclination: 7.89 degrees

Fig F-9(b). RD 17 Station 1151+06 – Waterside – Option 1: Circular (PHI = 5.2 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SC - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP - SC	125	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- ML	120	Nonlinear	Pore Pressure Interpolated
7	- CL	115	Nonlinear	Pore Pressure Interpolated
8	- SM	125	Nonlinear	Pore Pressure Interpolated
9	- CL	115	Nonlinear	Pore Pressure Interpolated

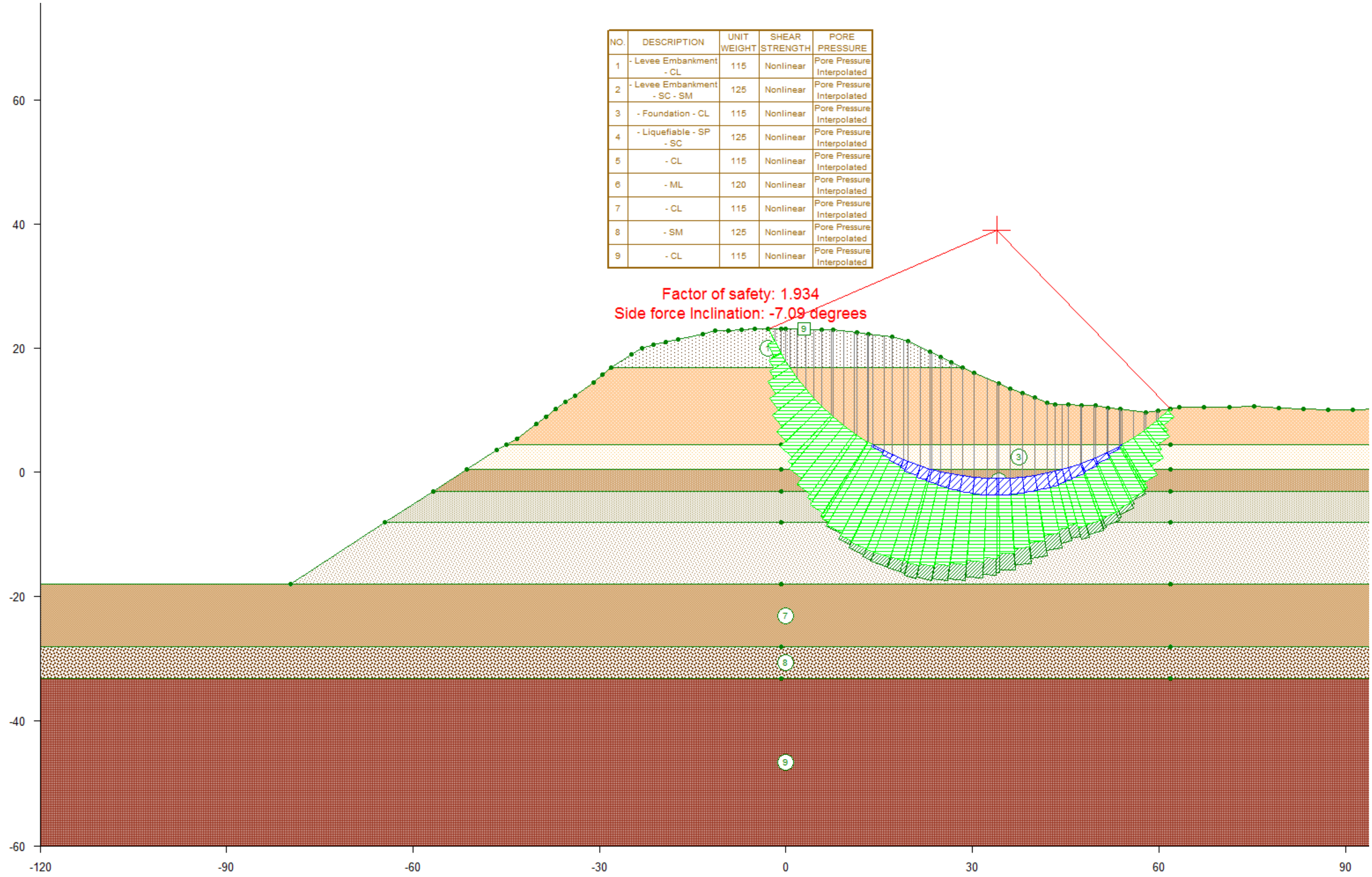
Fig F-10(a). RD 17 Northern, Station 1151+06– Waterside – Option 2: Wedges (Sr = 201 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SC - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP - SC	125	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- ML	120	Nonlinear	Pore Pressure Interpolated
7	- CL	115	Nonlinear	Pore Pressure Interpolated
8	- SM	125	Nonlinear	Pore Pressure Interpolated
9	- CL	115	Nonlinear	Pore Pressure Interpolated

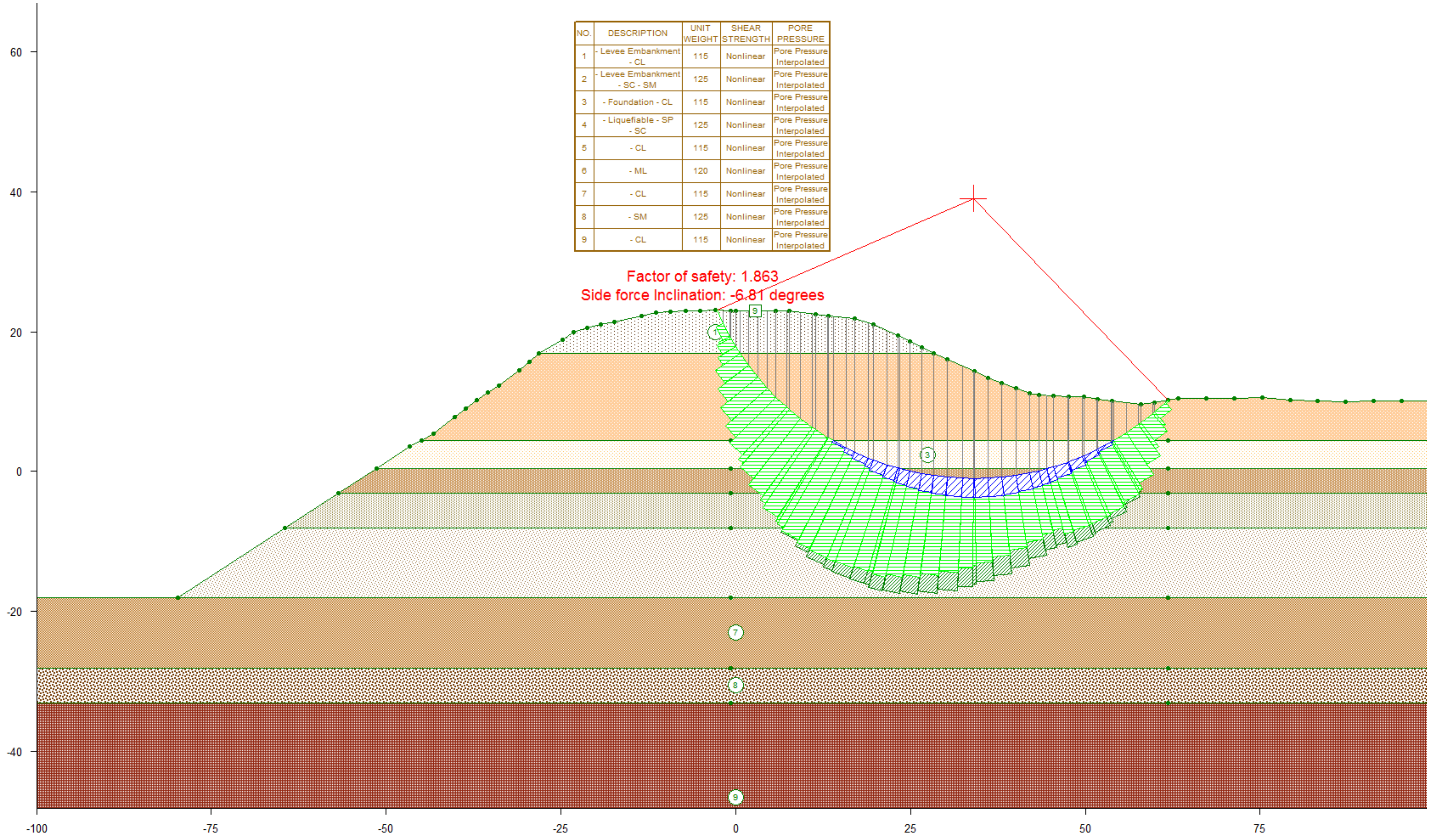
Factor of safety: 1.147
Side force Inclination: 11.86 degrees

Fig F-10(b). RD 17 Station 1151+06 – Waterside – Option 2: Wedges (PHI = 5.2 in liquefiable material)



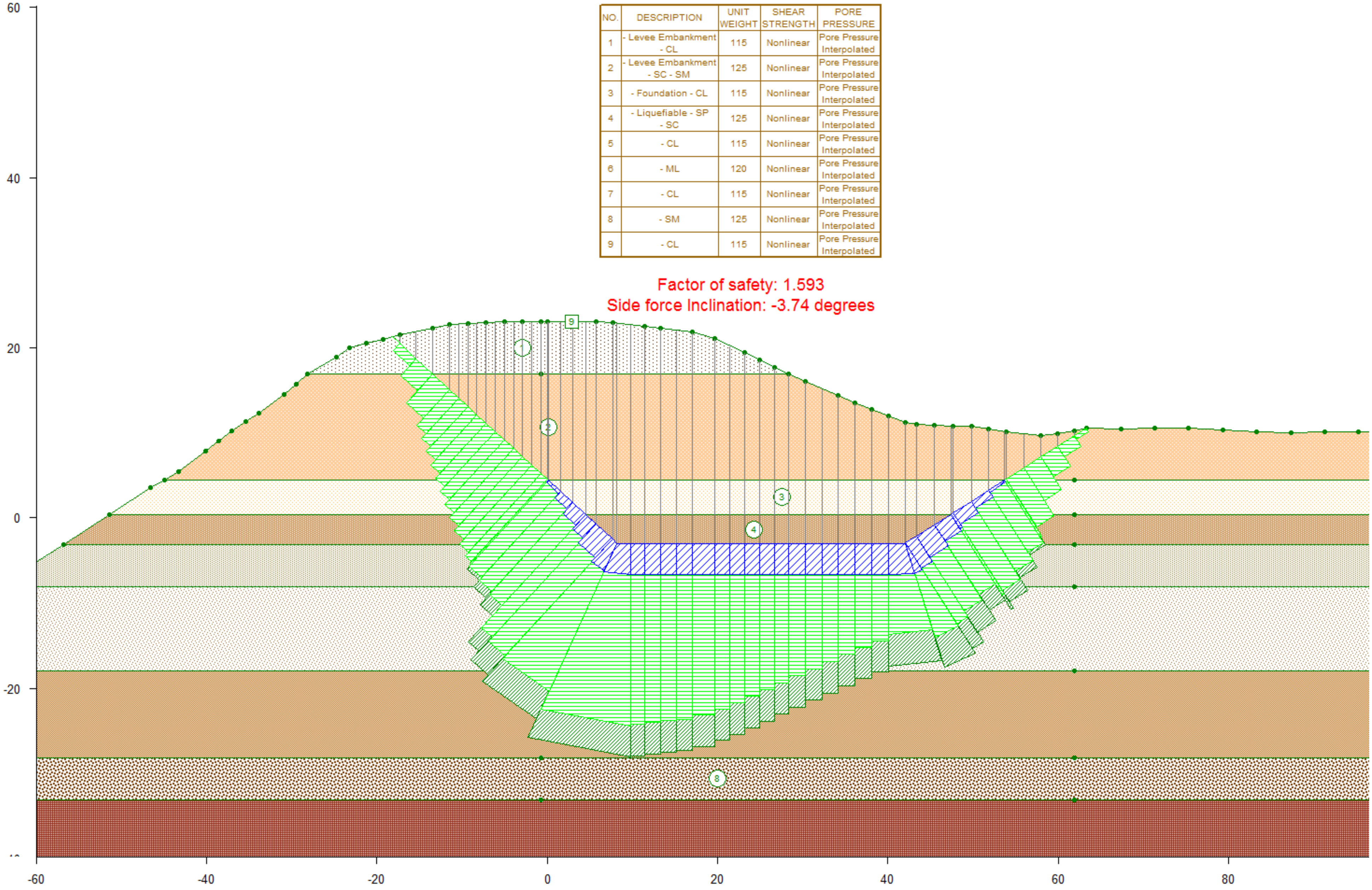
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SC - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP - SC	125	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- ML	120	Nonlinear	Pore Pressure Interpolated
7	- CL	115	Nonlinear	Pore Pressure Interpolated
8	- SM	125	Nonlinear	Pore Pressure Interpolated
9	- CL	115	Nonlinear	Pore Pressure Interpolated

Fig F-11(a). RD 17 Northern, Station 1151+06– Landside – Option 3: Circular (Sr = 201 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SC - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP - SC	125	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- ML	120	Nonlinear	Pore Pressure Interpolated
7	- CL	115	Nonlinear	Pore Pressure Interpolated
8	- SM	125	Nonlinear	Pore Pressure Interpolated
9	- CL	115	Nonlinear	Pore Pressure Interpolated

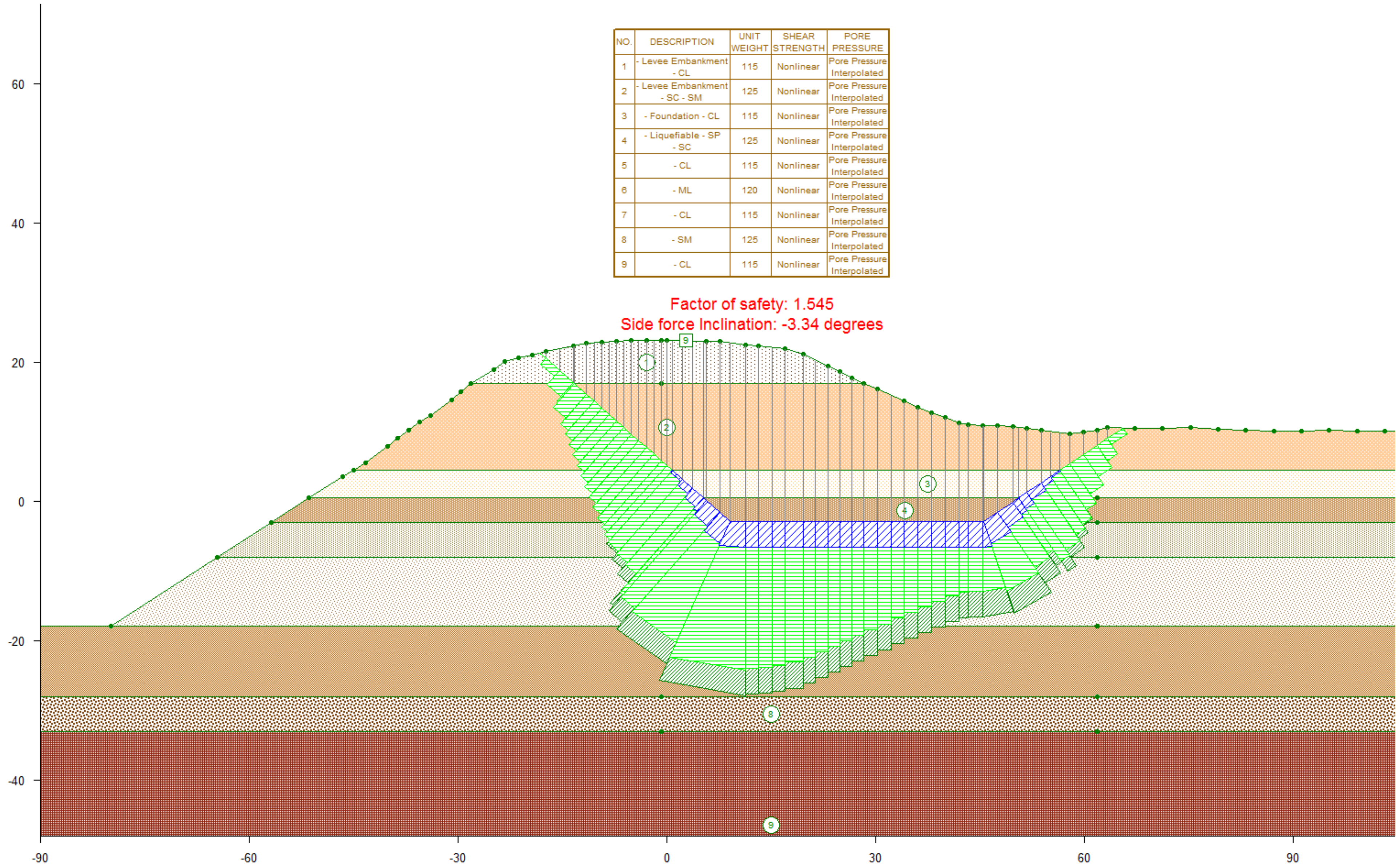
Fig F-11(b). RD 17 Station 1151+06 – Landside – Option 3: Circular (PHI = 5.2 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SC - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP - SC	125	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- ML	120	Nonlinear	Pore Pressure Interpolated
7	- CL	115	Nonlinear	Pore Pressure Interpolated
8	- SM	125	Nonlinear	Pore Pressure Interpolated
9	- CL	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.593
Side force Inclination: -3.74 degrees

Fig F-12(a). RD 17 Northern, Station 1151+06– Landside – Option 4: Wedge (Sr = 201 psf in liquefiable material)

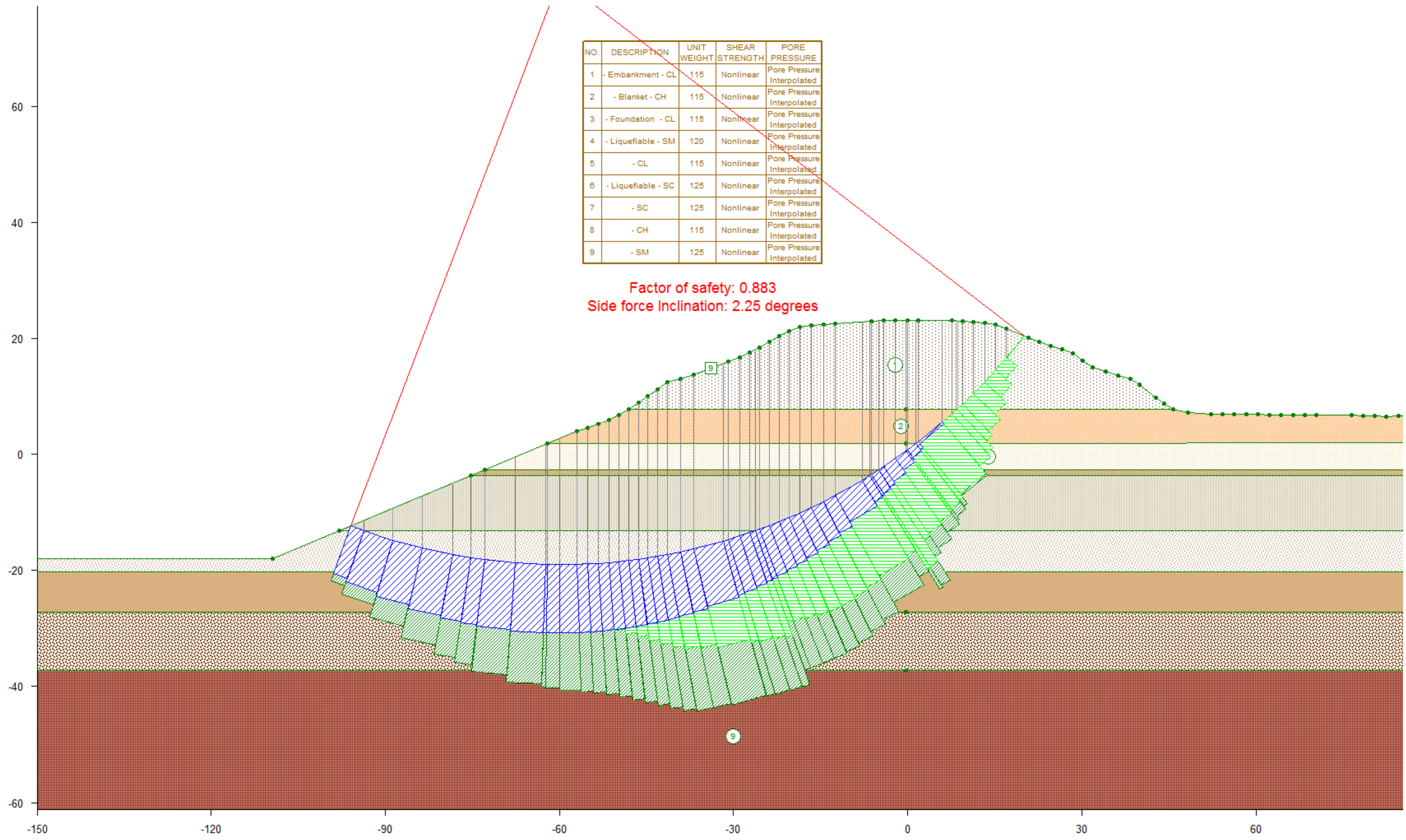


NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Levee Embankment - SC - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP - SC	125	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- ML	120	Nonlinear	Pore Pressure Interpolated
7	- CL	115	Nonlinear	Pore Pressure Interpolated
8	- SM	125	Nonlinear	Pore Pressure Interpolated
9	- CL	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.545

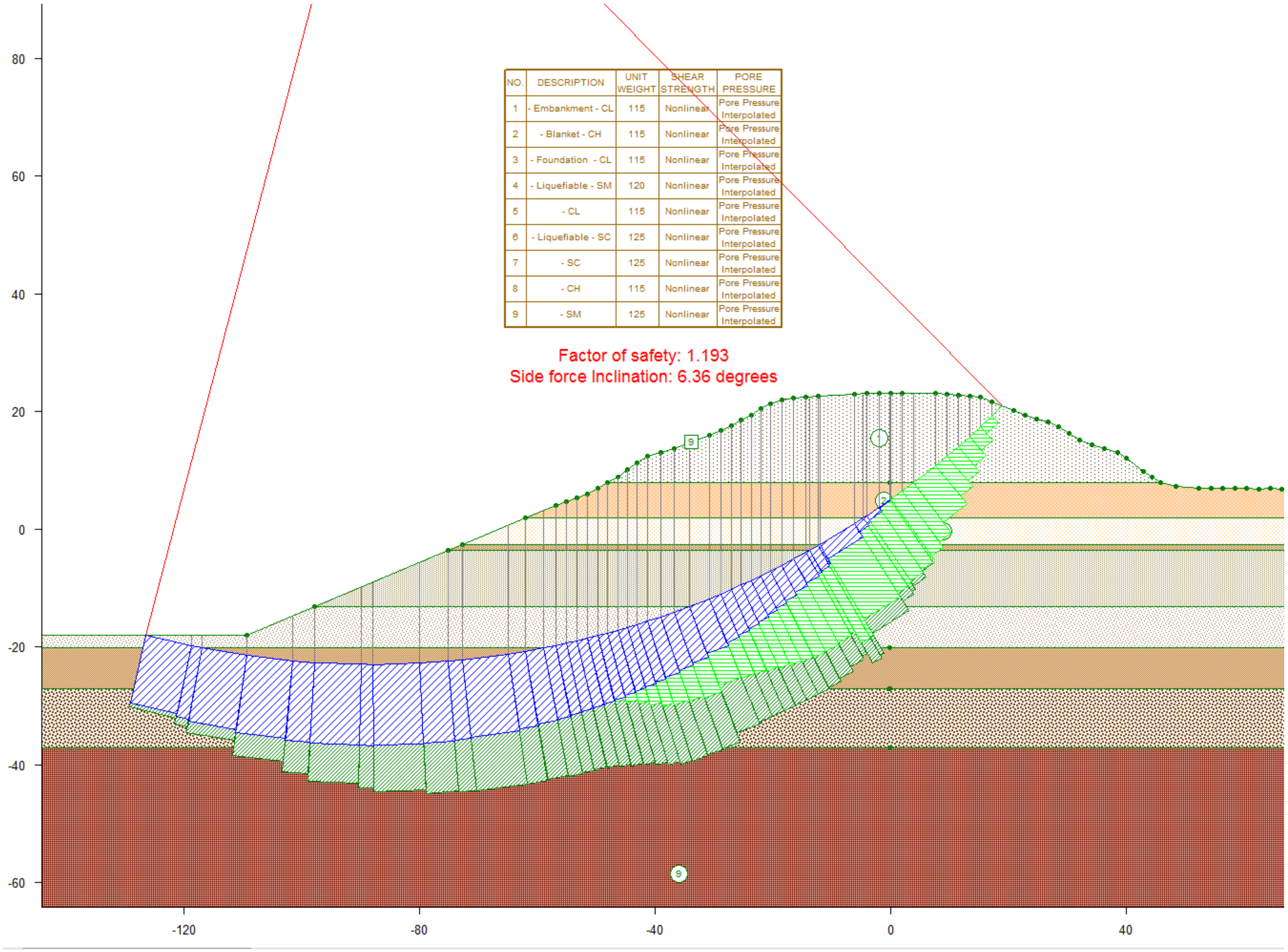
Side force Inclination: -3.34 degrees

Fig F-12(b). RD 17 Northern, Station 1151+06– Landside – Option 4: Wedge (PHI = 5.2 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SM	120	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- SC	125	Nonlinear	Pore Pressure Interpolated
8	- CH	115	Nonlinear	Pore Pressure Interpolated
9	- SM	125	Nonlinear	Pore Pressure Interpolated

Fig F-13(a). RD 17 Northern, Station 1191+43 – Waterside – Option 1: Circular (Sr = 164 & 111 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SM	120	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- SC	125	Nonlinear	Pore Pressure Interpolated
8	- CH	115	Nonlinear	Pore Pressure Interpolated
9	- SM	125	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.193
Side force Inclination: 6.36 degrees

Fig F-13(b). RD 17 Station 1191+43 – Waterside – Option 1: Circular (PHI = 4.3 & 2.7 in liquefiable materials)

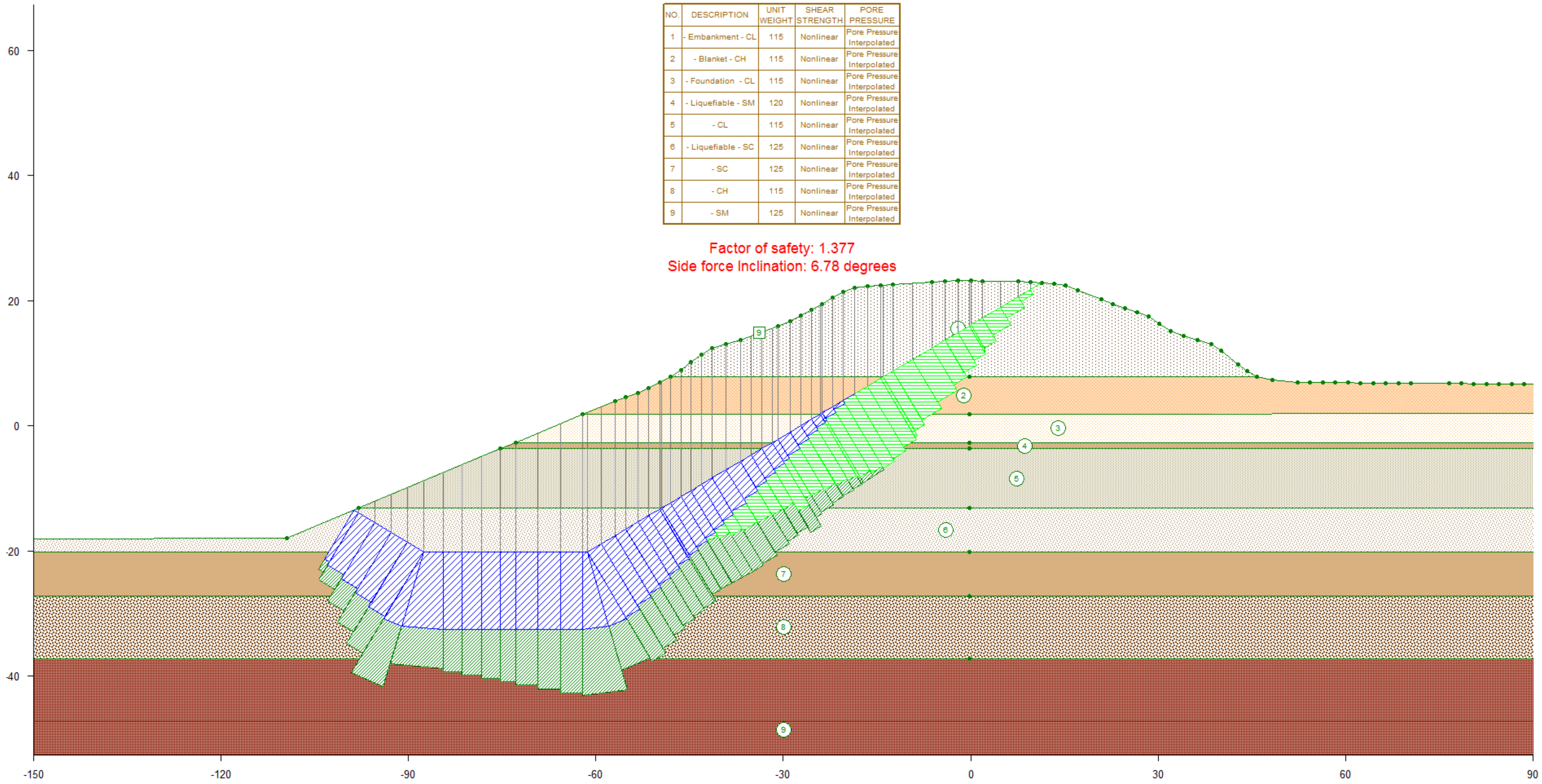
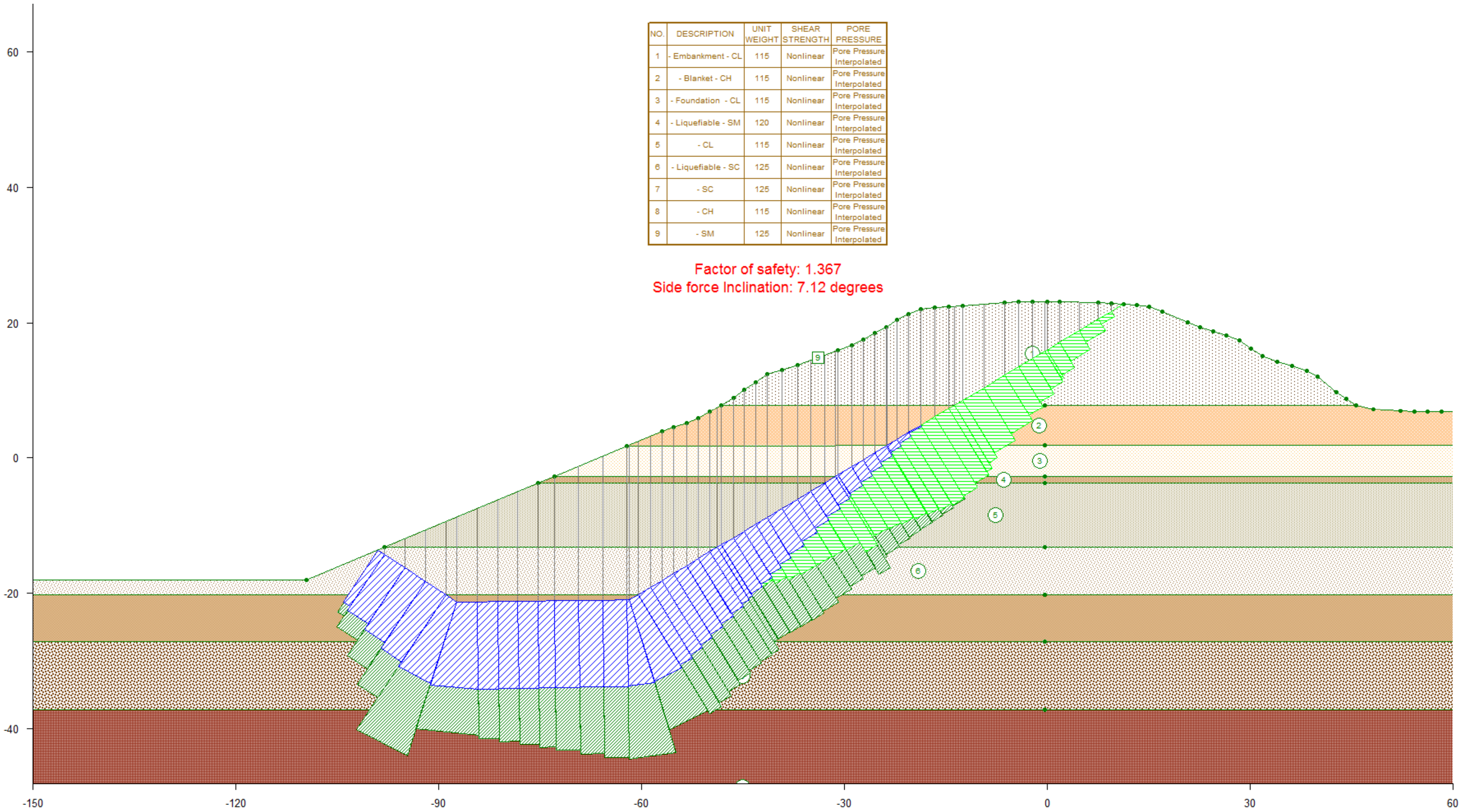


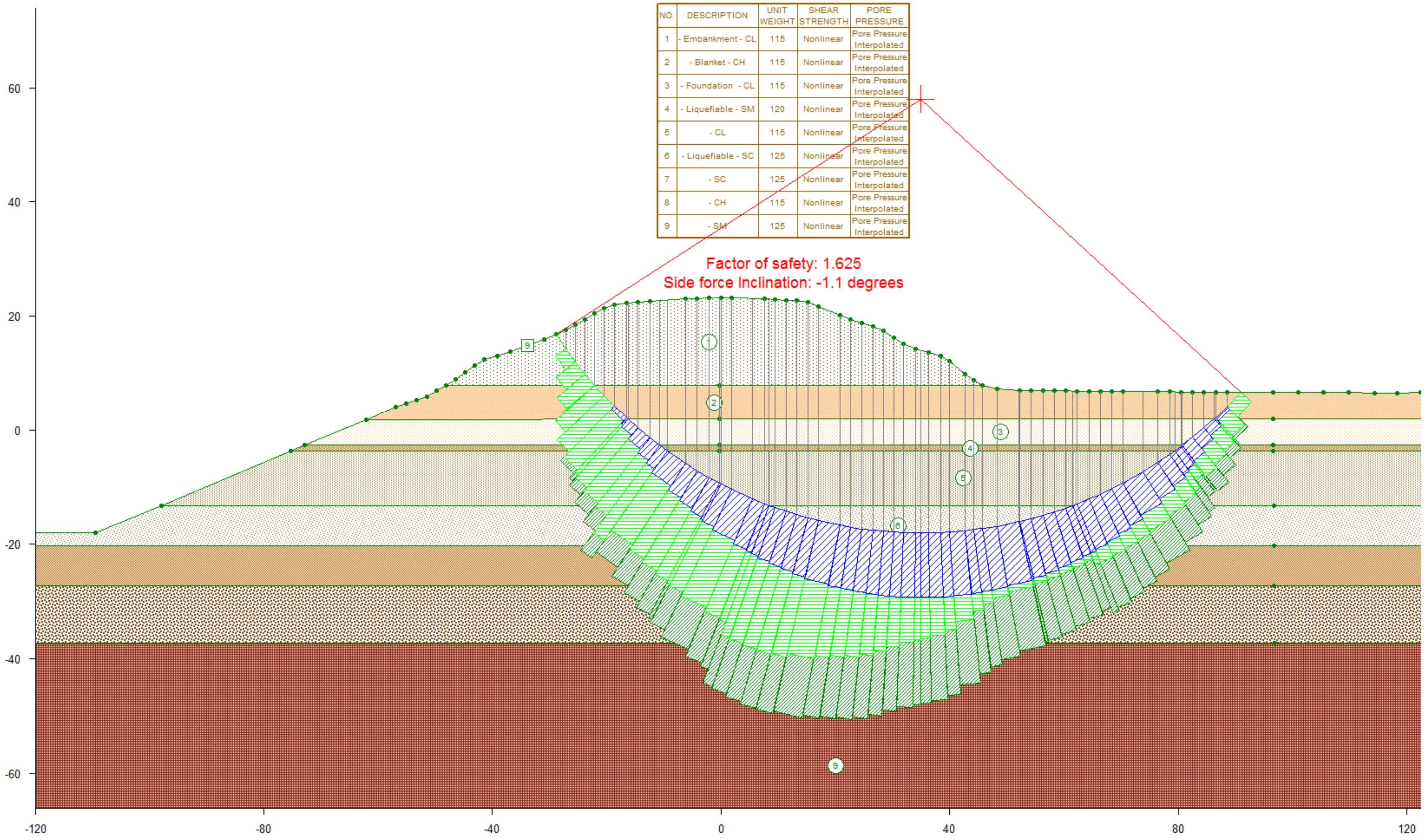
Fig F-14(a). RD 17 Northern, Station 1191+43– Waterside – Option 2: Wedges (Sr = 164 & 111 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SM	120	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- SC	125	Nonlinear	Pore Pressure Interpolated
8	- CH	115	Nonlinear	Pore Pressure Interpolated
9	- SM	125	Nonlinear	Pore Pressure Interpolated

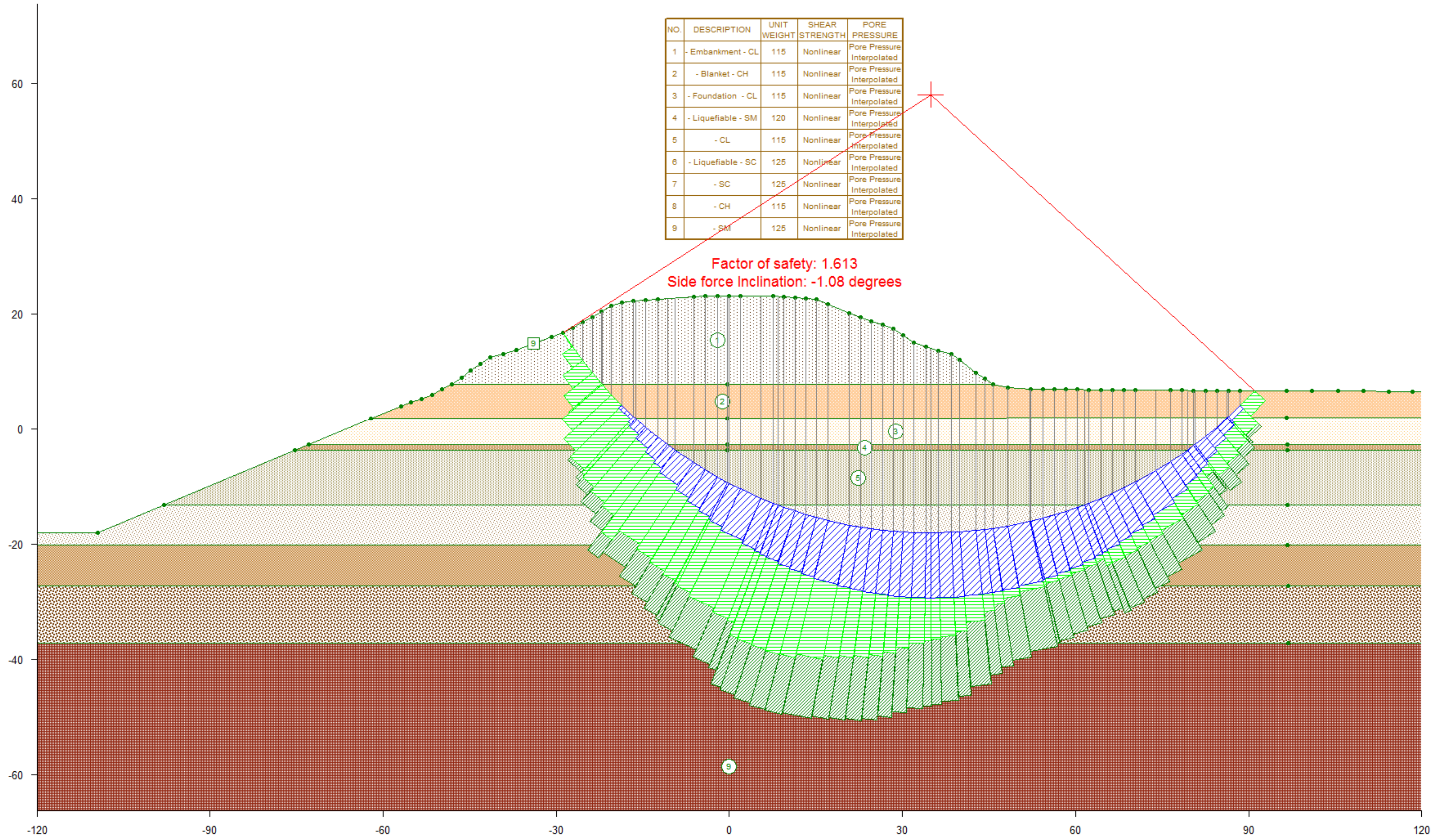
Factor of safety: 1.367
Side force Inclination: 7.12 degrees

Fig F-14(b). RD 17 Station 1191+43– Waterside – Option 2: Wedges (PHI = 4.3 & 2.7 in liquefiable materials)



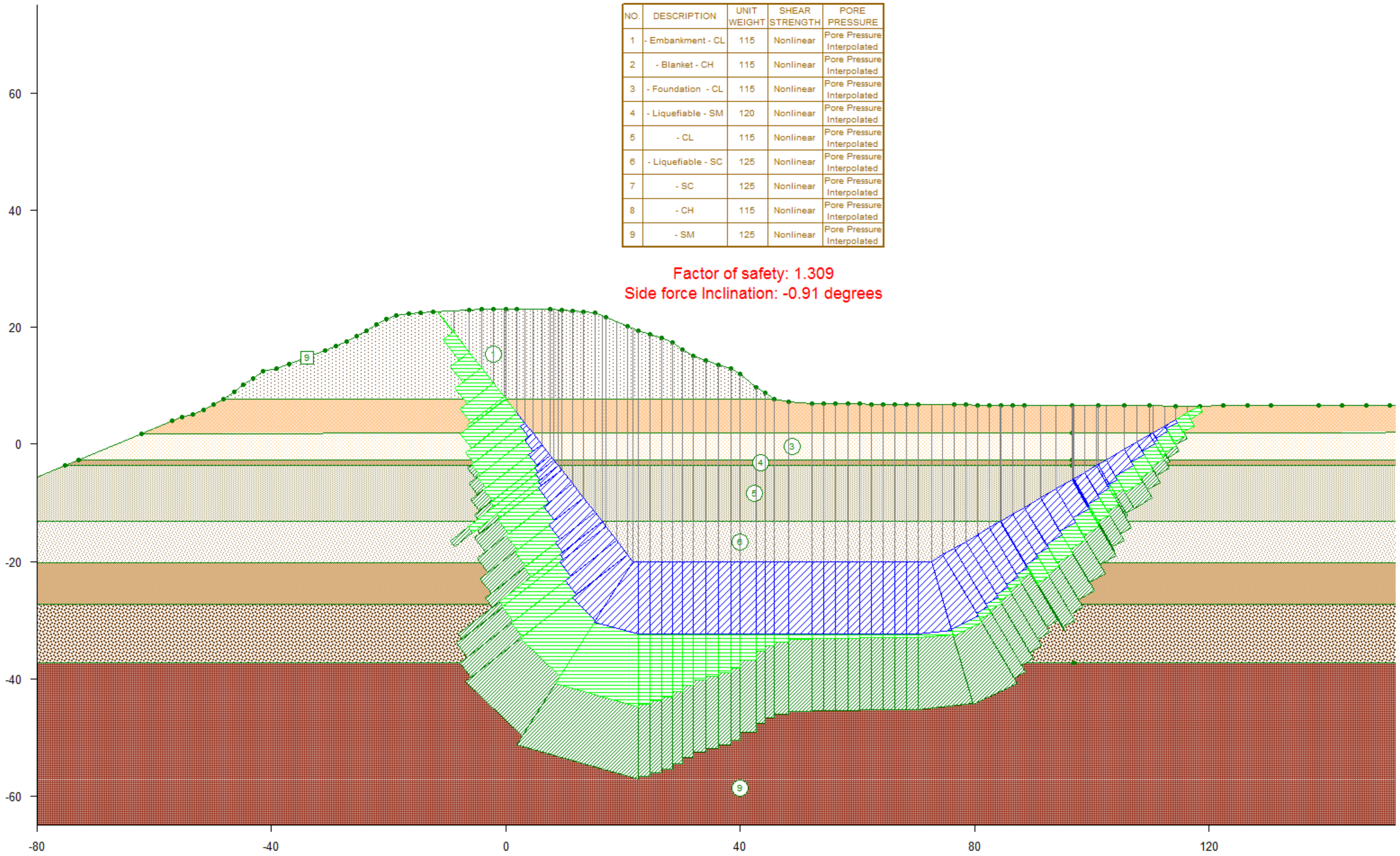
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SM	120	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- SC	125	Nonlinear	Pore Pressure Interpolated
8	- CH	115	Nonlinear	Pore Pressure Interpolated
9	- SM	125	Nonlinear	Pore Pressure Interpolated

Fig F-15(a). RD 17 Northern, Station 1191+43 – Landside – Option 3: Circular (Sr = 164 & 111 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SM	120	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- SC	125	Nonlinear	Pore Pressure Interpolated
8	- CH	115	Nonlinear	Pore Pressure Interpolated
9	- SM	125	Nonlinear	Pore Pressure Interpolated

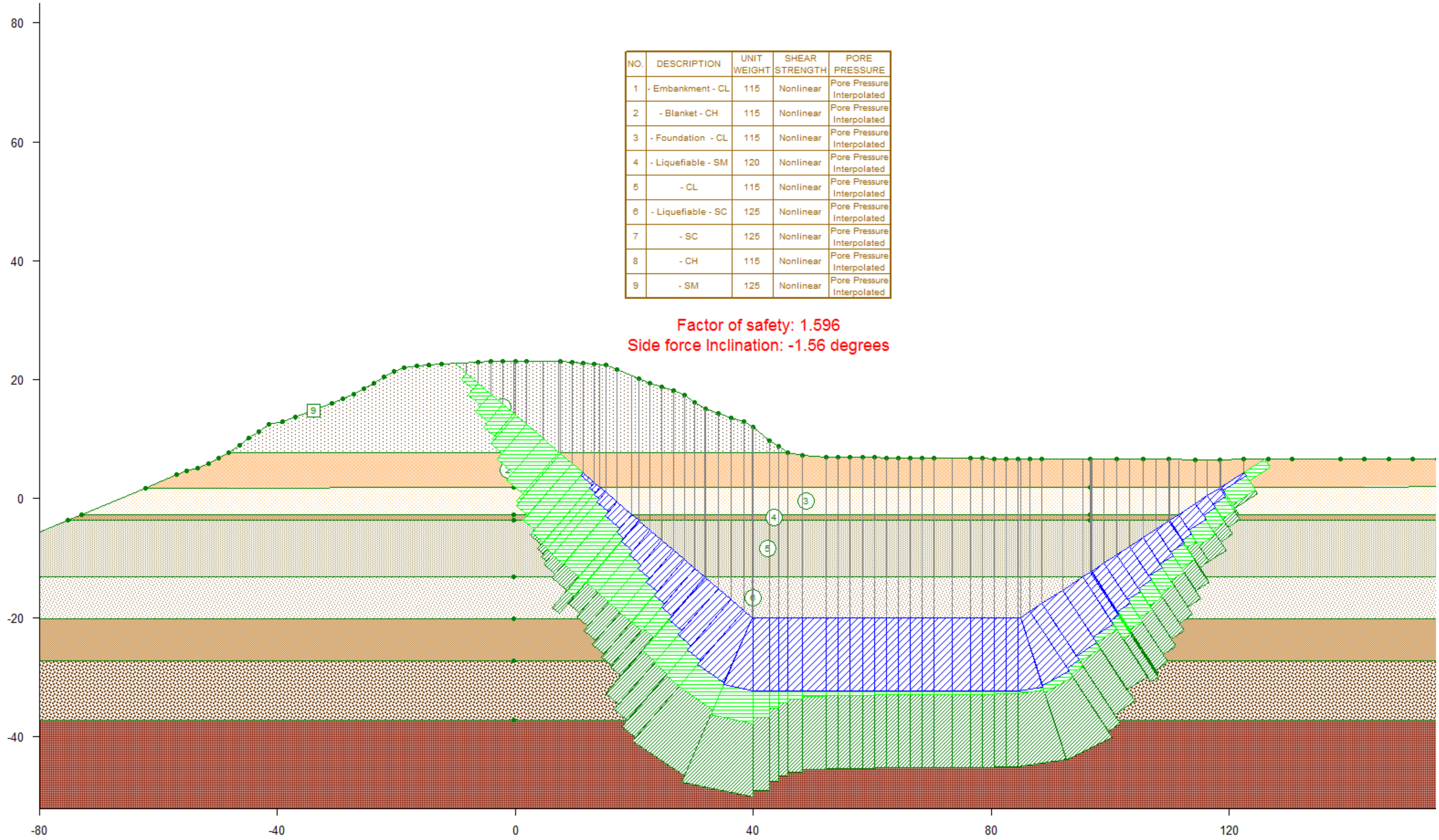
Fig F-15(b). RD 17 Station 1191+43 – Landside – Option 3: Circular (PHI = 4.3 & 2.7 in liquefiable materials)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SM	120	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- SC	125	Nonlinear	Pore Pressure Interpolated
8	- CH	115	Nonlinear	Pore Pressure Interpolated
9	- SM	125	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.309
Side force Inclination: -0.91 degrees

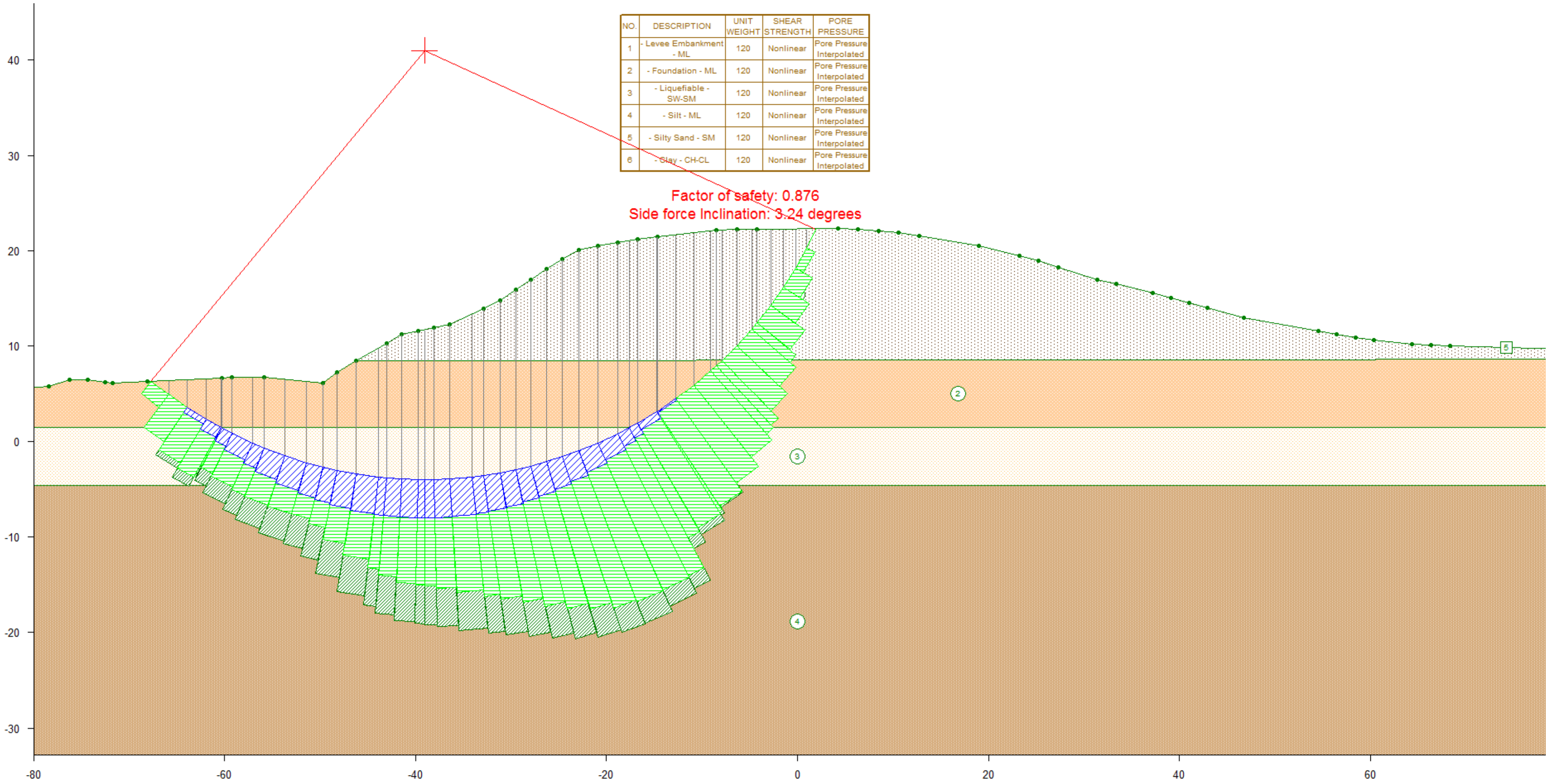
Fig F-16(a). RD 17 Northern, Station 1191+43 – Landside – Option 4: Wedge (Sr = 164 & 111 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Foundation - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SM	120	Nonlinear	Pore Pressure Interpolated
5	- CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable - SC	125	Nonlinear	Pore Pressure Interpolated
7	- SC	125	Nonlinear	Pore Pressure Interpolated
8	- CH	115	Nonlinear	Pore Pressure Interpolated
9	- SM	125	Nonlinear	Pore Pressure Interpolated

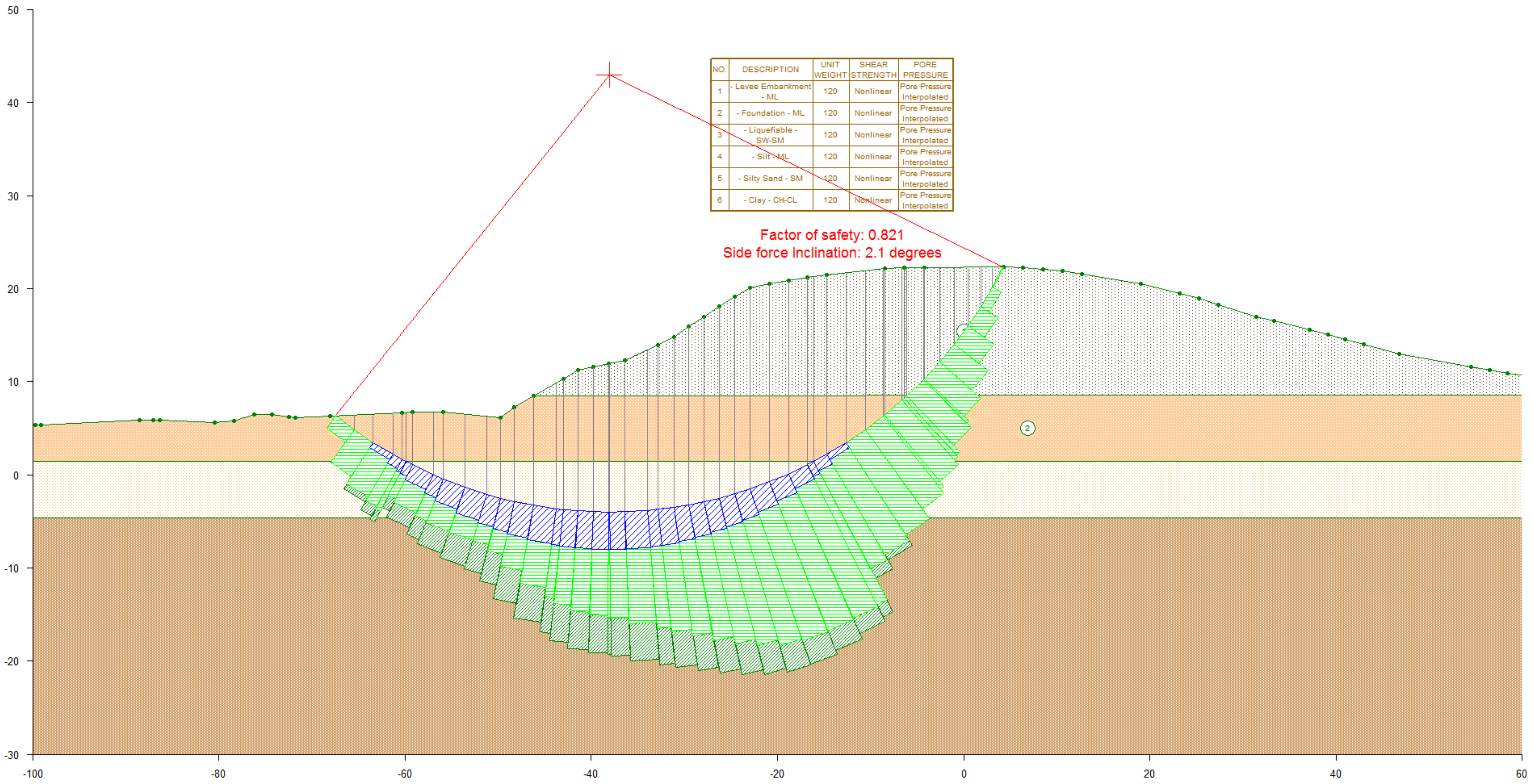
Factor of safety: 1.596
Side force Inclination: -1.56 degrees

Fig F-16(b). RD 17 Station 1191+43 – Landside – Option 4: Wedge (PHI = 4.3 & 2.7 in liquefiable materials)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable - SW-SM	120	Nonlinear	Pore Pressure Interpolated
4	- Silt - ML	120	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	120	Nonlinear	Pore Pressure Interpolated
6	- Clay - CH-CL	120	Nonlinear	Pore Pressure Interpolated

Fig F-17(a). RD 404 Station 1175+01 – Waterside – Option 1: Circular (Sr = 113 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable - SW-SM	120	Nonlinear	Pore Pressure Interpolated
4	- Silt - ML	120	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	120	Nonlinear	Pore Pressure Interpolated
6	- Clay - CH-CL	120	Nonlinear	Pore Pressure Interpolated

Fig F-17(b). RD 404 Station 1175+01 – Waterside – Option 1: Circular (PHI = 3.6 in liquefiable material)

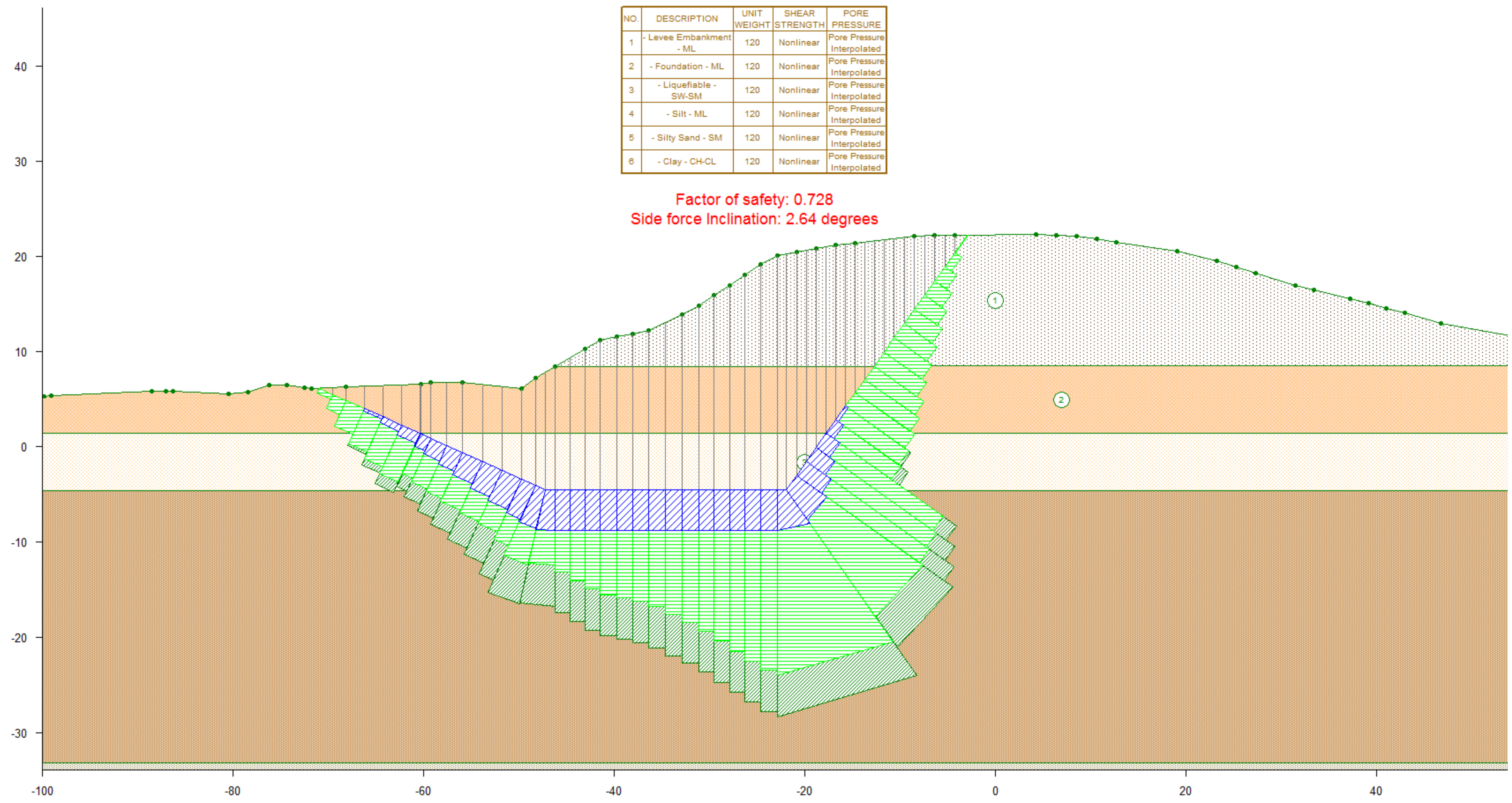
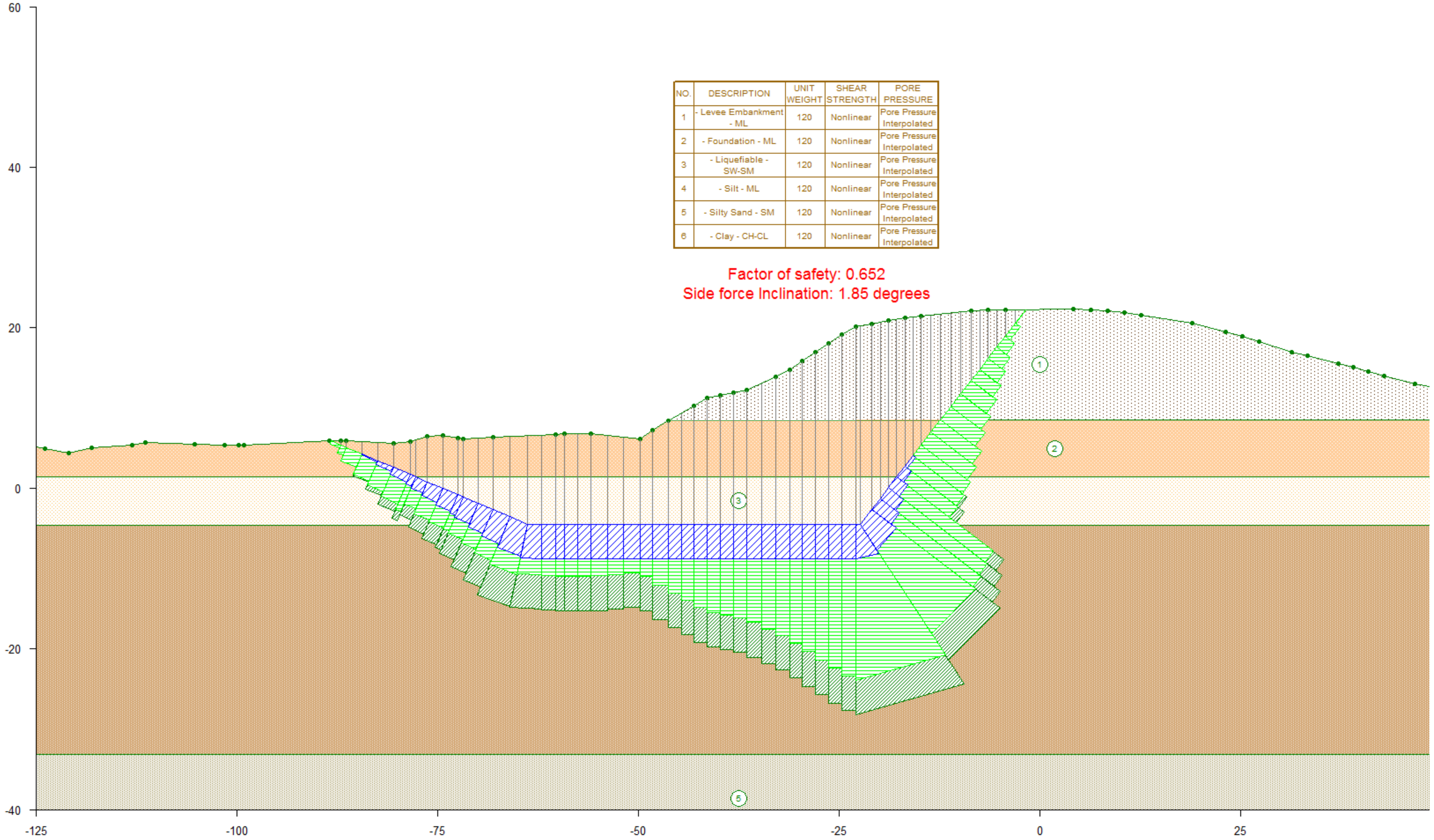


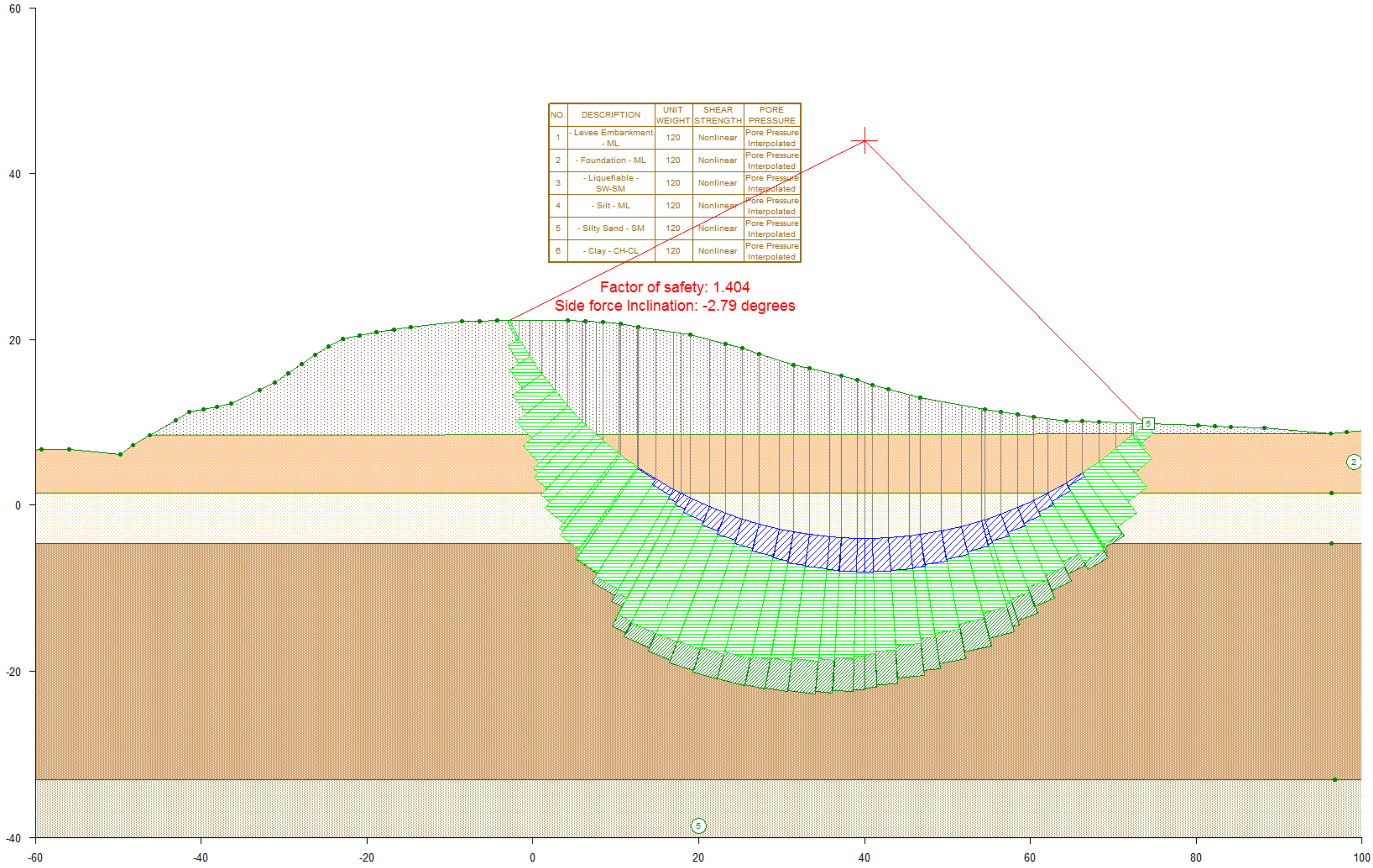
Fig F-18(a). RD 404 Station 1175+01 – Waterside – Option 2: Wedges (Sr = 113 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable - SW-SM	120	Nonlinear	Pore Pressure Interpolated
4	- Silt - ML	120	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	120	Nonlinear	Pore Pressure Interpolated
6	- Clay - CH-CL	120	Nonlinear	Pore Pressure Interpolated

Factor of safety: 0.652
Side force Inclination: 1.85 degrees

Fig F-18(b). RD 404 Station 1175+01 – Waterside – Option 2: Wedges (PHI = 3.6 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable - SW-SM	120	Nonlinear	Pore Pressure Interpolated
4	- Silt - ML	120	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	120	Nonlinear	Pore Pressure Interpolated
6	- Clay - CH-CL	120	Nonlinear	Pore Pressure Interpolated

Fig F-19(a). RD 404 Station 1175+01 – Landside – Option 3: Circular (Sr = 113 psf in liquefiable material)

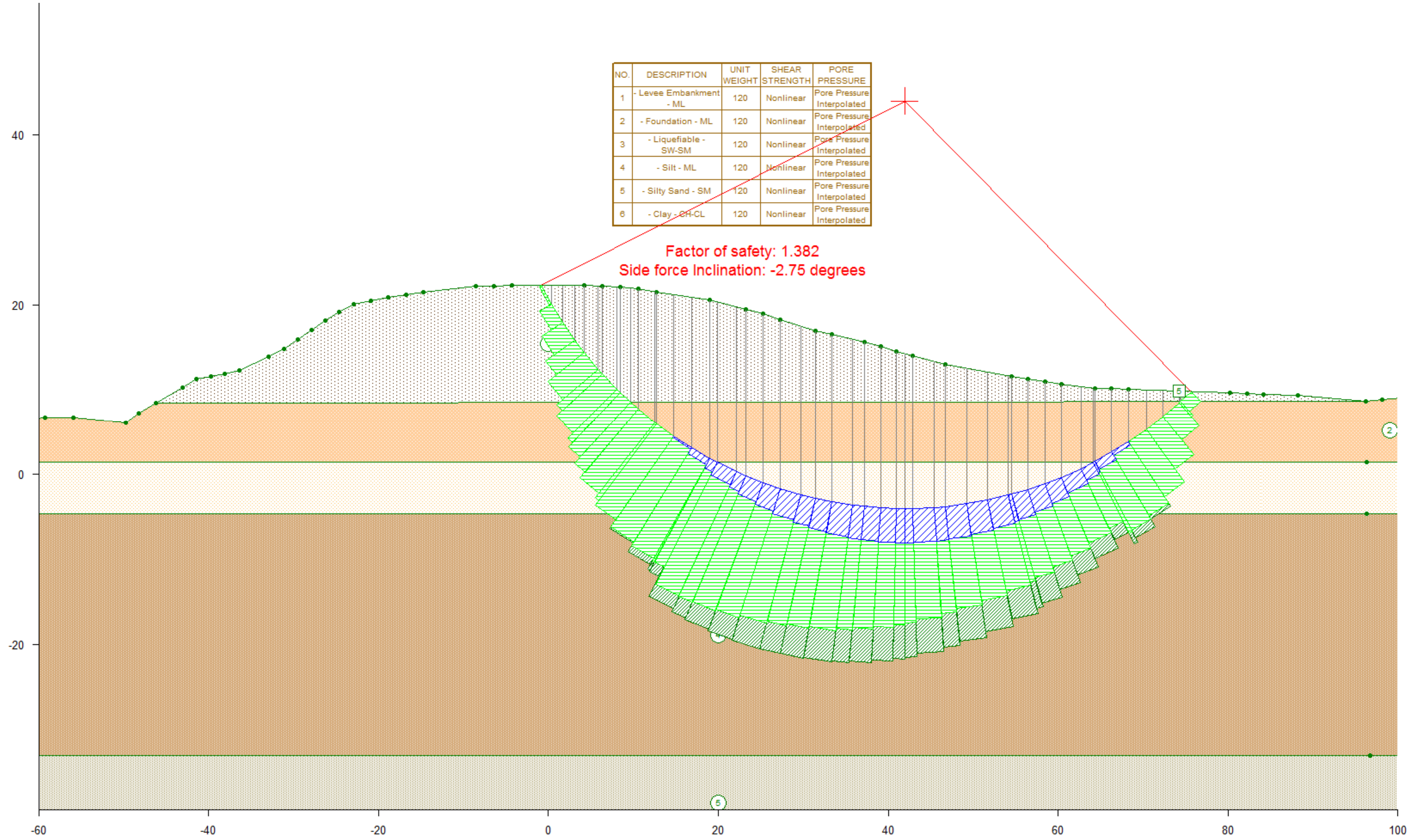


Fig F-19(b). RD 404 Station 1175+01 – Landside – Option 3: Circular (PHI = 3.6 in liquefiable material)

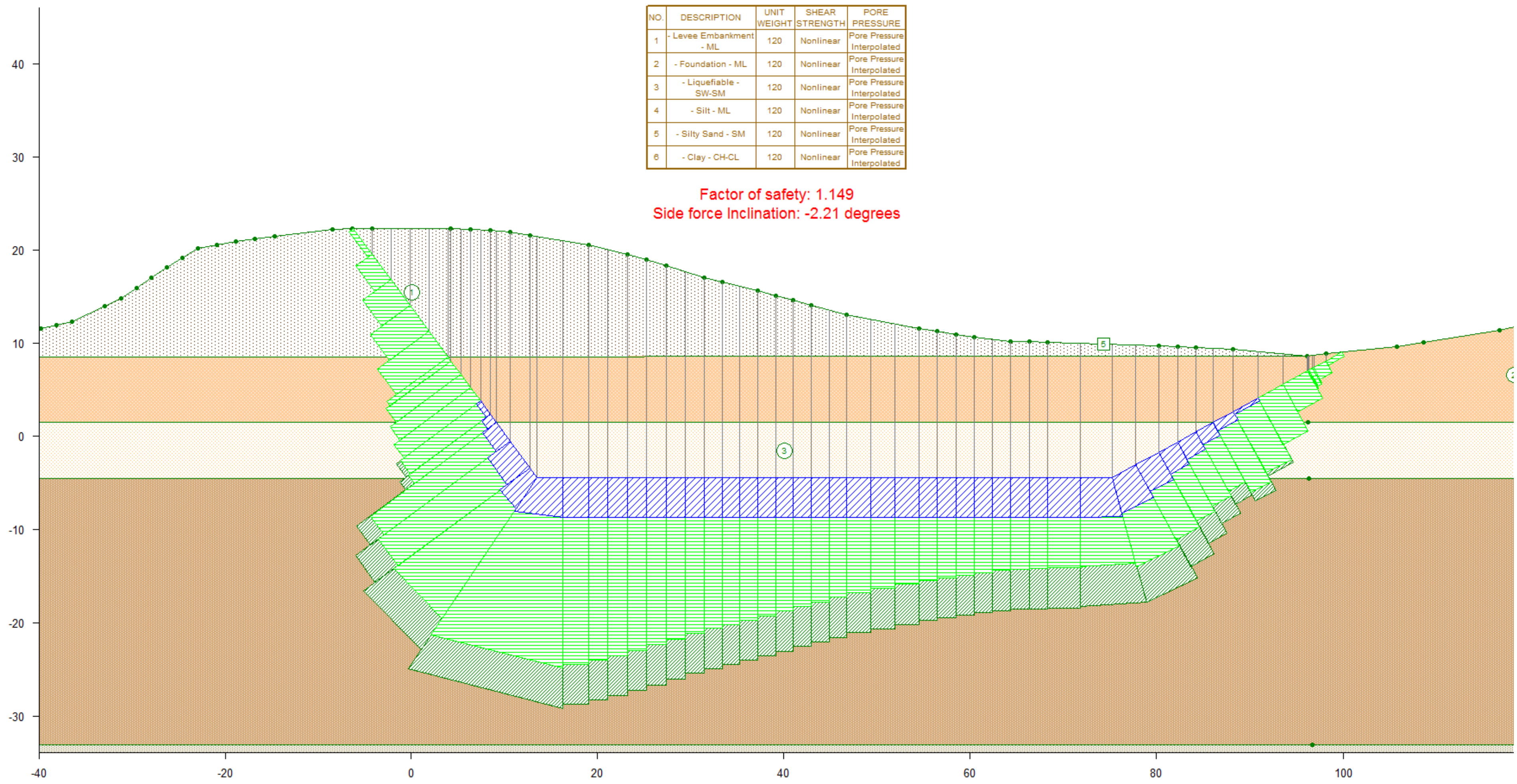
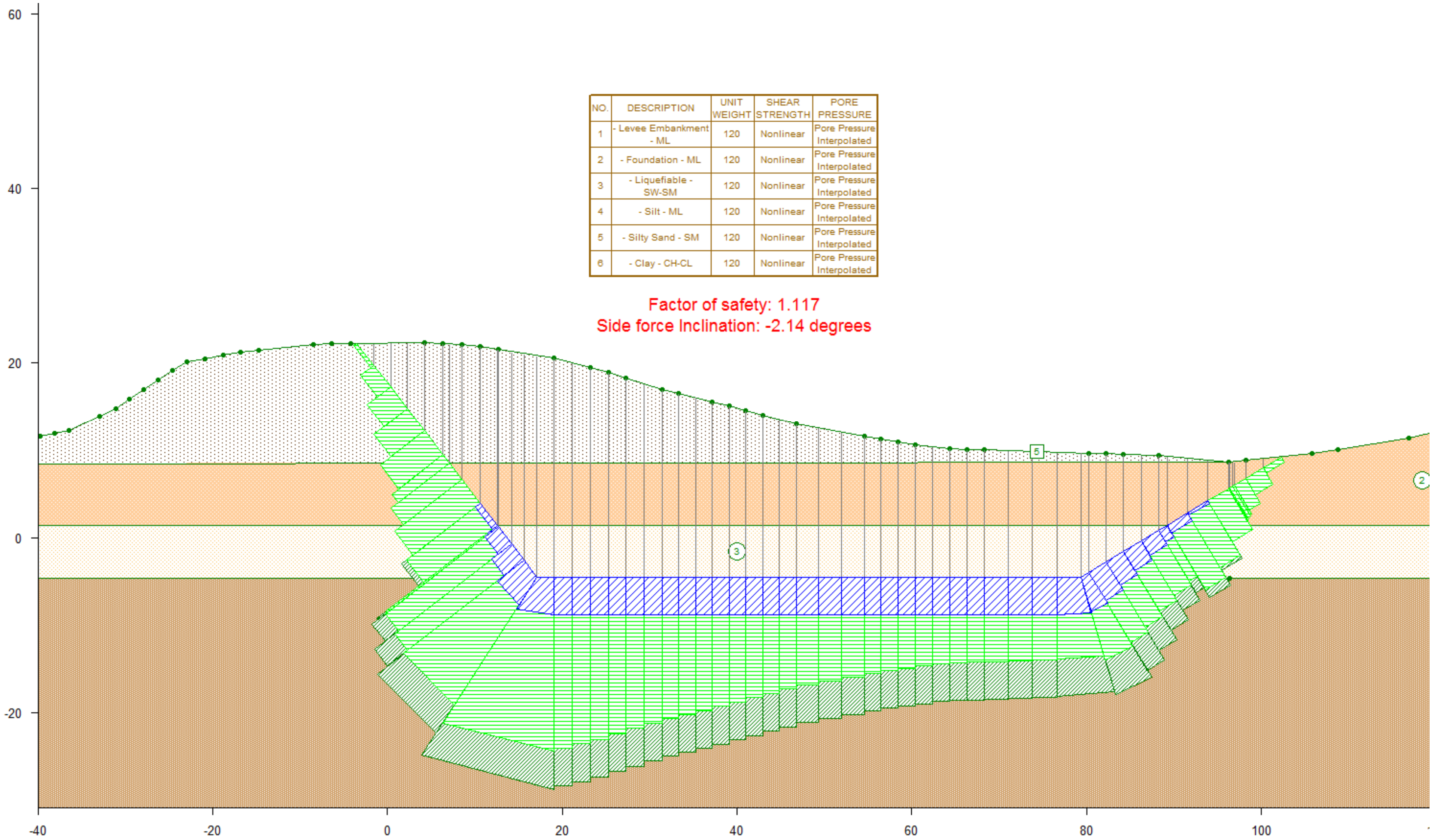


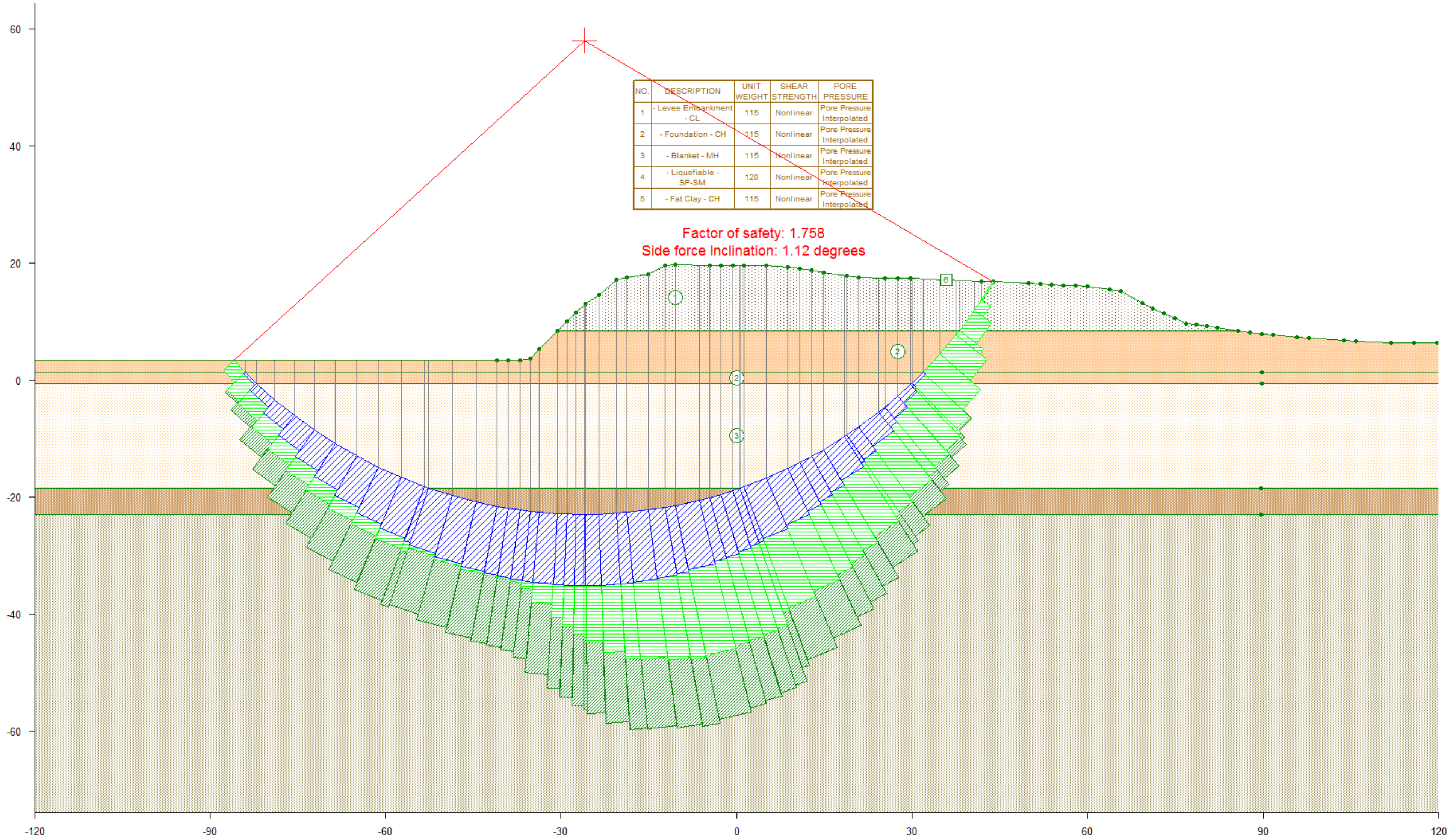
Fig F-20(a). RD 404 Station 1175+01 – Landside – Option 4: Wedge (Sr = 113 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - ML	120	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable - SW-SM	120	Nonlinear	Pore Pressure Interpolated
4	- Silt - ML	120	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	120	Nonlinear	Pore Pressure Interpolated
6	- Clay - CH-CL	120	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.117
Side force Inclination: -2.14 degrees

Fig F-20(b). RD 404 Station 1175+01 – Landside – Option 4: Wedge (PHI = 3.6 in liquefiable material)

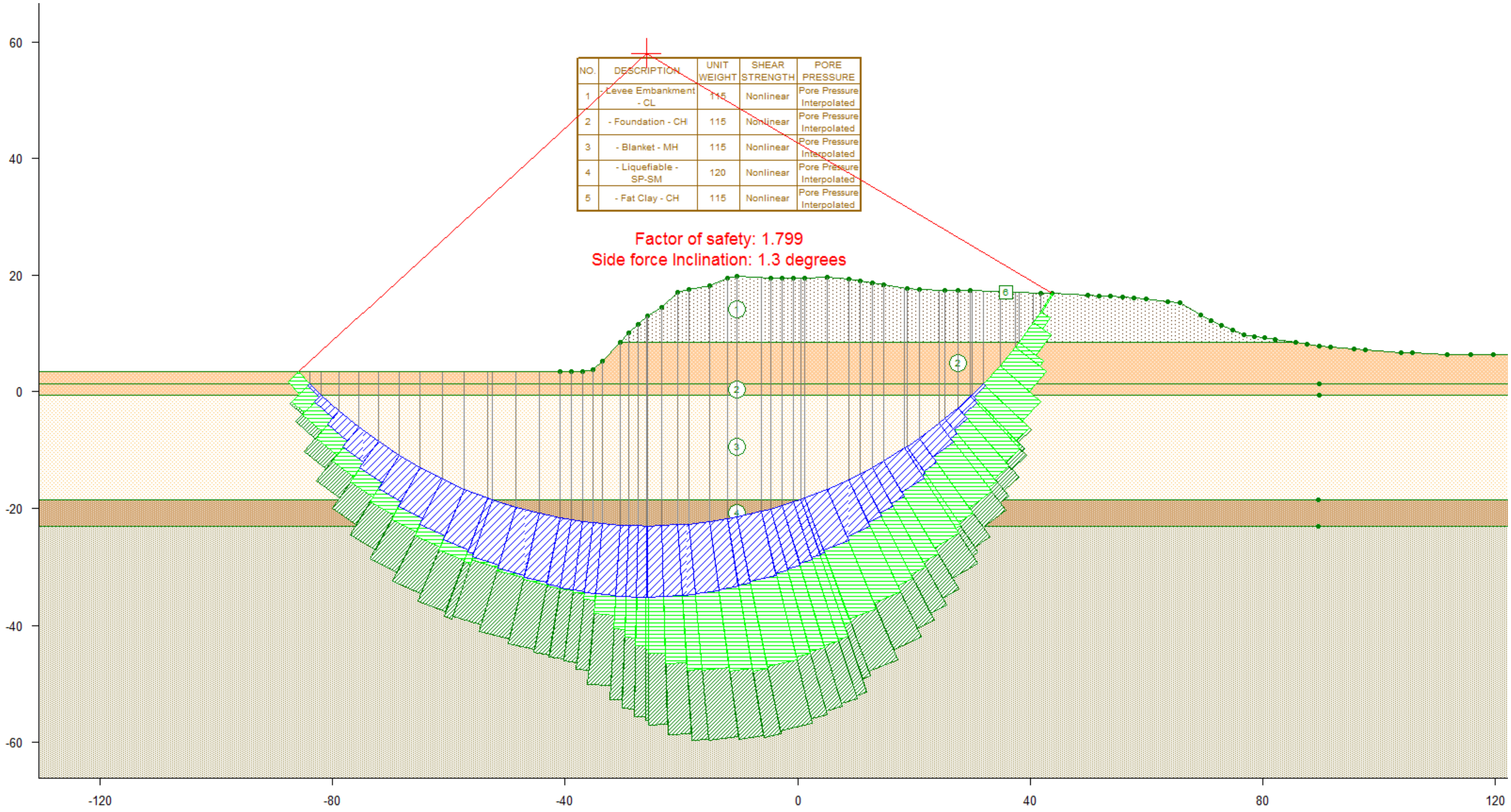


NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - MH	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	120	Nonlinear	Pore Pressure Interpolated
5	- Fat Clay - CH	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.758

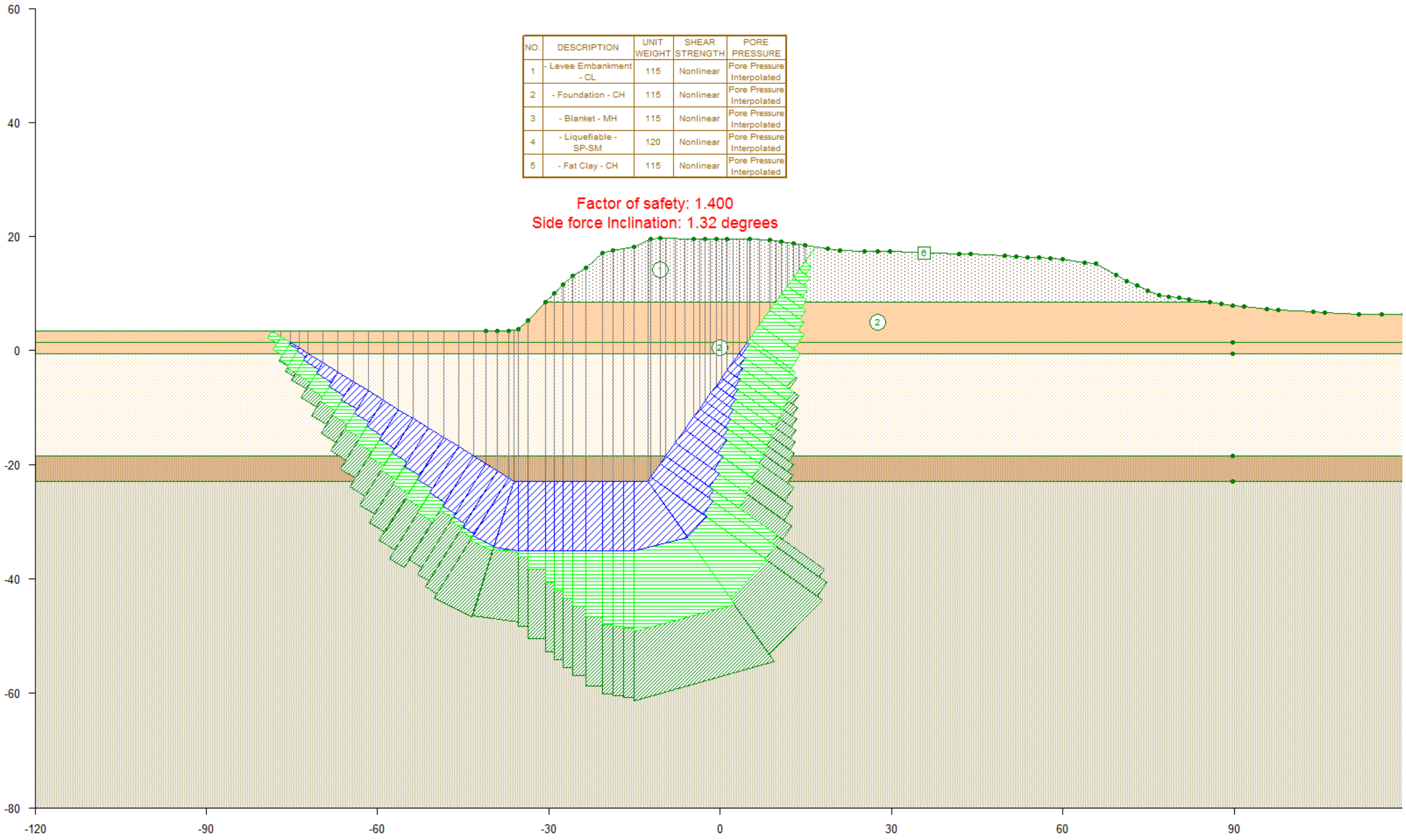
Side force Inclination: 1.12 degrees

Fig F-21(a). Calaveras River Station 6565+02 – Waterside – Option 1: Circular (Sr = 77 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - MH	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	120	Nonlinear	Pore Pressure Interpolated
5	- Fat Clay - CH	115	Nonlinear	Pore Pressure Interpolated

Fig 21(b). Calaveras River Station 6565+02 – Waterside – Option 1: Circular (PHI = 2.6 in liquefiable material)

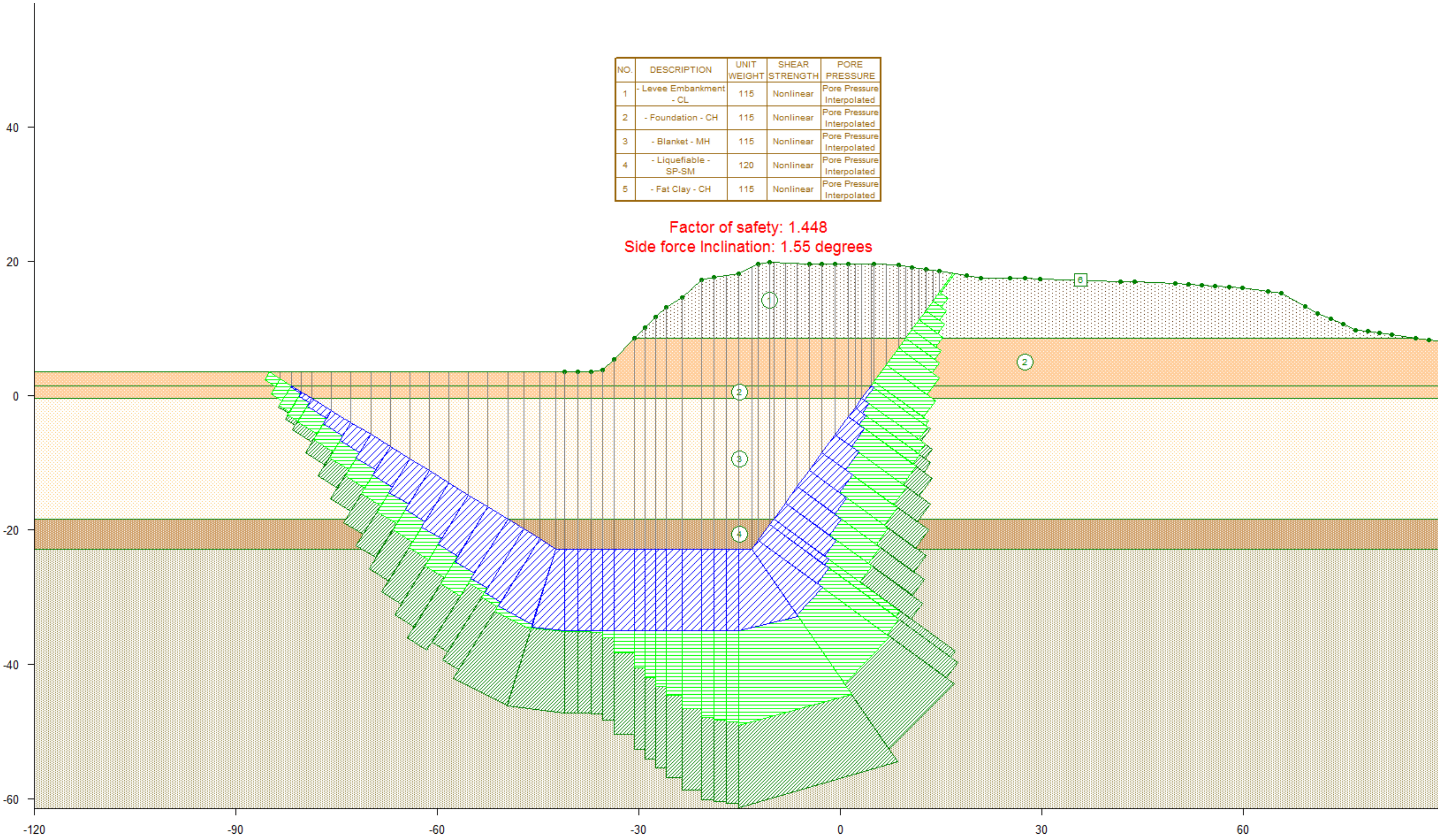


NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - MH	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	120	Nonlinear	Pore Pressure Interpolated
5	- Fat Clay - CH	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.400

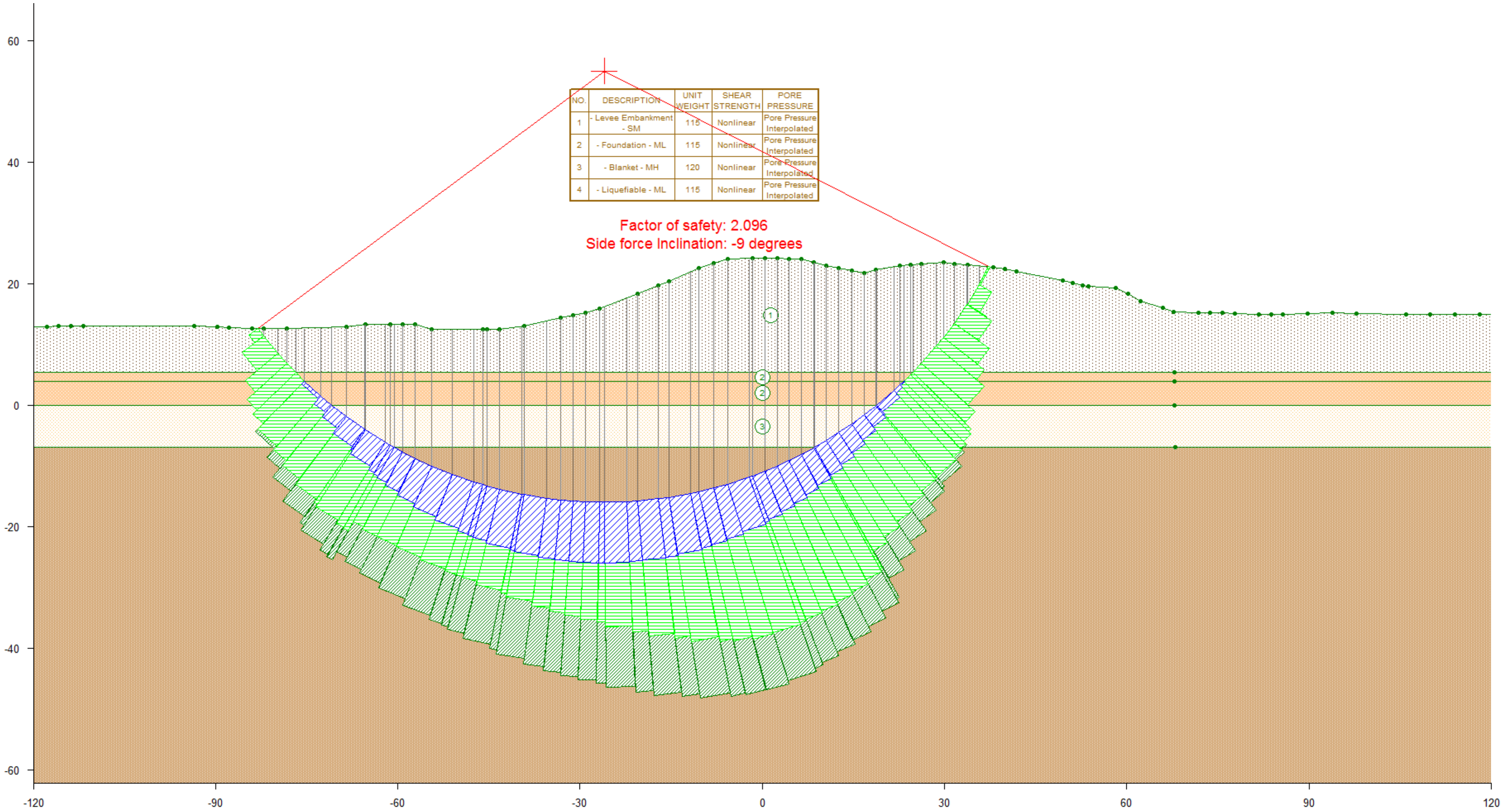
Side force Inclination: 1.32 degrees

Fig F-22(a). Calaveras River Station 6565+02 – Waterside – Option 2: Wedges (Sr = 77 psf in liquefiable material)



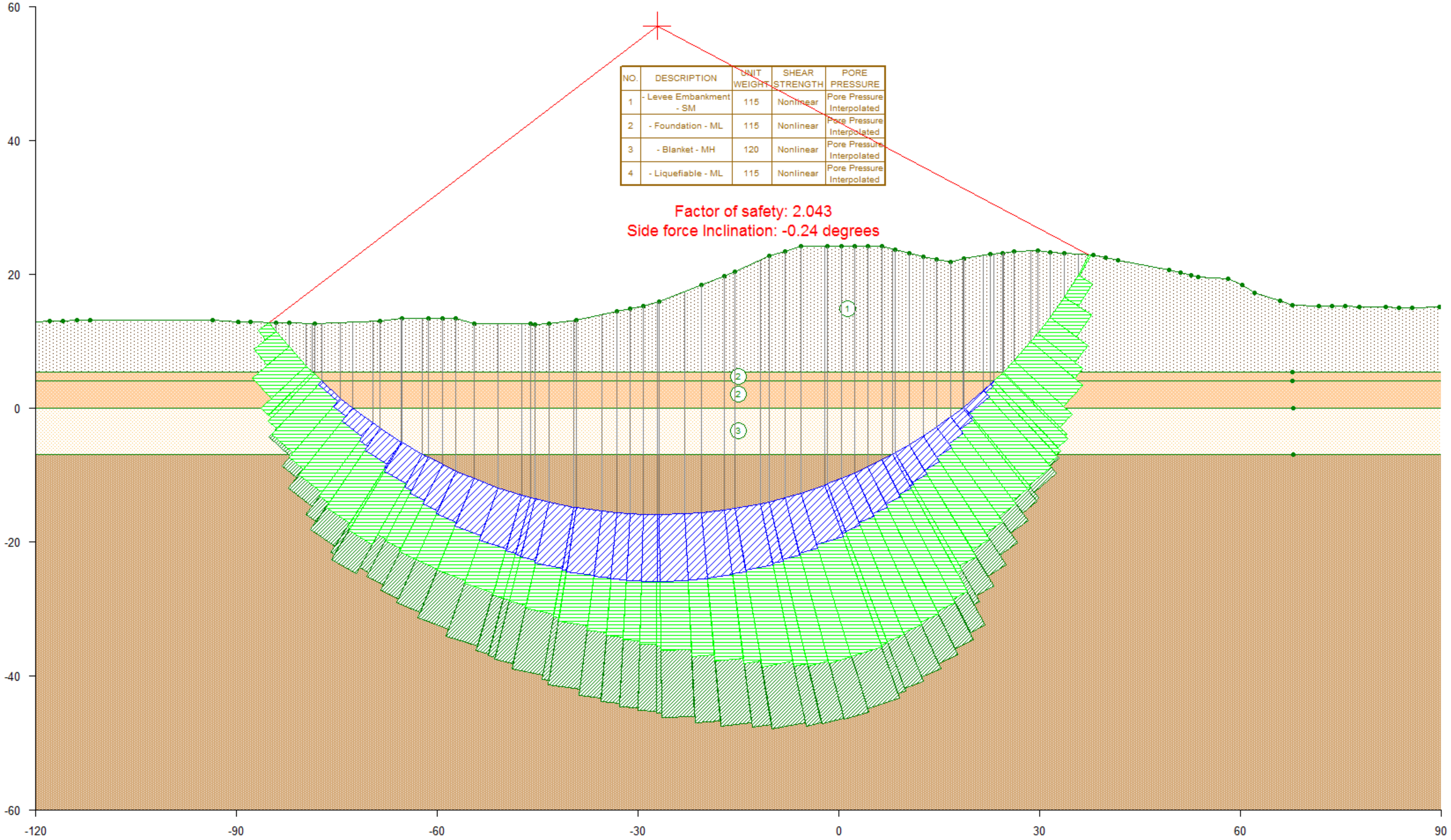
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - CH	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - MH	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - SP-SM	120	Nonlinear	Pore Pressure Interpolated
5	- Fat Clay - CH	115	Nonlinear	Pore Pressure Interpolated

Fig 22(b). Calaveras River Station 6565+02 – Waterside – Option 2: Wedges (PHI = 2.6 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SM	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - MH	120	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - ML	115	Nonlinear	Pore Pressure Interpolated

Fig F-23(a). Calaveras River Station 6669+40 – Waterside – Option 1: Circular (Sr = 98 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - SM	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - MH	120	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable - ML	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 2.043
Side force Inclination: -0.24 degrees

Fig 23(b). Calaveras River Station 6669+40 – Waterside – Option 1: Circular (PHI = 1.7 in liquefiable material)

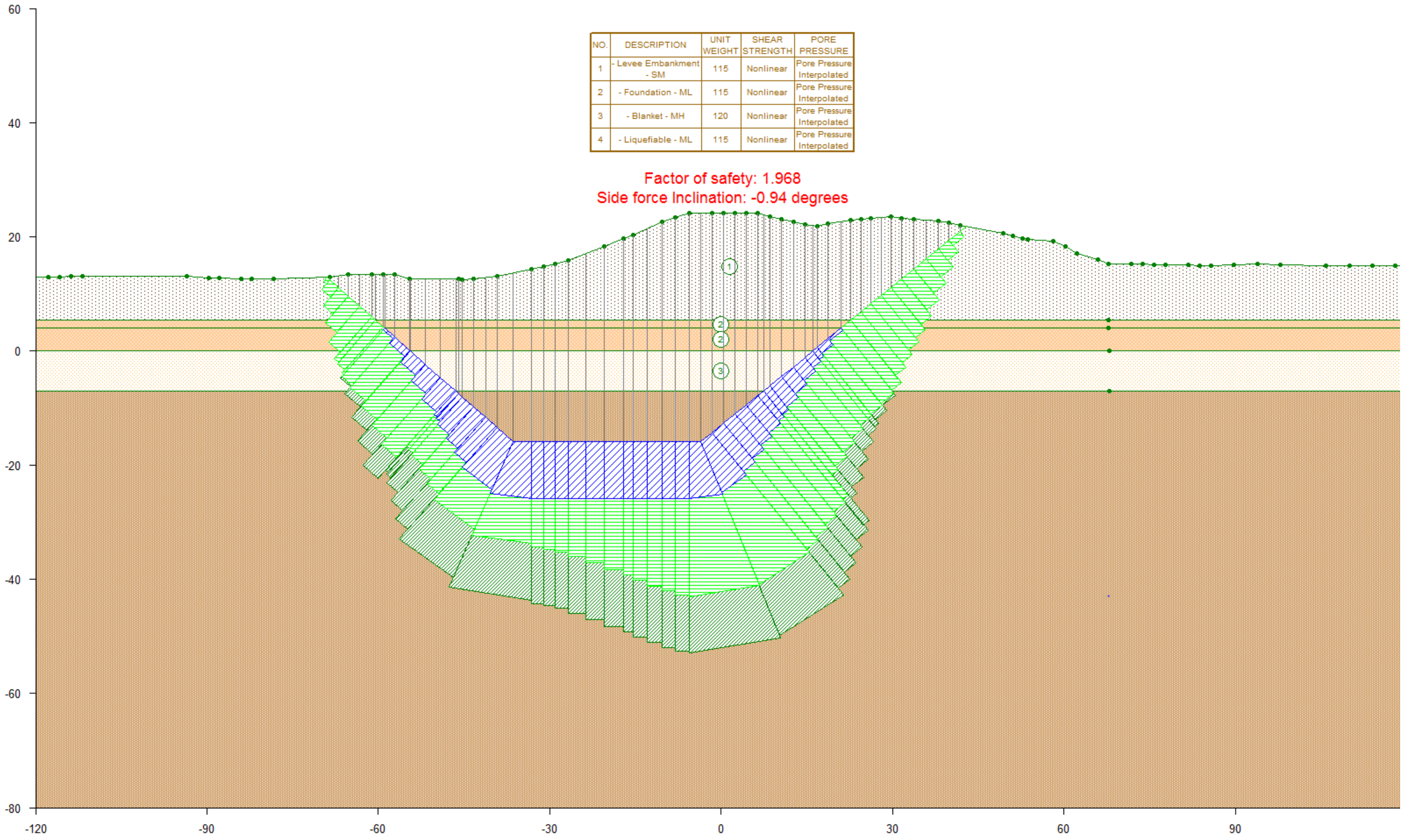


Fig F-24(a). Calaveras River Station 6669+40 – Waterside – Option 2: Wedges (Sr = 98 psf in liquefiable material)

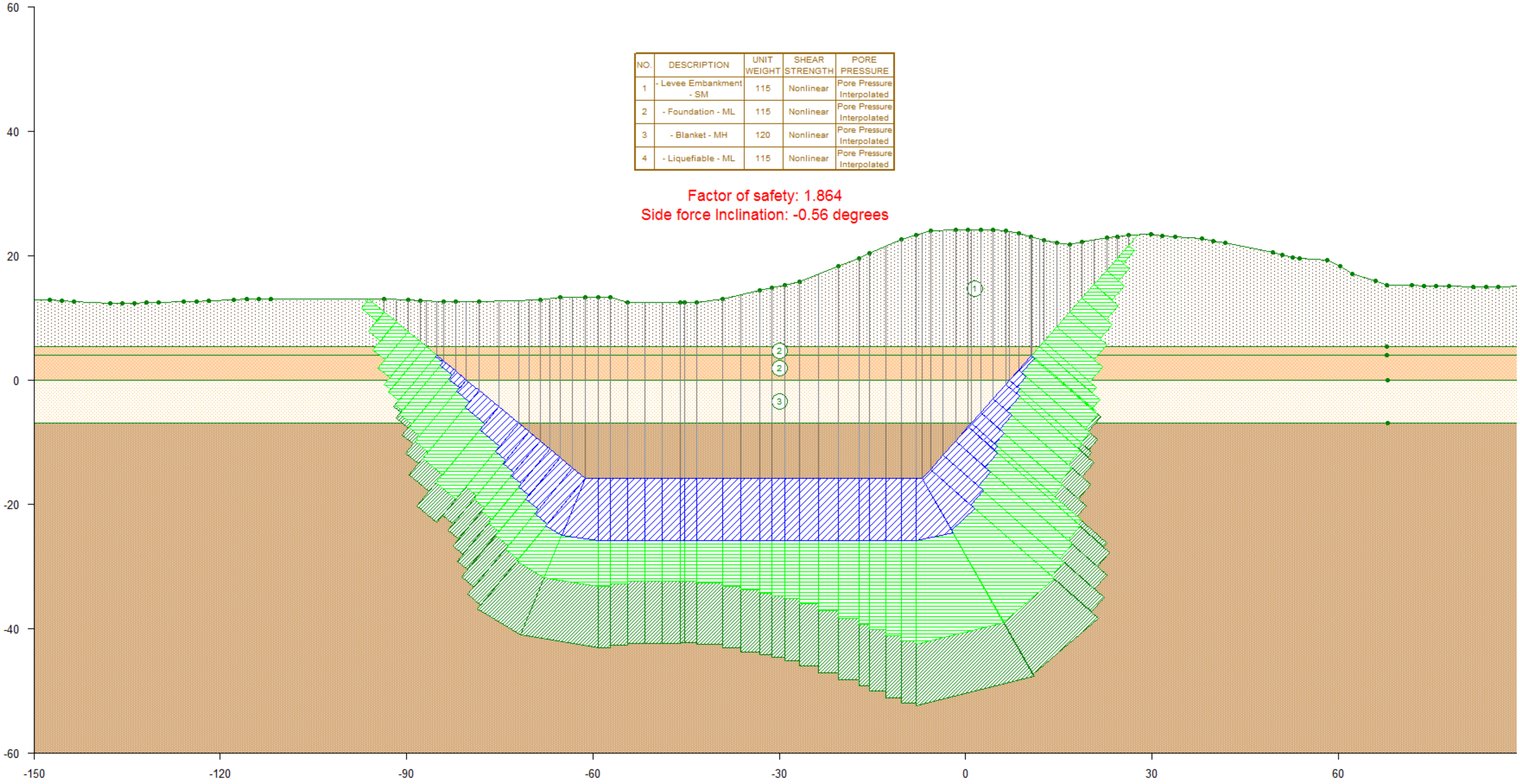
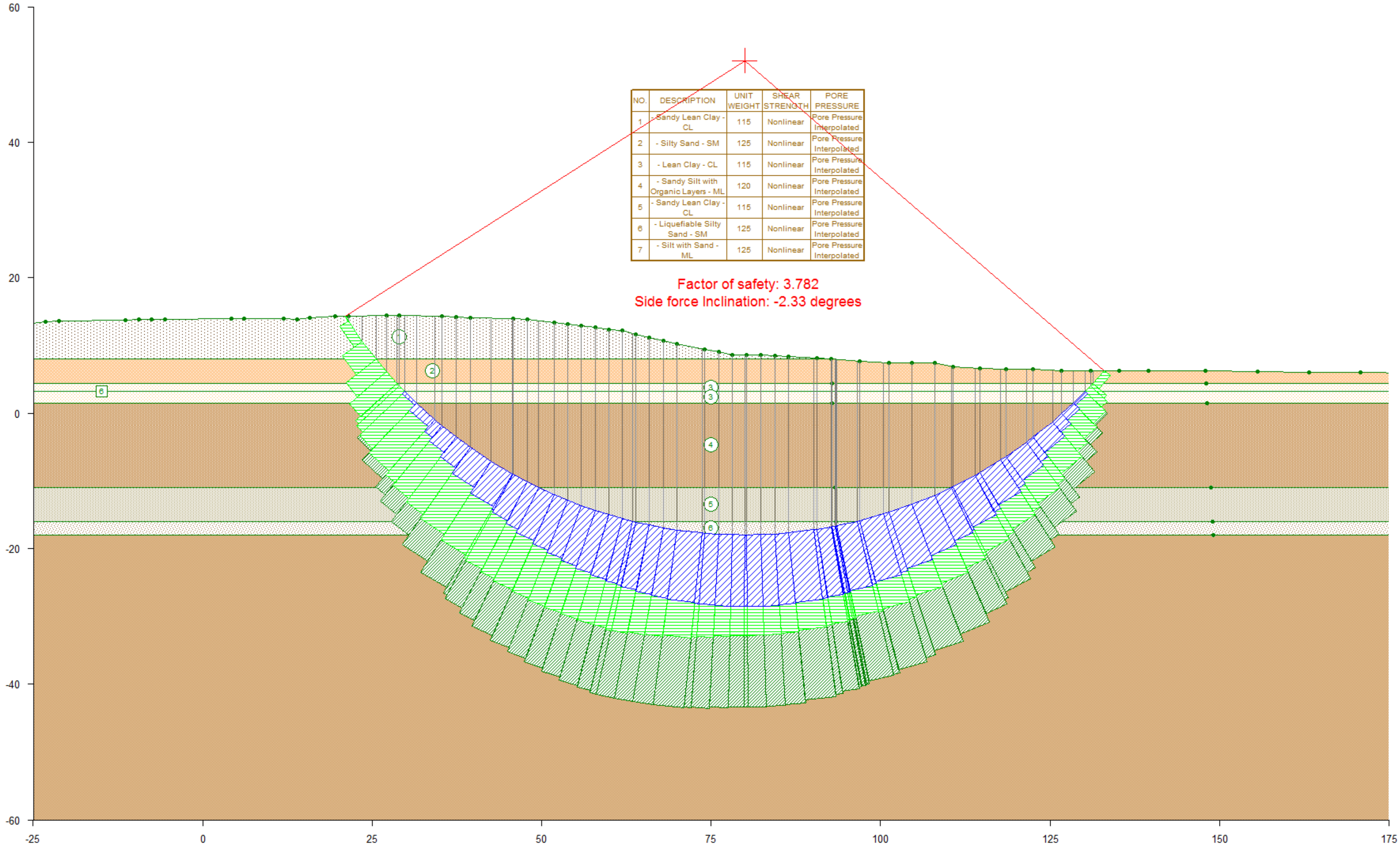
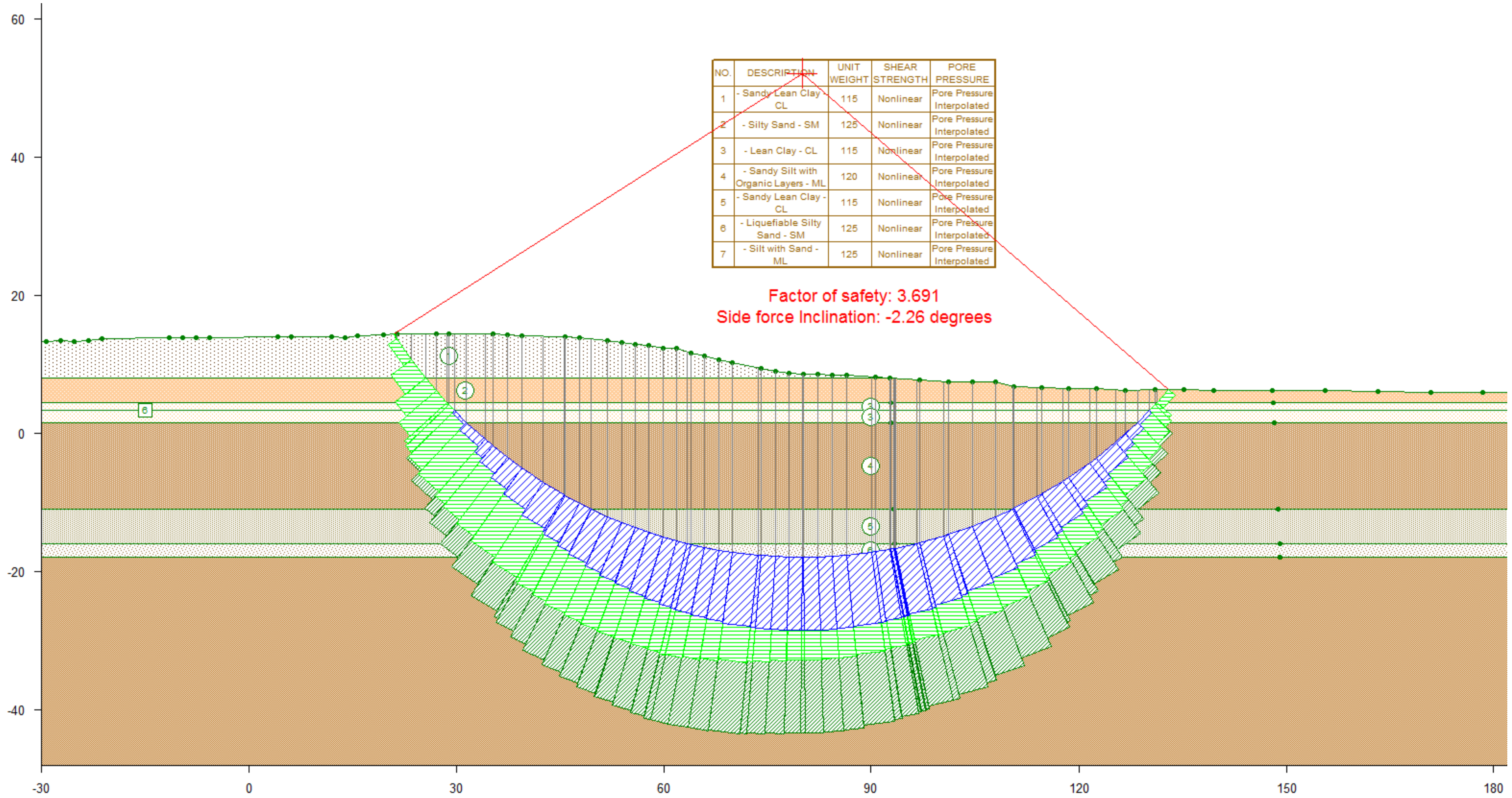


Fig 24(b). Calaveras River Station 6669+40 – Waterside – Option 2: Wedges (PHI = 1.7 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Sandy Silt with Organic Layers - ML	120	Nonlinear	Pore Pressure Interpolated
5	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
7	- Silt with Sand - ML	125	Nonlinear	Pore Pressure Interpolated

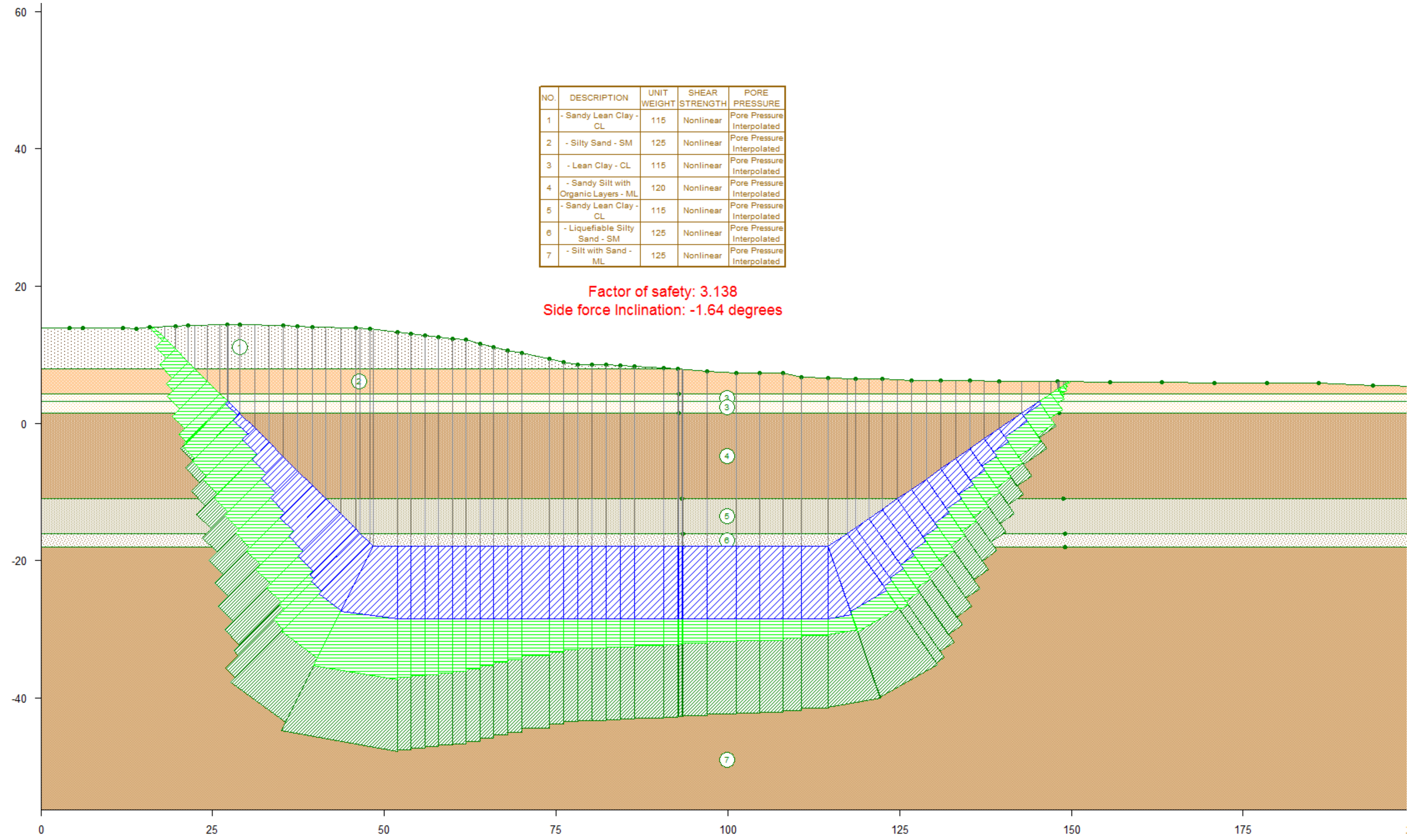
Fig F-25(a). Brookside Station 117+51 – Landside – Option 1: Circular (Sr = 189 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Sandy Silt with Organic Layers - ML	120	Nonlinear	Pore Pressure Interpolated
5	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
7	- Silt with Sand - ML	125	Nonlinear	Pore Pressure Interpolated

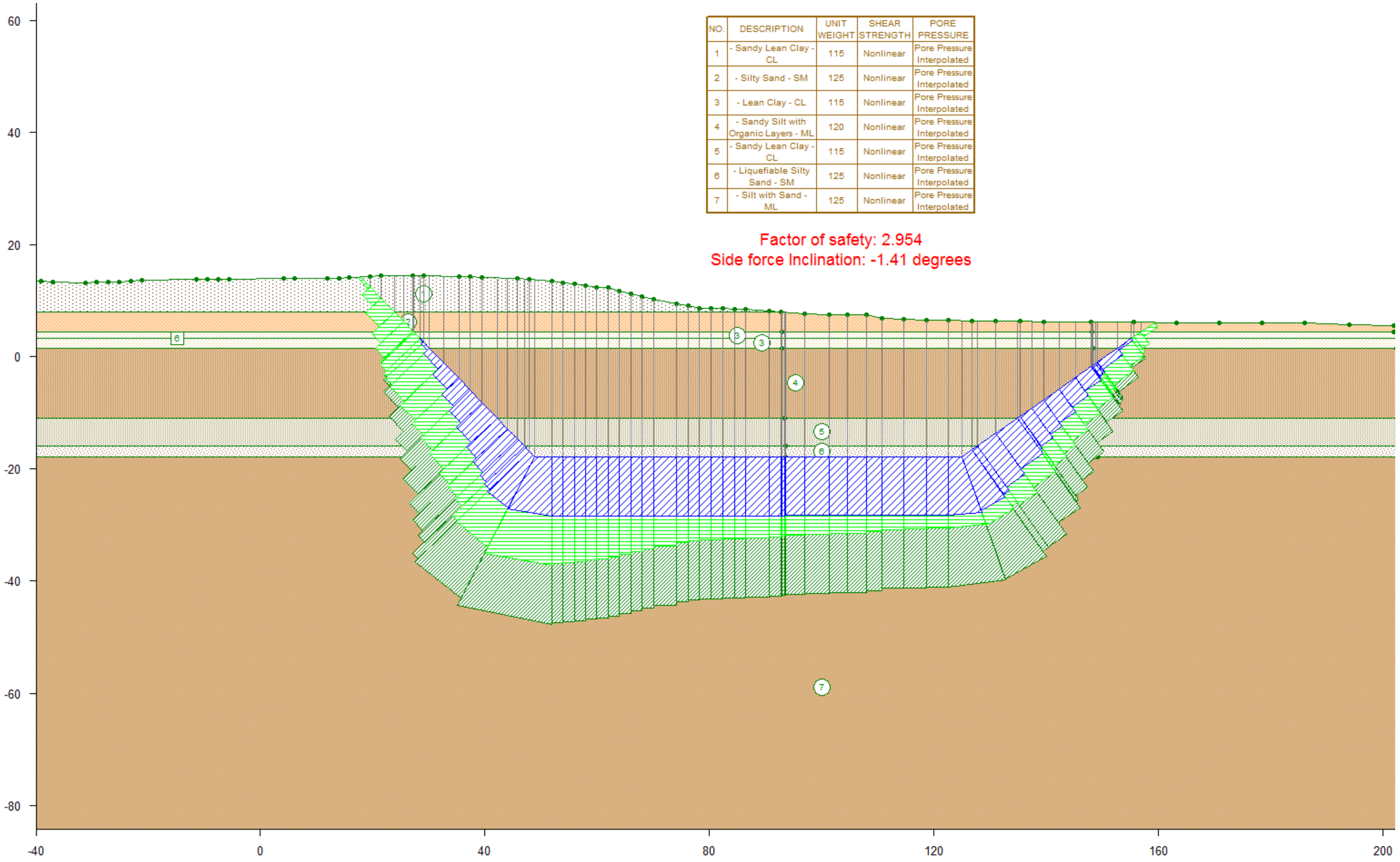
Factor of safety: 3.691
Side force Inclination: -2.26 degrees

Fig 25(b). Brookside Station 117+51 – Landside – Option 1: Circular (PHI = 4.3 in liquefiable material)



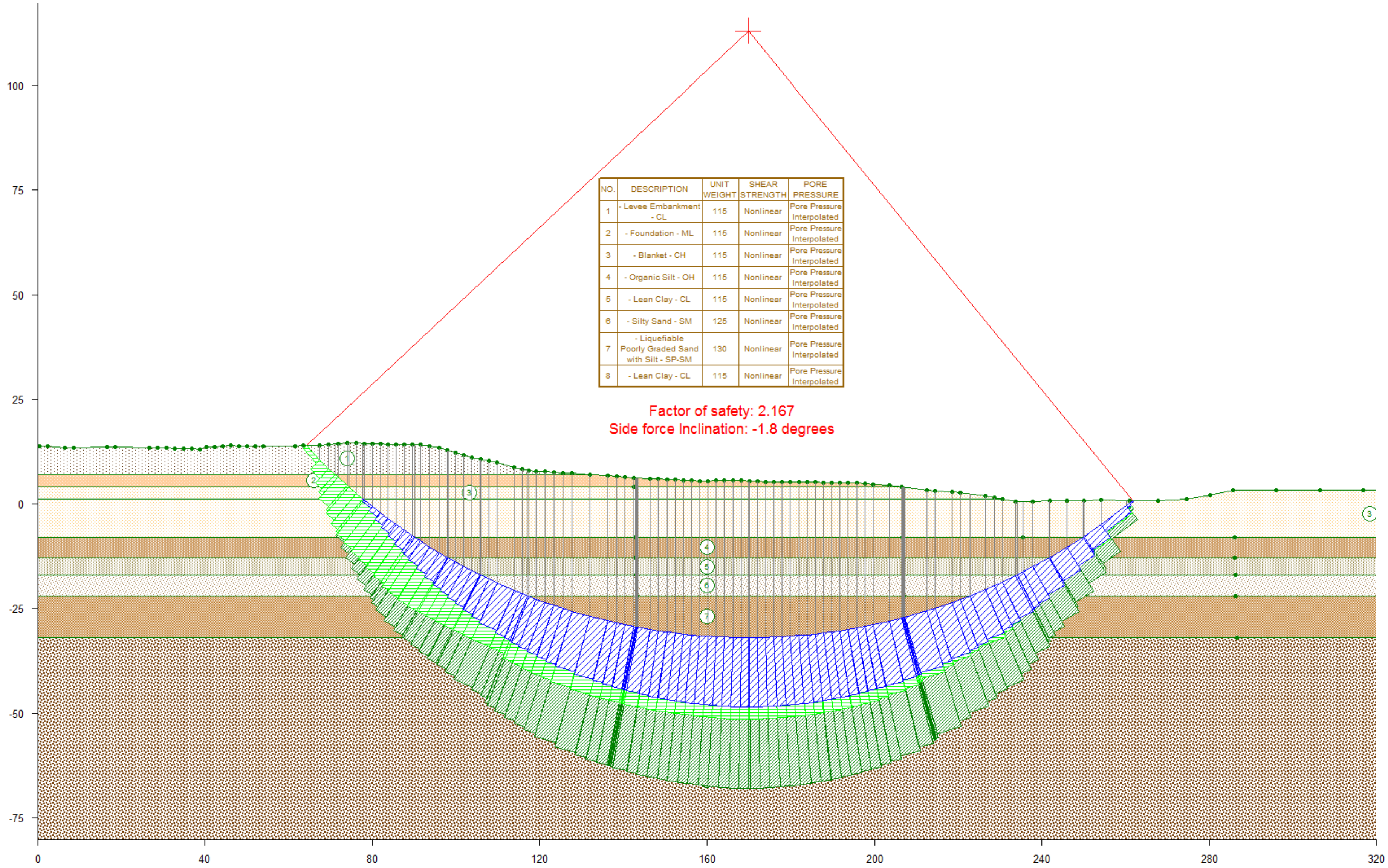
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Sandy Silt with Organic Layers - ML	120	Nonlinear	Pore Pressure Interpolated
5	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
7	- Silt with Sand - ML	125	Nonlinear	Pore Pressure Interpolated

Fig F-26(a). Brookside Station 117+51 – Landside – Option 2: Wedges (Sr = 189 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Sandy Silt with Organic Layers - ML	120	Nonlinear	Pore Pressure Interpolated
5	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
6	- Liquefiable Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
7	- Silt with Sand - ML	125	Nonlinear	Pore Pressure Interpolated

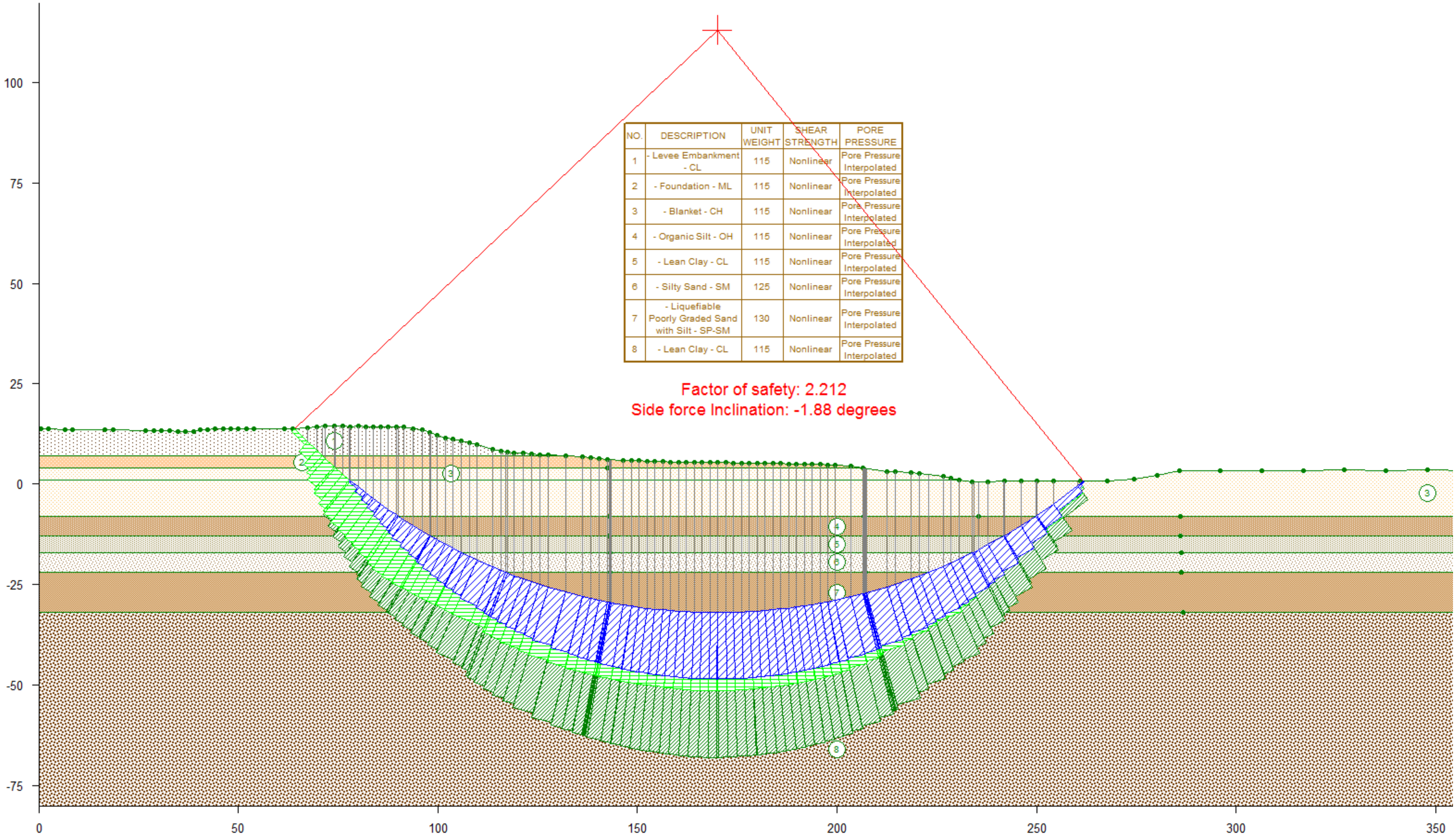
Fig 26(b). Brookside Station 117+51 – Landside – Option 2: Wedges (PHI = 4.3 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
4	- Organic Silt - OH	115	Nonlinear	Pore Pressure Interpolated
5	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
6	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
8	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated

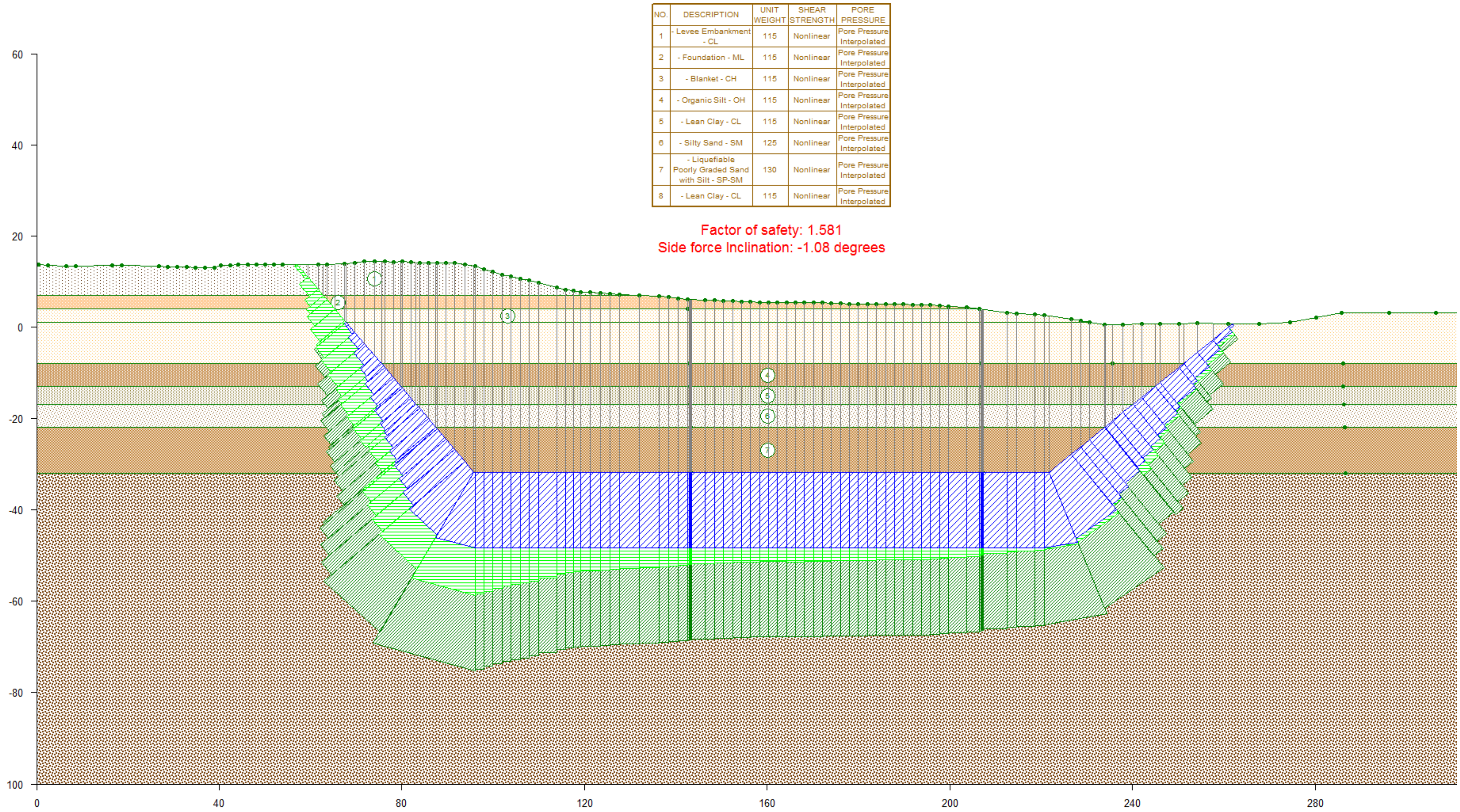
Factor of safety: 2.167
Side force Inclination: -1.8 degrees

Fig F-27(a). Brookside Station 118+02 – Landside – Option 1: Circular (Sr = 151 psf in liquefiable material)



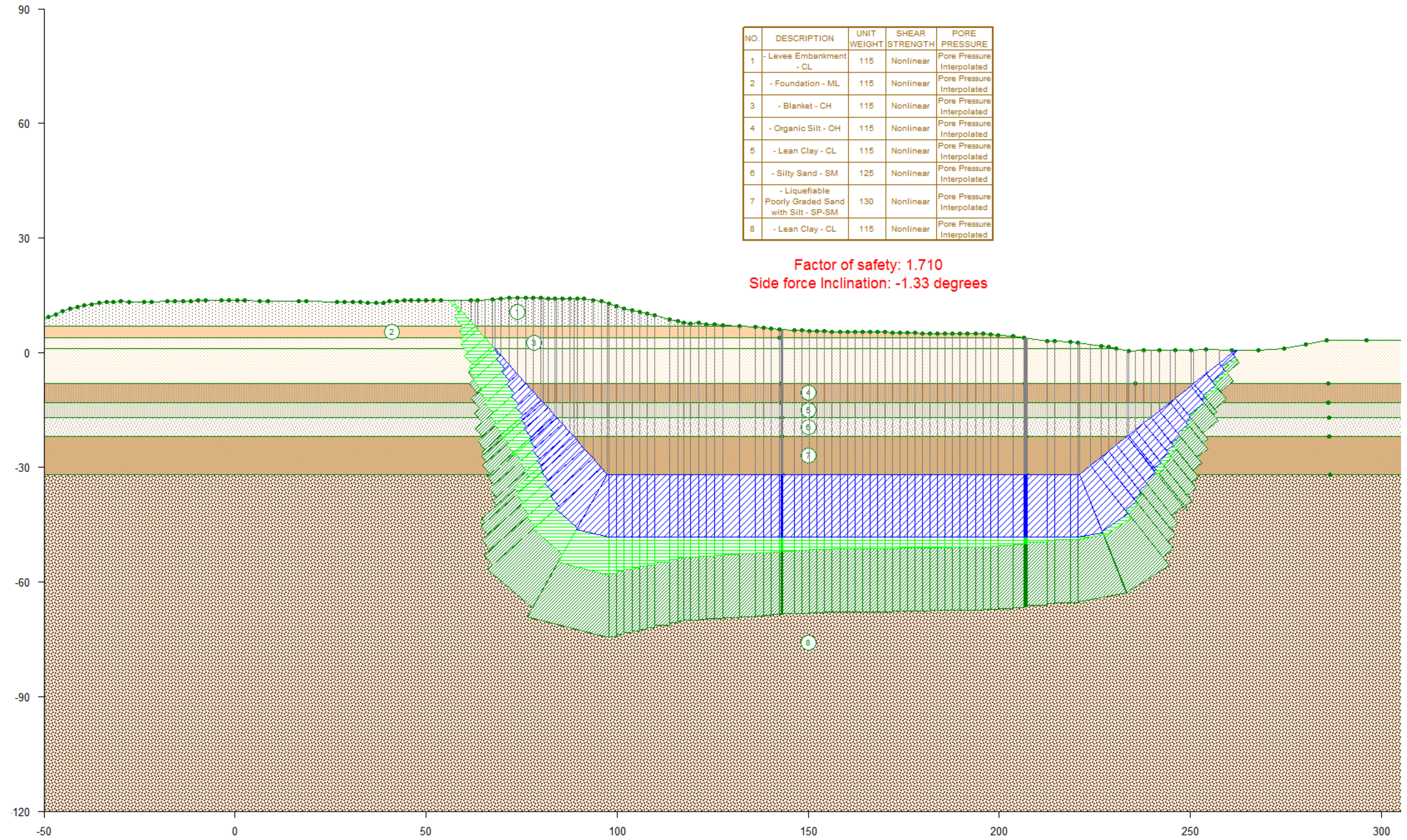
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
4	- Organic Silt - OH	115	Nonlinear	Pore Pressure Interpolated
5	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
6	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
8	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated

Fig 27(b). Brookside Station 118+02 – Landside – Option 1: Circular (PHI = 4.3 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
4	- Organic Silt - OH	115	Nonlinear	Pore Pressure Interpolated
5	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
6	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
8	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated

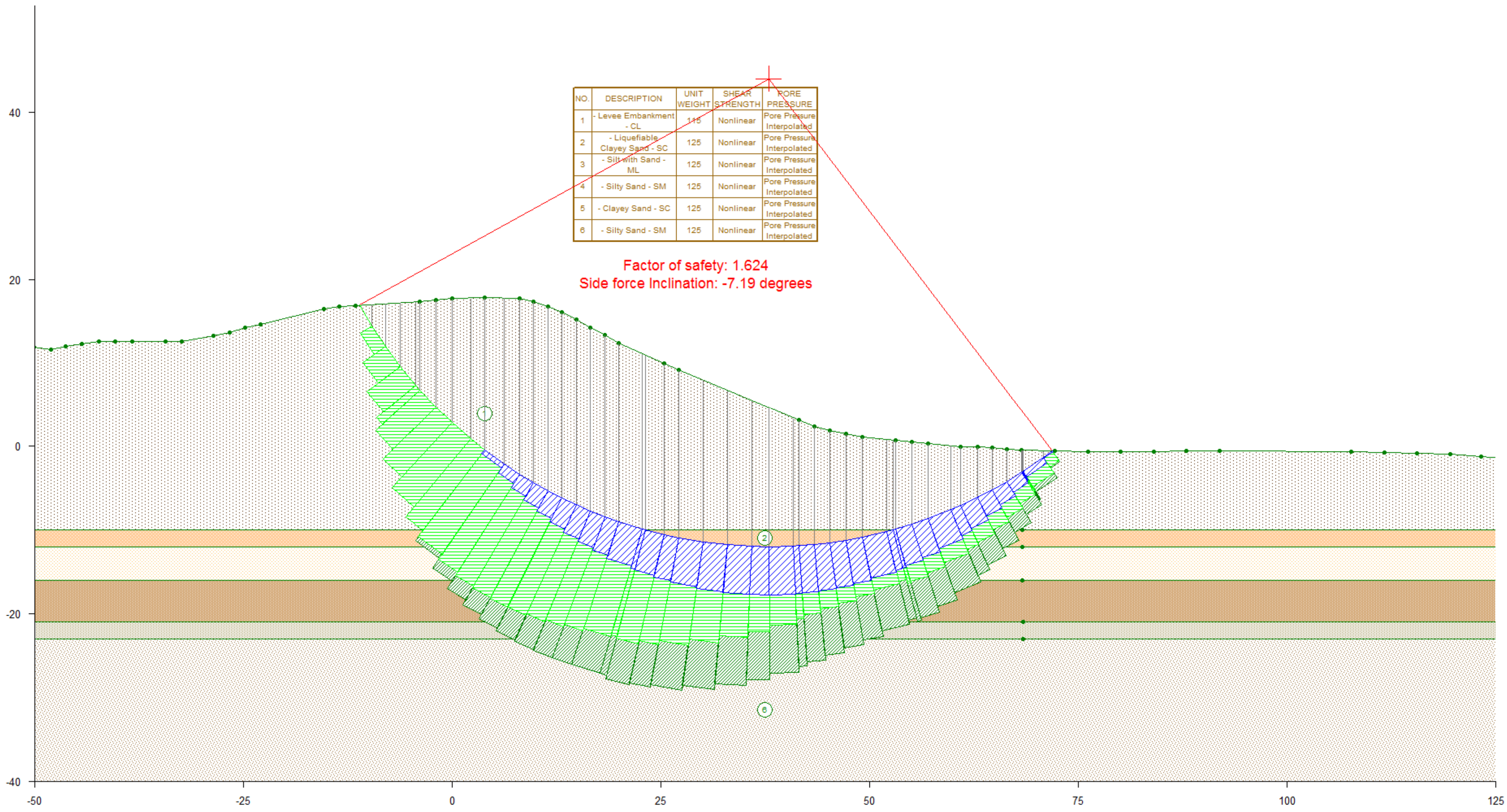
Fig F-28(a). Brookside Station 118+02 – Landside – Option 2: Wedges (Sr = 151 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Foundation - ML	115	Nonlinear	Pore Pressure Interpolated
3	- Blanket - CH	115	Nonlinear	Pore Pressure Interpolated
4	- Organic Silt - OH	115	Nonlinear	Pore Pressure Interpolated
5	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
6	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
8	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.710
Side force Inclination: -1.33 degrees

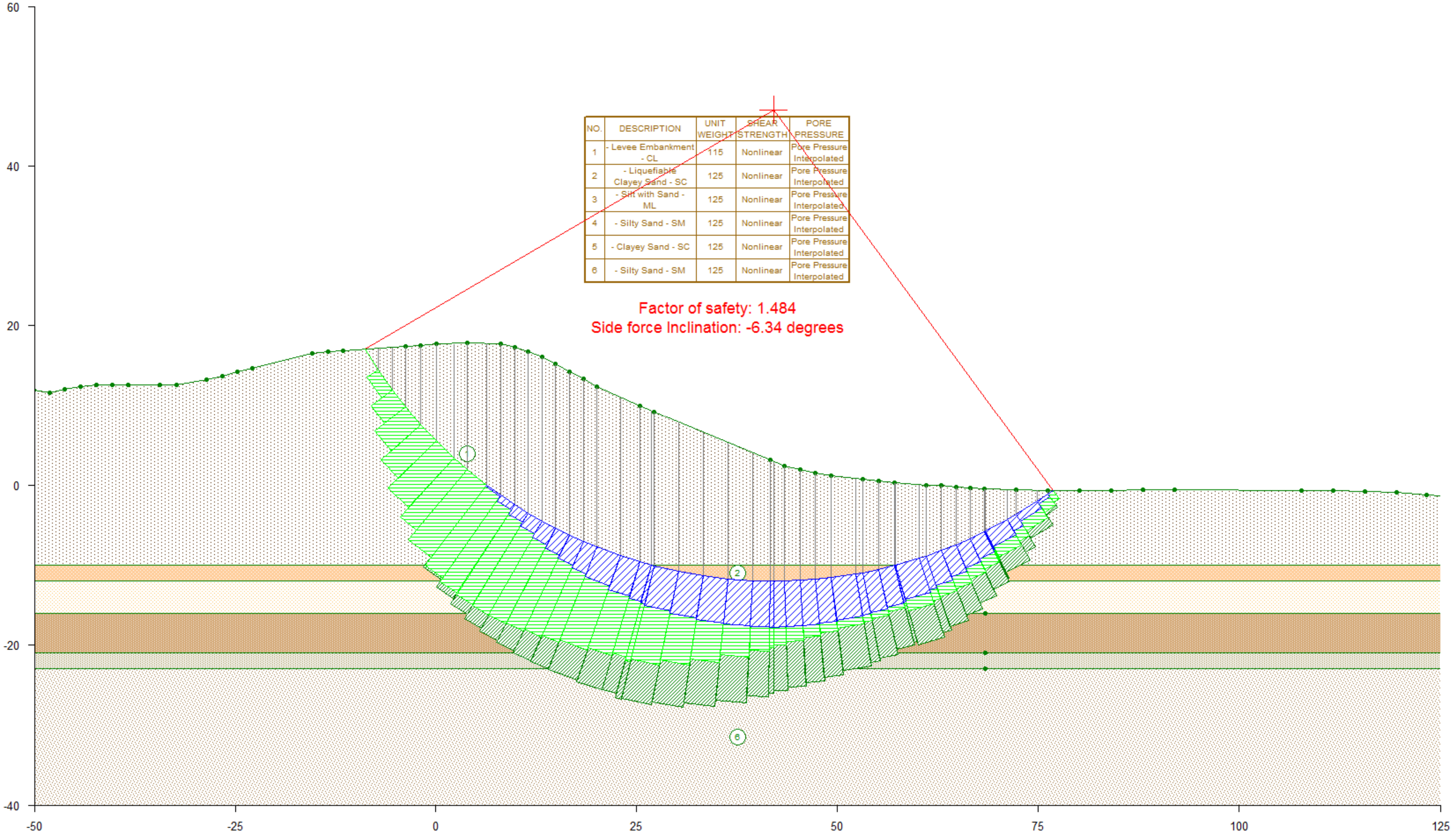
Fig 28(b). Brookside Station 118+02 – Landside – Option 2: Wedges (PHI = 4.3 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Liquefiable Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Silt with Sand - ML	125	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
6	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.624
Side force Inclination: -7.19 degrees

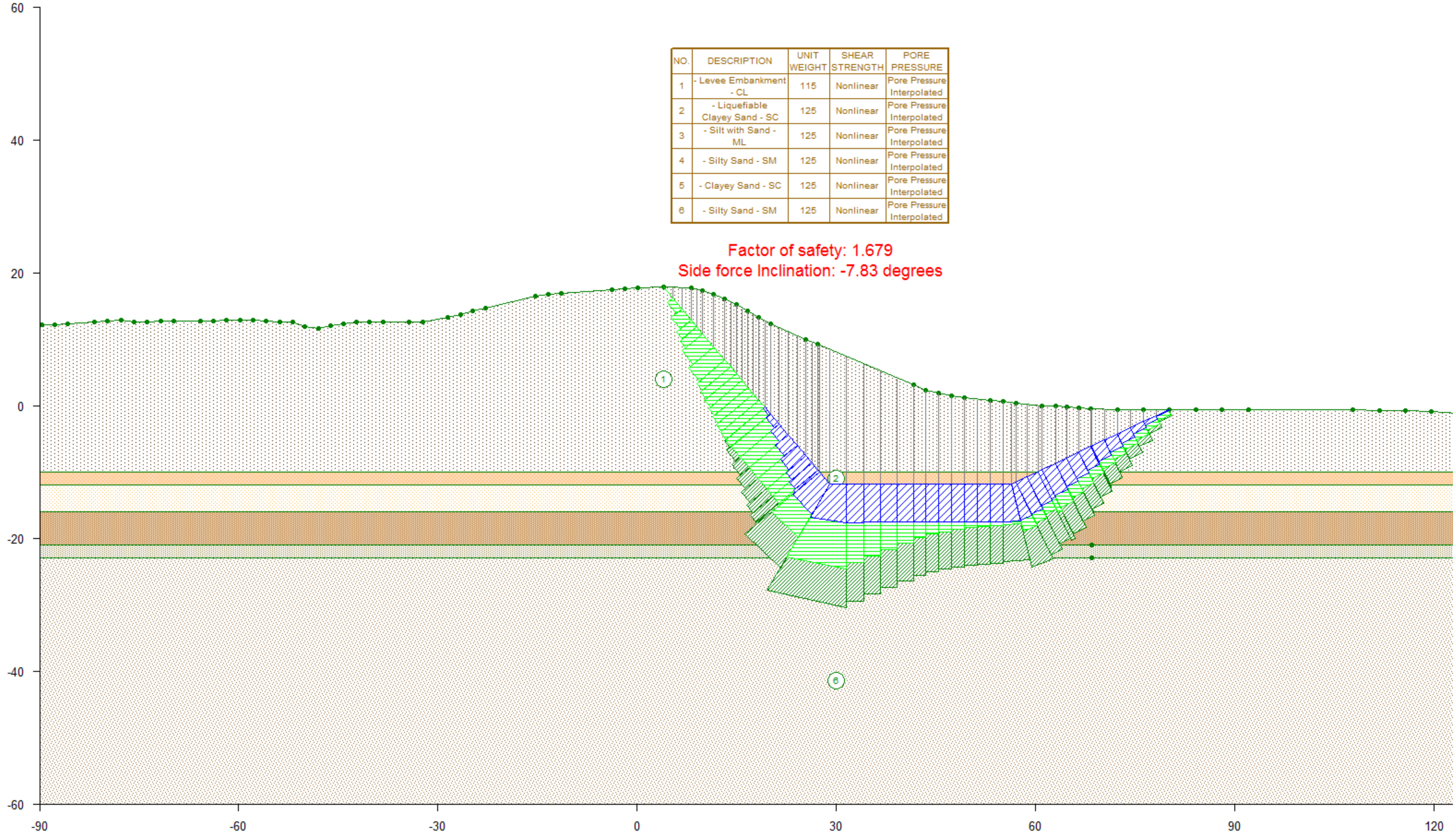
Fig F-29(a). Brookside Station 133+82 – Landside – Option 1: Circular (Sr = 242 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Liquefiable Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Silt with Sand - ML	125	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
6	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.484
Side force Inclination: -6.34 degrees

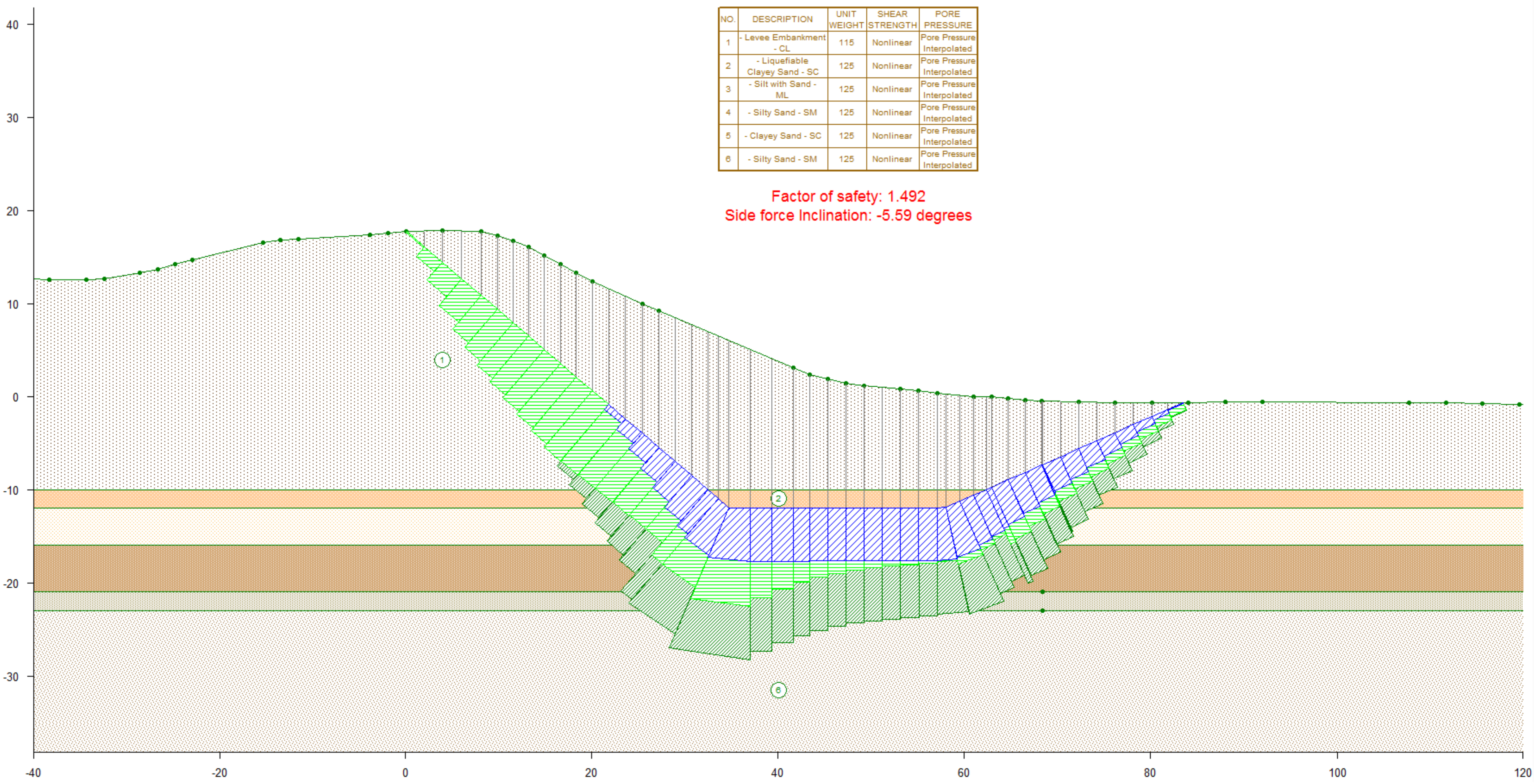
Fig 29(b). Brookside Station 133+82 – Landside – Option 1: Circular (PHI = 5.1 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Liquefiable Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Silt with Sand - ML	125	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
6	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.679
Side force Inclination: -7.83 degrees

Fig F-30(a). Brookside Station 133+82 – Landside – Option 2: Wedges (Sr = 242 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Liquefiable Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Silt with Sand - ML	125	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
6	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.492
Side force Inclination: -5.59 degrees

Fig 30(b). Brookside Station 133+82 – Landside – Option 2: Wedges (PHI = 5.1 in liquefiable material)

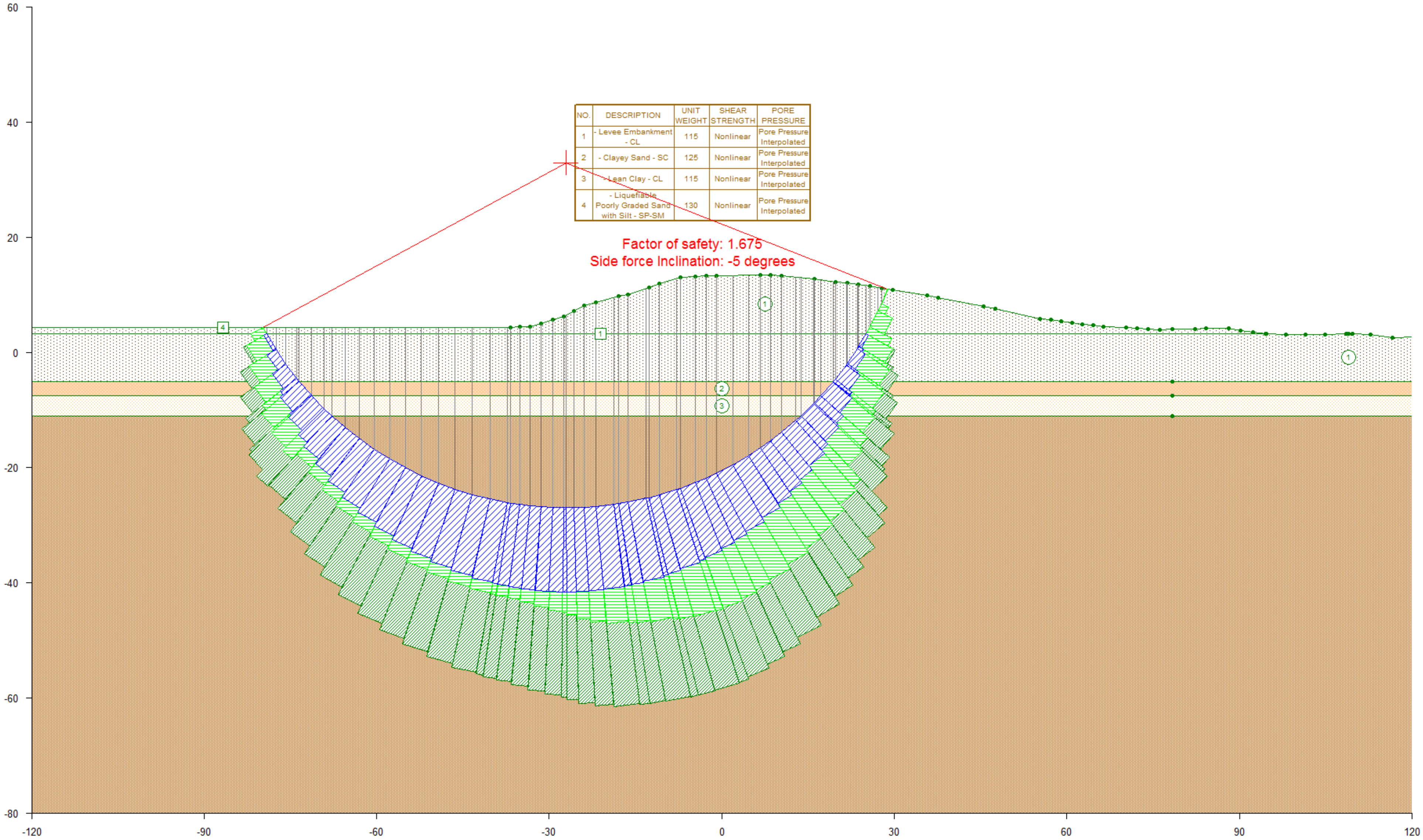
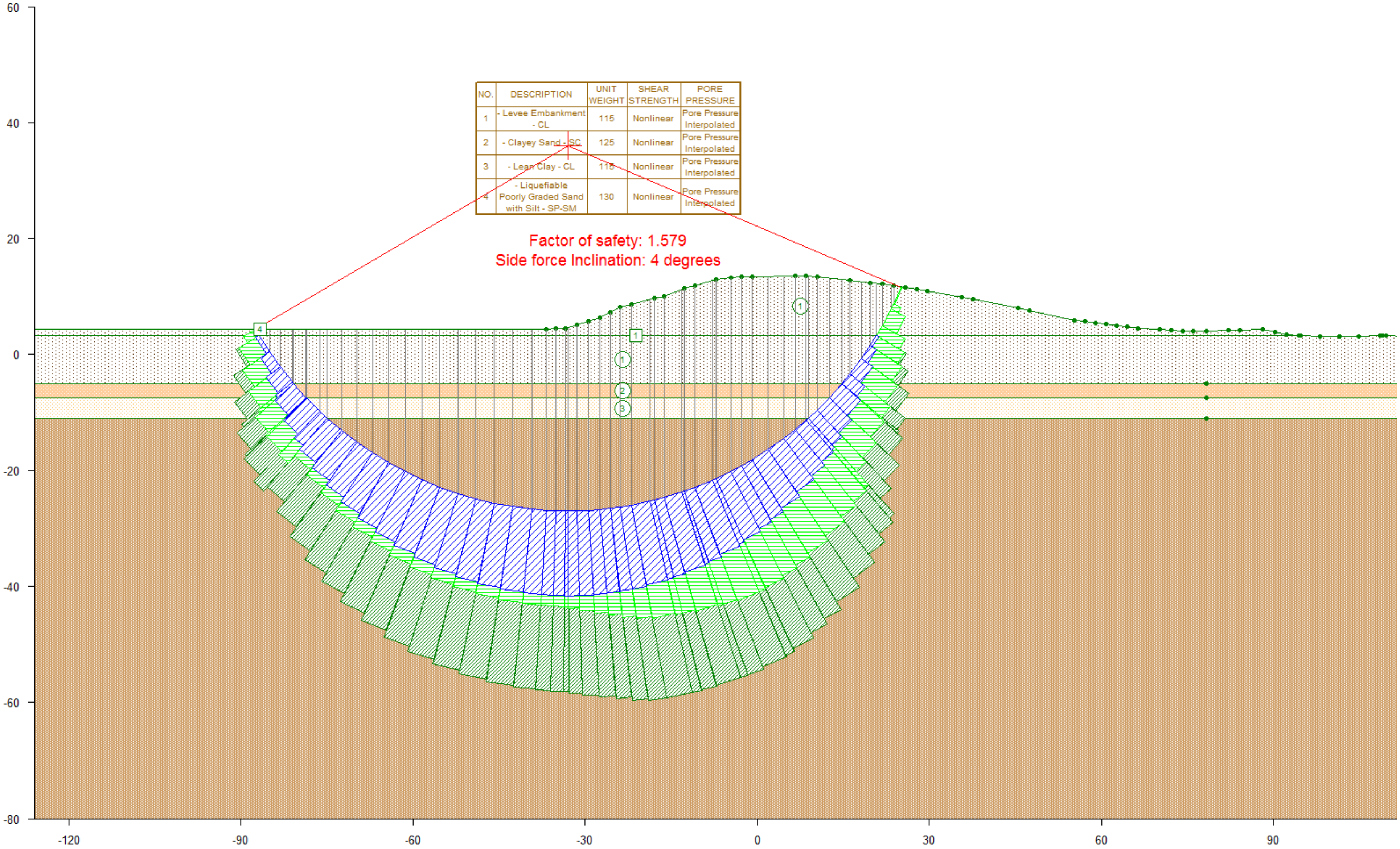


Fig F-31(a). Lincoln Village Station 43+57 – Waterside – Option 1: Circular (Sr = 201 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Fig 31(b). Lincoln Village Station 43+57 – Waterside – Option 1: Circular (PHI = 4.7 in liquefiable material)

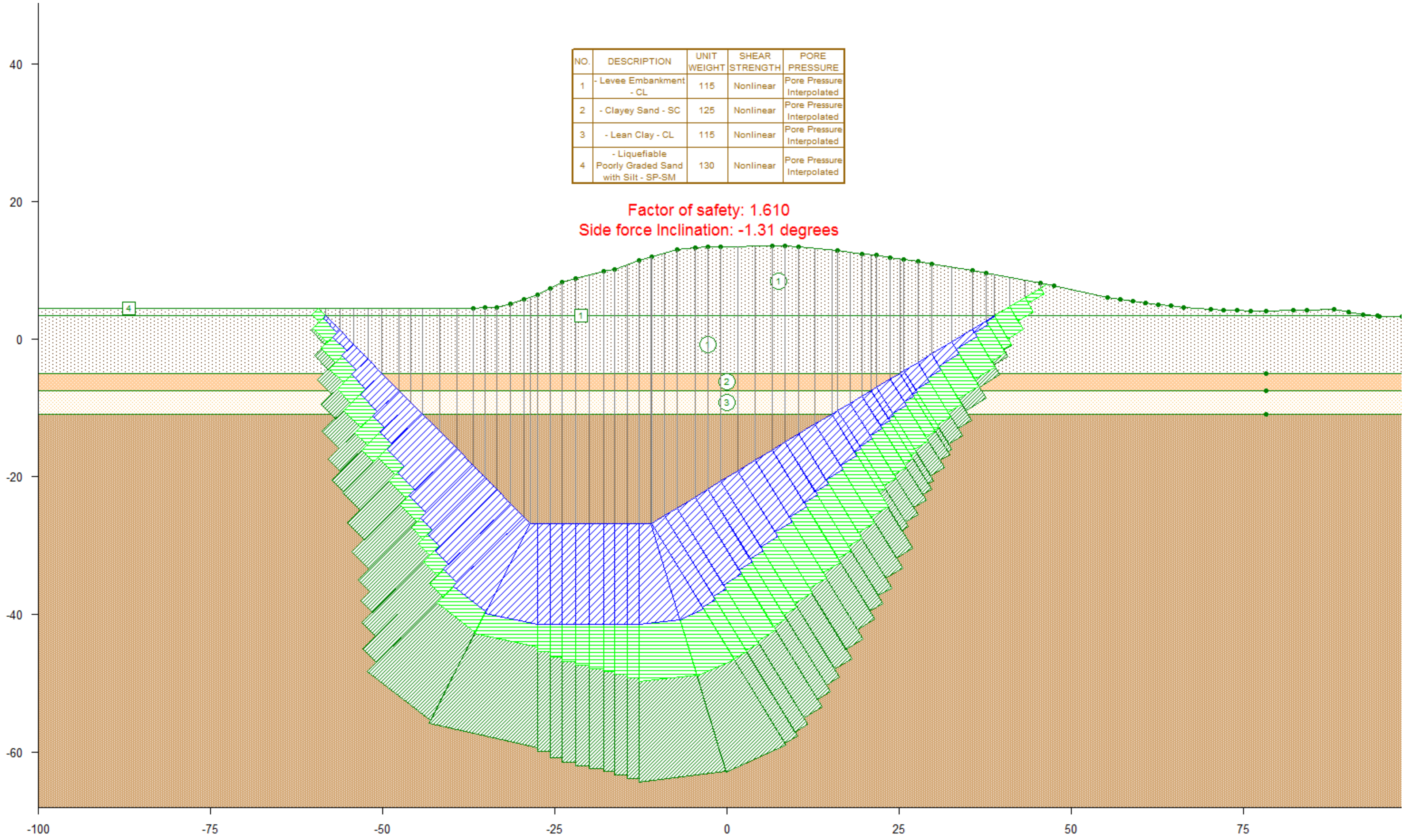
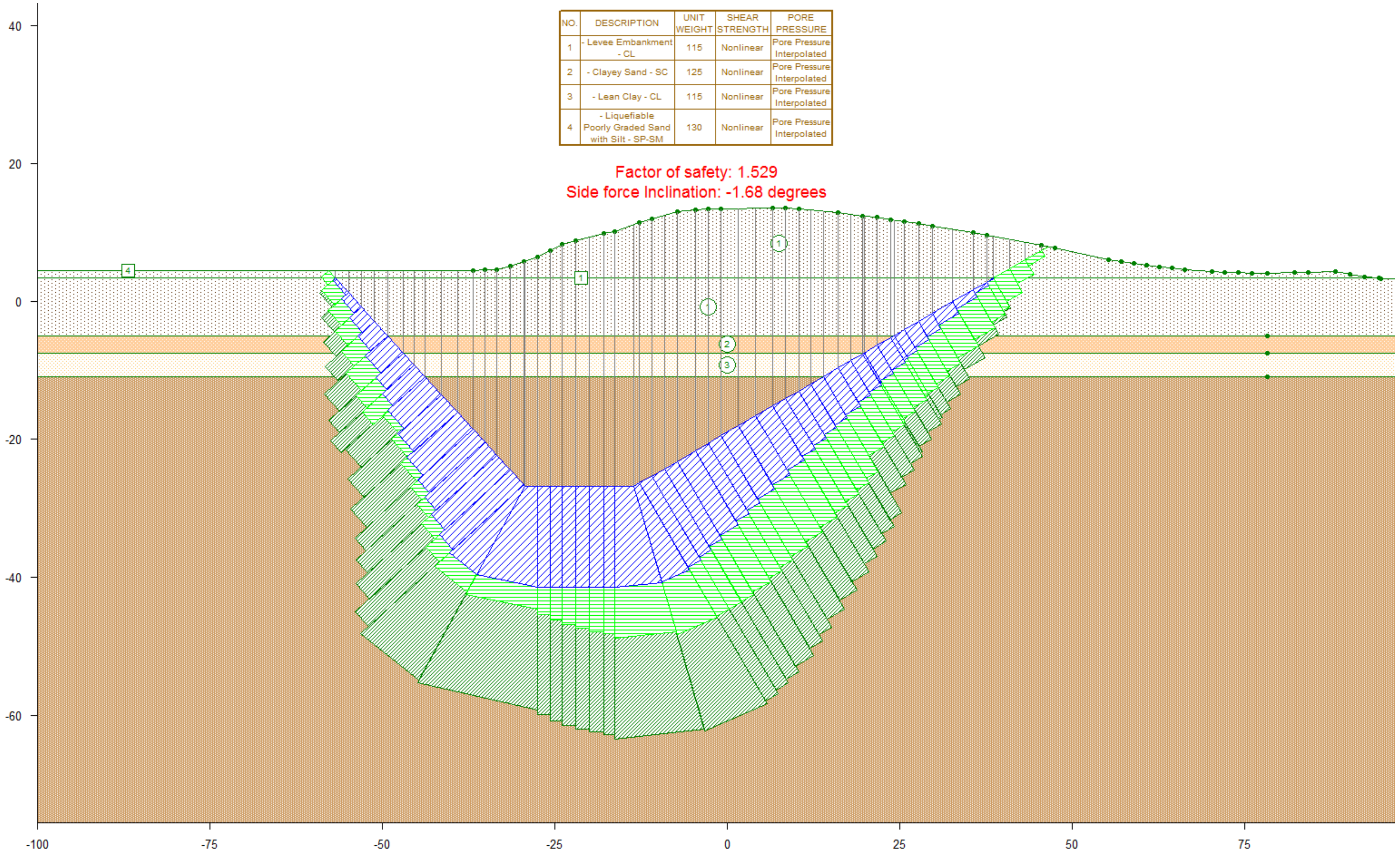


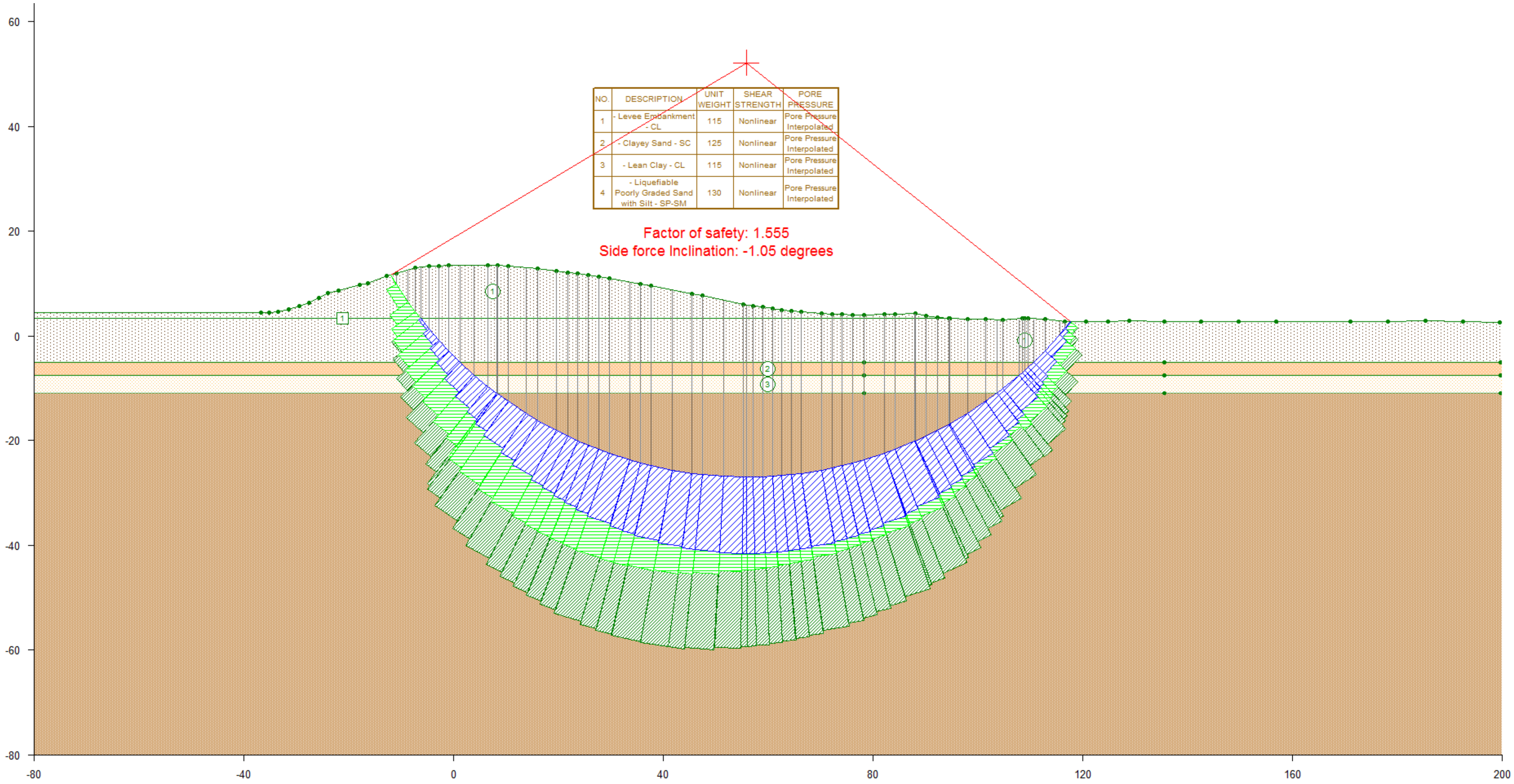
Fig F-32(a). Lincoln Village Station 43+57 – Waterside – Option 2: Wedge (Sr = 201 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

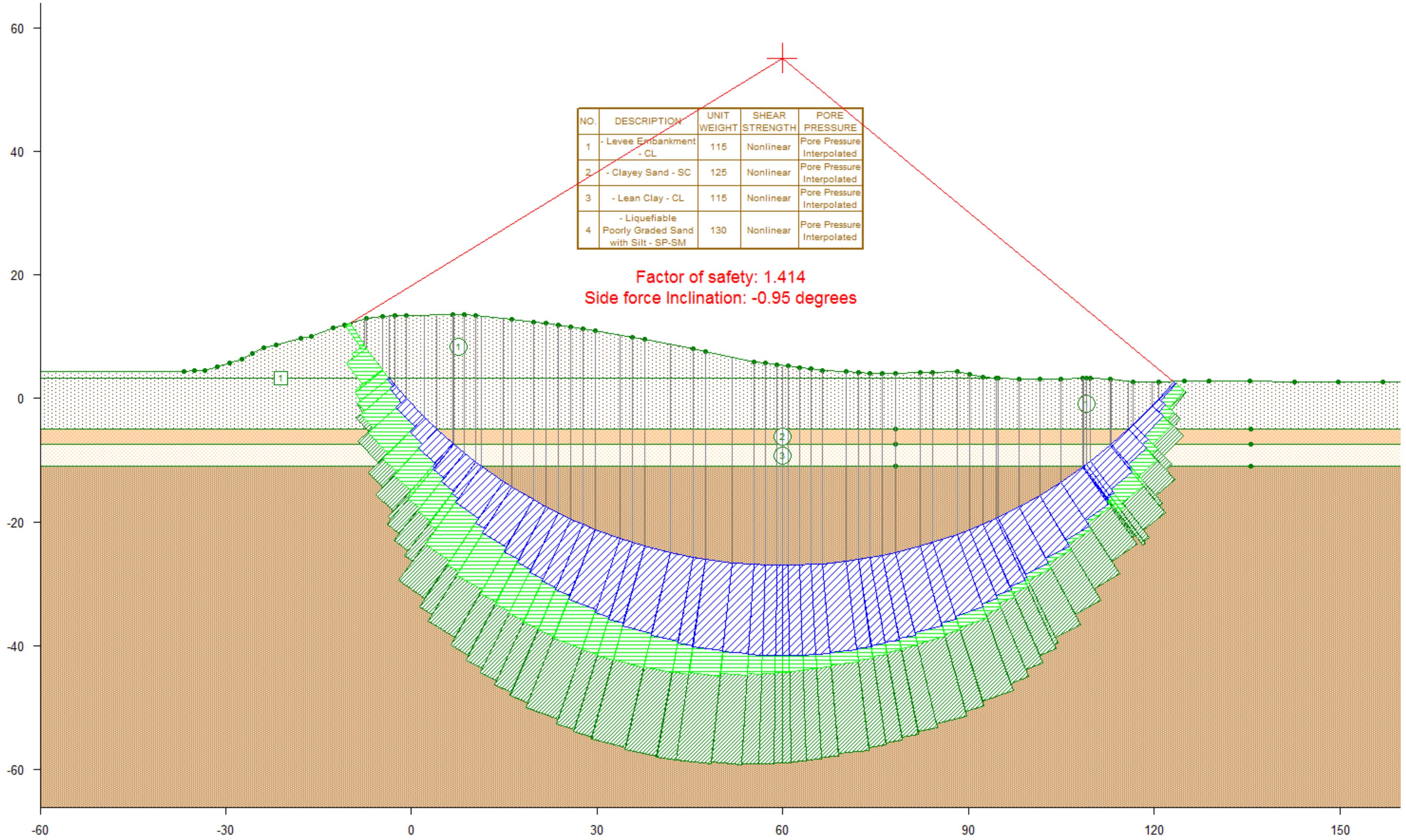
Factor of safety: 1.529
Side force Inclination: -1.68 degrees

Fig 32(b). Lincoln Village Station 43+57 – Waterside – Option 2: Wedge (PHI = 4.7 in liquefiable material)



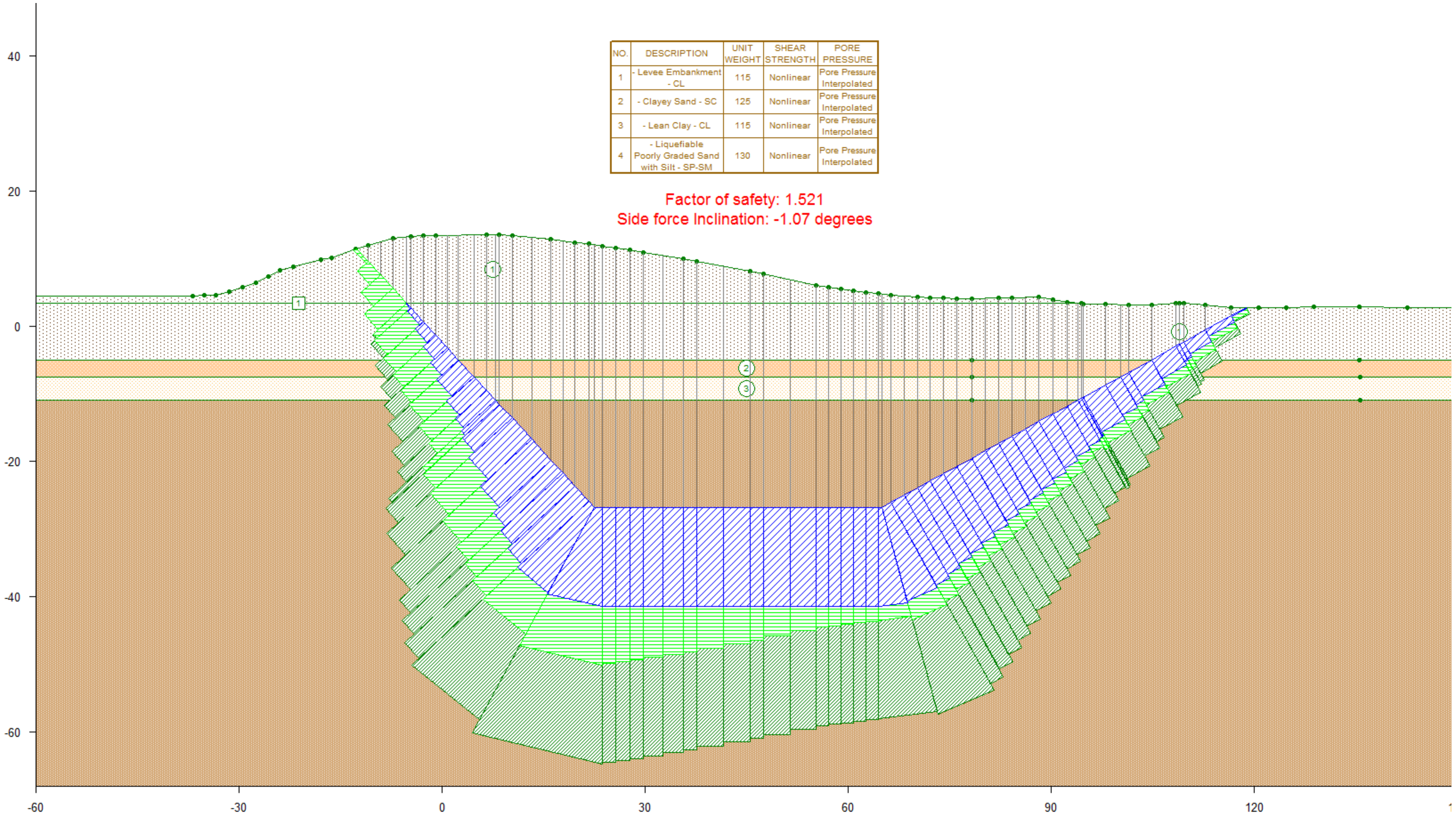
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Fig F-33(a). Lincoln Village Station 43+57 – Landside – Option 3: Circular (Sr = 201 psf in liquefiable material)



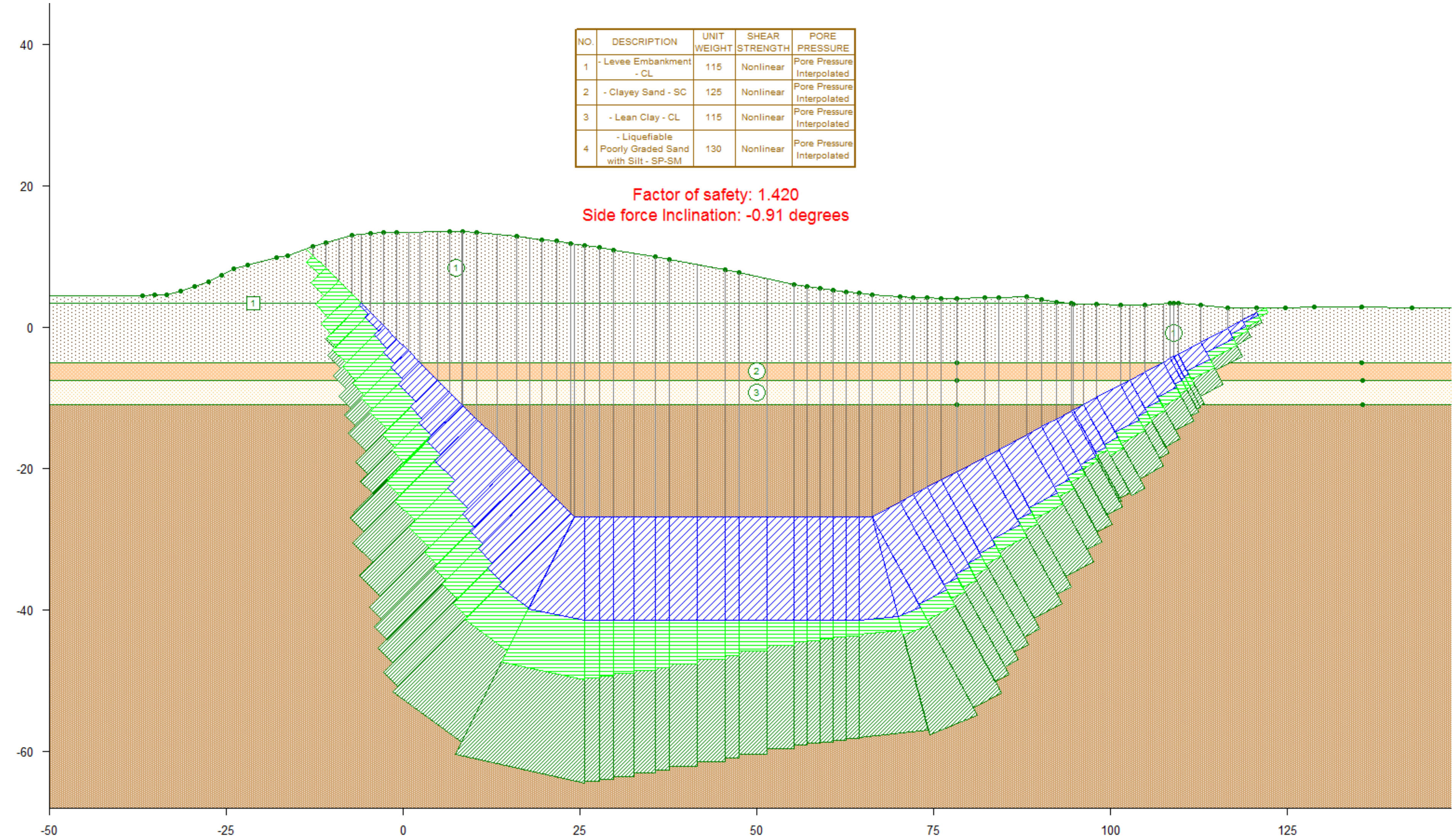
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Fig 33(b). Lincoln Village Station 43+57 – Landside – Option 3: Circular (PHI = 4.7 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

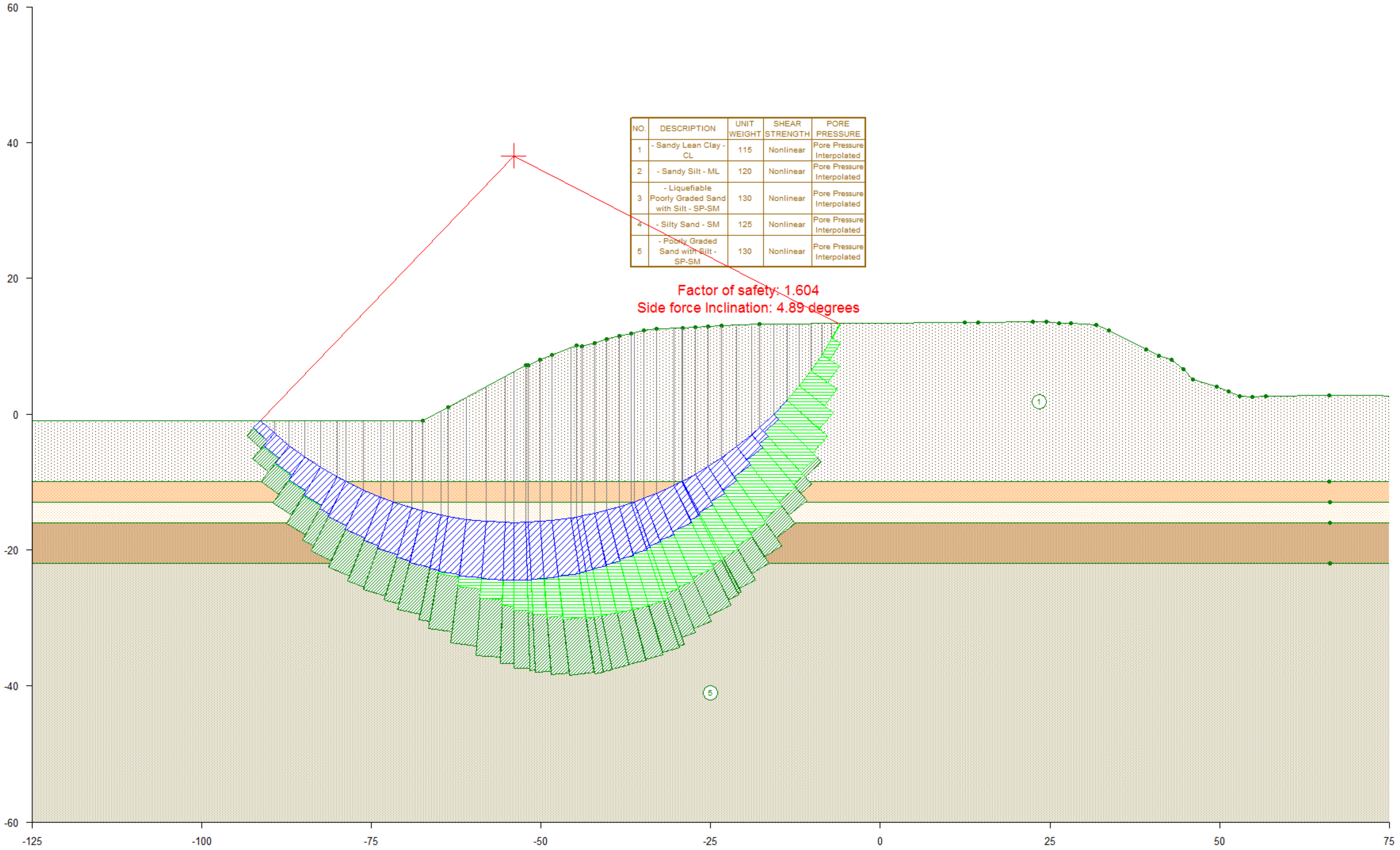
Fig F-34(a). Lincoln Village Station 43+57 – Landside – Option 4: Wedge (Sr = 201 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Clayey Sand - SC	125	Nonlinear	Pore Pressure Interpolated
3	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
4	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

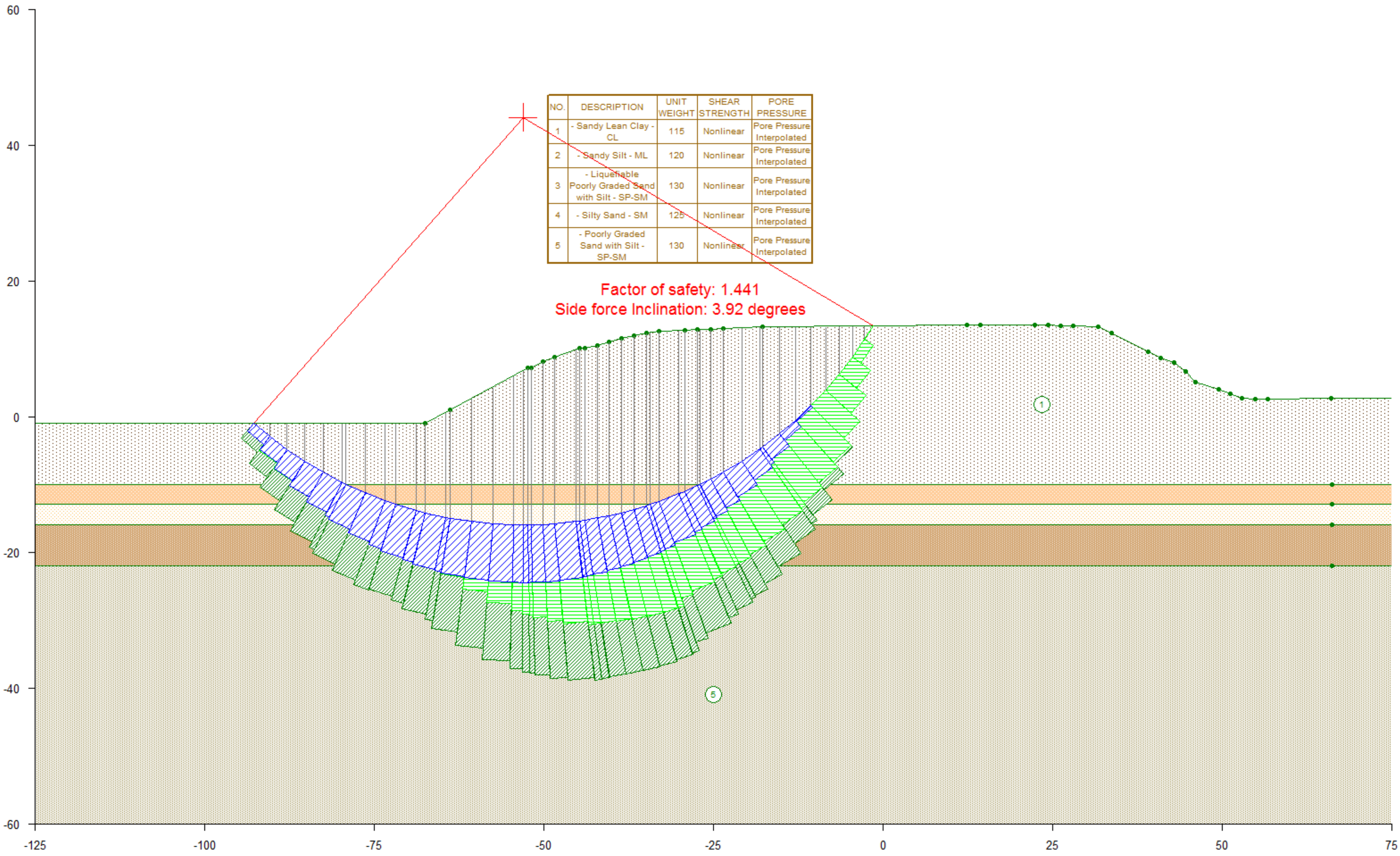
Factor of safety: 1.420
Side force Inclination: -0.91 degrees

Fig 34(b). Lincoln Village Station 43+57 – Landside – Option 4: Wedge (PHI = 4.7 in liquefiable material)



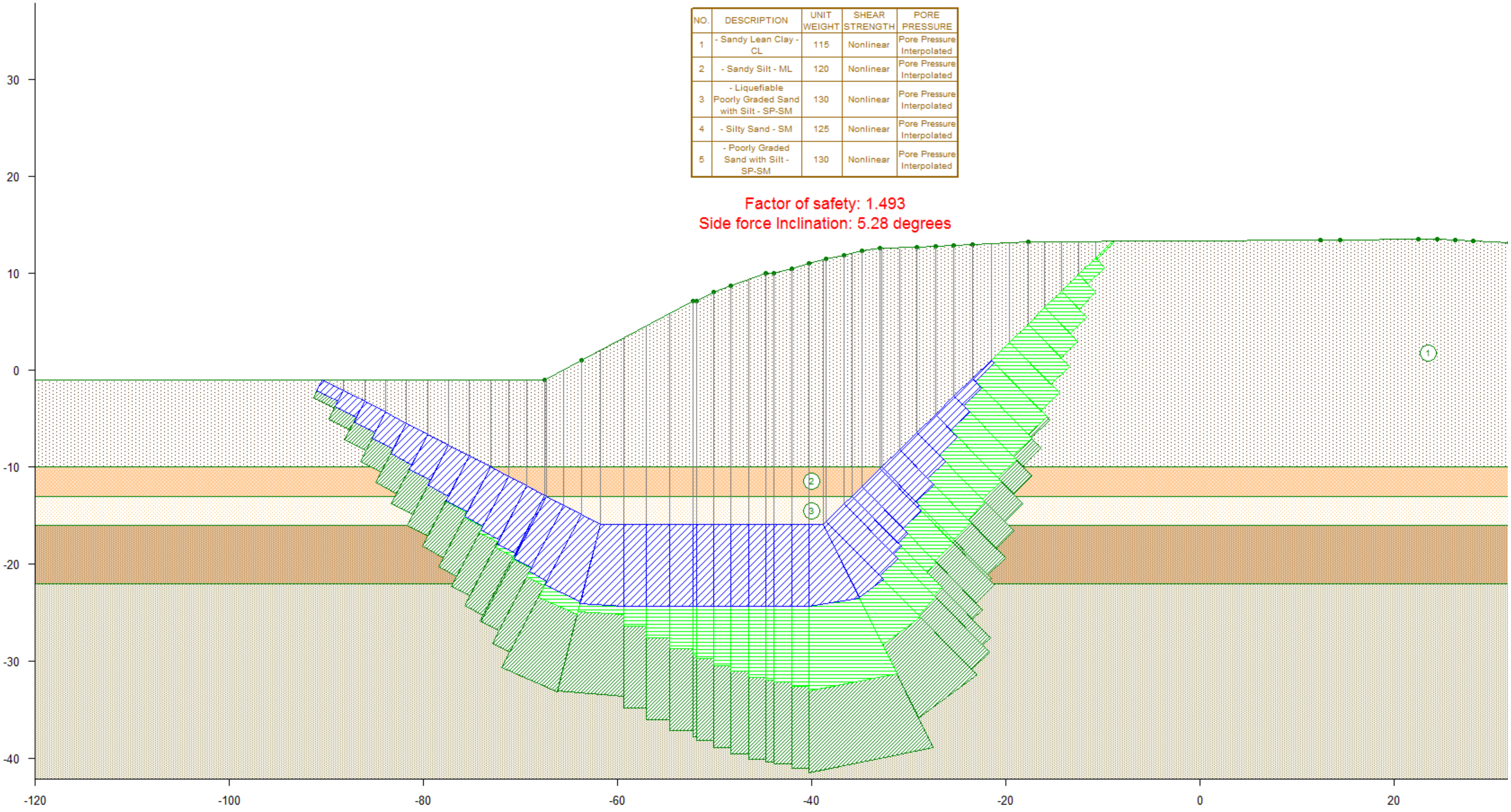
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Sandy Silt - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Fig F-35(a). Lincoln Village Station 109+90 – Waterside – Option 1: Circular (Sr = 282 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Sandy Silt - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Fig 35(b). Lincoln Village Station 109+90 – Waterside – Option 1: Circular (PHI = 6.0 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Sandy Silt - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Fig F-36(a). Lincoln Village Station 109+90 – Waterside – Option 2: Wedges (Sr = 282 psf in liquefiable material)

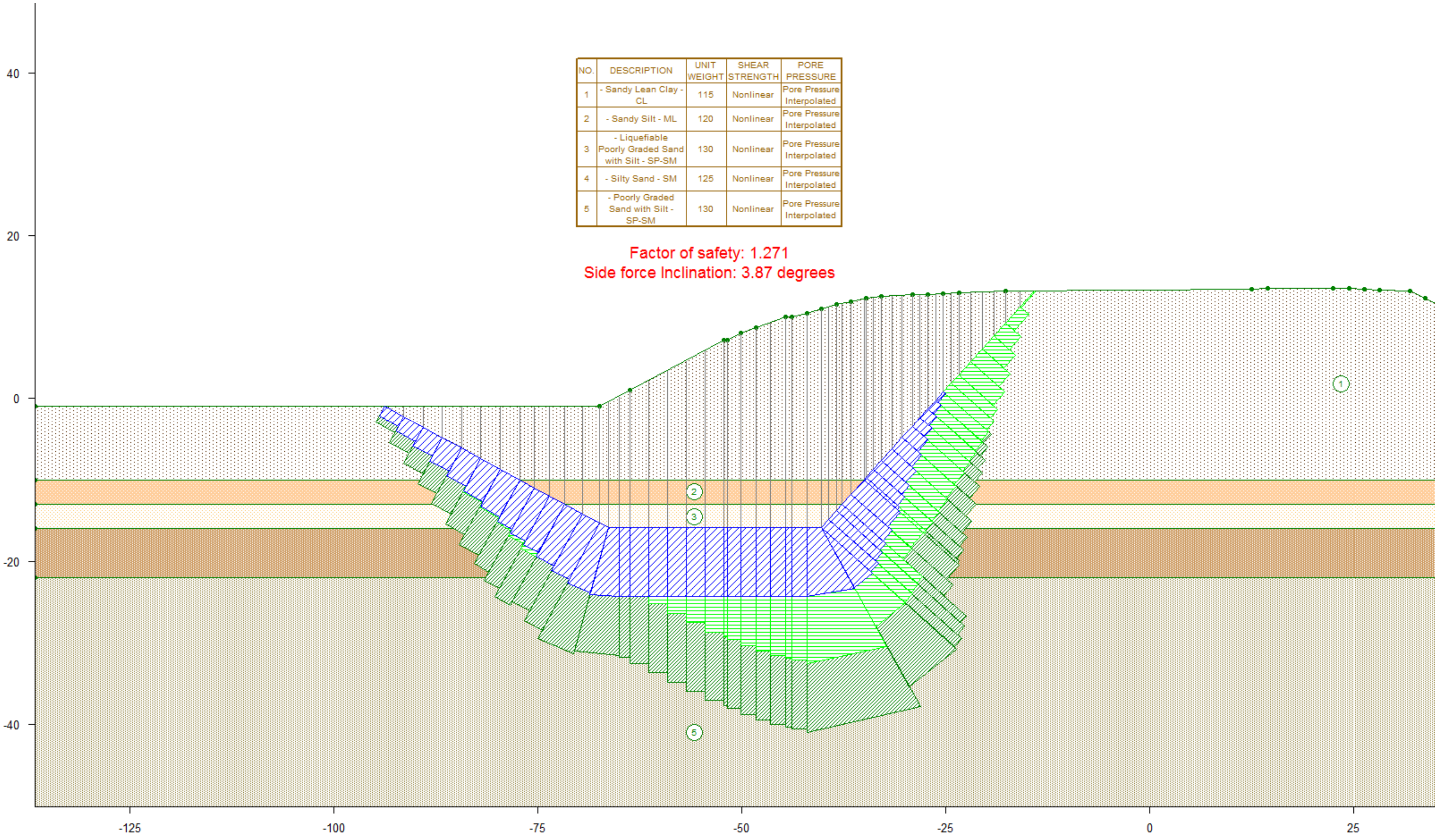
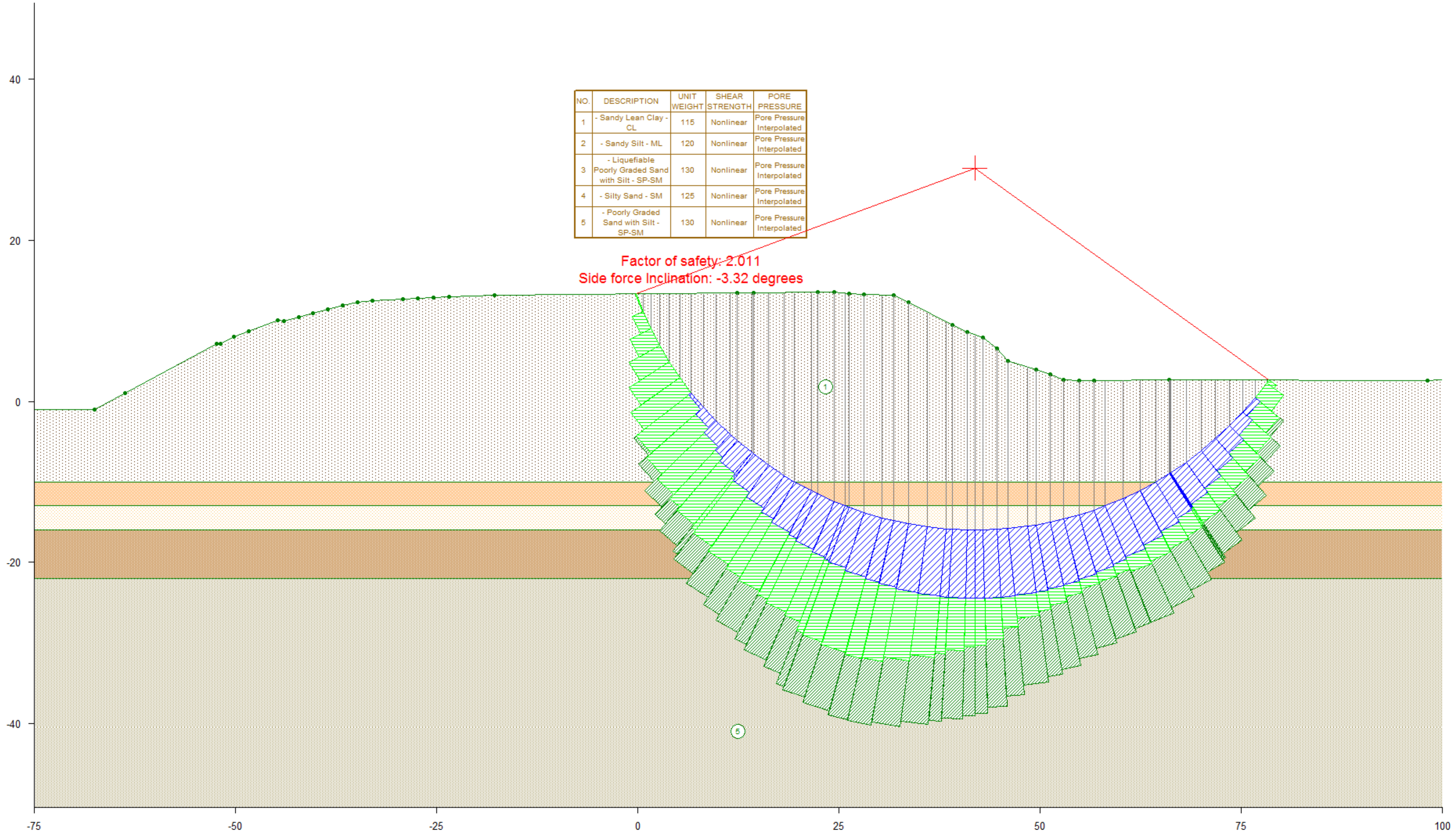
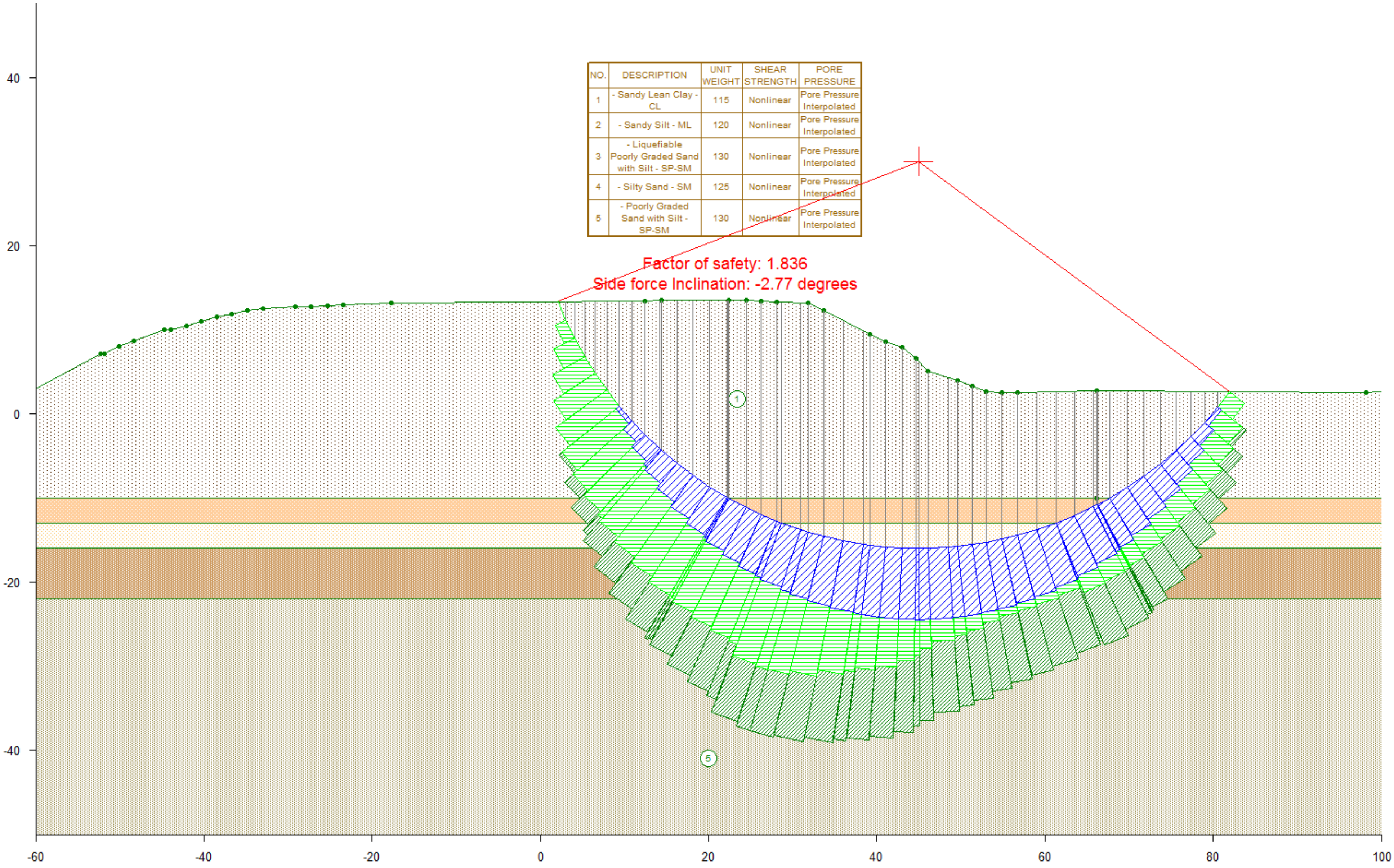


Fig 36(b). Lincoln Village Station 109+90 – Waterside – Option 2: Wedges (PHI = 6.0 in liquefiable material)



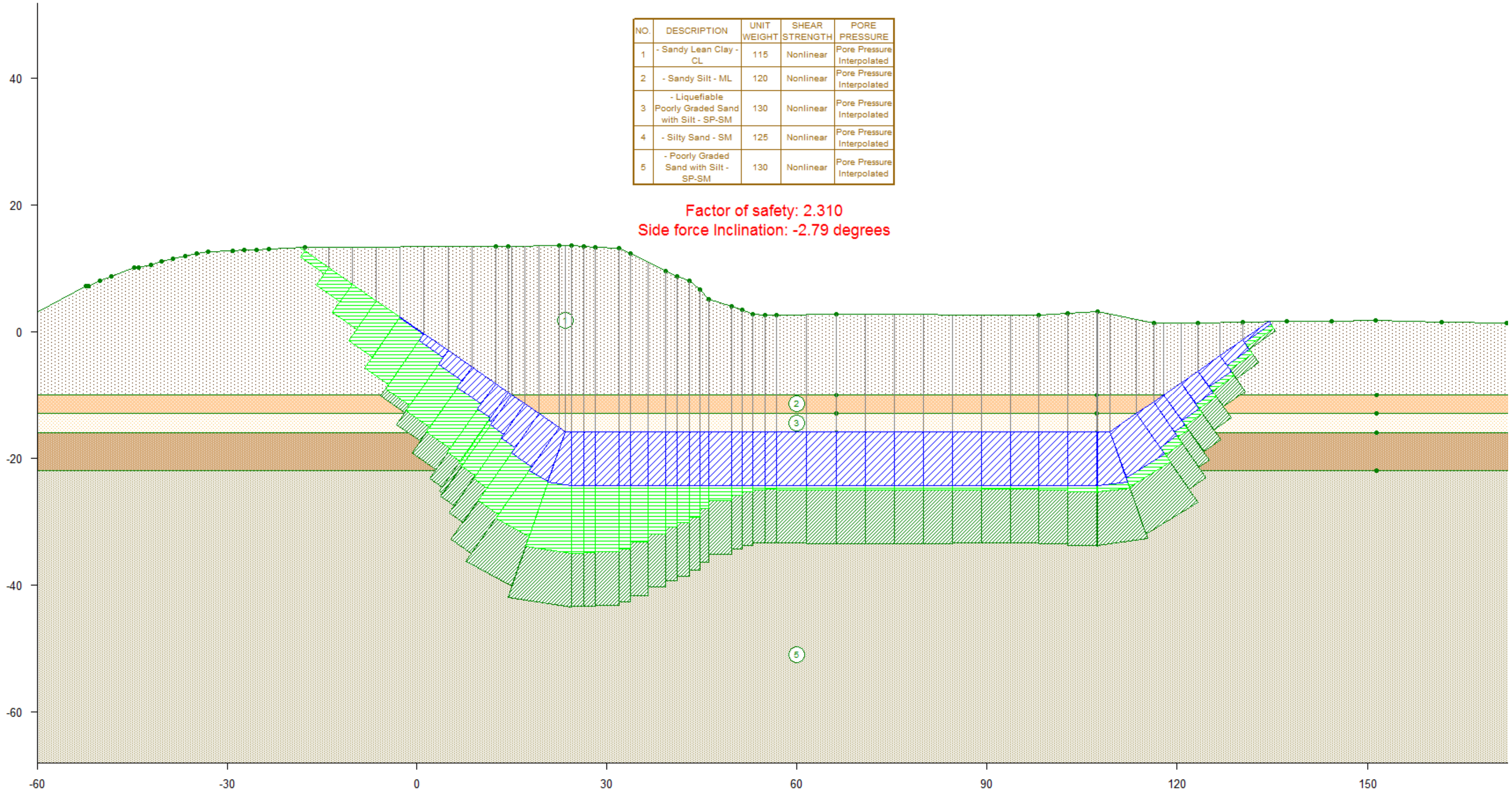
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Sandy Silt - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Fig F-37(a). Lincoln Village Station 109+90 – Landside – Option 3: Circular (Sr = 282 psf in liquefiable material)



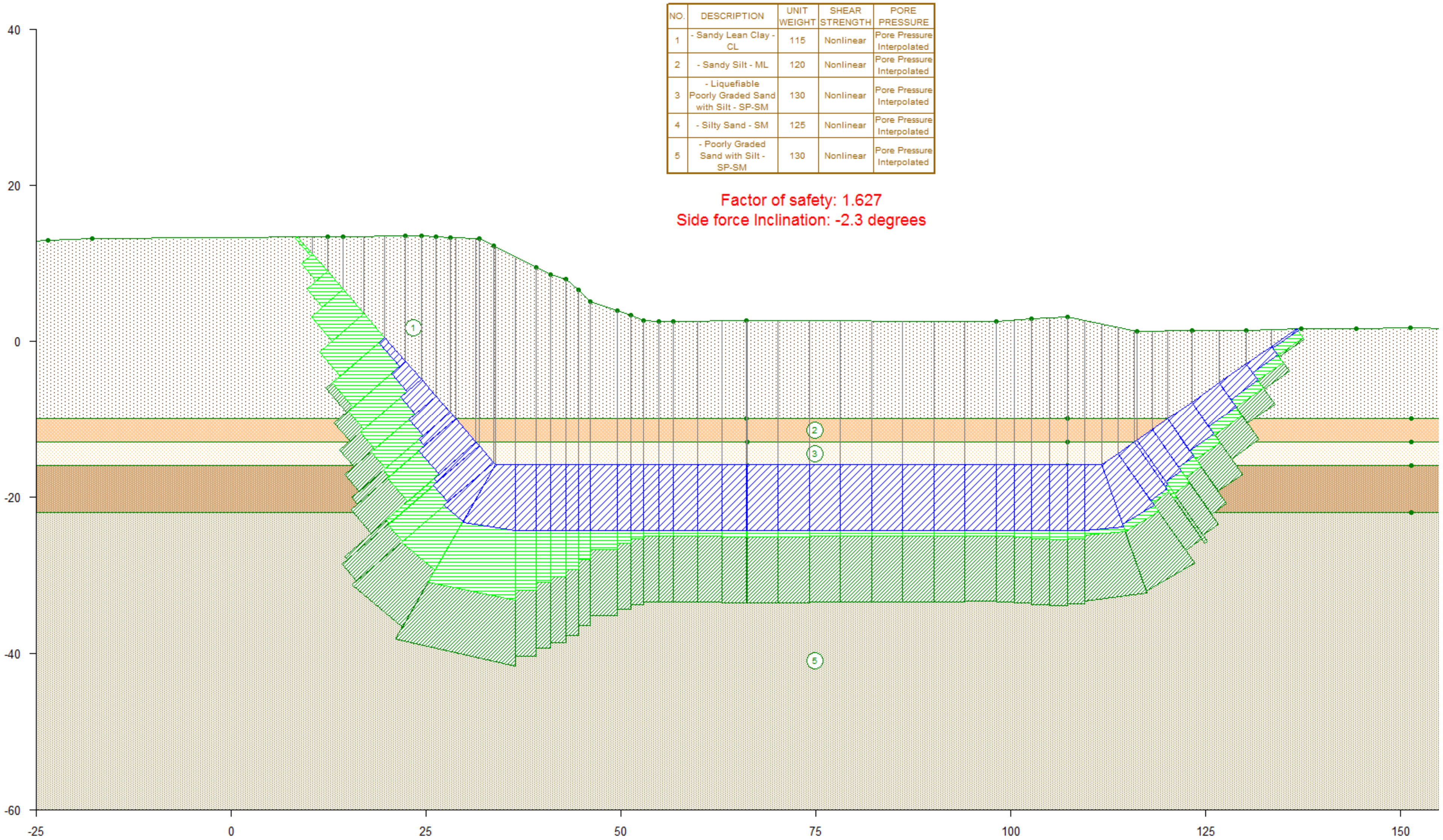
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Sandy Silt - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Fig 37(b). Lincoln Village Station 109+90 – Landside – Option 3: Circular (PHI = 6.0 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Sandy Silt - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

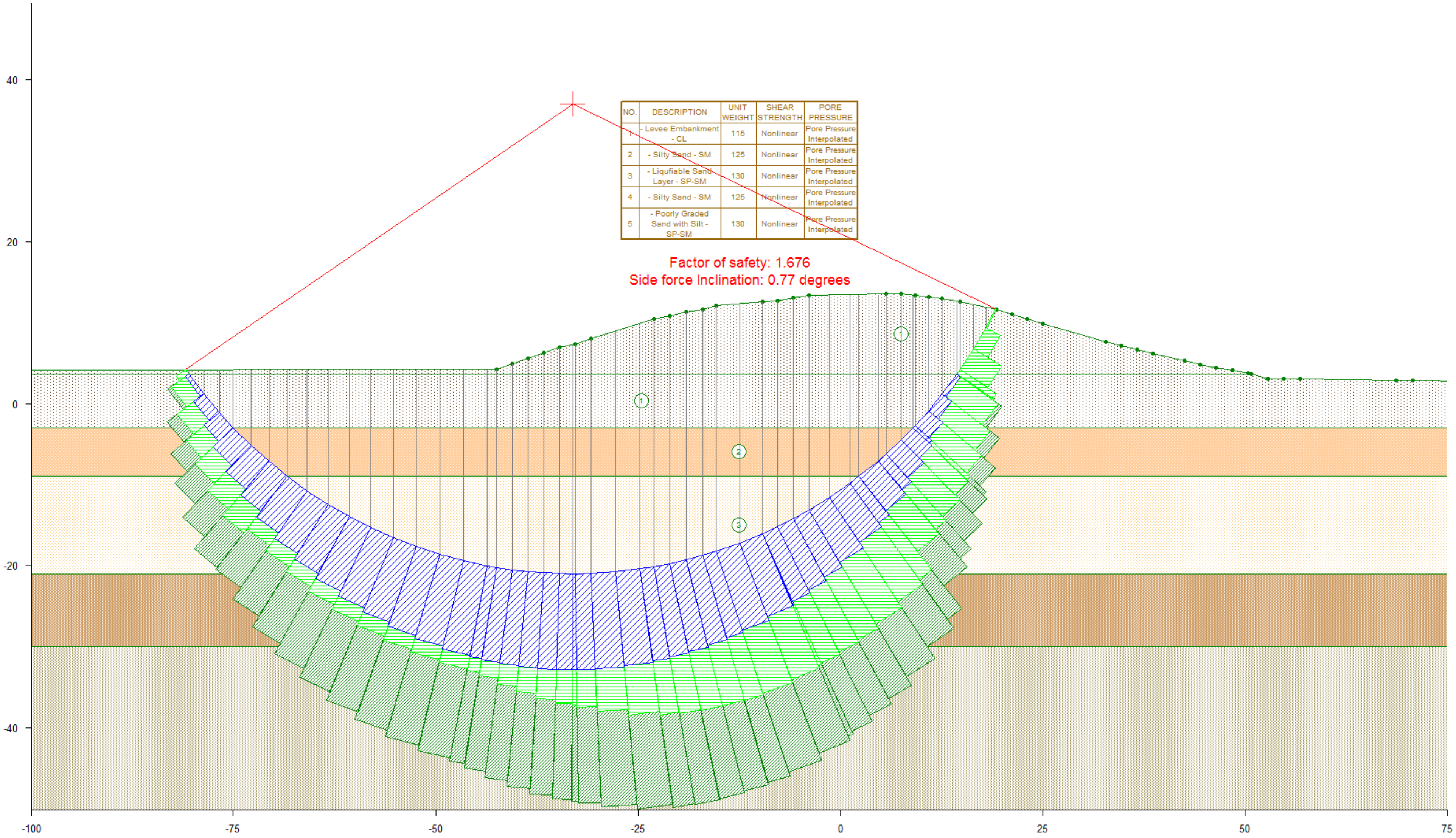
Fig F-38(a). Lincoln Village Station 109+90 – Landside – Option 4: Wedge (Sr = 282 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Sandy Silt - ML	120	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.627
Side force Inclination: -2.3 degrees

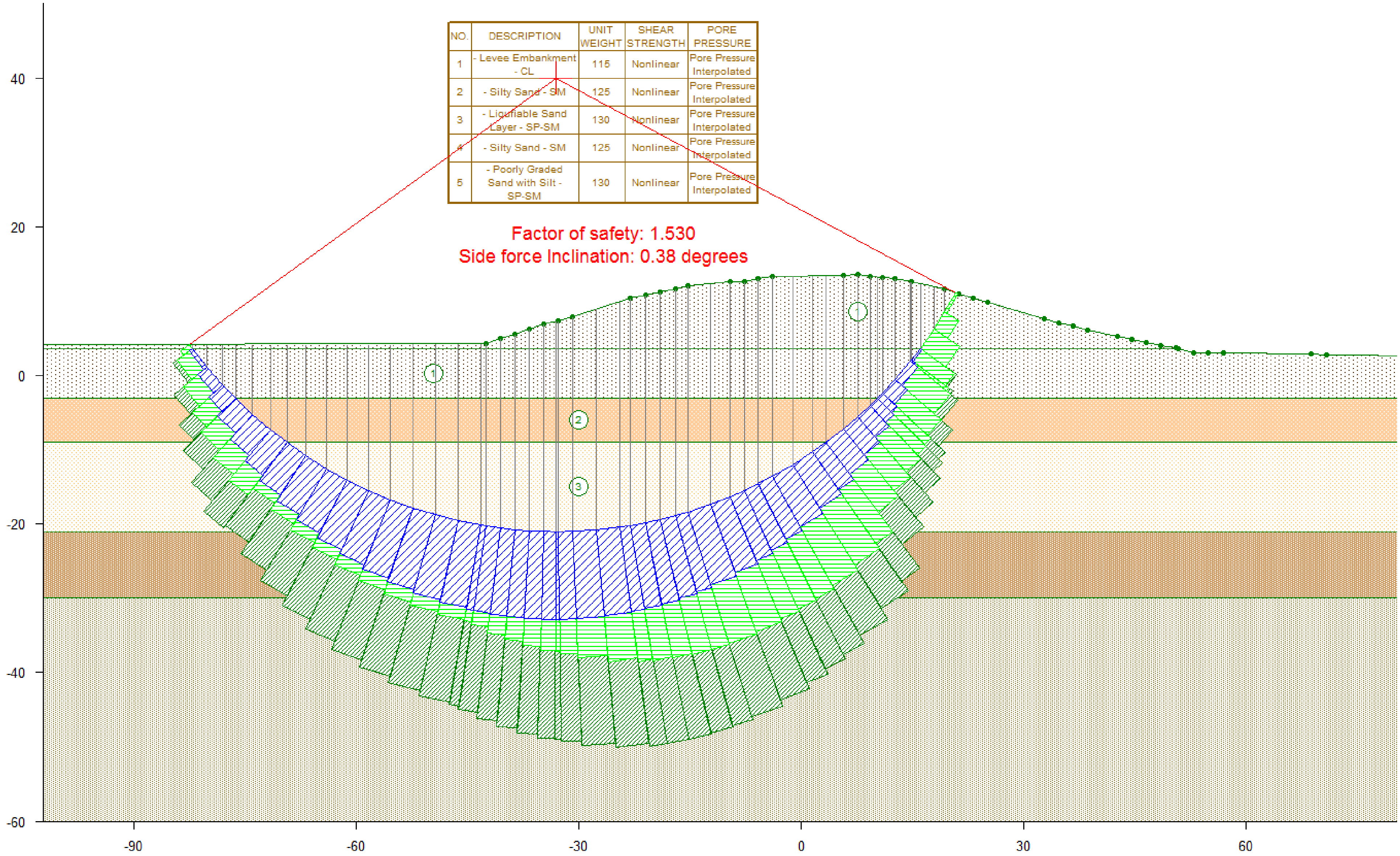
Fig 38(b). Lincoln Village Station 109+90 – Landside – Option 4: Wedge (PHI = 6.0 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liqufiable Sand Layer - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

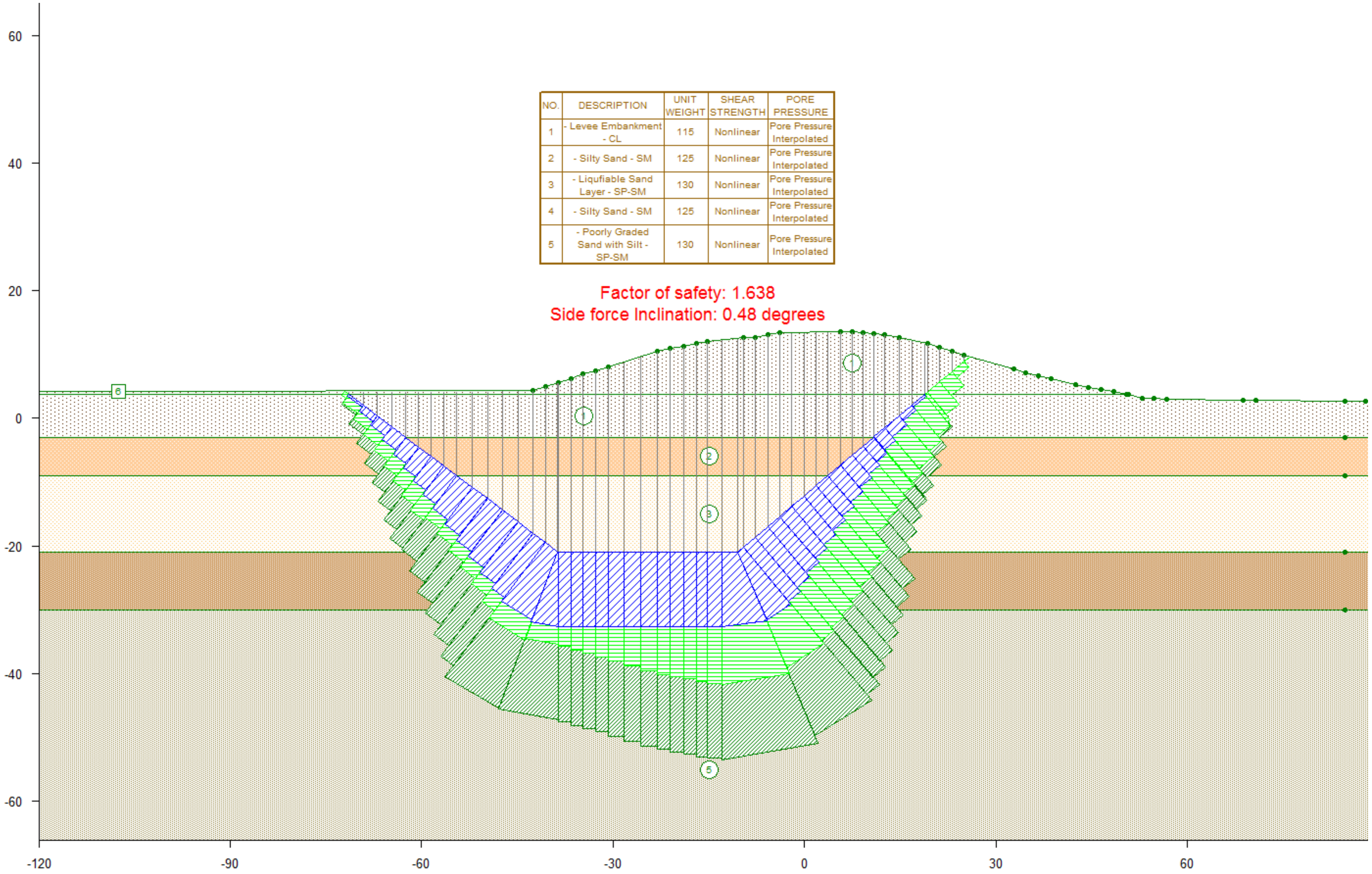
Factor of safety: 1.676
Side force Inclination: 0.77 degrees

Fig F-39(a). Lincoln Village Station 159+48 – Waterside – Option 1: Circular (Sr = 207 psf in liquefiable material)



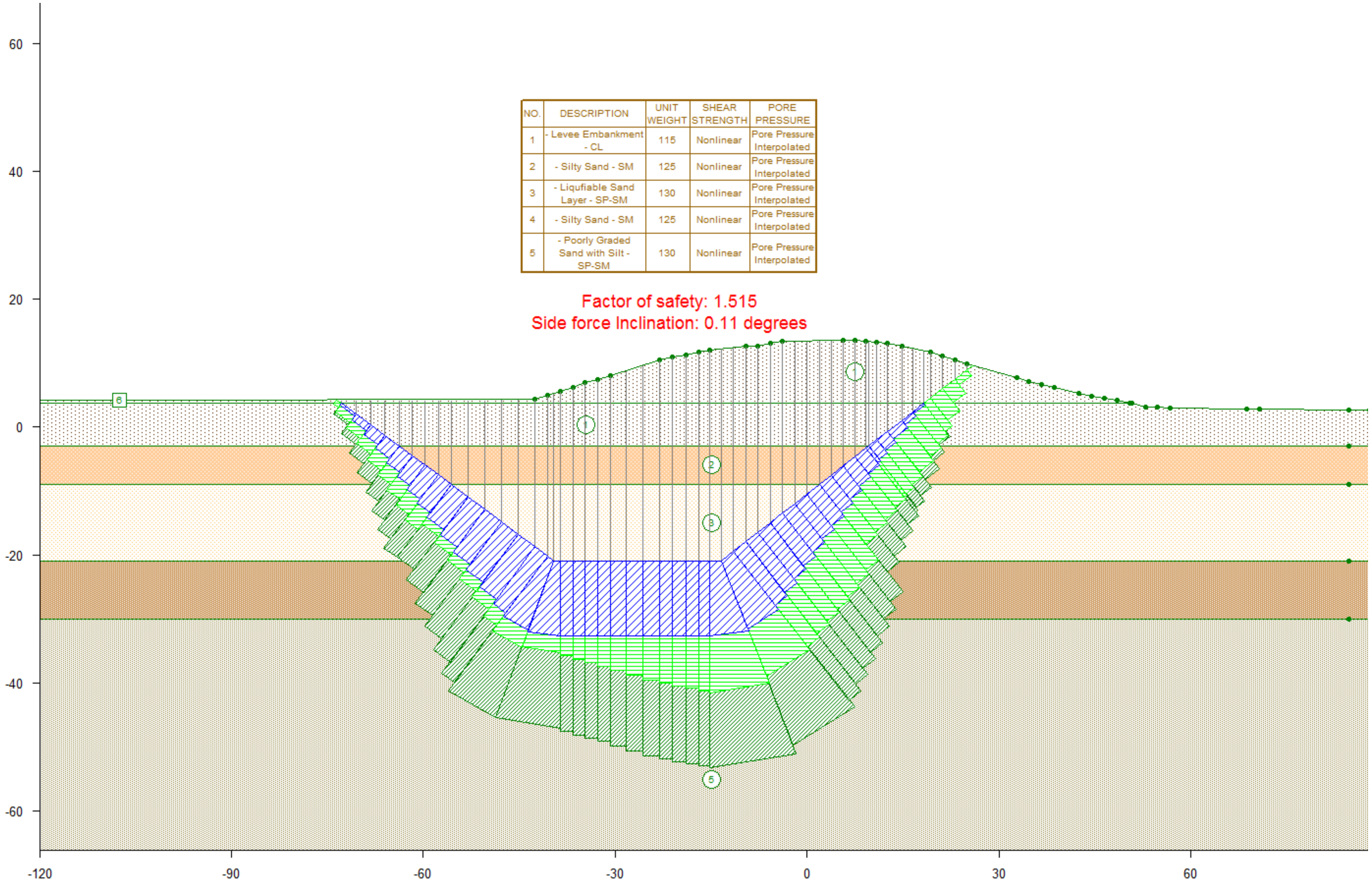
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liquifiable Sand Layer - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Fig 39b. Lincoln Village Station 159+48 – Waterside – Option 1: Circular (PHI = 5.1 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liqufiable Sand Layer - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

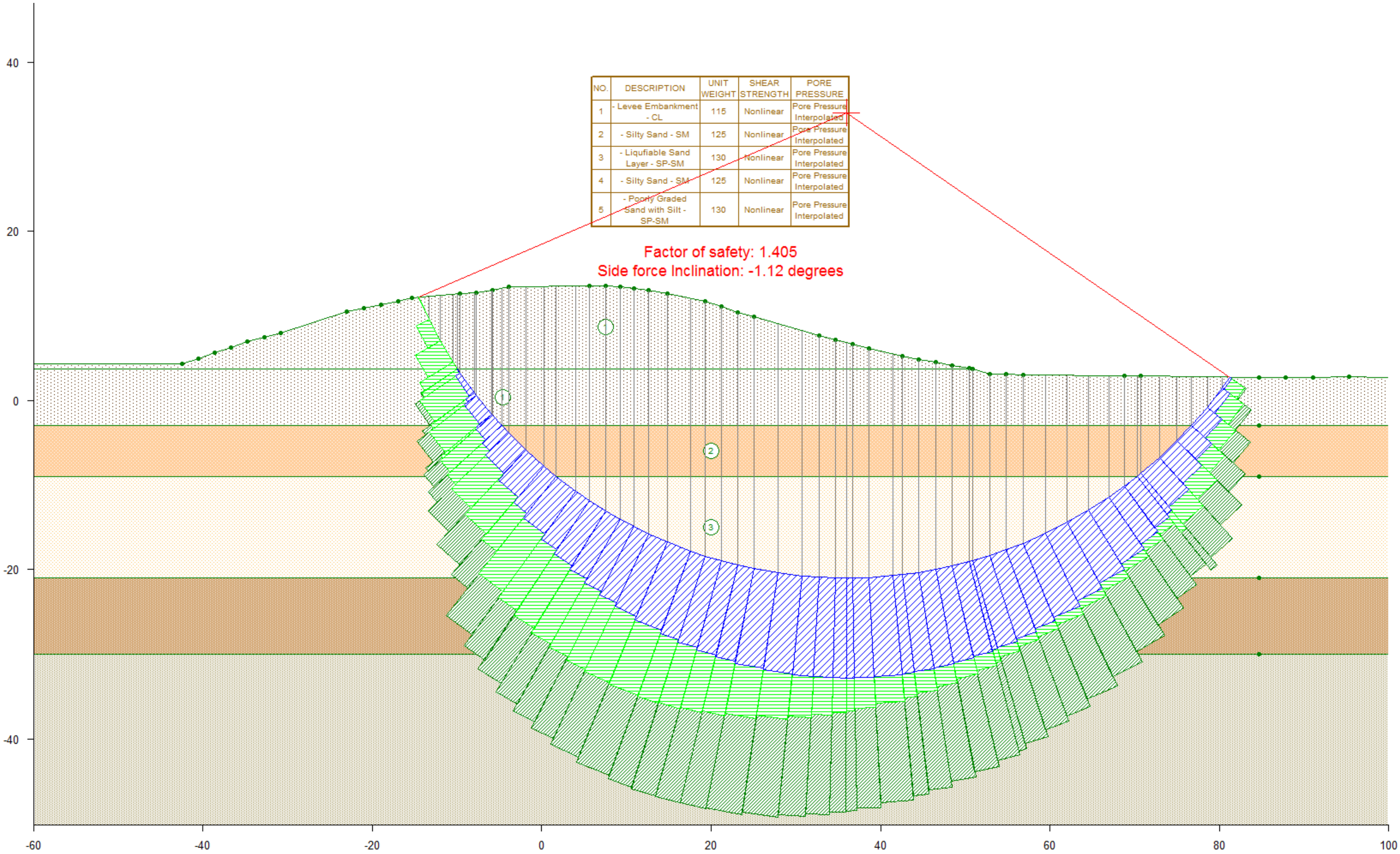
Fig F-40(a). Lincoln Village Station 159+48 – Waterside – Option 2: Wedges (Sr = 207 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liqufiable Sand Layer - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.515
Side force Inclination: 0.11 degrees

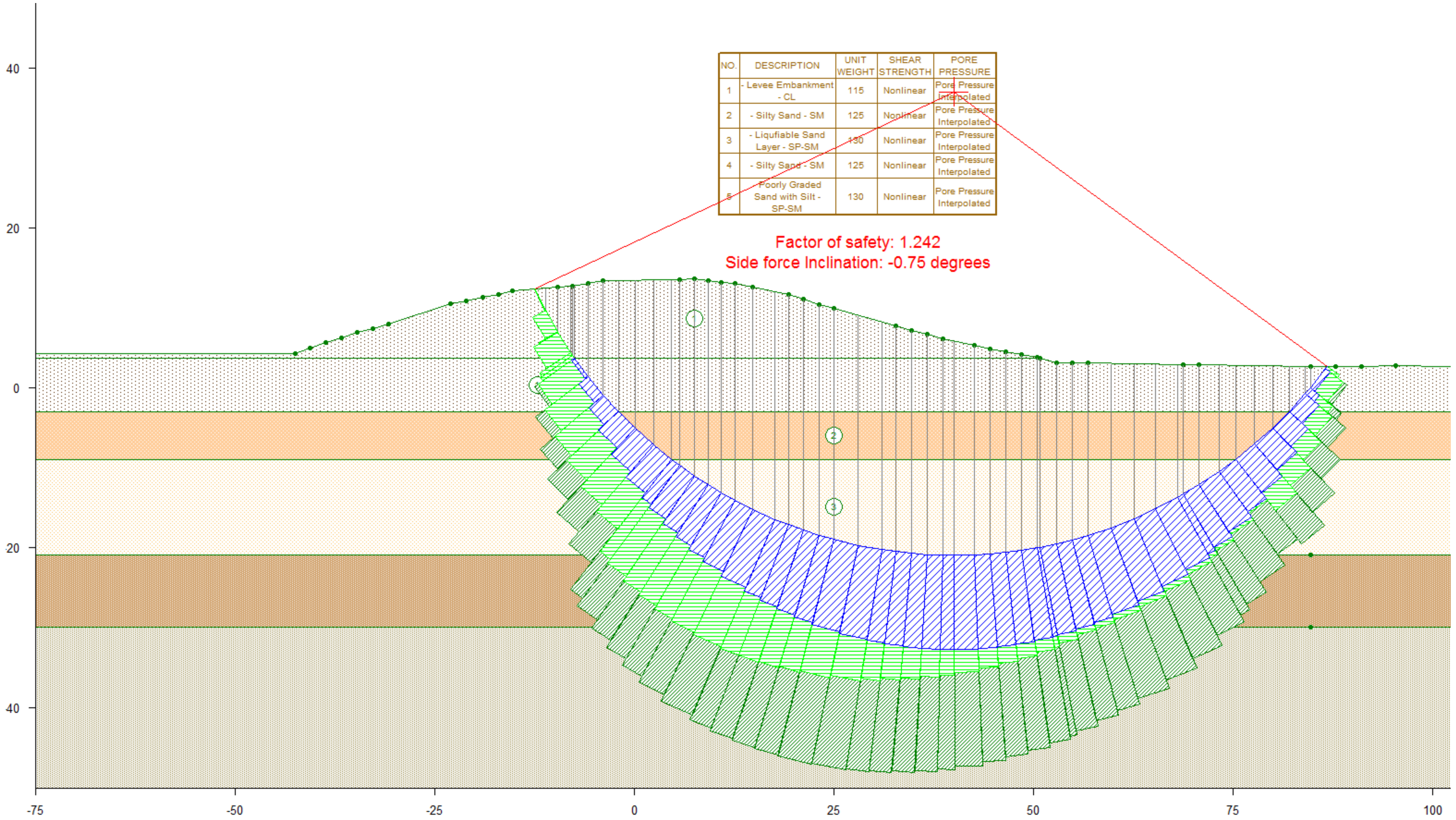
Fig 40(b). Lincoln Village Station 159+48 – Waterside – Option 2: Wedges (PHI = 5.1 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liqufiable Sand Layer - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.405
Side force Inclination: -1.12 degrees

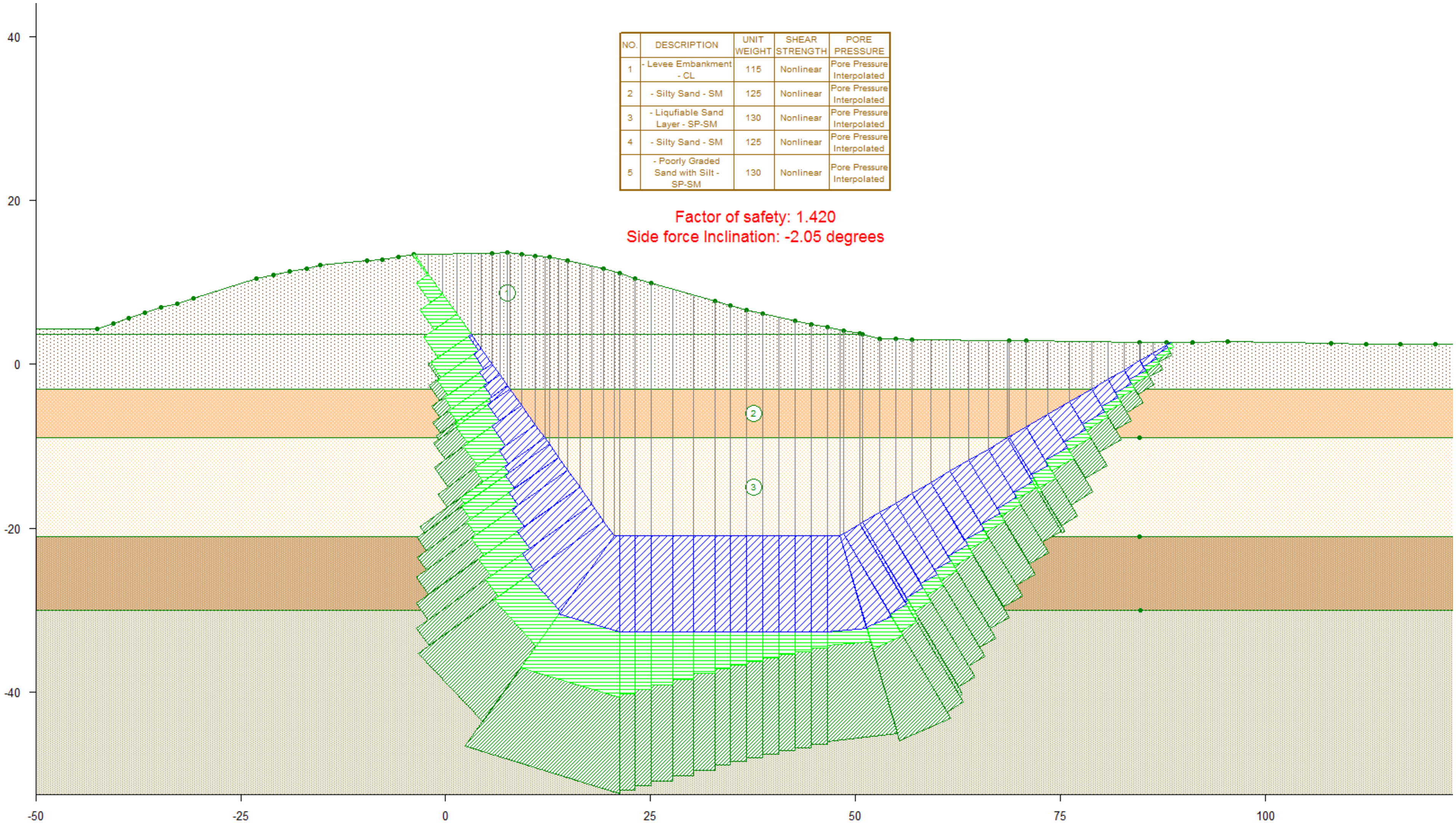
Fig F-41(a). Lincoln Village Station 159+48– Landside – Option 3: Circular (Sr = 207 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liqufiable Sand Layer - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

Factor of safety: 1.242
Side force Inclination: -0.75 degrees

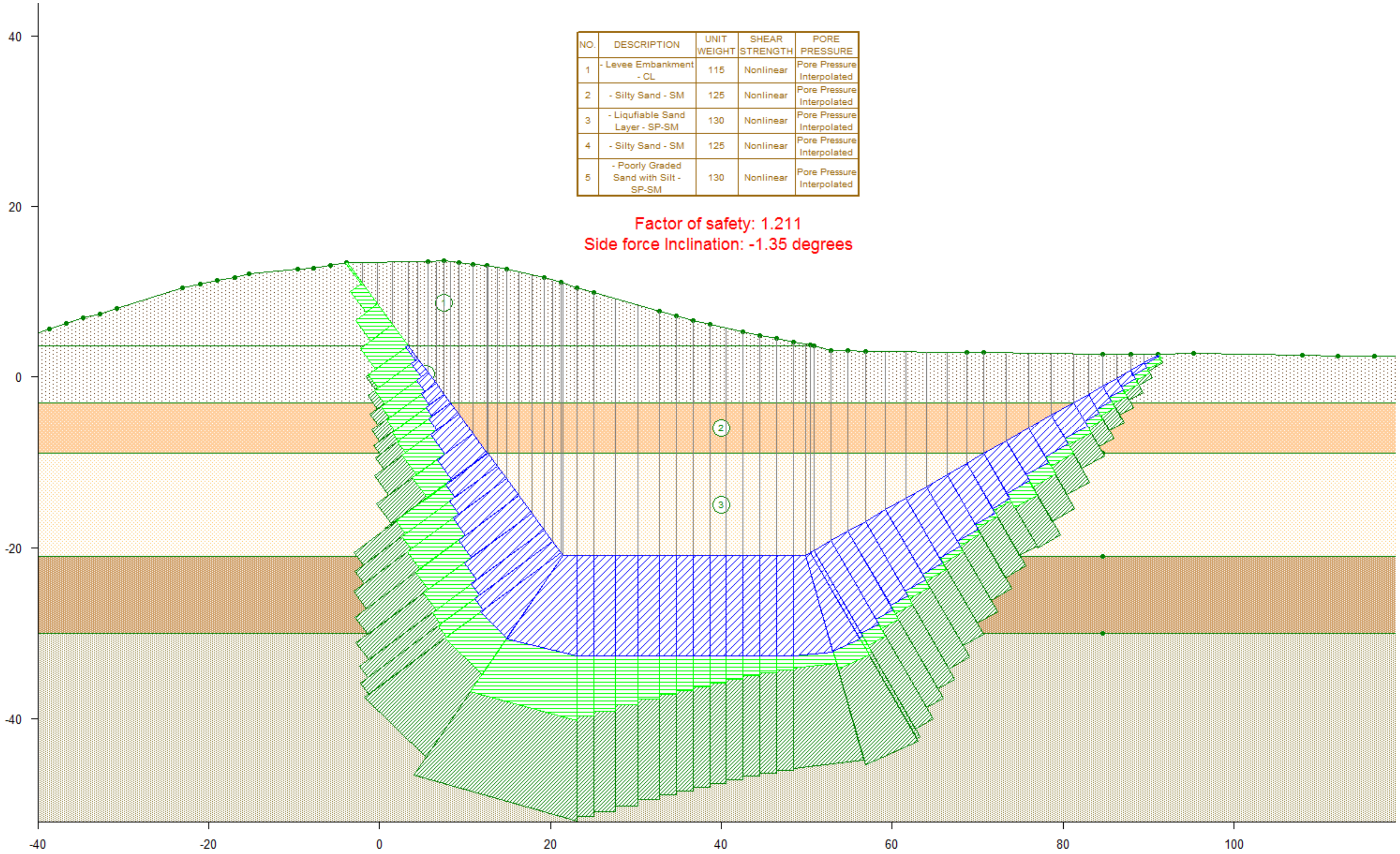
Fig 41(b). Lincoln Village Station 159+48– Landside – Option 3: Circular (PHI = 5.1 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liqufiable Sand Layer - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

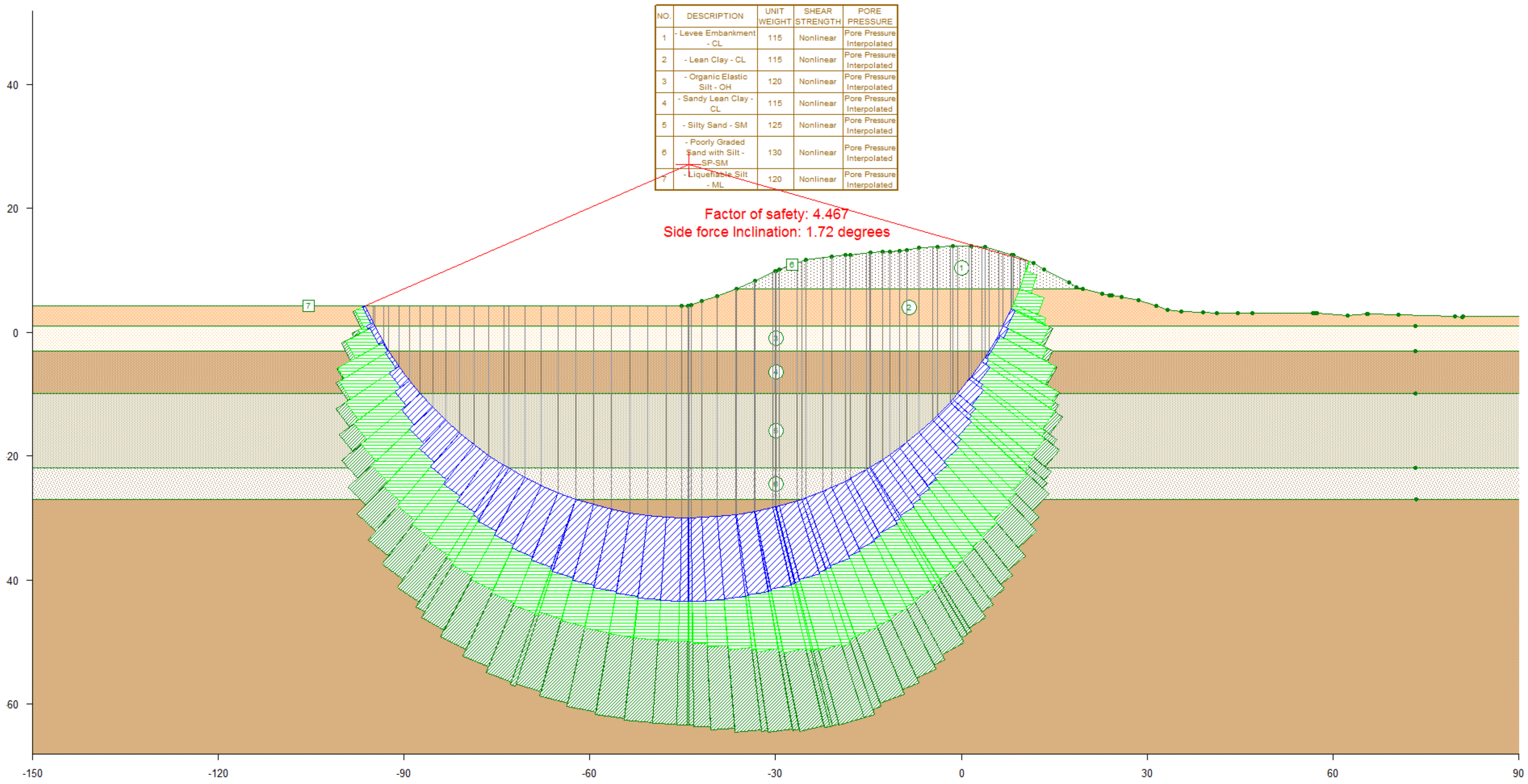
Factor of safety: 1.420
Side force Inclination: -2.05 degrees

Fig F-42(a). Lincoln Village Station 159+48 – Landside – Option 4: Wedge (Sr = 207 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liqufiable Sand Layer - SP-SM	130	Nonlinear	Pore Pressure Interpolated
4	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
5	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated

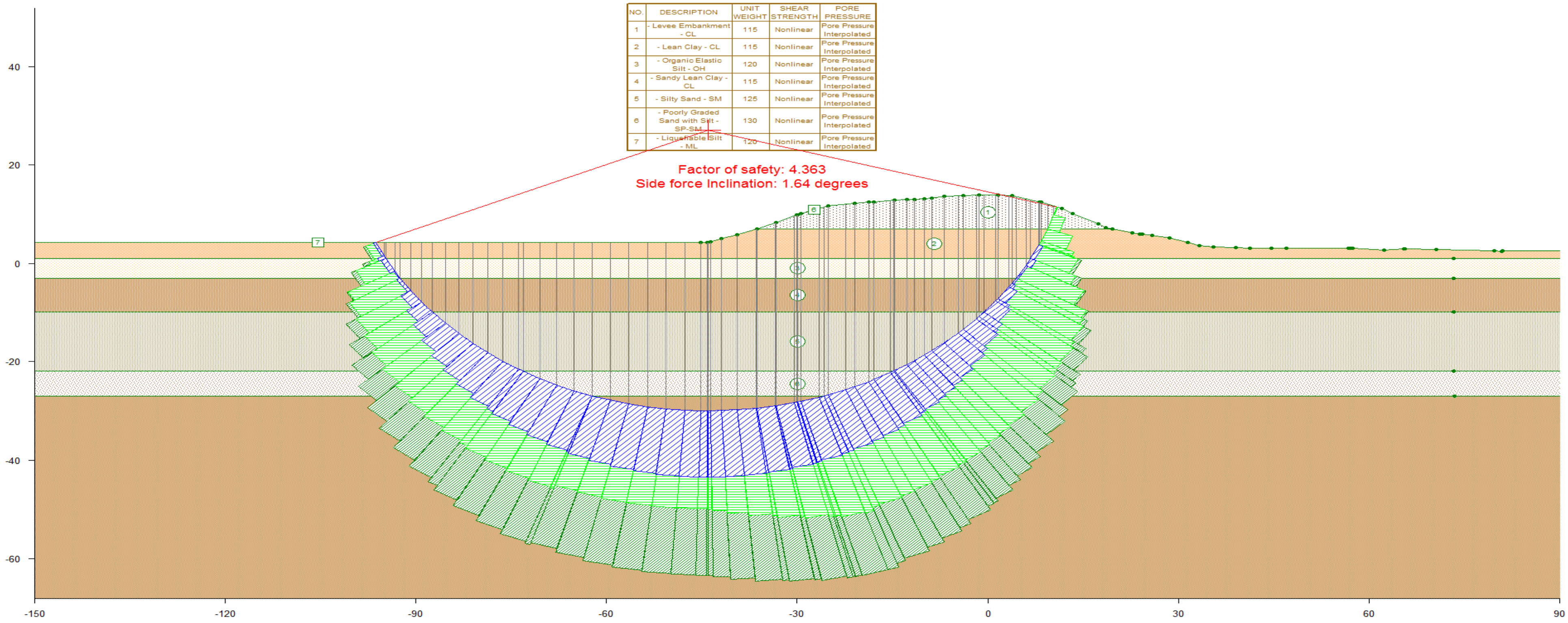
Fig 42(b). Lincoln Village Station 159+48 – Landside – Option 4: Wedge (PHI = 5.1 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
3	- Organic Elastic Silt - OH	120	Nonlinear	Pore Pressure Interpolated
4	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
6	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Silt - ML	120	Nonlinear	Pore Pressure Interpolated

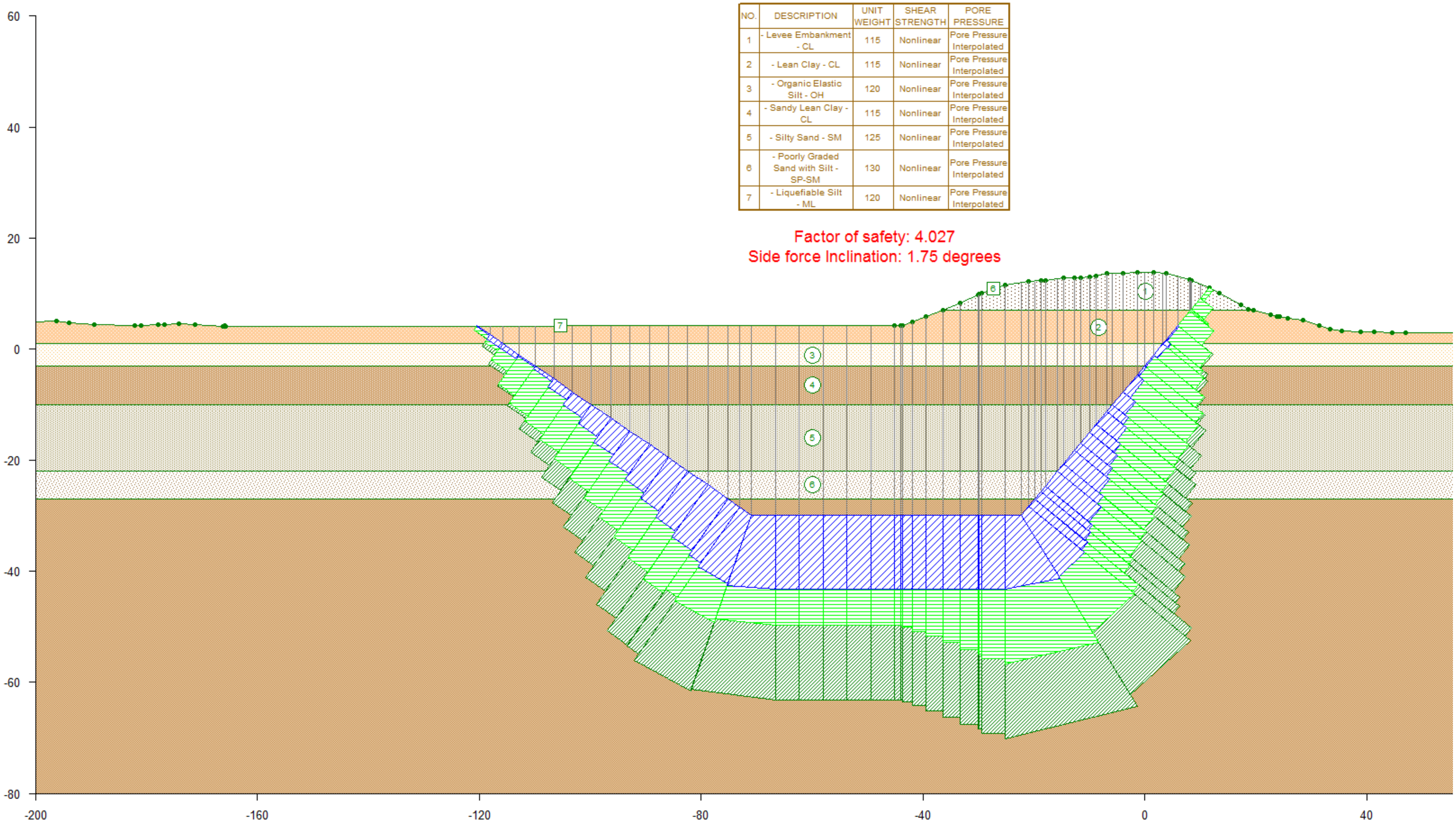
Factor of safety: 4.467
Side force Inclination: 1.72 degrees

Fig F-43(a). Lincoln Village Station 164+99 – Waterside – Option 1: Circular (Sr = 224 psf in liquefiable material)



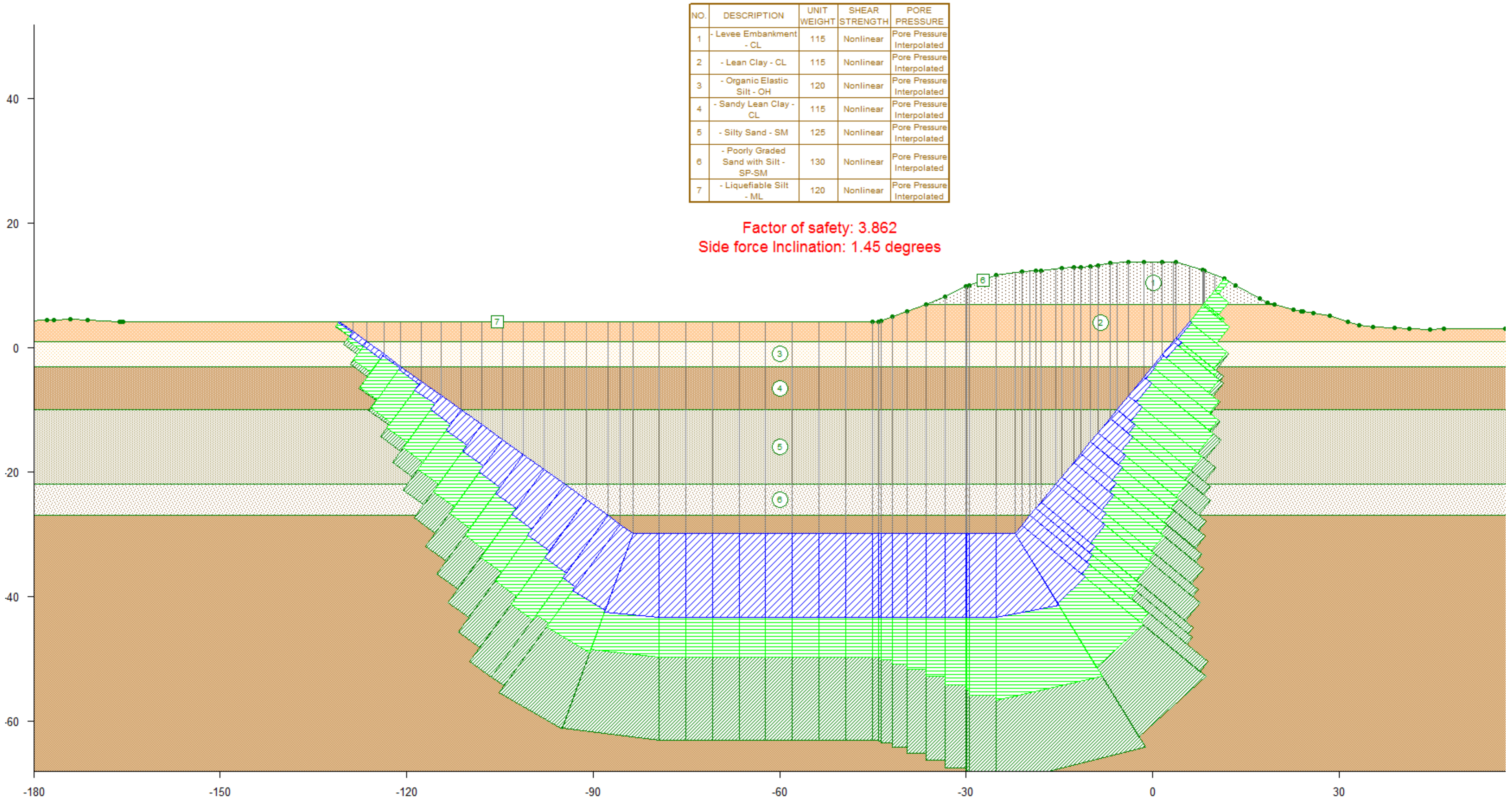
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
3	- Organic Elastic Silt - OH	120	Nonlinear	Pore Pressure Interpolated
4	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
6	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Silt - ML	120	Nonlinear	Pore Pressure Interpolated

Fig 43(b). Lincoln Village Station 164+99 – Waterside – Option 1: Circular (PHI = 3.4 in liquefiable material)



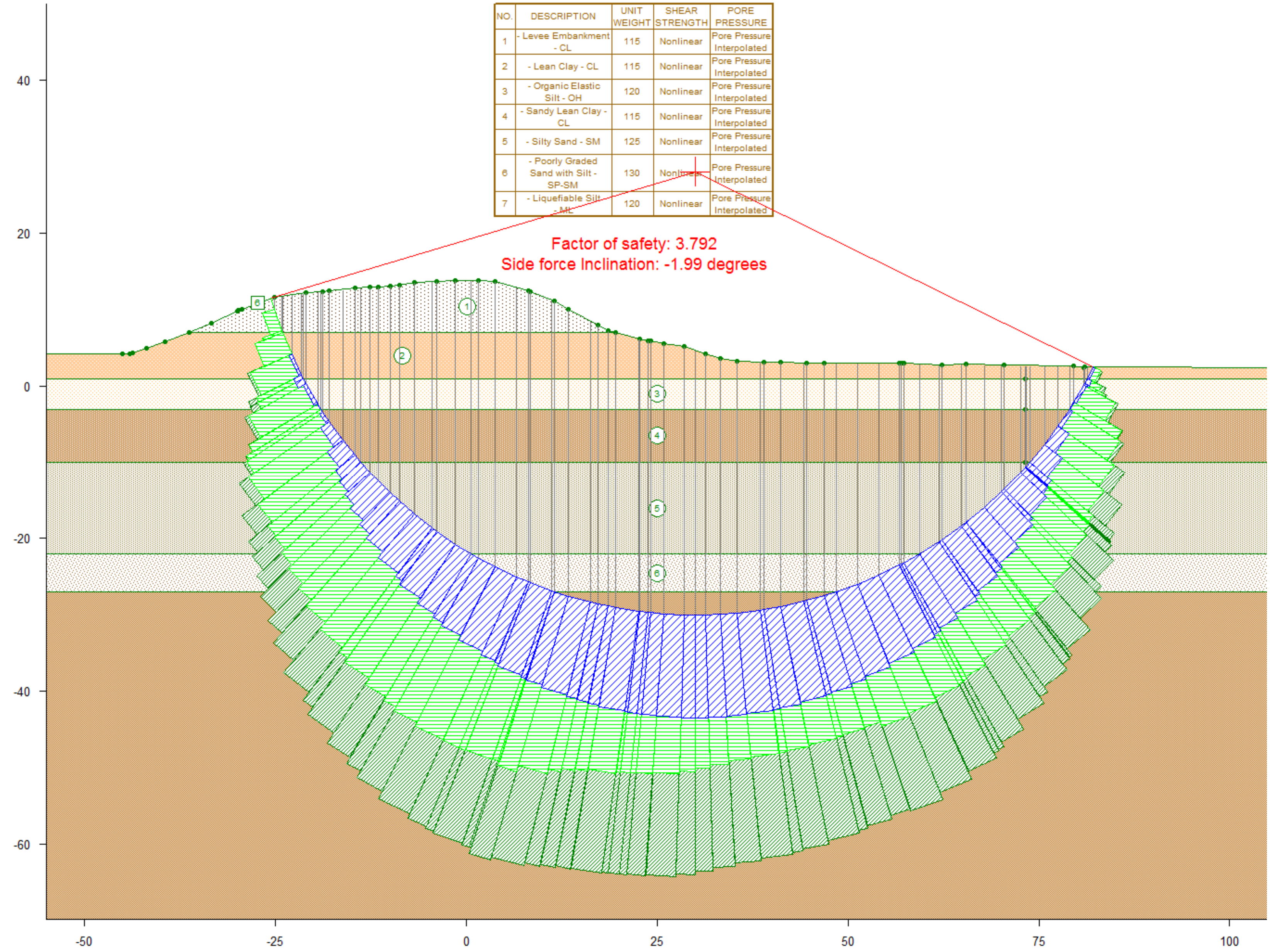
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
3	- Organic Elastic Silt - OH	120	Nonlinear	Pore Pressure Interpolated
4	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
6	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Silt - ML	120	Nonlinear	Pore Pressure Interpolated

Fig F-44(a). Lincoln Village Station 164+99 – Waterside – Option 2: Wedges (Sr = 224 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
3	- Organic Elastic Silt - OH	120	Nonlinear	Pore Pressure Interpolated
4	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
6	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Silt - ML	120	Nonlinear	Pore Pressure Interpolated

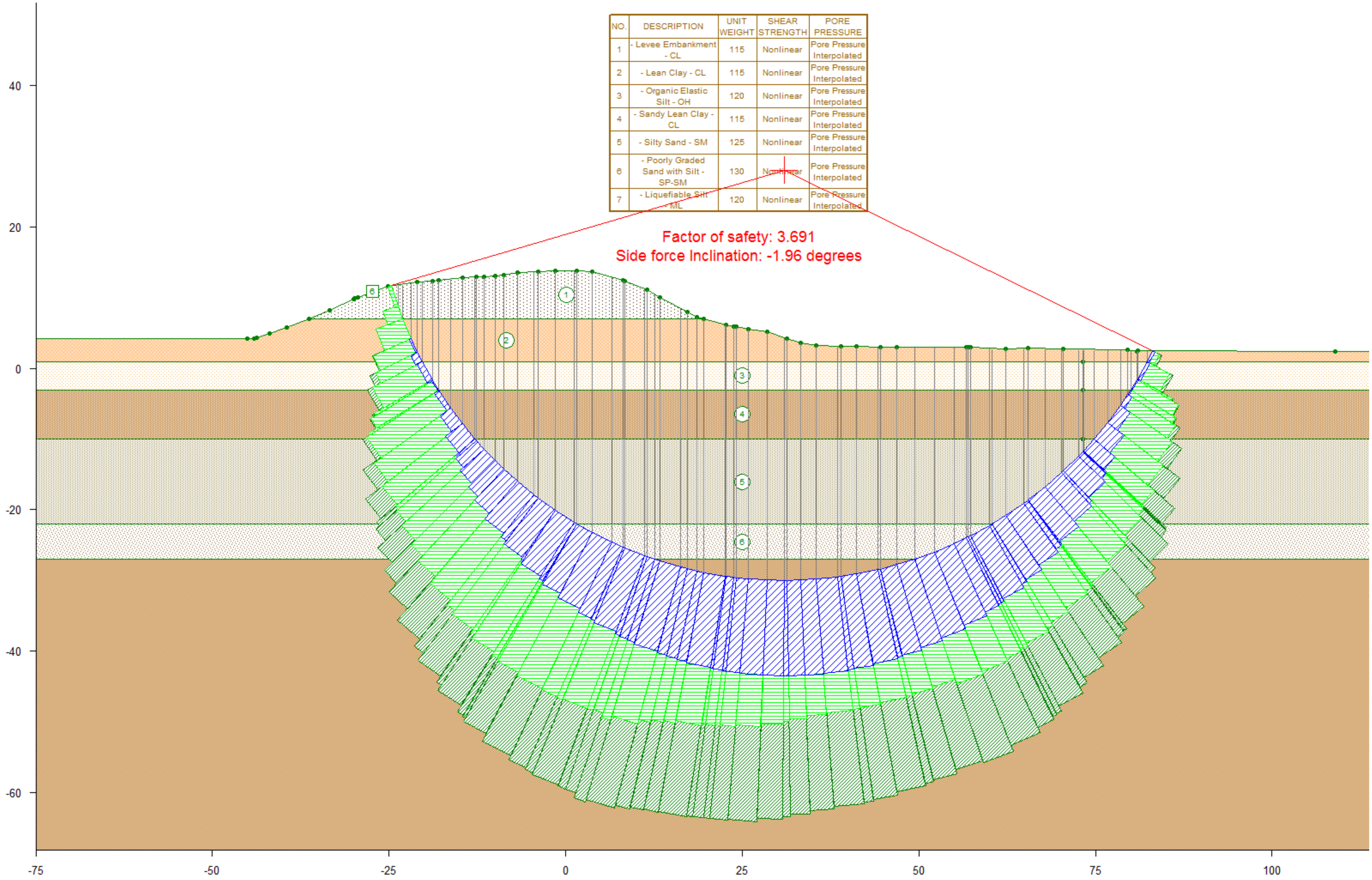
Fig 44(b). Lincoln Village Station 164+99 – Waterside – Option 2: Wedges (PHI = 3.4 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
3	- Organic Elastic Silt - OH	120	Nonlinear	Pore Pressure Interpolated
4	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
6	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Silt - ML	120	Nonlinear	Pore Pressure Interpolated

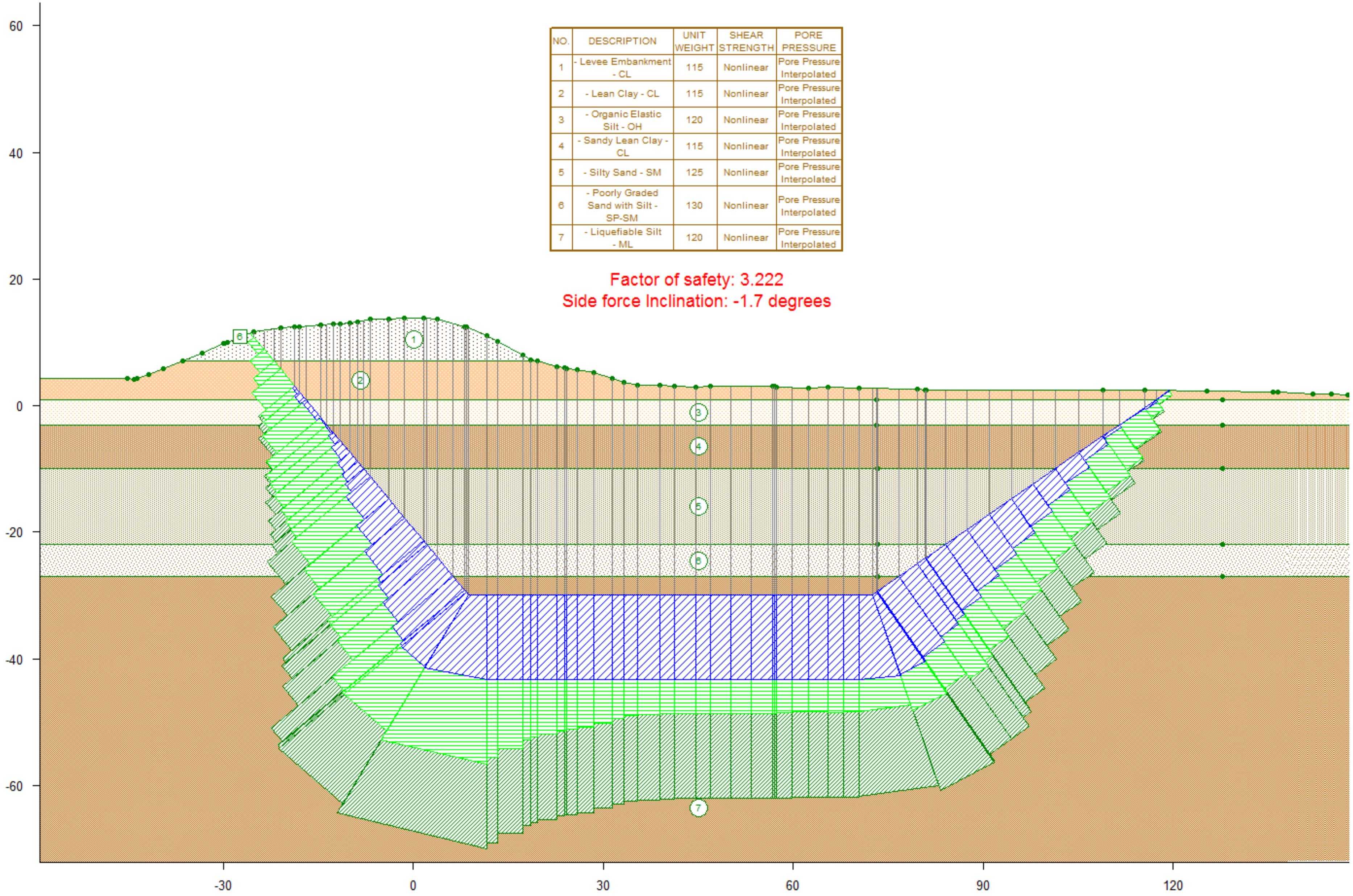
Factor of safety: 3.792
Side force Inclination: -1.99 degrees

Fig F-45(a). Lincoln Village Station 164+99– Landside – Option 3: Circular (Sr = 224 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
3	- Organic Elastic Silt - OH	120	Nonlinear	Pore Pressure Interpolated
4	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
6	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Silt - ML	120	Nonlinear	Pore Pressure Interpolated

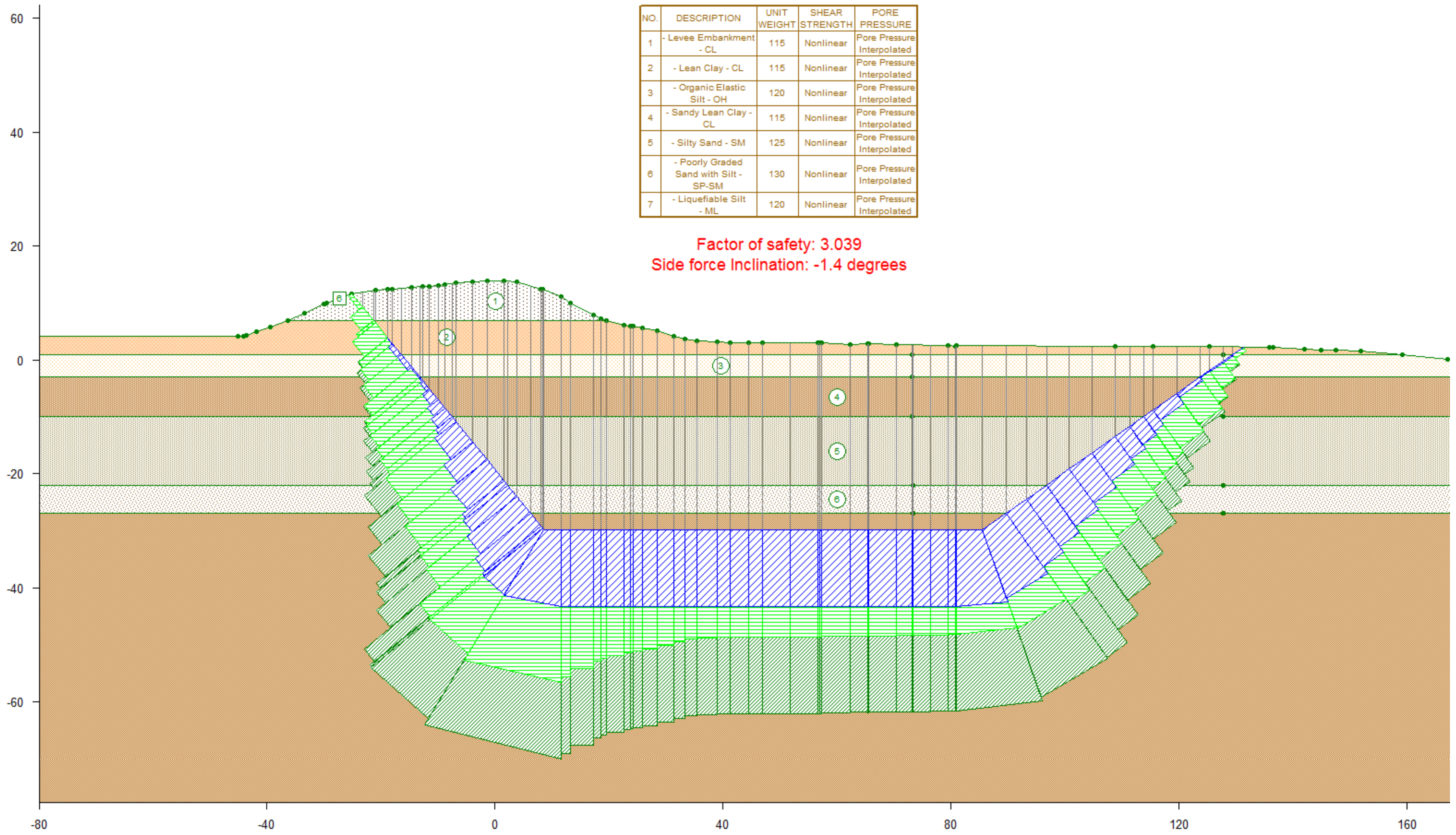
Fig F-45(b). Lincoln Village Station 164+99– Landside – Option 3: Circular (PHI = 3.4 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
3	- Organic Elastic Silt - OH	120	Nonlinear	Pore Pressure Interpolated
4	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
6	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Silt - ML	120	Nonlinear	Pore Pressure Interpolated

Factor of safety: 3.222
Side force Inclination: -1.7 degrees

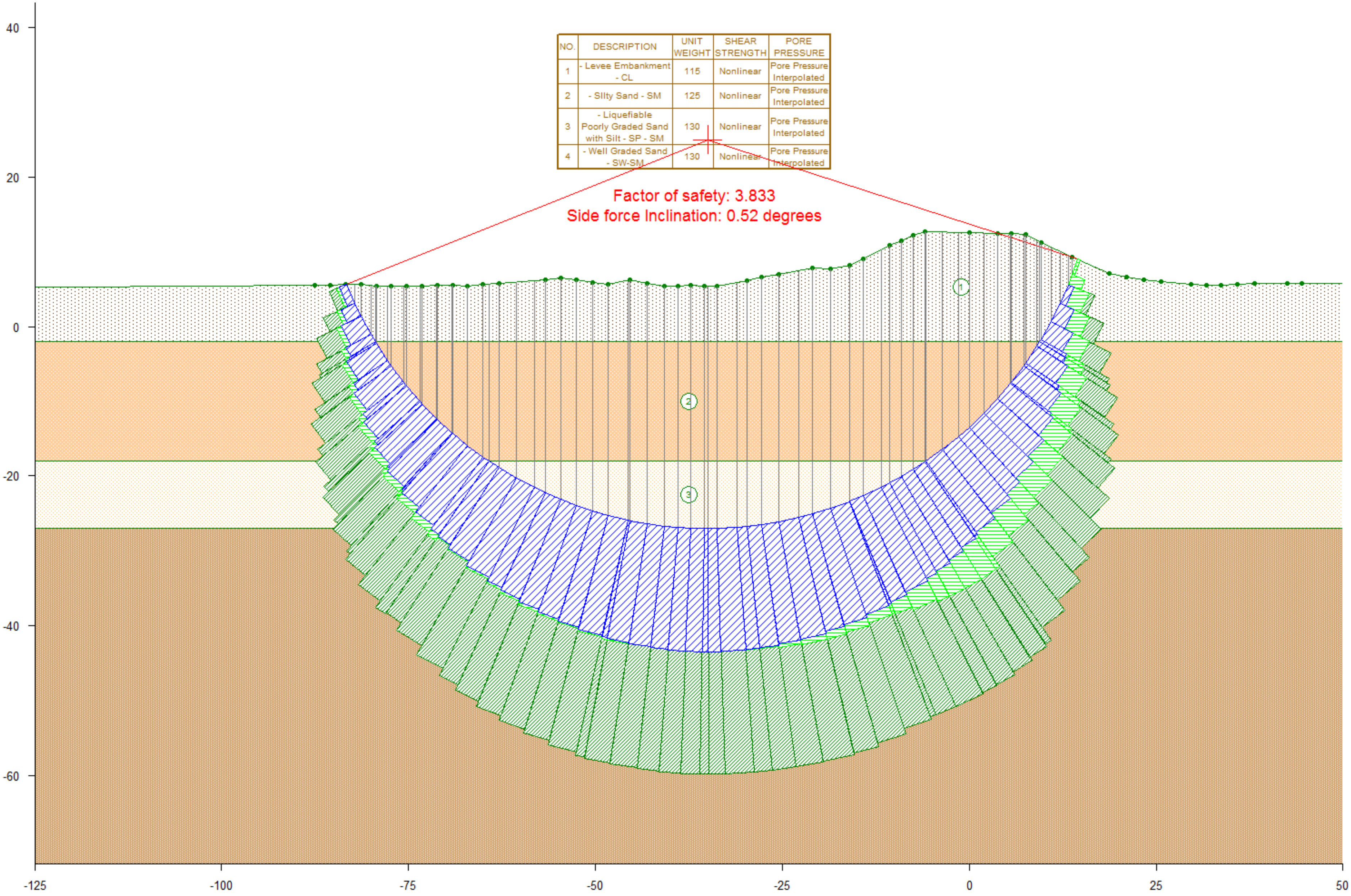
Fig F-46(a). Lincoln Village Station 164+99 – Landside – Option 4: Wedge (Sr = 224 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
3	- Organic Elastic Silt - OH	120	Nonlinear	Pore Pressure Interpolated
4	- Sandy Lean Clay - CL	115	Nonlinear	Pore Pressure Interpolated
5	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
6	- Poorly Graded Sand with Silt - SP-SM	130	Nonlinear	Pore Pressure Interpolated
7	- Liquefiable Silt - ML	120	Nonlinear	Pore Pressure Interpolated

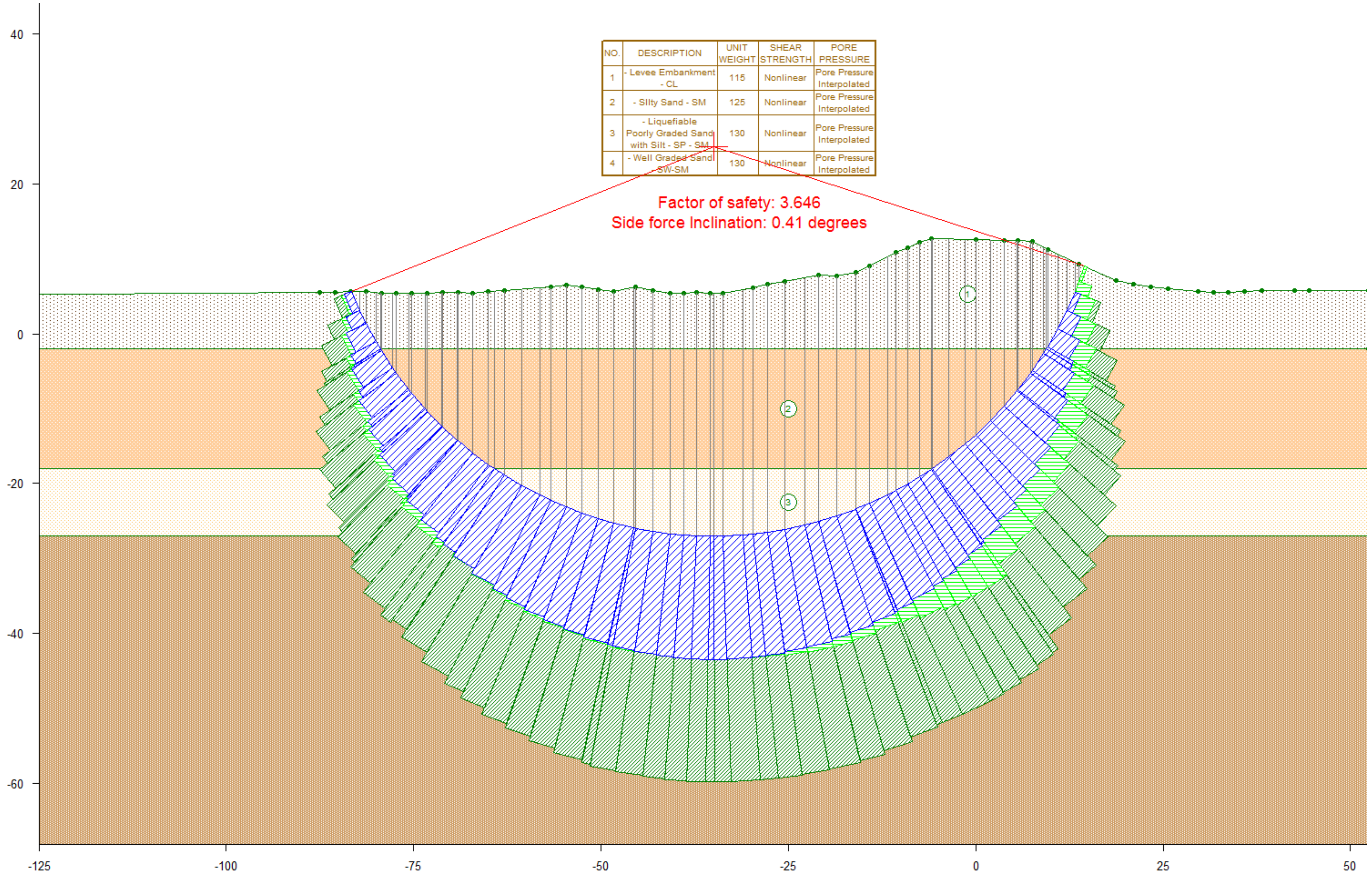
Factor of safety: 3.039
Side force Inclination: -1.4 degrees

Fig 46(b). Lincoln Village Station 164+99 – Landside – Option 4: Wedge (PHI = 3.4 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP - SM	130	Nonlinear	Pore Pressure Interpolated
4	- Well Graded Sand - SW-SM	130	Nonlinear	Pore Pressure Interpolated

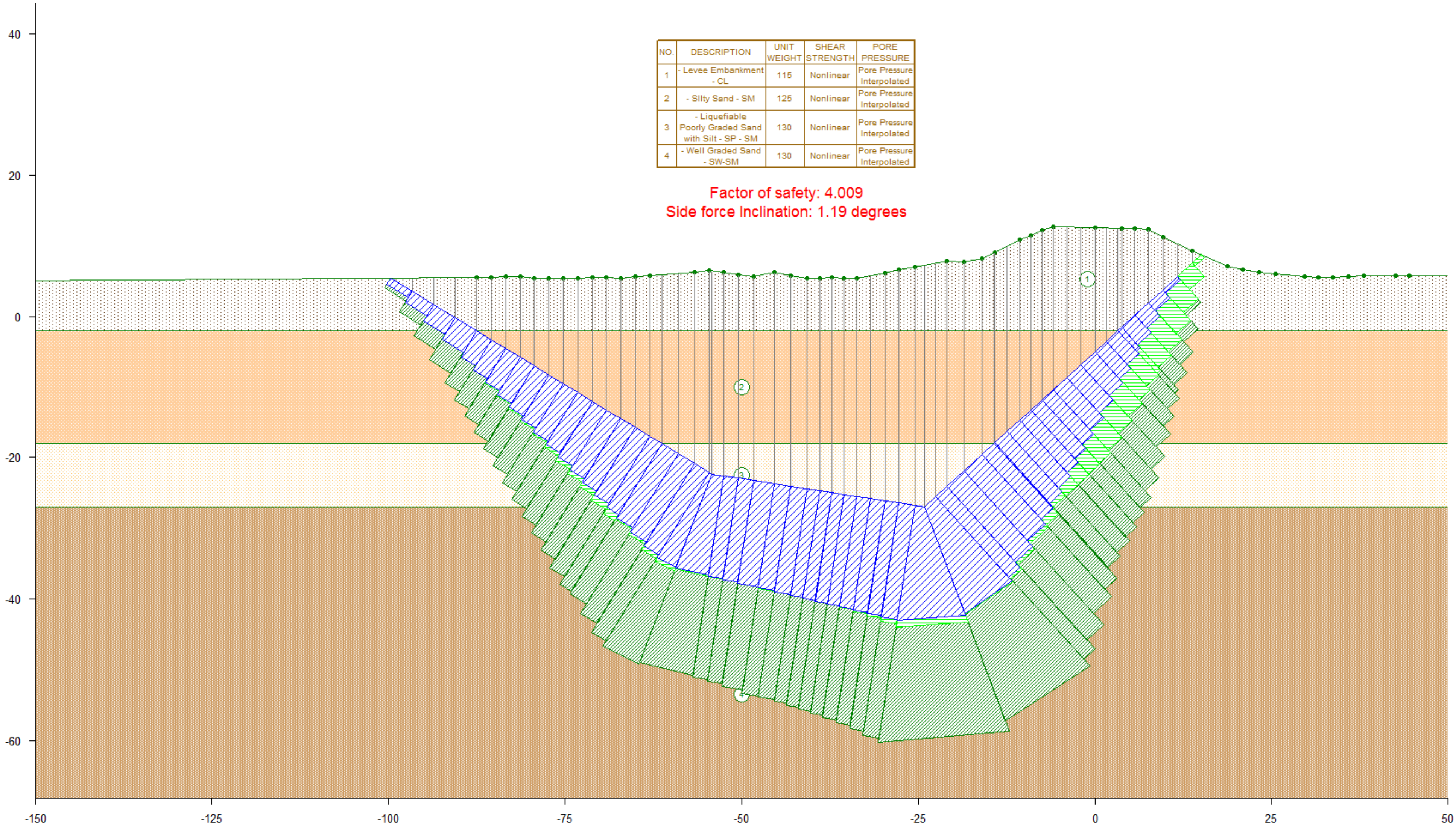
Fig F-47(a). Lincoln Village Station 201+51– Waterside – Option 1: Circular (Sr = 201 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- SIlty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP - SM	130	Nonlinear	Pore Pressure Interpolated
4	- Well Graded Sand SW-SM	130	Nonlinear	Pore Pressure Interpolated

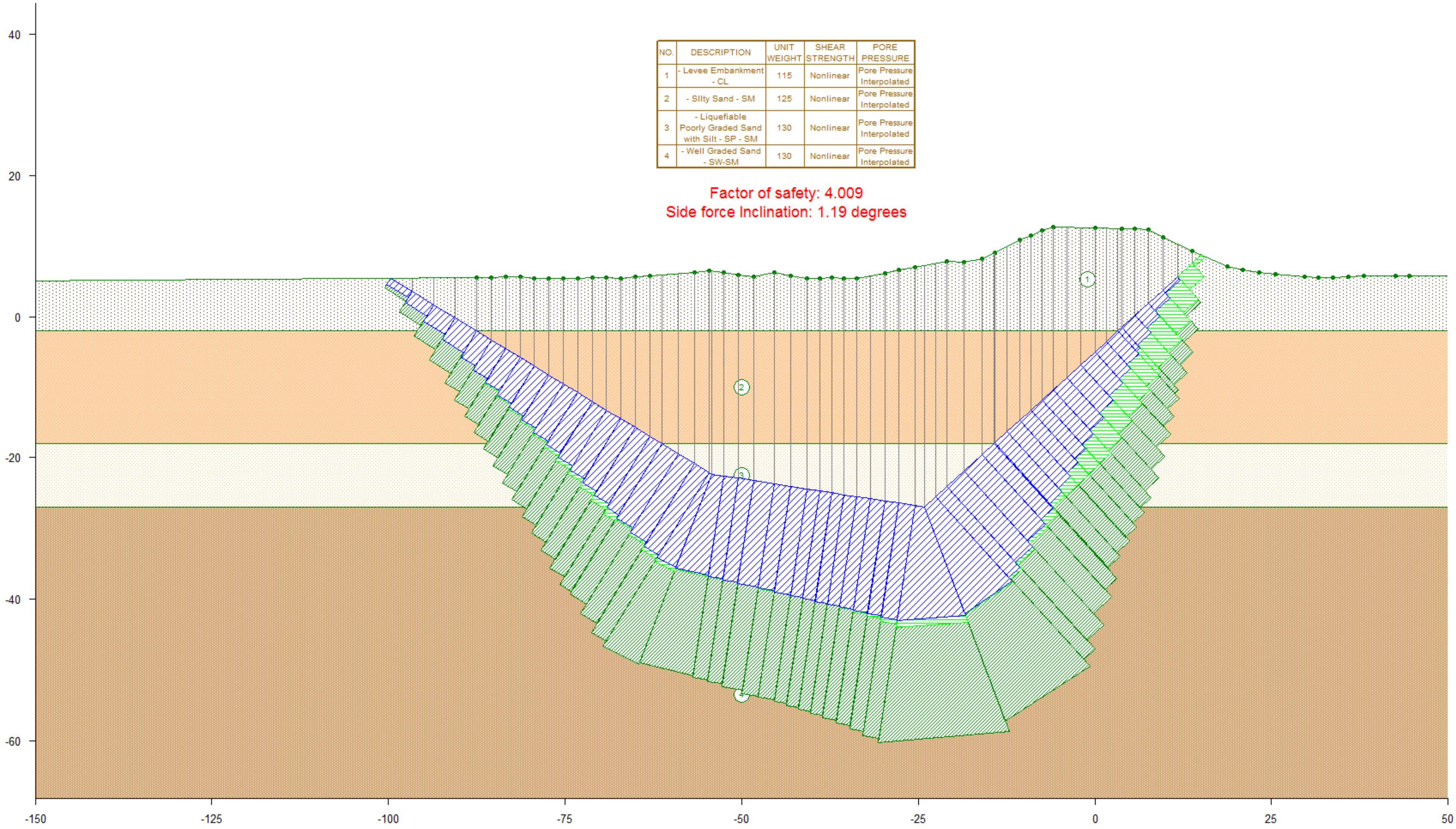
Factor of safety: 3.646
Side force Inclination: 0.41 degrees

Fig 47(b). Lincoln Village Station 201+51– Waterside – Option 1: Circular (PHI = 4.7 in liquefiable material)



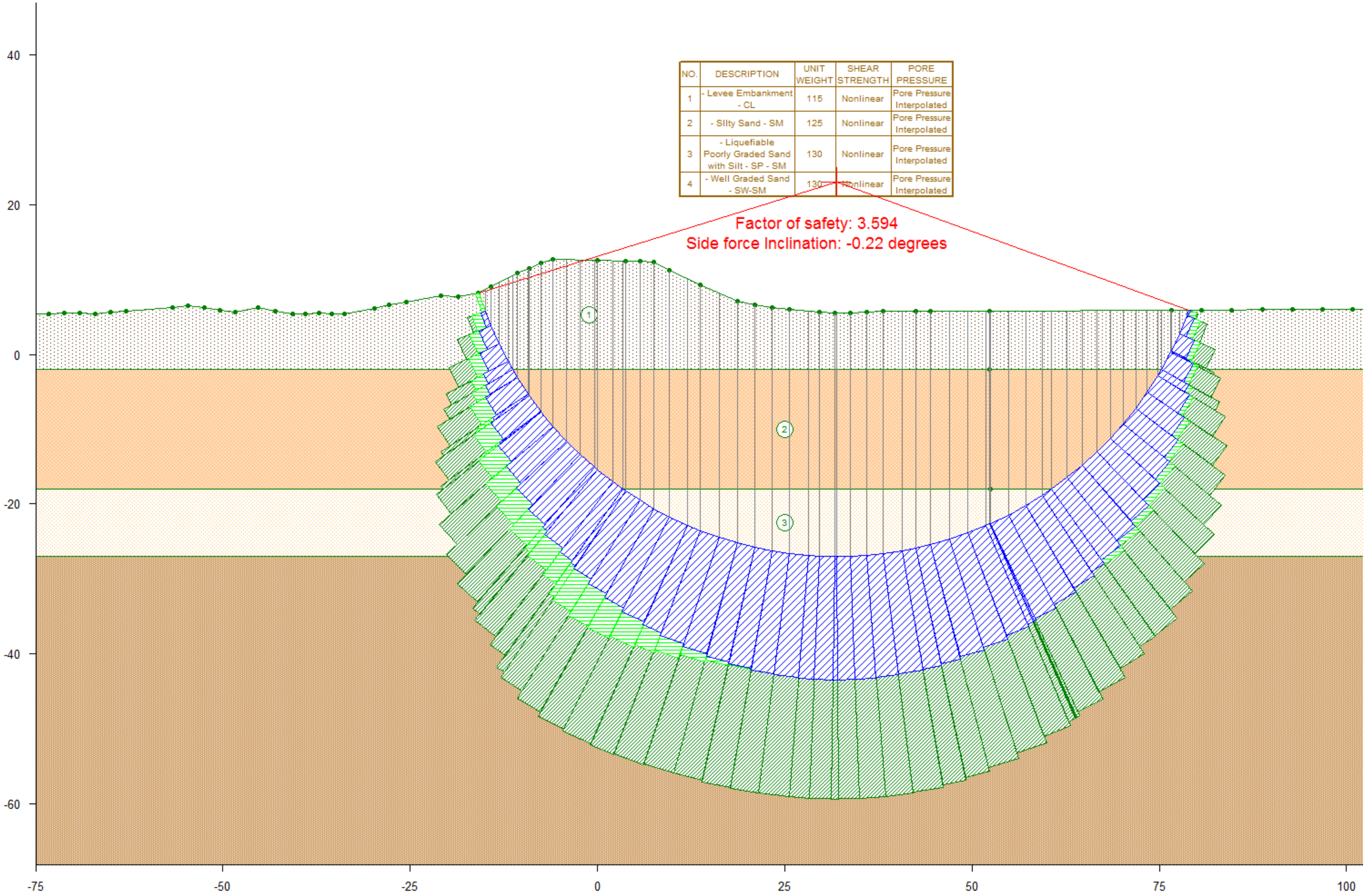
NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- SIlty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP - SM	130	Nonlinear	Pore Pressure Interpolated
4	- Well Graded Sand - SW-SM	130	Nonlinear	Pore Pressure Interpolated

Fig F-48(a). Lincoln Village Station 201+51 – Waterside – Option 2: Wedges (Sr = 201 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- SIlty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP - SM	130	Nonlinear	Pore Pressure Interpolated
4	- Well Graded Sand - SW-SM	130	Nonlinear	Pore Pressure Interpolated

Fig 48(b). Lincoln Village Station 201+51 – Waterside – Option 2: Wedges (PHI = 4.7 in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP - SM	130	Nonlinear	Pore Pressure Interpolated
4	- Well Graded Sand - SW-SM	130	Nonlinear	Pore Pressure Interpolated

Fig F-49(a). Lincoln Village Station 201+51 – Landside – Option 3: Circular (Sr = 201 psf in liquefiable material)

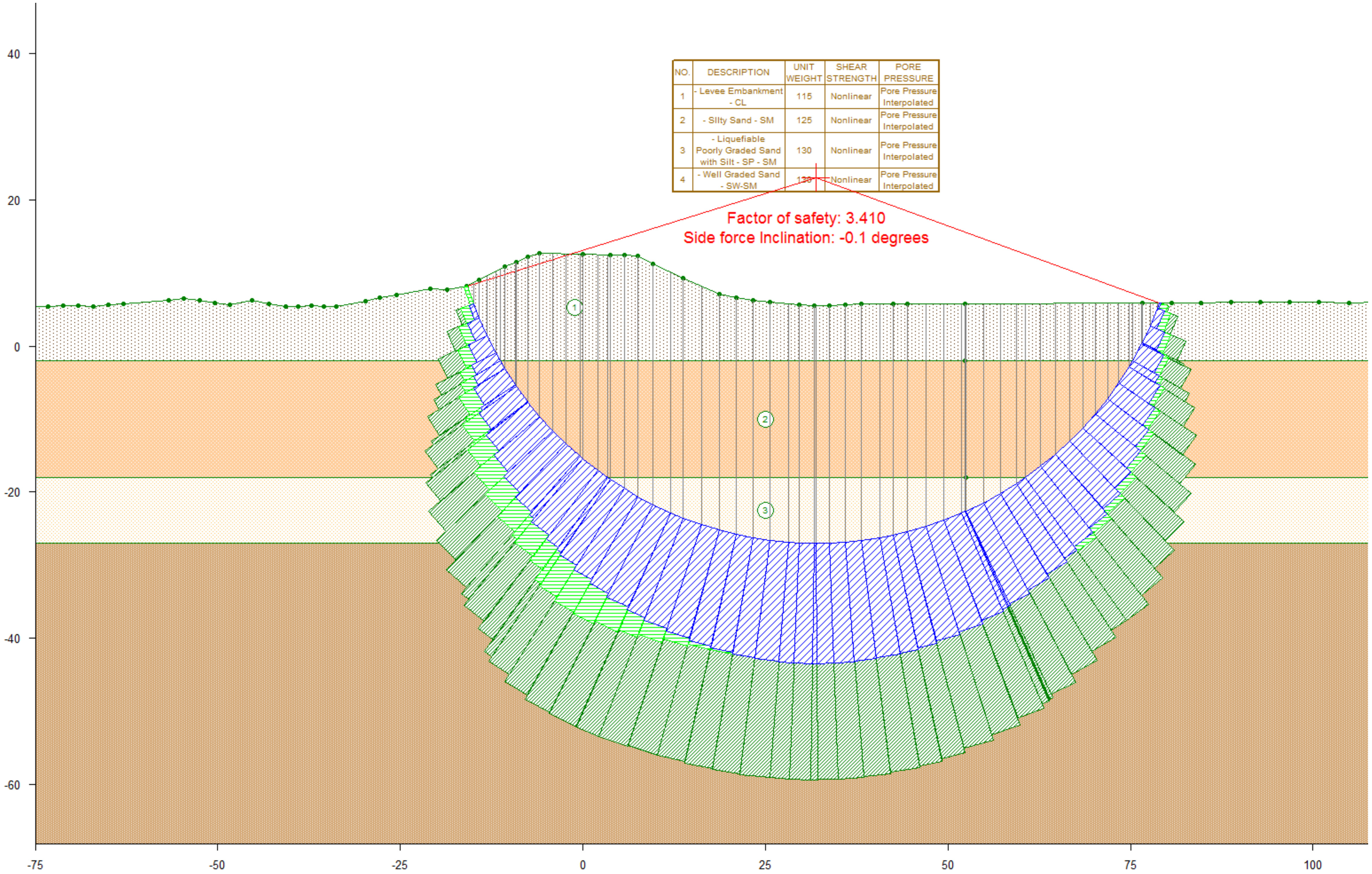


Fig 49(b). Lincoln Village Station 201+51 – Landside – Option 3: Circular (PHI = 4.7 in liquefiable material)

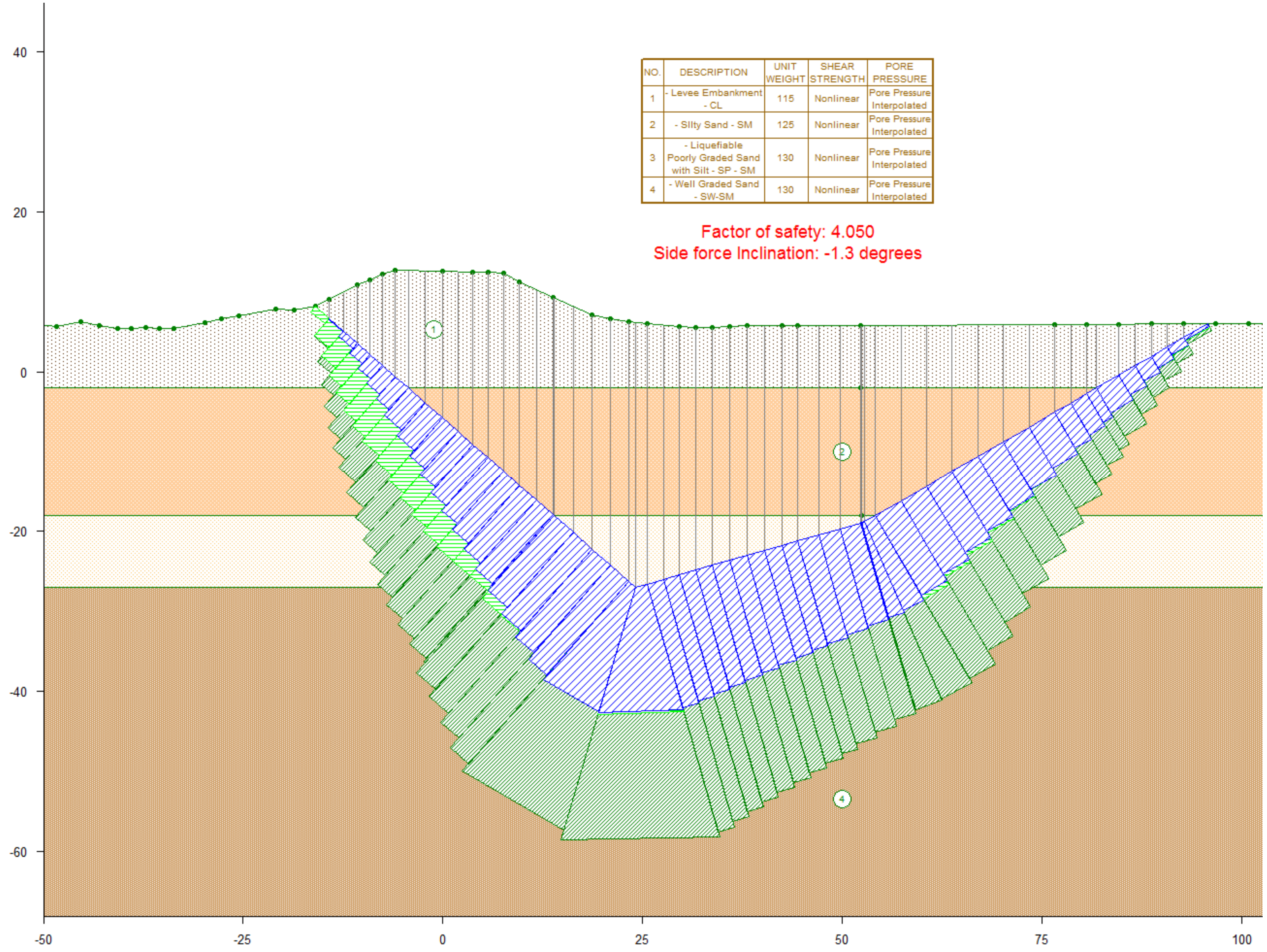
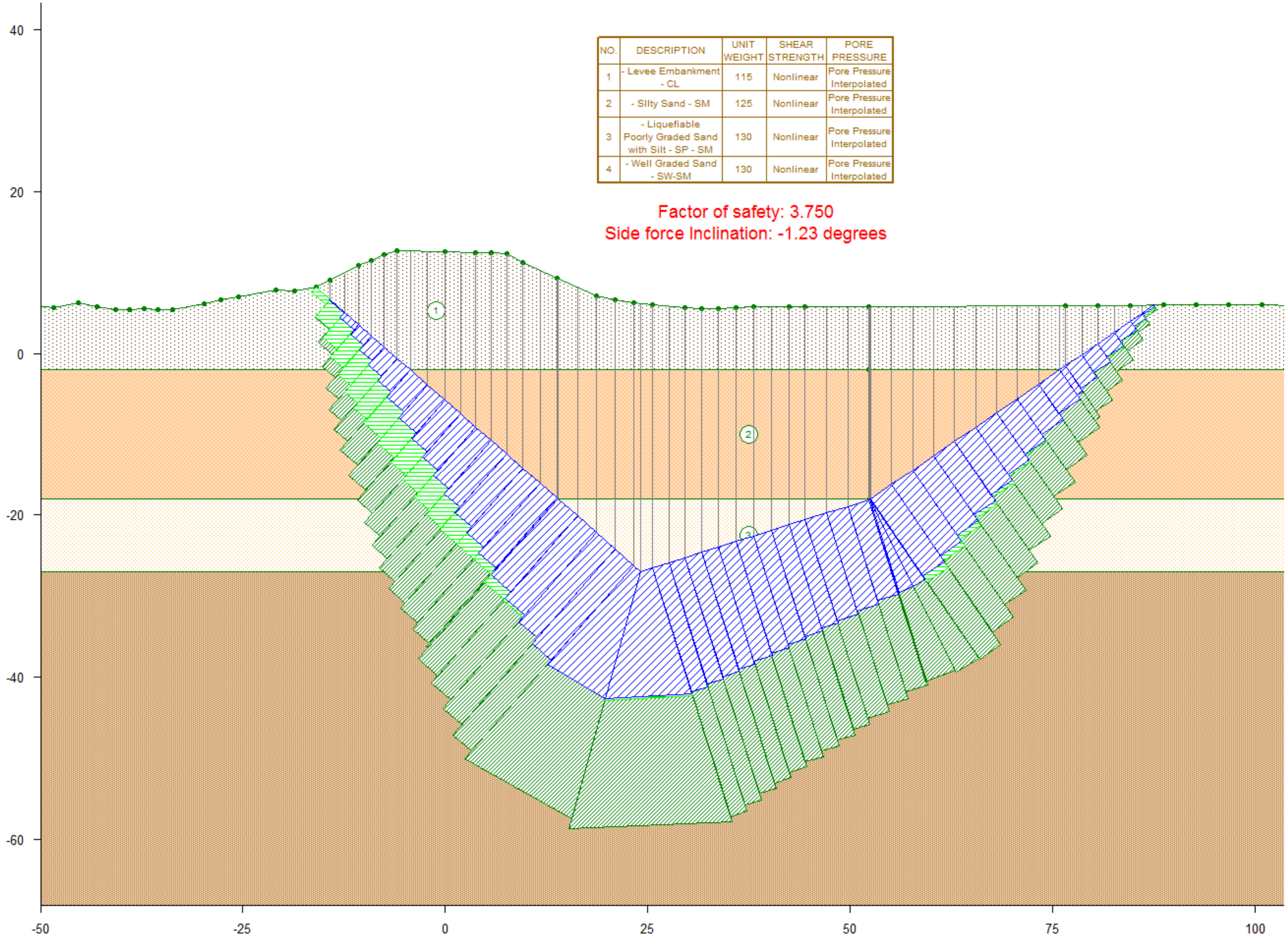


Fig F-50(a). Lincoln Village Station 201+51 – Landside – Option 4: Wedge (Sr = 201 psf in liquefiable material)



NO.	DESCRIPTION	UNIT WEIGHT	SHEAR STRENGTH	PORE PRESSURE
1	- Levee Embankment - CL	115	Nonlinear	Pore Pressure Interpolated
2	- Silty Sand - SM	125	Nonlinear	Pore Pressure Interpolated
3	- Liquefiable Poorly Graded Sand with Silt - SP - SM	130	Nonlinear	Pore Pressure Interpolated
4	- Well Graded Sand - SW-SM	130	Nonlinear	Pore Pressure Interpolated

Factor of safety: 3.750
Side force Inclination: -1.23 degrees

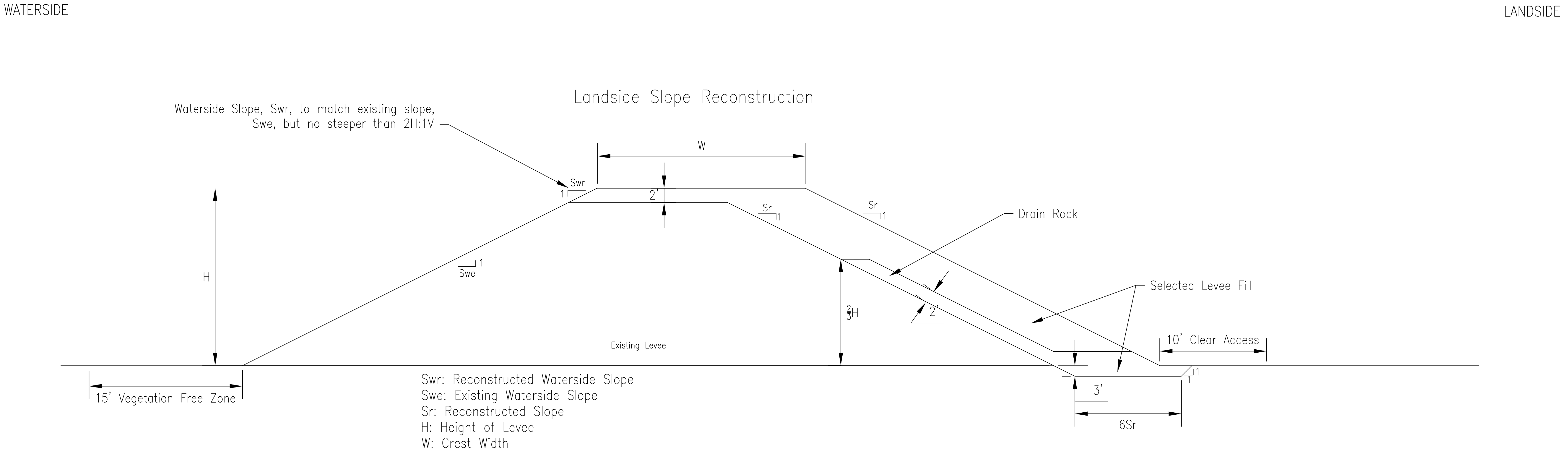
Fig 50(b). Lincoln Village Station 201+51 – Landside – Option 4: Wedge (PHI = 4.7 in liquefiable material)

LOWER SAN JOAQUIN RIVER
FEASIBILITY STUDY

GEOTECHNICAL REPORT

ENCLOSURE E5
TEMPLATE OPTIONS FOR ASSIGNED MITIGATION MEASURES

Landside Slope Reconstruction



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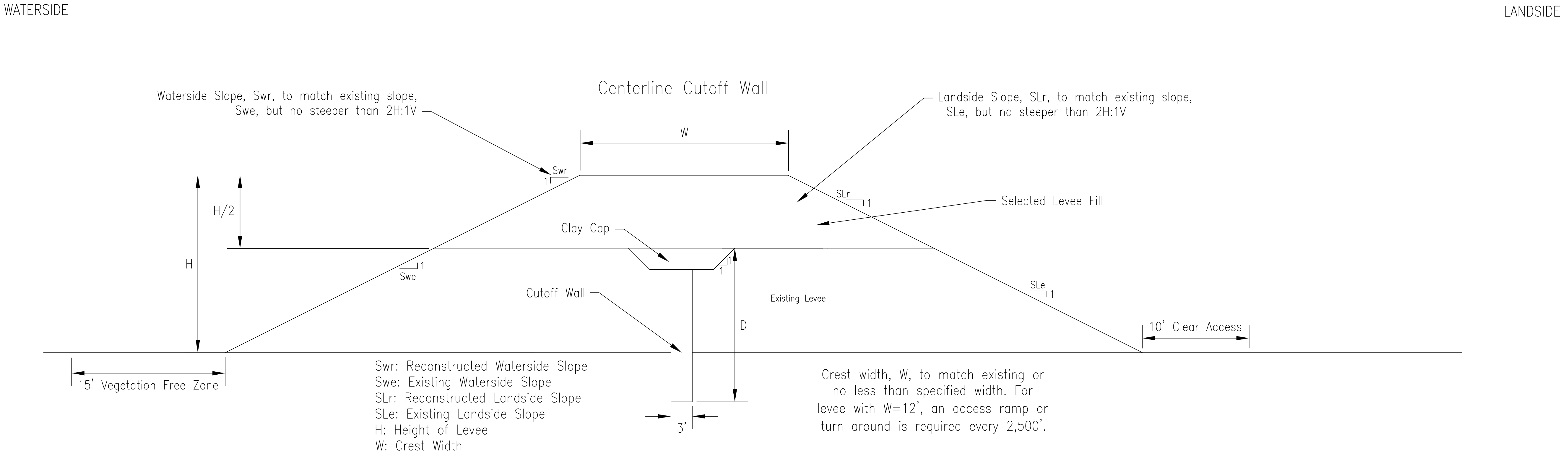
Lower San Joaquin River
Feasibility Study
Mitigation Measures
LANDSIDE SLOPE RECONSTRUCTION

DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	1 of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 9:35:03am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\ComputationSheet1_LandsideSlopeReconstruction.10ftLSE.dwg



Swr: Reconstructed Waterside Slope
Swe: Existing Waterside Slope
SLr: Reconstructed Landside Slope
SLe: Existing Landside Slope
H: Height of Levee
W: Crest Width
D: Depth of Cutoff Wall
Cutoff Wall Situated along Existing Levee Centerline

Crest width, W, to match existing or no less than specified width. For levee with W=12', an access ramp or turn around is required every 2,500'.

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Lower San Joaquin River
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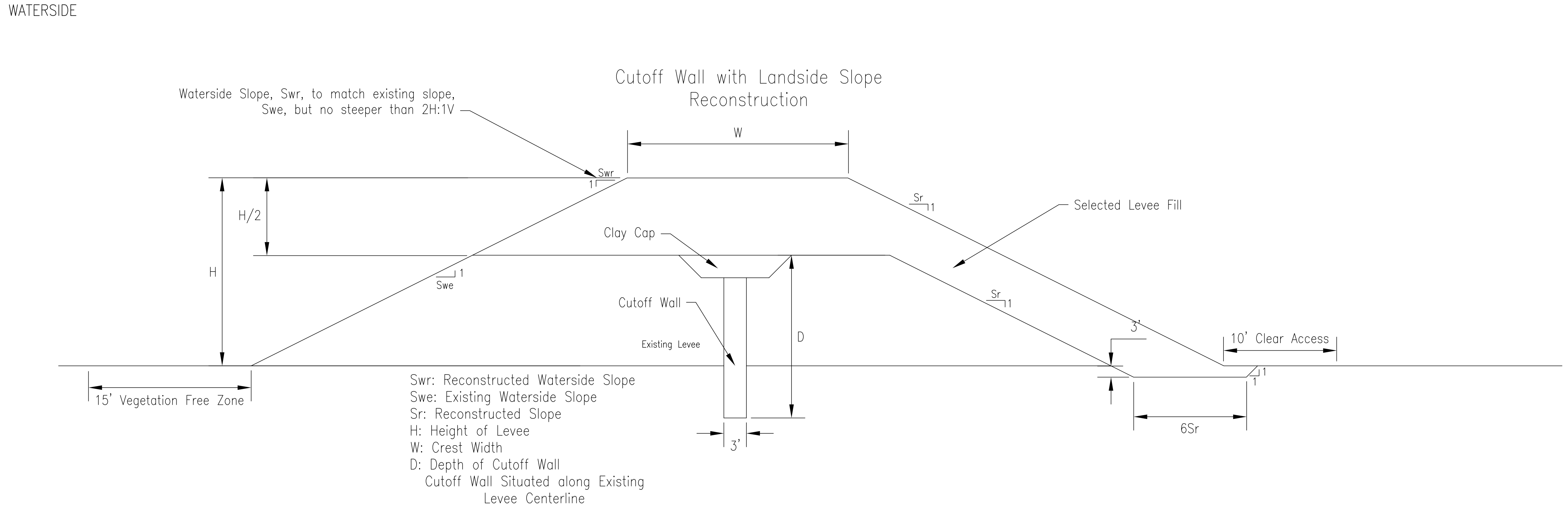
Mitigation Measures
CENTERLINE CUTOFF WALL

DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	2 of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 9:46:03am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\ComputationSheet7_Template6.10ftLSE.dwg

Cutoff Wall with Landside Slope Reconstruction



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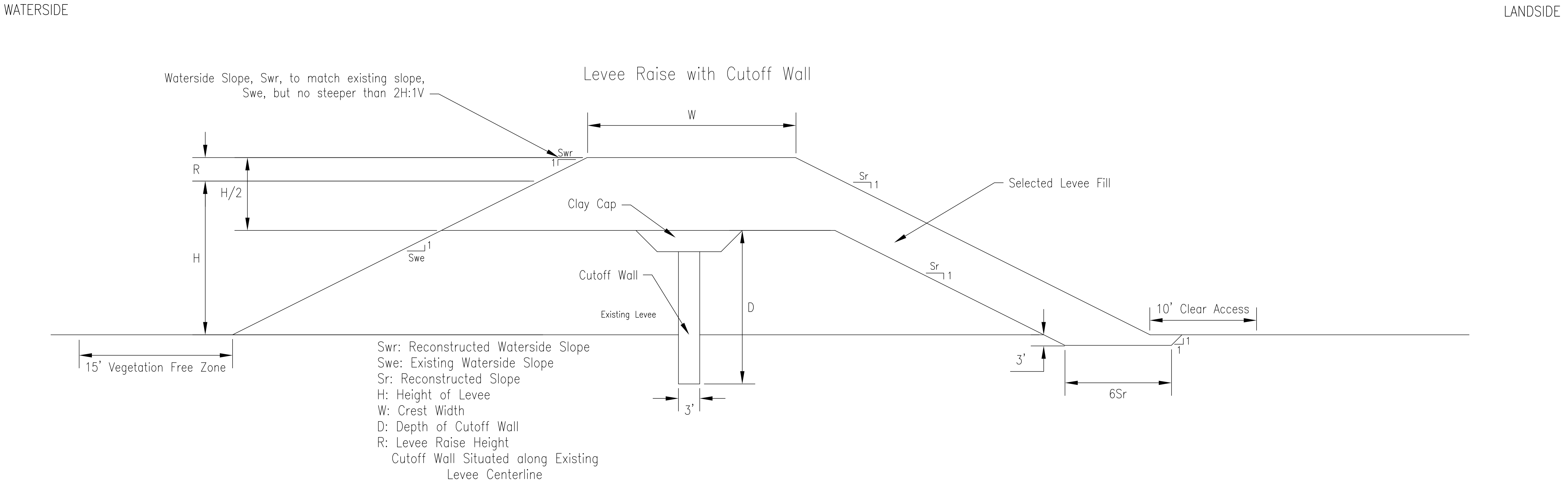
Lower San Joaquin River
Feasibility Study
Mitigation Measures
CUTOFF WALL WITH LANDSIDE SLOPE RECONSTRUCTION

DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	3 of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 9:48:00am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\ComputationSheet2_CutoffWallwithLandsideSLopeReconstruction.10ftLSE.dwg

Levee Raise with Cutoff Wall



Swr: Reconstructed Waterside Slope
Swe: Existing Waterside Slope
Sr: Reconstructed Slope
H: Height of Levee
W: Crest Width
D: Depth of Cutoff Wall
R: Levee Raise Height
Cutoff Wall Situated along Existing Levee Centerline

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Lower San Joaquin River
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Mitigation Measures
LEVEE RAISE WITH CUTOFF WALL

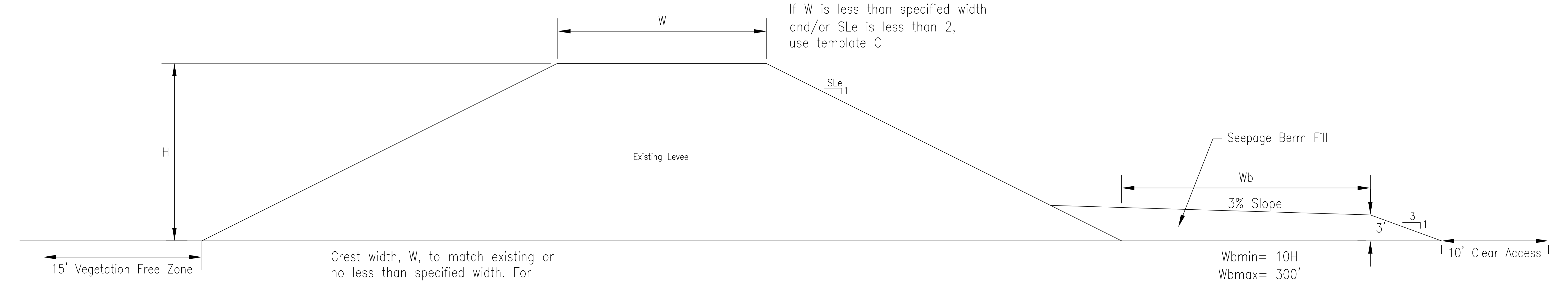
DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	4 of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 9:50:21am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\ComputationSheet5_LeveeRaisewithCutoffWall.10ftLSE.dwg

WATERSIDE

LANDSIDE

Seepage Berm



If W is less than specified width
and/or SLe is less than 2,
use template C

Wbmin= 10H
Wbmax= 300'

Crest width, W, to match existing or no less than specified width. For levee with W=12' an access ramp or turn around is required every 2,500'.

SLe: Existing Landside Slope
H: Height of Levee
W: Crest Width
Wb: Width of Seepage Berm

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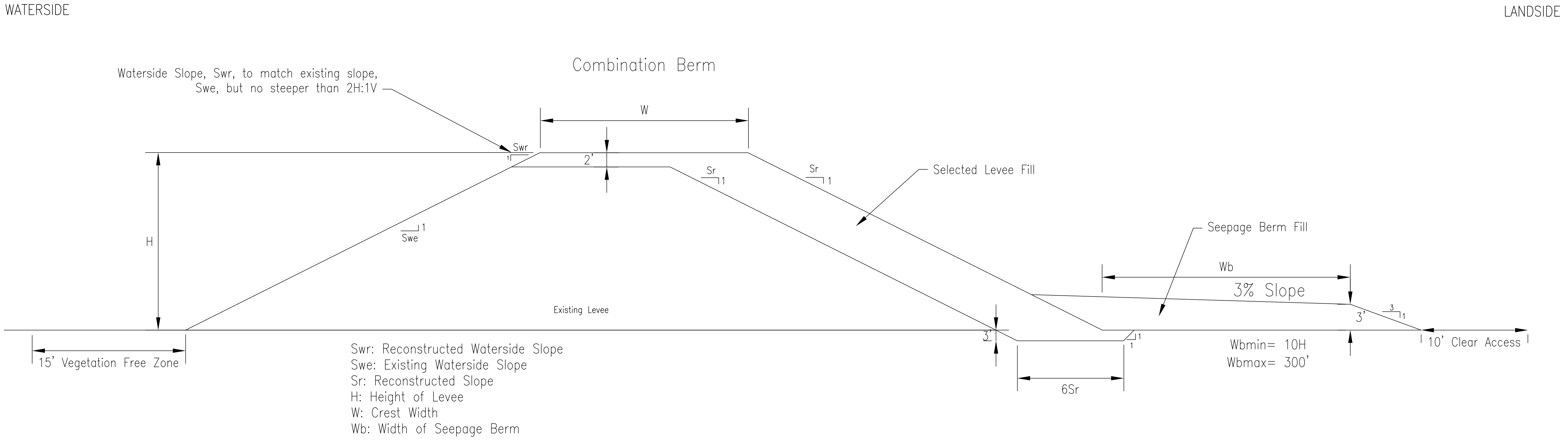
Lower San Joaquin River
Feasibility Study
Mitigation Measures
SEEPAGE BERM

DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	5 of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 9:53:48am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\ComputationSheet8_Template3.10ftLSE.dwg



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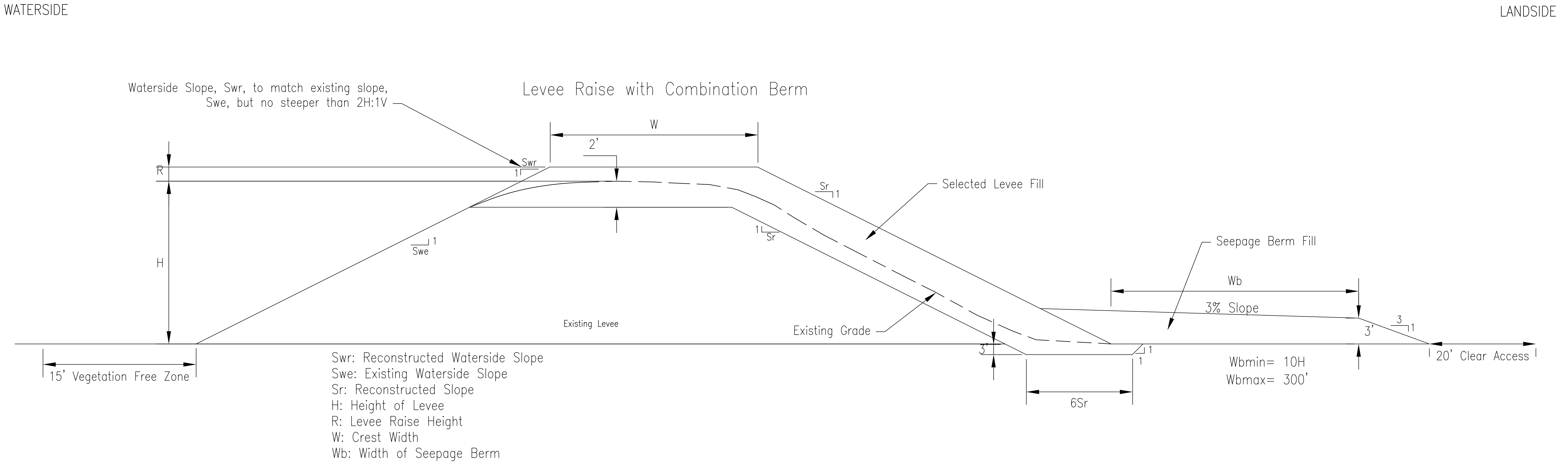
Lower San Joaquin River
Feasibility Study
Mitigation Measures
COMBINATION BERM

DATE: 31 - July - 13
SCALE: Not to Scale
SHEET NO. 6 of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 9:57:33am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\ComputationSheet3_CombinationBerm.10ftLSE.dwg



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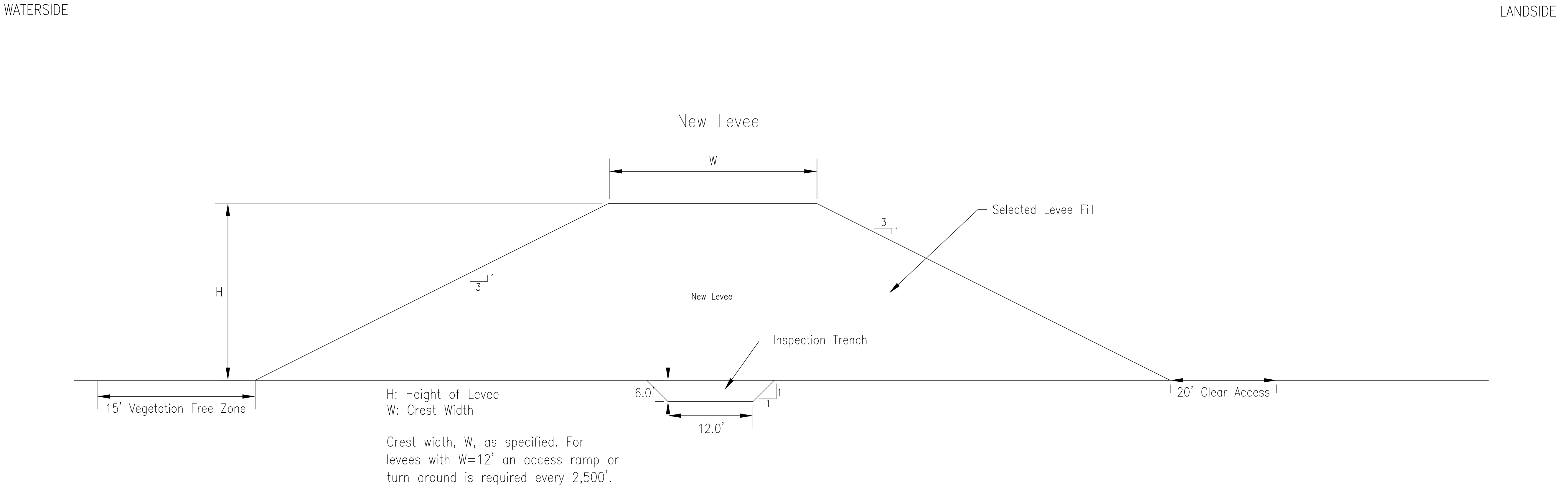
Lower San Joaquin River
Feasibility Study
Mitigation Measures
LEVEE RAISE WITH COMBINATION BERM

DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	7 of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 11:46:57am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\ComputationSheet6_LeveeRaisewithCombinationBerm.10ftLSE.dwg



H: Height of Levee
W: Crest Width

Crest width, W, as specified. For levees with W=12' an access ramp or turn around is required every 2,500'.

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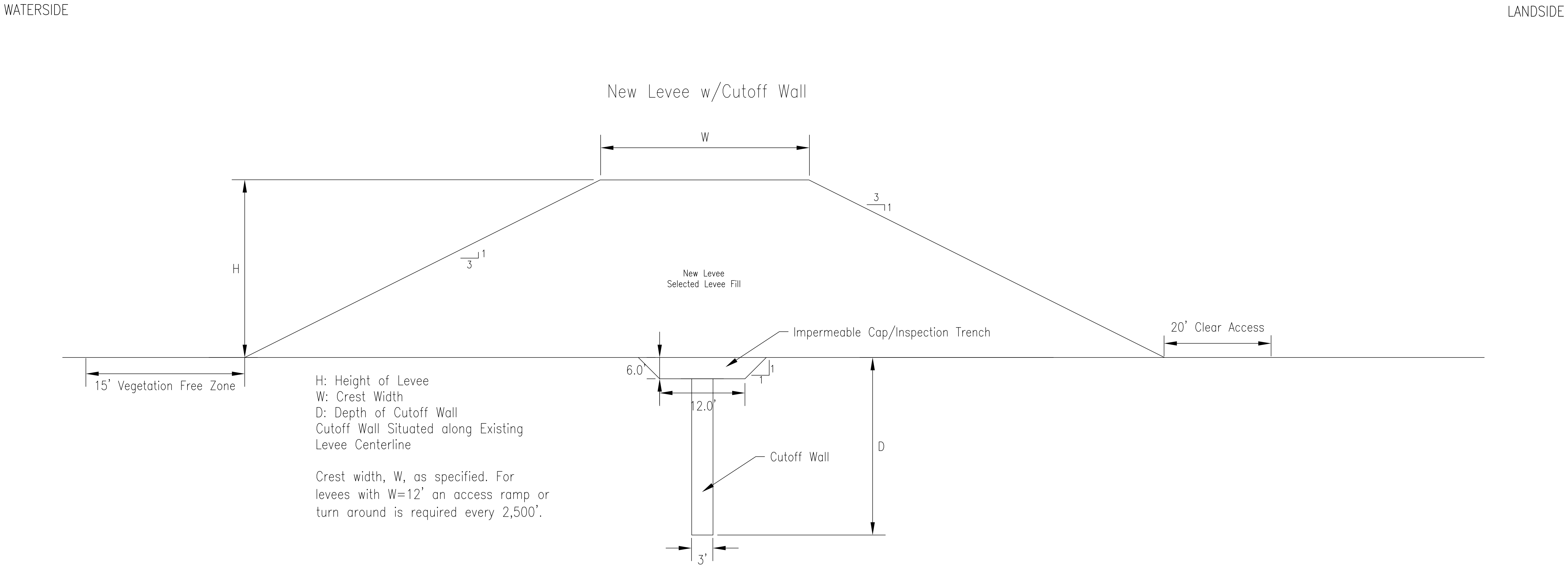
Lower San Joaquin River
Feasibility Study
Mitigation Measures
NEW LEVEE

DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	8 of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 11:15:27am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\ComputationSheet9_Template7.10ftLSE.dwg

New Levee w/Cutoff Wall



H: Height of Levee
W: Crest Width
D: Depth of Cutoff Wall
Cutoff Wall Situated along Existing Levee Centerline

Crest width, W, as specified. For levees with W=12' an access ramp or turn around is required every 2,500'.

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Lower San Joaquin River
Feasibility Study
Mitigation Measures
NEW LEVEE W/CUTOFF WALL

DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	9 of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 11:53:37am
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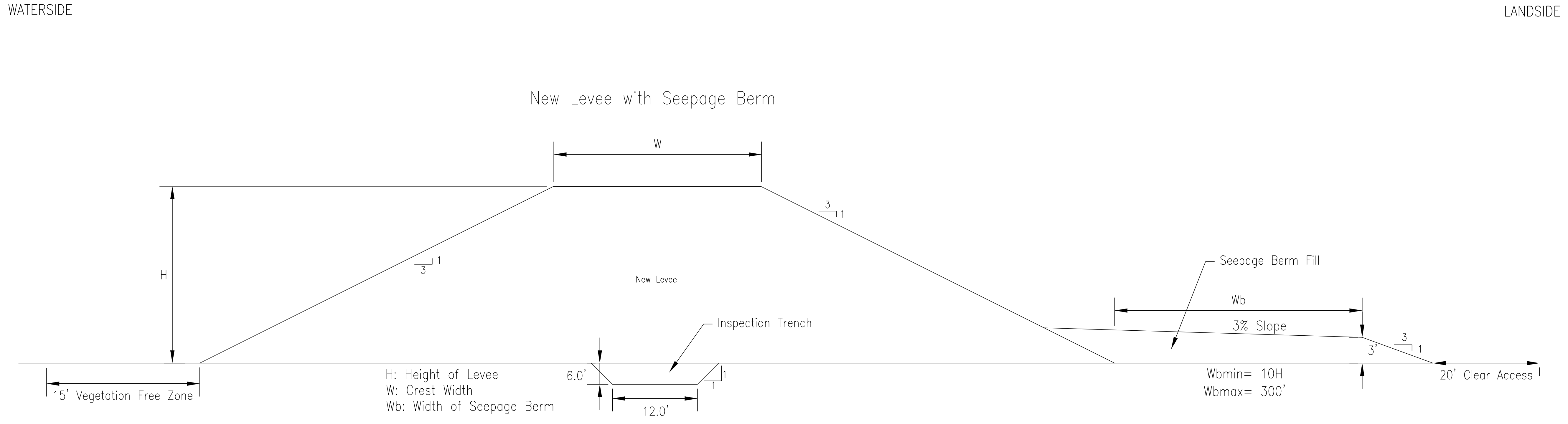

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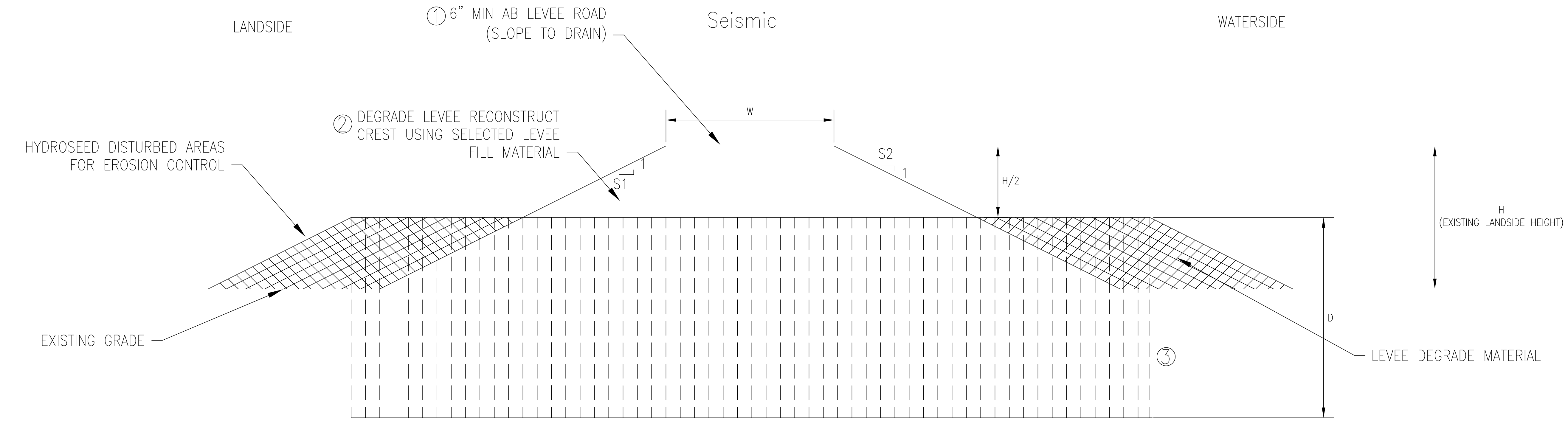
Lower San Joaquin River
Feasibility Study
Mitigation Measures
NEW LEVEE WITH SEEPAGE BERM

DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	10of 11

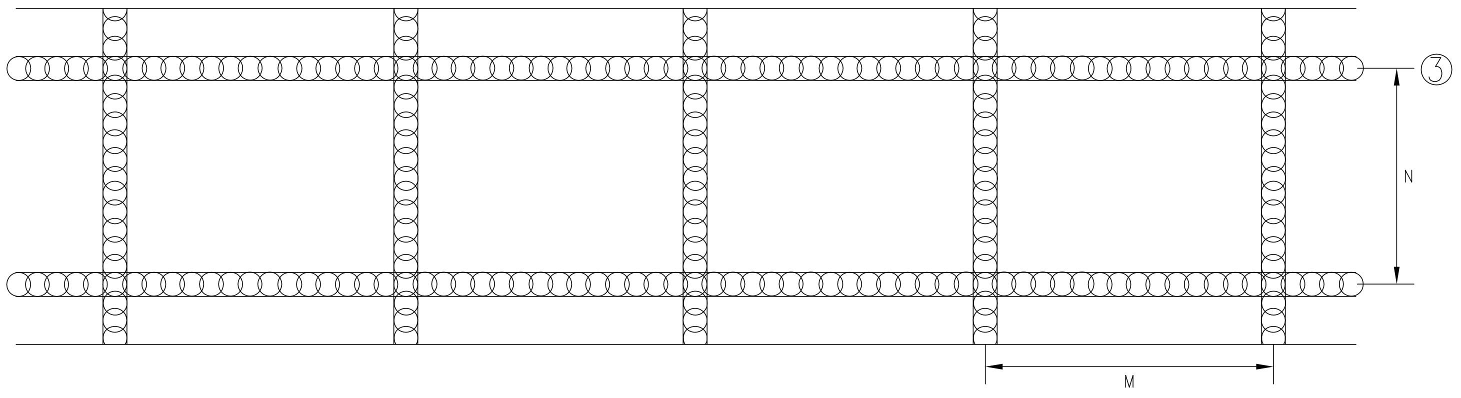
PLOT BY: L2EDGGAJ - May 18, 2015 - 11:56:36am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\ComputationSheet4_NewLeveewithSeepageBerm.10ftLSE.dwg

Seismic



SECTION VIEW

S1: Landside Slope
S2: Waterside Slope
M: DSM Cell Transverse Spacing
N: DSM Cell Longitudinal Spacing
D: DSM Wall Depth
W: Crest Width
1: Levee Road
2: Select Levee Fill
3: DSM Wall



PLAN VIEW

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Lower San Joaquin River
Feasibility Study
Mitigation Measures
SEISMIC

DATE:	SCALE:	SHEET NO.
31 - July - 13	Not to Scale	11of 11

PLOT BY: L2EDGGAJ - May 18, 2015 - 11:33:20am
DRAWING: I:\FU\Draft-Final Geotechnical Appendix\CAD for Templates\PCET_ULE - SeismicRem1.dwg

LOWER SAN JOAQUIN RIVER
FEASIBILITY STUDY

GEOTECHNICAL REPORT

ENCLOSURE E6
MEETING MINUTES FOR
EXPERT 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 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 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
- 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
  - 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 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 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 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.

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 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. 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%
        - 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:
      - 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 -
    - 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
- 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