Appendix D. Geotechnical Analysis for Pre-Design Formulation

GEOTECHNICAL ANALYSES FOR PRE-DESIGN FORMULATION

Feather River West Levee Rehabilitation
Early Implementation Project

HDR Agreement 2586

DRAFT
February 2011

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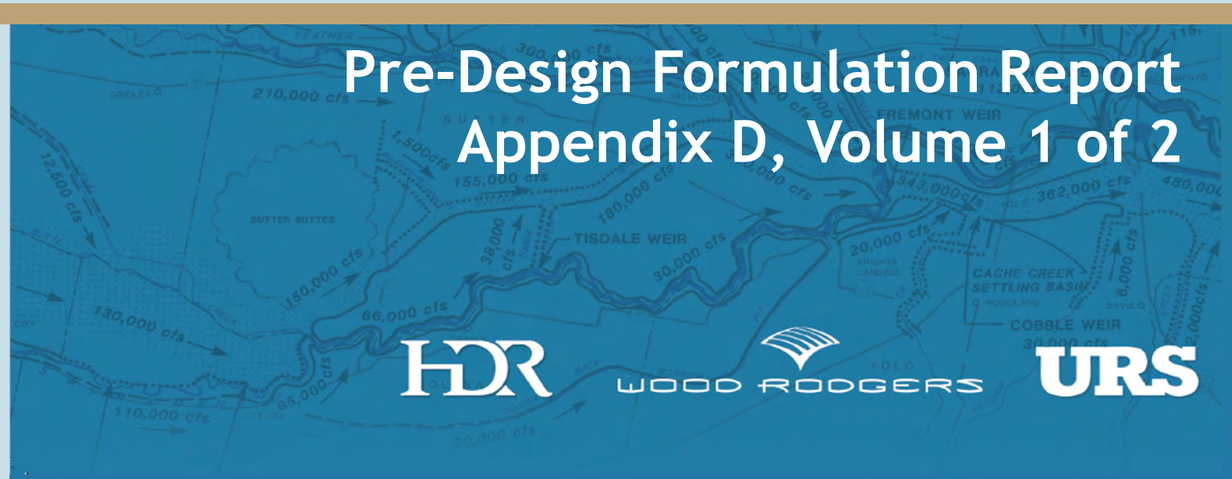
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Feather River West Levee Improvement Program

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Pre-Design Formulation Report
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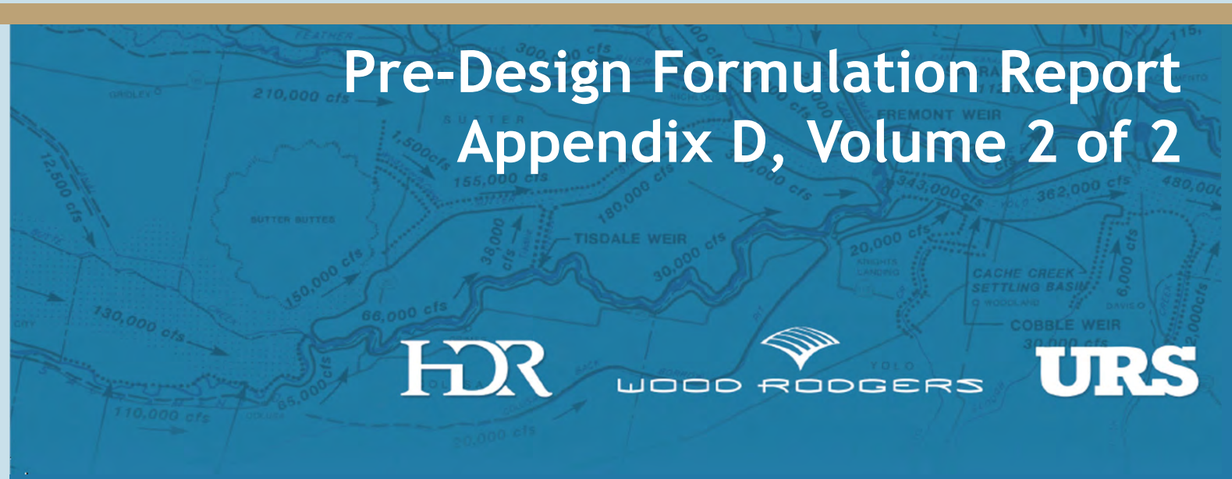
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Acronyms and Abbreviations

Term	Description
BCI	Blackburn Consulting Incorporated
CPT	cone penetration test
DWR	California Department of Water Resources
DWSE	design water surface elevations
EIP	Early Implementation Project
FRWL	Feather River West Levee
HDR	HDR Engineering, Inc.
HEM	helicopter-borne multi-frequency electromagnetic
HTOL	hydraulic top of levee
ILDC	Interim Levee Design Criteria
LD	Levee District
LiDAR	light detection and ranging
LM	levee mile
MA	Maintenance Area
NAD83	North American Datum, 1983
NAVD88	North American Vertical Datum, 1988
P1GDR	Phase 1 Geotechnical Data Report from DWR Urban Levee Evaluations Project
P1GER	Phase 1 Geotechnical Evaluation Report from DWR Urban Levee Evaluations Project
PBI	Peterson Brustad, Inc.
RD	Reclamation District
RM	river mile
SBFCA	Sutter Butte Flood Control Agency
SGDR	Supplemental Geotechnical Data Report from DWR Urban Levee Evaluations Project
SPT	standard penetration test
Sta	station
ULE	Urban Levee Geotechnical Evaluations
URS	URS Corporation
USACE	United States Army Corps of Engineers
WRI	Wood Rodgers, Inc.
WSE	water surface elevation

1.0 INTRODUCTION

This report presents the results of geotechnical analyses for Pre-Design Formulation of the Feather River West Levee (FRWL) Rehabilitation Early Implementation Project, or FRWL Project. The FRWL Project is being conducted by the Sutter Butte Flood Control Agency (SBFCA) to rehabilitate portions of the existing Feather River West Levee. This report was prepared to support of the Pre-Design Formulation of levee rehabilitation measures, to facilitate selection of appropriate levee rehabilitation measures and to provide information needed for estimating construction costs of the rehabilitation measures. This report will be used as a basis for preparing 30 percent designs of rehabilitation measures for the FRWL.

This report was prepared by URS Corporation (URS) in association with Blackburn Consulting, Inc. (BCI). URS and BCI are members of SBFCA's FRWL Project design team, led by HDR Engineering, Inc. (HDR). This report will become an appendix to the *FRWL Project Pre-Design Formulation Report*, prepared by HDR in association with other design team members.

1.1 FRWL Project Overview

The FRWL is situated along the Feather River in Sutter and Butte Counties, as shown on Figure 1-1. Within the FRWL Project and this report, FRWL refers to the 44 miles of west levee – which is along the right bank – of the Feather River from Thermalito Afterbay to the confluence of the Feather River with the Sutter Bypass. Other levees along portions of the Feather River upstream and downstream of this stretch are not included in the FRWL Project and are not referred to by the term FRWL within this project.

The FRWL is part of a levee system protecting the Sutter Butte basin, bounded to the east by the Feather River and to the south and west by the Sutter Bypass and Wadsworth Canal (refer to Figure 1-1). The basin includes extensive orchard and croplands and several cities and towns, including Yuba City (population approximately 60,000), Live Oak (population approximately 9,000), Gridley (population approximately 6,000), and Biggs (population approximately 2,000).

During past high water events along the Feather River, the FRWL has experienced performance problems, including a breach in 1955 that flooded Yuba City and much of the Sutter Butte basin. Studies by the United States Army Corps of Engineers (USACE), the California Department of Water Resources (DWR), and others have generated extensive geotechnical data for the FRWL and indicated that significant portions of the FRWL need rehabilitation to perform reliably. In 2007, local levee districts joined with local cities and Sutter and Butte Counties to form a joint powers agency, SBFCA, to improve flood protection within the basin. SBFCA conceived and initiated the FRWL Project to rehabilitate the FRWL.

The 44 miles of contiguous levees that compose the FRWL were divided by SBFCA into seven segments, as shown on Figure 1-2. Initial studies commissioned by SBFCA for rehabilitation of the FRWL covered Segments 1 through 4 (i.e., the portion of the FRWL north of Yuba City). In September of 2009, a *Preliminary Problem Identification and Conceptual Alternatives Analysis Report* for Segments 1 through 4 was issued (Kleinfelder, Inc., 2009); the report identified the need to rehabilitate nearly all of the levees in Segments

1 through 4. A *Preliminary Design Report and 10% Design Plans* for Segments 1 through 4 also were issued in September of 2009 (Peterson Brustad, Inc., 2009); the report identified possible levee rehabilitation measures along most of the length of the FRWL through Segments 1 through 4 and provided preliminary cost estimates for construction of the measures. SBFCA subsequently extended its scope of consideration to include Segments 5 through 7 (from Yuba City southward) and developed preliminary cost estimates for levee rehabilitation within these segments. In early summer of 2010, property owners within the Sutter Butte basin approved a benefit assessment for rehabilitation of the FRWL.

SBFCA defined flood protection goals for the FRWL Project. The levees in all seven segments will be designed to achieve FEMA accreditation for 100-year level of flood protection. In addition, the levees in Segments 1 through 6, and the northern portions of Segment 7 (north of FRWL Project Station 461+00), will be designed to meet State of California requirements for 200-year urban flood protection.

1.2 Purpose and Scope of Geotechnical Analyses for Pre-Design Formulation

On July 14, 2010, SBFCA contracted HDR to provide engineering services for the FRWL Project. The project involves developing designs, plans, specifications, cost estimates, and related engineering documents for rehabilitating the FRWL. Task Order 1 for this project, also issued on July 14, 2010, includes pre-design activities for levee rehabilitation measures for the FRWL. As part of pre-design, the scope of Task Order 1 includes geotechnical evaluation of the existing levees composing the FRWL to identify geotechnical problems that necessitate levee rehabilitation. For those levees found to need rehabilitation due to geotechnical problems, the scope of work includes analyzing potential levee rehabilitation measures.

The scope of geotechnical services in Task Order 1 included supplemental geotechnical site characterization of the FRWL, including drilling exploratory borings, performing cone penetration tests (CPTs), and conducting geotechnical laboratory testing. These activities are summarized in this report and are described in greater detail in a separate *Draft Interim Geotechnical Data Report* (URS, 2010b).

Geotechnical problem identification consisted of evaluating existing levee conditions for the purpose of identifying which portions of the FRWL need rehabilitation and which portions do not. The scope included:

- Characterizing levee reaches and analysis cross sections;
- Using existing data from previous studies and new data from supplemental site characterization to update previously developed reaches and cross sections (from previous studies);
- Using existing data and new data to develop new analysis cross sections;
- Performing problem identification analyses for each reach in Segments 5 to 7;
- Performing problem identification analyses at selected locations in Segments 1 to 4; and
- Preparing a report of the findings of the problem identification analyses.

Geotechnical analyses of potential levee rehabilitation measures were performed for levees identified as needing rehabilitation. The purpose of analyzing each levee rehabilitation measure is to determine the approximate dimensions of its main features that would be necessary for the rehabilitated levee to meet project goals. Dimensions of the main features are needed to estimate construction costs and areas of disturbance (i.e., the footprint of rehabilitation measures). The scope included:

- Analyzing two alternative rehabilitation measures for each reach in Segments 5 to 7 where rehabilitation is needed;
- Performing supplemental analysis of alternative rehabilitation measures at selected locations in Segments 1 to 4; and
- Preparing a report of the findings of analysis of alternative rehabilitation measures.

URS, as a subconsultant to HDR on the project design team, is responsible for the geotechnical aspects of the project, including analyzing existing levee conditions and potential levee rehabilitation measures. URS performed these analyses in association with BCI, a subconsultant to URS on the project design team. BCI performed analyses and evaluation for levee Reaches 1 through 7, in Segment 7 and the southern part of Segment 6. URS performed analyses and evaluation for levee Reaches 8 through 41, in the northern part of Segment 6 and in Segments 1 through 5. Evaluation of levee geometry, penetrations, discharge structures, pump stations, and closure structures was not included in the geotechnical scope. The scope of services to be performed by URS was outlined in the subconsultant agreement between HDR and URS dated August 10, 2010.

1.3 Report Organization

This report presents the methodology and findings of:

1. Geotechnical evaluation of existing levees composing the FRWL to identify geotechnical problems that necessitate levee rehabilitation;
2. Geotechnical analyses of alternative levee rehabilitation measures for those levees needing rehabilitation due to geotechnical problems.

Methodology and results of supplemental geotechnical site investigation performed during Task Order 1 are presented in a separate *Draft Interim Geotechnical Data Report*. The *Draft Interim Geotechnical Data Report* also includes as appendices two geotechnical data reports from DWR: the *Phase 1 Geotechnical Data Report* (P1GDR) and the *Supplemental Geotechnical Data Report* (SGDR) for the Sutter Study Area within DWR's Urban Levee Geotechnical Evaluations (ULE) Project (URS, 2008, and URS, 2010a, respectively). The Sutter P1GDR and SGDR contain the bulk of geotechnical data upon which the FRWL Project Task Order 1 analyses were based.

This report, *Geotechnical Analyses for Pre-Design Formulation*, is organized into eight sections and has three appendices. As stated previously, this report was prepared for inclusion as an appendix to the FRWL Project Pre-Design Formulation Report, prepared by HDR in association with other design team members.

The first section of this report provides introduction information for the project. Section 2.0 identifies the information forming the basis of geotechnical evaluation and analyses presented in this report. Section 3.0 provides a brief synopsis of the geologic and geomorphic setting of the project, and provides in tabular form the history of known levee performance and improvements along the FRWL. Section 4.0 describes the methodology used to perform geotechnical evaluation and analysis of the levees in this project.

Section 5.0 presents findings and information that support the primary purpose of this report. This section outlines reaches that were developed in this study, providing extents and geotechnically-relevant characteristics of the reaches, and identifies analytical cross sections developed for the reaches. Information characterizing reaches is presented in a series of tables (one table for each reach). Much of the data used to characterize the reaches and cross sections were compiled onto working draft plan views and working draft profile views showing simplified exploration logs; the working draft drawings are presented in Appendix A.

Section 5.0 also presents the geotechnical analysis results, for existing conditions (i.e., problem identification) and for alternative levee rehabilitation measures. The findings are presented in a series of tables (one table for each reach). Each table includes:

- Results of analyses for existing conditions;
- Conclusions as to whether analysis results meet project criteria;
- Identification of alternative rehabilitation measures, where needed;
- Results of analyses incorporating levee rehabilitation measures, for each levee rehabilitation measure alternative analyzed;
- Approximate dimensions of primary features of rehabilitation measures necessary to meet project criteria (for each levee rehabilitation measure alternative analyzed); and
- Comments and considerations about the information presented.

Figures depicting the analytical models and analysis results are presented for each of the cross sections analyzed; these figures are presented in Appendix B. Working sketches for cross section development for the analytical models are included in Appendix C.

Section 6.0 of this report discusses limitations of this study and outlines additional geotechnical exploration and analysis needed for design of the project. Section 7.0 summarizes report findings, presenting a summary table for existing conditions (i.e., problem identification) for all reaches and a summary table for alternative levee rehabilitation measures for all reaches. Section 8.0 lists documents and other information resources cited in this report.

2.0 FRWL PROJECT PRE-DESIGN INFORMATION

This section discusses information forming the basis of geotechnical evaluation and analyses presented in this report. Most information and data discussed in this section are presented in detail in other reports. For the most part, these data and information are not reproduced in this report, but rather are referenced and in some cases summarized. Section 8.0 lists documents and other information sources cited in this report.

2.1 Previous Geotechnical Studies

Numerous previous geotechnical studies have been performed for portions of the FRWL, and a few studies have covered much of its length. Notably, from 2007 to 2010, the DWR ULE Project investigated nearly the entire length of the FRWL, including performing extensive subsurface exploration and laboratory testing, conducting geotechnical analyses, and compiling information from previous geotechnical studies (compiled in 2008).

2.1.1 Studies Prior to 2008

Table 2-1 presents a synopsis of pre-2008 studies of the FRWL. The information in Table 2-1 is adapted from information compiled in the DWR ULE Project. For further detail about these studies or for original references, please refer to the P1GDR and SGDR for the Sutter Study Area of DWR's ULE Project. Subsurface explorations performed for these studies are addressed in Section 2.3, below.

2.1.2 BCI Evaluations for Star Bend Setback Levee

As listed in Table 2-1, in 2006, BCI prepared a geotechnical investigation report for the Star Bend Setback Levee project. Subsequently, the Star Bend Setback Levee project proceeded through final design and then construction in 2009. Between completion of the geotechnical report and construction, BCI published the following documents:

- Addendum No. 1 on November 20, 2007. This addendum provided findings of additional subsurface exploration along the setback alignment, confirmation of the geotechnical suitability of the proposed setback alignment, confirmation of the slurry wall depth, end-around seepage analysis at tie-in points, updated conclusions for the O'Connor Lake borrow sites, and responses to the USACE comments to the 2006 geotechnical report.
- Updated boring logs with lab data for logs B1-07 through B7-07 on December 9, 2007.
- Response to USACE back-check comments 7, 10, 18, 19, 25, 28 and 34 on January 12, 2009. The document included seepage analysis for Borrow Site No. 3, updated end-of-construction slope stability analysis and updated settlement analysis.
- Geotechnical Memorandum No. 2 on March 18, 2009. This memorandum contained BCI's conclusions and recommendations regarding Borrow Site No. 4.
- Geotechnical Memorandum No. 3 on May 1, 2009. This memorandum contained BCI's conclusions and recommendations regarding the use of the existing levee material as levee fill for the new setback levee.

BCI was retained by Levee District 1 to provide consulting services during construction in 2009. BCI attended weekly construction meetings, reviewed slurry depth logs, reviewed

compaction and classification test results for levee fill, and provided geotechnical-related input during construction. BCI reported that the setback levee and cutoff wall were designed and constructed in accordance with the approved plans and specifications that followed USACE guidelines, and that analyses and construction documentation indicated that the USACE requirements for seepage gradients, slope stability, and settlement were met.

2.1.3 DWR Urban Levee Evaluations

The DWR ULE Project performed investigation and analyses of the FRWL to evaluate seepage and slope stability and identify potential levee deficiencies. The evaluations were performed in phases; to date, several data collection phases have been completed, but analysis and evaluation of the levees have not been completed. For the FRWL, the DWR ULE Project has produced two principal data reports (the Sutter Study Area P1GDR and SGDR) and a preliminary (Phase 1) evaluation report.

The Sutter Study Area P1GDR and SGDR present logs of subsurface exploration performed during the ULE Project, as well as available logs of historical explorations performed in prior studies. Based on the presented information, a total of 420 subsurface explorations were performed for the ULE Project along the FRWL, and an additional 288 historical explorations from prior studies were performed within 500 feet of the FRWL. During the ULE Project, geomorphic mapping and helicopter-borne electromagnetic (HEM) geophysical surveying also were performed along the FRWL. The two data reports, which include subsurface exploration logs, geomorphic maps, and HEM survey plots, are included as appendices to the *Draft Interim Geotechnical Data Report* prepared for the FRWL project. Distribution of explorations along the length of the FRWL is shown in Appendix A and discussed in subsequent sections of this report.

The working draft drawings included as Appendix A, showing plan views along the FRWL and corresponding profile views of exploration stick logs, were first prepared by URS as part of DWR's ULE Project. In that project, logs of crown explorations performed for that project, as well as some previous crown explorations for other studies, were plotted onto the profile views. The resulting sheets were issued as a deliverable for that project. For the FRWL Project, the design team received permission from DWR to use these data and update these sheets for purposes of the FRWL Project. The design team has added many of the historical exploration logs to the profile views on these sheets, and as of the date of this report continues to add these data. Not all exploration logs have been added, and some logs were midway through the process of being added at the time of issuance of this report. As indicated in the title of the appendix, these sheets are working draft drawings. The inclusion of these sheets with this report is to facilitate understanding of data available and types of conditions present along the FRWL. These sheets are not intended nor claimed to convey all available data. Use or review of the sheets in Appendix A should be consistent with their status as working draft drawings.

2.1.4 Preliminary Problem Identification and Conceptual Alternatives Analysis for Segments 1 through 4

In September of 2009, a *Preliminary Problem Identification and Conceptual Alternatives Analysis Report* for Segments 1 through 4 was issued for the FRWL Project. The report did

not include new subsurface exploration, but did include additional geomorphic mapping, evaluation, and geotechnical analyses at various locations along the FRWL from north of Yuba City to Thermalito Afterbay. The report identified the need to rehabilitate nearly all of the levees in Segments 1 through 4, and proposed conceptual alternative rehabilitation measures to mitigate identified geotechnical deficiencies.

2.2 FRWL Project Task Order 1 Geotechnical Investigation

For the FRWL Project, the design team discerned that additional data and information were needed to:

1. Clarify past performance events at various locations;
2. Clarify whether levee improvements were or were not constructed;
3. Fill data gaps along a few locations on the levee crown;
4. Generate more subsurface data along the landside of the levee;
5. Obtain data specifically targeted at locations that might control design decisions and design elements; and
6. For future phases of design, confirm and refine design elements and characterize borrow sites.

To address past performance and levee improvements, the design team pursued additional sources of historical information (in addition to information compiled in previous studies). To fill data gaps, generate more landside data, and obtain specifically targeted data, the design team performed supplemental subsurface exploration at targeted locations along the FRWL.

Additional data needed for future phases of design were not collected during the current phase of study; additional data needs for future phases of design are discussed in subsequent sections of this report.

2.2.1 Historical Data Collection

As indicated in preceding sections, historical data and information about levee performance and levee improvements along the FRWL have been compiled in previous studies. Additional historical data about levee performance and improvements were sought in the current study to clarify data discrepancy or compile key missing data at various locations along the FRWL.

Understanding of past performance is important for reliable evaluation of levees and for appropriate levee rehabilitation design. At some locations along the FRWL, previously compiled information about past performance was unclear or did not appear to be consistent with other information. Therefore, in the current study, the design team sought clarification for past performance events at such locations.

Accurate knowledge of levee improvements also is important for reliable evaluation and for appropriate rehabilitation design. At some locations along the FRWL, previously compiled information about levee improvements was unsubstantiated or was insufficient to model the improvements in geotechnical analyses. In particular, missing were as-constructed drawings (also referred to as “as-builts”) documenting that levee improvements believed to be present

along the FRWL were actually constructed, and documenting as-constructed dimensions, materials used, and conformance to design plans and specifications. The design team sought clarification regarding levee improvements. In particular, the design team attempted to obtain as-constructed drawings for levee improvements reported to be present.

The design team sought to obtain additional historical data and documents from various sources, including USACE, DWR, local levee-maintaining authorities, and publicly accessible archives (e.g., historical newspaper articles from libraries). Some additional information was collected from various sources; most of the additional information obtained was provided by Levee District 1.

To supplement documented historical data, the design team also performed site reconnaissance. Site reconnaissance was performed to attempt to identify remnant indications of past performance (e.g., deformed slope geometry at historic slope instability locations). Site reconnaissance also was performed to confirm the presence and extent of readily observable levee improvement measures (e.g., stability berms). Site reconnaissance was effective in providing this information at various locations along the FRWL.

Information and data about past performance and levee improvements along the FRWL, including information collected during this study, are presented in subsequent sections of this report.

2.2.2 Subsurface Exploration

Although significant quantities of geotechnical data exist along most of the FRWL, supplemental subsurface exploration was performed at targeted locations to:

- Fill data gaps at a few locations on the levee crown;
- Generate more subsurface data along the landside of the levee; and
- Obtain data specifically targeted at locations that might control design decisions and design elements.

At the northernmost end of the FRWL, in Maintenance Area 7 from Station (Sta) 2355+60 to Sta 2368+00, no explorations had been performed previously along the levee. At a few other locations along the levee crown, previous explorations were either spaced such that, or provided data such that, they did not provide sufficient information for geotechnical analysis of the levee. The design team performed supplemental exploration and laboratory testing to fill these data gaps.

With the exceptions noted above, the crown of the FRWL had subsurface explorations spaced at approximately 1,000 feet apart or closer and sufficient data along the crown for geotechnical analysis. However, along much of the FRWL, especially in the northern reaches of the project, there were relatively few explorations along the landside toe of the levee and further away from the levee on the landside (i.e., landside field explorations). The design team discerned that additional explorations were needed along the landside of the levee to support problem identification analysis and analysis of alternative rehabilitation measures for Pre-Design Formulation.

Most of the evaluation and analyses in previous studies of the FRWL were intended to identify the most "critical" locations along levee reaches, with "critical" locations being considered those exhibiting the highest values of seepage exit gradient or lowest values of stability factor of safety. For levee design, however, other locations may be more critical for controlling design decisions or for determining design element dimensions. For example, in most cases, the design of a slurry cutoff wall (within a reach that requires rehabilitation) is unlikely to be affected by the location of the highest exit gradient or the degree to which this exit gradient exceeds the project criterion. Rather, the depth to which the wall must extend to cut off seepage layers is likely to be the critical variable for design, and the location of this critical value does not necessarily coincide with the location of the highest exit gradient. Supplemental exploration was performed at various locations judged potentially critical for design decisions or design element dimensions.

Supplemental exploration included exploratory drilling and cone penetration testing. Drilling was performed using hollow-stem-auger and rotary-wash (i.e., mud-rotary) methods. Drilling and sampling methods used during this study are described in the *Draft Interim Geotechnical Data Report*.

The *Draft Interim Geotechnical Data Report* includes information about the 47 subsurface explorations performed for Task Order 1 of the FRWL Project. Table 2-2 provides a summary of this subsurface exploration, and Table 2-3 summarizes the rationale for each exploration. Locations of the explorations are shown on draft plan views (and working draft profile views showing simplified exploration logs) presented in Appendix A of this report. Further information about locations and other characteristics of the explorations are provided in the *Draft Interim Geotechnical Data Report*.

Additional discussion of supplemental exploration performed for Task Order 1, as well as further exploration and studies to be performed in subsequent phases of the FRWL Project, are included in Sections 4.0 and 6.0 of this report.

2.3 Topographic and Bathymetric Information

Topography for Task Order 1 of the FRWL Project was prepared by Wood Rodgers, Inc. (WRI), a subconsultant to HDR on the project design team. Topography was based on light detection and ranging (LiDAR) data obtained from DWR. The datum used was the 1988 North American Vertical Datum (NAVD88).

Levee centerline stationing for the FRWL Project was developed by WRI. FRWL Project stationing starts at Sta 10+00 at the confluence with Sutter Bypass and runs northward, ending at Sta 2368+00 at Thermalito Afterbay. Recent previous studies along the FRWL by DWR (ULE Project), Kleinfelder, Inc. (FRWL Project), and Peterson Brustad, Inc. (FRWL Project) used a levee stationing line developed for the DWR ULE Project. Most geotechnical data along the FRWL are included in the Sutter Study Area P1GDR and SGDR, and these reports identify the locations of explorations using the levee stationing line developed for the DWR ULE Project. For convenience of reference, the working draft plan views presented in Appendix A of this report show both the FRWL Project stationing and DWR ULE Project stationing.

DWR has recently developed bathymetric sections at various locations across the Feather River. However, bathymetric data available from DWR does not provide contiguous bathymetric contours. Contiguous bathymetric contours are needed to develop cross sections for geotechnical analyses. For Pre-Design Formulation geotechnical analyses, bathymetric contours of the Feather River available from work by USACE in 2002 were used to develop analysis cross sections. The bathymetric sections from DWR were considered in comparison to the USACE bathymetry in developing the cross sections.

At various locations along the FRWL are canals, ditches, long excavation troughs, and other low areas that are commonly partially filled with water. Some of these features were dry at the time of the LiDAR survey used to generate topography, and so the bottom of these features is available. Other such features had water in them at the time of the LiDAR survey, so the bottom of the features was not identified. No bathymetric survey has been performed for these features.

2.4 Design Water Surface Elevations

The levees in all seven segments of the FRWL Project will be designed to achieve FEMA accreditation for 100-year level of flood protection. In addition, the levees in Segments 1 through 6, and the northern portions of Segment 7 (north of Sta 461+00), will be designed to meet State of California requirements for 200-year urban flood protection.

Peterson Brustad, Inc. (PBI) developed the design water surface elevations (DWSE) for the FRWL Project. The DWSE and model approach used by PBI are summarized in a Technical Memorandum dated October 26, 2010, and titled *Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project* (PBI, 2010). The Technical Memorandum provides 100-year, 200-year, and 500-year water surface elevations (WSEs). As directed by PBI, an additional 1 foot was added to the DWSE elevations during Pre-Design Formulation to allow rehabilitation measures to be more resilient in consideration of climate change and any uncertainties in the hydrologic/hydraulic analyses. The addition of an extra 1 foot is recommended by the current (Fourth) draft of DWR's *Interim Levee Design Criteria* (ILDC) documents (DWR, 2010a).

Table 2-4 summarizes DWSE for the FRWL Project, as well as the USACE 1957 WSE along the FRWL. Figure 2-1 shows the 100-year, 200-year, 500-year, and the 1957 WSEs, and also the existing top of levee elevations.

3.0 PROJECT SETTING

This section summarizes the geologic/geomorphic setting of the FRWL and the construction and performance background of the levees that compose the FRWL.

3.1 Geologic and Geomorphic Setting

The following synopsis of geologic and geomorphic setting of the FRWL Project is adapted from information presented in previous reports (URS, 2008; URS, 2009; URS, 2010a); further information may be found in those documents and in the *Preliminary Problem Identification and Conceptual Alternatives Analysis Report* for FRWL Segments 1 through 4.

3.1.1 Geomorphic History

The FRWL is in the central portion of the Sacramento Valley (Valley), which is the northern half of the Great Valley Geomorphic Province of California. Most of the levees that compose the FRWL are near active river channels (of the Feather River), with some levees near the east margin of the Valley (along the northern portions of the FRWL).

The Sacramento Valley lies between the northern Coast Ranges to the west and the northern Sierra Nevada mountain range to the east, and has been a depositional basin throughout most of the late Mesozoic and Cenozoic periods. During the Pliocene-Pleistocene era, deeper bedrock units were covered by coalescing alluvial fans deposited by the major ancestral rivers of the Sacramento Valley (Sacramento, Feather, Yuba, Bear, and American) that funneled huge volumes of sediments into the Sacramento basin. Periodically, volcaniclastic sediments and tuffs were also broadly deposited. Late Pleistocene and Holocene alluvial deposits now cover low-lying areas, consisting largely of reworked fan and stream materials deposited by meandering rivers prior to the construction of the existing flood control systems.

From the mid-1800s to the early-1900s, hydraulic mining in the Sierra Nevada mountain range introduced massive amounts of mining debris into the Feather, Yuba, and Bear Rivers. This debris backfilled river channels and raised channel elevations. Mining debris was also transported and deposited atop the more consolidated Pleistocene- to Holocene-age deposits during numerous flood events.

In the FRWL Project area, fine-grained Holocene basin and/alluvium deposits overlie coarser late Pleistocene deposits of the Modesto and Riverbank Formations. Typically, a well developed soil with impervious horizons (e.g., a hardpan) is found at the top of the late Pleistocene deposits, separating the basin and/or alluvium deposits from the underlying coarser deposits. The fine-grained basin and/or alluvium deposits and the hardpan generally have much lower hydraulic conductivity than the underlying late Pleistocene deposits. This configuration of deposits may constitute a geotechnical blanket condition.

3.1.2 Geomorphic Units

The working draft plan views included in Appendix A of this report include surficial geologic map units along the FRWL corridor. The generalized geologic map units in the study area

are detailed below with descriptions typically summarized from Helley and Harwood (1985). The map symbol for each mapped geologic unit is noted after the formal name of the unit. Typically, each younger geologic unit is deposited into broad channels cut into the progressively older geologic units. Map symbols used on the working draft plan views are slightly different since they are based on the geomorphologic mapping, which is more detailed.

Holocene (Historical) Artificial Fill (L, DT). Historical Artificial Fills (less than 150 years old) are culturally-emplaced deposits of varying amounts of clay, silt, sand, and gravel from local sources. These deposits include levee structures (L) and dredge tailings (DT). Dredge tailings are located along the northernmost reach of the Feather River.

Holocene (Historical) Alluvial Deposits (Ra). Historical Alluvial Deposits (less than 150 years old) occur generally between the Feather River channel levees and on the landside. These deposits also occur in historical stream and overflow channels that transport high-stage water flow across the ground surface landside of the levees. Deposits consist of silt and sand with traces of gravel. The upper few feet of these deposits (particularly those derived from the Feather River) typically would be expected to be filled with debris from upstream hydraulic mining activities.

Holocene Alluvium (Qa). Holocene (less than 11,000 years before present) alluvial deposits are present within the floodplains of the Sacramento River, Feather River, and lesser streams and water courses in the area. These sediments were deposited into and along channels incised into the older latest-Pleistocene formations of similar fluvial origin. The alluvium includes sand and gravel deposits of the active and abandoned stream channels, as well as sands, silts and minor gravel lenses deposited as overbank deposits during high water stages.

Holocene Basin Deposits (Qn). Basin Deposits primarily dominate the Sutter Basin (between the Sacramento and Feather Rivers) in the western portion of the project area. The majority of the Sutter Bypass is underlain by these deposits, but closer to the Feather River, on both sides, Basin Deposits are less extensive and are mapped as scattered exposures overlying the Modesto and Riverbank Formations. These fluvial sediments consist of fine-grained silt and clay, and represent the distal facies of Holocene alluvial deposits in the area.

Pleistocene Modesto Formation (Qm). The youngest Pleistocene fluvial deposits in the project area are Modesto Formation. The Modesto Formation is exposed at the ground surface predominantly along the landsides of most of the Feather River levee system and to a lesser degree along the eastern edge of Sutter Buttes. This formation underlies the younger Basin Deposits east of Sutter Buttes and most of the Feather River channel alluvium. These deposits are recognized by distinct alluvial terraces, alluvial fans and abandoned channel ridges lying topographically above and outboard of the Holocene alluvial deposits. The Modesto Formation generally consists of unconsolidated gravel, sand, silt and clay and can be divided into two members: an upper member, identified as Upper Modesto Formation or Qmu (12,000 to 26,000 years before present), showing poor soil development; and a lower member, identified as Lower Modesto Formation or Qml (30,000 to 50,000 years before present), characterized by thicker soils with a developing argillic B horizon. Hardpan may be present near the top of each member of the Modesto Formation as an indicator of

the upper boundary with the overlying alluvium. On the western side of the Feather River, the Modesto Formation is a common source of fresh water, as coarse-grained deposits are thick and have good hydraulic connection.

Pleistocene Riverbank Formation (Qr). The Riverbank Formation is exposed along the eastern margin of the Feather River with limited exposures on the western margin at the extreme northern and southern ends of the Feather River. However, the Riverbank Formation is predominantly separated from the Feather River alluvial deposits by the Modesto Formation. This formation consists primarily of gravel, sand, and silt and can typically be distinguished from the Modesto Formation by topographic position and presence of a thick, well-developed soil horizon. The Riverbank Formation is subdivided into the Upper and Lower members identified as Upper Riverbank Formation (Qru) and Lower Riverbank Formation (Qrl), each associated with periods of geologic stability. Hardpan may be present near the top of each member as the result of pedogenic processes during periods of non-deposition. The Riverbank Formation is estimated to be 130,000 to 450,000 years old. The Riverbank Formation can be a source for fresh water in the northern Feather River area, but the interbedded nature of the fine- and coarse-grained units and the varying degree of connectivity between coarse-grained beds may limit groundwater production at some locations.

3.2 Levee Construction, Performance, and Improvements History

The FRWL extends approximately 44 miles, from the Feather River confluence with the Sutter Bypass at the southern end of the FRWL, to its northern end where it ties in to an outfall structure of Thermalito Afterbay (Figure 1-1). The FRWL extends through several levee maintenance authority districts (from south to north): Maintenance Area 3 (MA3), Levee District 1 (LD1), Levee District 9 (LD9), Maintenance Area 16 (MA16), and Maintenance Area 7 (MA7).

Levees along the western side of the Feather River (right bank) are part of the Sacramento River Flood Control Project authorized by the Flood Control Act of 1917. No as-constructed drawings of original levee construction along the FRWL are available. Limited information about original levee construction is included in operation and maintenance documents for portions of the FRWL.

Along the southern half of the FRWL (i.e., Yuba City southward), the levees of LD1 and MA3 were first constructed and maintained by local interests as early as 1868 (URS, 2010a). The USACE reconstructed levees in LD1 from 1939 to 1940 and enlarged a portion of the levees in MA3 in 1943. This construction left the levees with nominally the dimensions that exist at present, except for locally reconstructed areas (e.g., Star Bend, Shanghai Bend, areas where toe berms have been added, etc.). In 1951, the USACE transferred operation and maintenance authority to the State Reclamation Board (MA3) and to LD1.

North of Yuba City, no information is available about the original construction of the levees, except in the northern part of MA7. In the northern part of MA7, from north of Biggs to the Sutter-Butte Headgate at Hamilton Bend, the levee was constructed in 1947. South of this area in MA7, locally constructed levees were reconstructed in 1954 (USACE O&M Manual, Unit 152). Further south, locally constructed levees in MA16 and LD9 were enlarged in the

early to mid-1930s and mid-1940s (USACE O&M Manual, Unit 148). As-constructed drawings are not available for any of these levees.

Based on a USACE Memorandum of Understanding (USACE, 1953) between USACE and The State of California, the Feather River Right Bank Levee from Sutter Bypass to the Western Canal Headgate (at that time a total of 44.3 miles) was considered part of the "Old Project". The Old Project includes portions of levees adopted by the Federal Flood Control Acts and approved on March 1, 1917, May 15, 1928, August 26, 1937, and August 18, 1941. For design basis, the so-called 1957 water surface profiles represent the Sacramento River Flood Control Project (SRFCP) design conditions (USACE, 1957). This profile is not related to a specific return period flood event, but represents the design conditions adopted for the SRFCP.

High water events have caused repeated performance problems along the FRWL, including levee breaks in 1909, 1914, and 1955. During the 1955 event, water was approximately 21 feet high on the levee in the area of the break, at the southern end of Yuba City. In 1986, a high water event nearly caused failure of the FRWL. During this event, however, the nearby Yuba River South Levee broke, and resulting flooding of the Linda area caused rapid drop-off in water levels in the Feather River. In 1997, a high water event again nearly caused failure of the FRWL. During this event, a levee on the east bank of the Feather River broke, resulting in rapid drop-off of water levels in the Feather River.

During high water events, the FRWL has experienced performance problems at numerous locations. Most commonly, the levees have experienced underseepage problems, including boils, piping of soil material, and sinkholes. Some locations along the FRWL have experienced other geotechnical-related problems during high water events that appeared to have been associated with through-seepage, landside instability, waterside instability, or erosion. Table 3-1 tabulates, by location, past performance problems documented or reported orally during communication with levee maintenance personnel.

Levee improvements have been constructed at various locations along the FRWL. Most commonly, these improvements were in response to performance problems observed during high water events. Improvements present along the FRWL include stability berms, drainage trenches, relief wells, slurry cutoff walls, and other measures. Table 3-1 tabulates the locations of reported or observed levee improvement measures. As-constructed drawings were not found or obtained during this study (or reported in previous studies to be available).

4.0 EVALUATION METHODOLOGY

This section describes the methodology used to perform geotechnical analyses for Pre-Design Formulation. Overall approach and considerations are presented, and more specific methodologies and criteria are described. The technical approach for the FRWL Project is discussed in detail in the FRWL Project *Design Criteria and Technical Approach Memorandum* (HDR, 2010). The November 30, 2010, Draft of the *Design Criteria and Technical Approach Memorandum* was used for geotechnical analyses and results presented in this report.

4.1 Evaluation Approach

The design team sought to develop an overall approach that was both sufficient for the purpose of the work and efficient in its use of project resources. To meet these objectives, the design team was judicious in its delineation of the scope of evaluation and the process by which the evaluation would be performed, as described below.

4.1.1 Scope of Evaluation

The purpose of the evaluations and analyses presented in this report was to support the Pre-Design Formulation for the FRWL Project. The Pre-Design Formulation is the first phase of the design for the full length of the FRWL Project. The design process will involve multiple phases and design refinements. As such, it was not the intent of this evaluation to address all geotechnical conditions, analytical cases, regulatory requirements, and construction considerations that ultimately will need to be addressed for final design. Rather, the intent of this evaluation was to address those issues necessary to support the goals of the Pre-Design Formulation.

From a geotechnical standpoint, the primary goals of the Pre-Design Formulation are to:

- Identify which reaches of the FRWL need rehabilitation and which do not;
- Select a preferred rehabilitation alternative for each reach needing rehabilitation (which involves developing approximate costs of rehabilitation alternatives); and
- Estimate the approximate areal extent (i.e., footprint) of the anticipated project features.

As described in preceding sections of this report, a significant amount of data has been collected in previous investigations along the FRWL, and these data were supplemented by additional exploration performed for the FRWL Project. The available data are sufficient for achieving the goals of the Pre-Design Formulation, specifically, the above-listed goals. The design team recognizes that additional data and analyses will be needed for subsequent phases of design. Future studies anticipated for the FRWL Project are discussed in subsequent sections of this report.

The design team also recognized that to address more than what was necessary for Pre-Design Formulation would be wasteful of resources that are being applied to the FRWL Project. Performing exploration or analyses that do not explicitly support the Pre-Design Formulation needs, or that go beyond what is explicitly needed for the Pre-Design

Formulation, would not be an appropriate use of resources. In consideration of this, the design team considered carefully how to approach the evaluation, with respect to new exploration and to analyses to be performed.

Currently, the amount of available geotechnical data is not sufficient to support final design of rehabilitation measures (where needed). More data will need to be collected to complete design. During the current design stage, however, it was unknown which rehabilitation alternatives will be selected for final design. Although only one alternative per reach will be selected, multiple alternatives were being evaluated, so it was necessary to apply resources to exploring and analyzing multiple alternatives. Resources applied to exploration and analysis of the alternative that is eventually selected will have been well invested. But, necessarily, resources also have been applied to exploration and analysis of alternatives that will not be selected. It would be an inefficient use of resources to invest more than is necessary to evaluate alternatives that will not be selected. Therefore, the design team performed only those explorations and analyses necessary to support the Pre-Design Formulation goals.

For example, if a reach needing rehabilitation will be rehabilitated by constructing either a cutoff wall or a seepage berm, both alternatives must have sufficient exploration and analysis to support the selection of a preferred alternative. But to fully design either measure would require more exploration and analysis than is needed to identify which alternative is preferable. For complete design of a seepage berm, explorations distributed over a wide areal extent across the landside field along the levee are needed. If the cutoff wall alternative is selected, most of the field explorations would be of little value for design of the wall. On the other hand, more densely-spaced explorations along the levee crown would be appropriate for complete design of a cutoff wall. If the berm alternative is selected, though, densely-spaced crown explorations would be of much less value.

These considerations and similar considerations of resource investment versus possible outcomes were factored into the design team's approach to exploration and analysis. As discussed previously in this report, exploration performed for this design phase was targeted at specific locations to address specific data needs for the Pre-Design Formulation. Exploration performed for this design phase is described in the *Draft Interim Geotechnical Data Repor*t.

4.1.2 Evaluation Process

The evaluation process was specifically designed to be both sufficient for the purpose of the work and efficient in its use of project resources. Geotechnical analyses for Pre-Design Formulation considered levee through-seepage, underseepage, landside slope stability under steady-state conditions, and waterside slope stability under rapid drawdown conditions. End-of-construction stability analyses were not performed; these analyses will be performed in a subsequent design stage. The following process was implemented for evaluating seepage and slope stability for the FRWL Project.

1. Establish levee reaches where the levee and foundation conditions can be considered generally similar throughout the reach.
2. Update previous geotechnical site characterizations along the FRWL Project.

3. Evaluate previous geotechnical analyses and update with new layering and properties where appropriate.
4. Perform seepage and stability analyses for different reaches to evaluate levee integrity. Base analyses on critical conditions. In some cases, analyses from one reach may be used to evaluate conditions in another reach if conditions are similar.
5. Determine which levee reaches can be shown to meet project criteria for the design water surface elevations with existing conditions (i.e., without new levee rehabilitation measures).
6. Review and consider past performance of the levee with respect to seepage and stability to discern whether this information is consistent with analytical results or if both must be evaluated further to make judgments about whether the reach meets project criteria.
7. Identify seepage and stability deficiencies and their extents.
8. Complete analyses of alternative rehabilitation measures for each levee reach with identified deficiencies.
9. Develop, or update, preferred alternatives and approximate dimensions of primary features for each levee reach found to be deficient.

The evaluation process explicitly considers past performance as well as analysis results. The past performance of levees, particularly past seepage or stability distress, is of fundamental importance for evaluating levee through-seepage, underseepage, and slope stability. If there is reliable documentation of previous underseepage problems (such as major boils) that have not been remediated, then the design team must conclude that the areas where the performance problems occurred do not meet underseepage criteria. Similarly, if there are well-documented levee stability problems (such as slumping of a landside slope during a high-water event), the design team must conclude that slope stability criteria are not met, unless the stability problems have been satisfactorily corrected.

Analyses performed for evaluation were associated with specific WSEs, in accordance with the FRWL Project *Design Criteria and Technical Approach Memorandum*, November 30, 2010, Draft. The *Design Criteria and Technical Approach Memorandum* specifies WSEs for analysis of existing conditions (i.e., problem identification) and for analysis of alternative rehabilitation measures. In each case, project criteria are defined for the DWSE and for WSEs associated with an extreme high water event condition.

As indicated in Section 2.4, the DWSE for the FRWL Project are the 200-year WSE north of Sta 461+00 and the 100-year WSE south of Sta 461+00. Project criteria for analyses using the DWSE are presented in Section 4.6.

Section 4.6 also includes project criteria for analyses using WSEs associated with an extreme high water event condition. These criteria were established to help ensure that the principal mode of levee failure (should it occur) is by overtopping, and that the levee does not fail by other mechanisms before the levee actually overtops. For the FRWL Project, the WSE associated with an extreme high water event was considered to be, at any particular location, the lowest of:

- The median 200-year WSE plus 3 feet north of Sta 461+00, and the median 100-year WSE plus 3 feet south of Sta 461+00; or

- The median 500-year WSE; or
- The existing top of levee elevation.

This WSE (i.e., the lowest of the three WSEs listed above) is referred to in this report as the hydraulic top of levee (HTOL). Further discussion of HTOL is included in the FRWL Project *Design Criteria and Technical Approach Memorandum*.

As indicated above, analyses must first be performed to evaluate existing conditions and identify where deficiencies exist. Existing conditions are required to meet project criteria for both the DWSE and the HTOL. If existing conditions do not meet any of the project criteria, then rehabilitation is needed. As a result, the process of performing problem identification for existing levee conditions was organized into procedural steps. Figure 4-1 shows the steps used to analyze existing levee conditions for the FRWL. As indicated by the process shown, if the levee is found to meet criteria for the step being analyzed, the following step of the process is performed. If at every step the levee is found to meet criteria, the step-by-step process demonstrates that existing conditions meet project criteria and no levee rehabilitation is needed (for seepage or stability) based on analyses of modeled conditions. If at any step the analysis indicates the levee does not meet criteria, the levee is identified as needing rehabilitation, and the analysis of existing conditions is complete.

For evaluation of rehabilitation measures, analyses must demonstrate that the rehabilitated levee meets all project criteria. Both seepage and stability must be analyzed, for both the DWSE and the HTOL. As stated in Section 2.4, an additional 1 foot was added to the DWSE and HTOL elevations for analysis of rehabilitation measures during Pre-Design Formulation. As a result, each rehabilitation measure alternative analyzed must meet project criteria for both seepage and stability for both the DWSE plus 1 foot condition and the HTOL plus 1 foot condition.

Table 4-1 summarizes the WSEs used for seepage and stability analysis during Pre-Design Formulation.

4.2 Reach Selection Methodology

The objective of reach selection is to subdivide the length of the FRWL into discrete lengths to enable the incremental geotechnical analyses needed for overall FRWL evaluation. Detailed analysis and evaluation is performed on transverse cross sections modeled from conditions present in reaches. Analysis and evaluation results for a modeled cross section are considered to pertain to the full length of the reach within which the cross section is located. The principal reach selection premise is that each reach should be represented adequately (in terms of geotechnical characterization and analysis) by one transverse cross section (and one set of associated analysis input parameters). Conditions vary along the length of a levee, and where variations become significant enough that they are not adequately represented by the preceding cross section, a new reach begins. The new reach is represented by a new cross section.

The physical conditions that characterize a cross section – and by extension, characterize a reach – are generally either geologic/geotechnical conditions, geometric conditions, or

hydrologic/hydraulic conditions. When selecting reaches, the design team considered the following factors and characteristics:

- Geology, geomorphology, foundation profile stratigraphy, and geotechnical properties of foundation materials;
- Levee composition, geotechnical properties of levee materials, and levee construction method (where known);
- Levee geometry, including height and slope angles;
- Topography of the ground adjacent to the levee, including the presence or absence of ditches, canals, or other locally lower surfaces;
- Adjacent bathymetry and distance to the river channel;
- Levee improvement measures, including extent, type, dimensions, and effectiveness (if known);
- Levee performance history, including extent of problems, types of distress, recurrence of performance problems, and degree of loading (i.e., water surface elevation) that causes distress to occur (where known);
- Water surface elevations to be used for assessment (i.e., relative degree of loading to be evaluated); and
- Adjacent land use and presence of structures or features that may affect decisions regarding preferable rehabilitation alternatives.

Reaches generally were characterized by relatively consistent physical characteristics such that the analytical results were considered to pertain to the full length of the reach. When developing reaches, the design team considered that refining, splitting, or creating additional reaches might increase consistency in physical characteristics, but might not result in changes in analytical results. As indicated in the FRWL Project *Design Criteria and Technical Approach Memorandum*, approximately 40 reaches having an average length of about 1 mile were expected to be established.

The design team anticipates that in future design stages, the characteristics within reaches will be further refined. Design of rehabilitation measures, where needed, may be similarly refined. For the purposes of Pre-Design Formulation, though, the design team considered further discretization of reaches to be unbeneficial.

4.3 Analysis Model Development

As indicated above, the process of reach characterization also involves considering and developing transverse cross sections to represent reaches. Each transverse cross section forms the basis of the corresponding analytical model to be analyzed.

4.3.1 Data Interpretation and Representation

The analytical models include:

- Geometric characterization of the ground surface profile, including levee geometry;
- Geometric characterization of the soil layering, including variation in depth and thickness of each soil layer;

- Geotechnical characterization of the soil layering, including soil parameters needed for each type of analysis to be performed; and
- Hydraulic characterization of the loading conditions, represented by water surface elevation on the levee waterside and hydraulic boundary conditions.

Typically, soil borings and CPTs located at or near a cross section location are used to identify soil layer types and geometry for a cross section; this process was used for this evaluation. Subsurface explorations were projected onto the transverse cross section, and soil layering was interpolated between the explorations on the section. Soil layering also was extrapolated laterally to the waterside and to the landside of the exploration locations in order to complete the analysis model over the distance necessary to perform the analyses.

Additionally, the design team considered other information about subsurface conditions when interpolating and extrapolating soil layering exhibited in the explorations. Such information is useful for supporting judgment commonly needed to complete cross section development, including for:

- Resolving apparent inconsistencies between explorations;
- Justifying extrapolation of layers in a non-horizontal manner;
- Identifying the usefulness of performing sensitivity analysis on the model;
- Extending model depth beyond the depths of explorations; and
- Incorporating soil layering that was not readily apparent in the explorations.

An example of such interpretation might include removing a thin waterside blanket layer from the model that would otherwise be modeled as a result of horizontal projection of soil layers from a crown exploration (where no waterside explorations have been performed). An alternative example might be incorporating into the model a layer of dredge tailings on the waterside of the levee, even though no waterside explorations had been performed.

Information used to make these judgments and develop appropriate analytical models includes:

- Geologic and depositional history;
- Variation in surficial geologic units and geomorphology along the reach and across the section;
- Variation in geophysical survey results along the reach and across the section:
- Observations of surficial soils at locations other than exploration locations;
- Number and distribution of explorations along the reach and across the section;
- Apparent quality and reliability of the subsurface explorations; and
- Type and nature of past performance events that have occurred within the reach.

Development of analytical models using transverse cross sections needs to consider how the geometric characterization of soil layering and the geotechnical characterization of the soil layering affect modeling results. This consideration, and judgment used to develop the analytical models, was informed by review of the information outlined above.

Note that the geometric characterization of the ground surface includes both topography and bathymetry. The bathymetry used (USACE, 2002) was compared to recent bathymetric information from DWR; the recent information provided only bathymetric sections (not contiguous bathymetric contours). Comparison indicated that, during the time interval between bathymetric data sets, some areas had not changed notably and that other areas had. Analysis models and methodologies were considered with respect to potential impact due to bathymetry changes. Because for most sections the river is located a significant distance away from the levee (hundreds to thousands of feet), changes to the bathymetric section have little effect on the analysis for those sections. For sections where the river is adjacent or close to the levee, the sections indicate little change to the bathymetry between data sets.

4.3.2 De-Coupling of Geotechnical Model from Civil Plans

While developing the analysis sections, the design team incorporated a form of de-coupling of the geotechnical cross sections from civil cross sections. The intended result was that ongoing development and changes to civil cross sections would not impact development and use of the geotechnical cross sections for analyses. Additionally, the design team intended to develop geotechnical cross sections that, should the civil cross sections be modified, still would produce analytical results that are valid for the modified civil cross sections.

To de-couple the geotechnical cross sections from the civil cross sections, the design team used existing levee geometry as the basis for rehabilitated levee geometry when analyzing rehabilitation alternatives. For example, for a slurry cutoff wall rehabilitation alternative, a levee will be de-graded to half the levee height, the cutoff wall will be constructed, and then the levee will be reconstructed. There will be design grades, elevations, and slopes to which the levee is reconstructed, in accordance with various civil requirements. In the geotechnical analysis cross section, however, the reconstructed levee profile was set to match the existing levee profile.

The design team considered existing levee geometry of the FRWL in comparison to expected ranges of civil requirements for levee geometry. This consideration indicates that in some areas these geometries will be very similar, and that in others the required civil geometry will be more robust than the existing geometry. In the first case, basing the geotechnical analyses on the existing geometry should produce analytical results that very closely correspond to outcomes that would result from analysis of the civil geometry. In the second case, basing the geotechnical analyses on the existing geometry should produce results that are close to or slightly conservative relative to outcomes that would result from analysis of the civil geometry. This approach provides some adaptability of the geotechnical analysis results to changes or variations in civil requirements for levee geometry.

Note that any conservatism this approach may incorporate into the analysis affects only the analyses of rehabilitation measures. This approach does not induce any conservatism into the evaluation of existing conditions.

An exception to this de-coupling approach was implemented for waterside rapid drawdown slope stability analysis. For analyzing rapid drawdown stability of rehabilitation measures, the

design team used a 3H:1V waterside slope to represent all rehabilitation cases, regardless of existing geometry.

4.3.3 Consideration of Three-Dimensional Effects

The use of two-dimensional cross sections for analysis of levee conditions is typical engineering practice, and is generally considered appropriate for analysis of most levee conditions. Some conditions, however, are not represented well by two-dimensional cross sections. Common examples include anomalous geometric conditions around pump stations and anomalous geotechnical conditions around penetrations. These types of conditions will be considered further using additional evaluation methods in subsequent stages of design.

The FRWL Project includes another, less common condition that may not be represented well by two-dimensional analysis. At several locations along the northern part of the FRWL, the levee makes a 90-degree bend (in plan view), and at one location the bend is even more acute (about 50 degrees between adjoining limbs of the levee). At these locations, three-dimensional seepage effects would be expected to occur during high water events. Due to the angle of the bend, water seeping through or under the levee on each side of the bend would tend to converge towards the landside. This convergence may create more severe seepage conditions than would be modeled in two-dimensional analyses. The design team considered these effects while evaluating existing levee conditions. Where these bends are located in reaches needing rehabilitation, subsequent design stages may include three-dimensional analysis of seepage conditions, depending on the types of rehabilitation measures selected.

4.4 Material Parameters Selection

Hydraulic conductivity parameters for seepage models were developed based on the values recommended by the Board of Senior Consultants for the Natomas Levee Improvement Project and then adjusted for the FRWL Project. Adjustments in hydraulic conductivities were made after reviewing predicted values based on grain size and void ratio data available for soils along the FRWL. Predicted values were developed using the Kozeny-Carman equation (Chapuis and Aubertin, 2003) and the Chapuis equation (Chapuis, 2004). For the most part, adjustments consisted of increasing hydraulic conductivities by about half an order of magnitude (about a factor of 3) for sands and gravels with fines contents less than 30 percent. The other presumptive hydraulic conductivities recommended by the Natomas Board of Senior Consultants remained the same. Hydraulic conductivity values for materials to be used in rehabilitation measures were selected based on materials anticipated to be used to construct the rehabilitation measures.

The presumptive hydraulic conductivity values used in this study are shown in Table 4-2. These values were used to model the respective material types as characterized in Table 4-2 in each of the seepage analyses. Sensitivity analyses using different hydraulic conductivities also were performed for some analyses.

Steady-state seepage slope stability models incorporated effective shear strengths for the different soil layers. Presumptive effective shear strengths are summarized in Table 4-3 and were selected after reviewing the available soils data, including laboratory test results and

correlations between classification test results and effective shear strengths. Strengths for coarse-grained soils were based on SPT blow counts and CPT values. Comparisons also were made to parameters previously adopted by the USACE, to values recommended by the DWR ULE Project, and to shear strengths used by consulting firms in previous analyses for the FRWL and other levee projects in the region. Table 4-3 also presents total stress strength parameters used for rapid drawdown stability analyses. Total stress parameters were estimated based on evaluation of triaxial strength tests (consolidated undrained tests) performed in previous studies of the FRWL.

During subsequent design phases of the FRWL Project, additional laboratory shear strength data will be obtained for FRWL soils, and the presumptive shear strengths may be revised for final design.

4.5 Analysis Methodology

The design team performed two-dimensional seepage analyses using the finite-element computer program SEEP/W (GEO-SLOPE International Ltd., 2007a). Seepage analyses were performed to model levee through-seepage and underseepage. The analytical models developed described above were entered into the program. Steady-state conditions were analyzed for seepage conditions associated with the WSEs listed in Section 4.1.2. Details of analysis assumptions (e.g., landside ditch assumed to be empty) and modeling/software settings (e.g., fixed-head boundary condition used at waterside edge of model) are listed in the FRWL Project *Design Criteria and Technical Approach Memorandum*.

The design team also performed sensitivity studies for some analytical models by changing model geometry and/or parameters and re-analyzing the models. These analyses afforded consideration of the sensitivity of analysis results to model characteristics, and in some cases they were used to refine models.

For each cross section analyzed, the design team plotted SEEP/W results showing seepage equipotentials and gradients. Average vertical gradients across the landside blanket layer at the landside levee toe and, if present, at the landside berm toe were calculated and identified on the plots. Seepage analysis results were reviewed for reasonableness, and in some cases used to identify the need for additional sensitivity analyses. Seepage analysis results were compared to project criteria, outlined below.

The design team performed two-dimensional slope stability analyses using the limit-equilibrium computer program SLOPE/W (GEO-SLOPE International Ltd., 2007b). Analytical models developed as described above were entered into the program. Pore pressures from steady-state seepage analyses associated with the WSE conditions to be analyzed were imported into the landside stability analyses. Analysis assumptions and modeling/software settings are listed in the FRWL Project *Design Criteria and Technical Approach Memorandum*.

As for seepage, sensitivity studies of stability also were performed for some analytical models. SLOPE/W results were plotted showing the minimum factor of safety and associated potential slip surface. Stability results were reviewed for reasonableness, and in some cases

used to identify the need for additional sensitivity analyses. Stability analysis results were compared to project criteria, outlined below.

Rapid drawdown stability analyses also were performed using SLOPE/W. Three-stage analyses were performed, incorporating both drained and undrained strengths. Analysis assumptions and modeling/software settings are listed in the FRWL Project *Design Criteria and Technical Approach Memorandum*.

4.6 Analysis Criteria

This section summarizes the criteria used to evaluate the results of geotechnical analyses for Pre-Design Formulation. Criteria are also presented and discussed in detail in the FRWL Project *Design Criteria and Technical Approach Memorandum*.

4.6.1 Analysis Criteria for Seepage Evaluation

In accordance with the *Design Criteria and Technical Approach Memorandum*, analyzed hydraulic exit gradients were compared to maximum allowable gradients. Table 4-4 presents the maximum allowable average exit gradients that were used as criteria with the geotechnical analyses for Pre-Design Formulation. Exit gradients were checked for the DWSE condition and for the HTOL condition. Maximum allowable exit gradients for the HTOL condition were required to not increase by more than 10 to 20 percent (depending on location being checked; see table) from the maximum allowable exit gradients for the DWSE condition. These criteria were used for evaluation of existing levee conditions (i.e., problem identification) and for developing and dimensioning rehabilitation measures where rehabilitation was needed.

In addition to exit gradient criteria, the design team used minimum and maximum berm dimensions to design seepage berms for Pre-Design Formulation. Analyses included a minimum seepage berm width of four times the levee height and a minimum seepage berm thickness of 3 feet. A maximum seepage berm width of 300 feet was used for the geotechnical analyses for Pre-Design Formulation. If the criterion for exit gradient at the toe of the seepage berm was not met for a berm having a width of 300 feet, the berm was not further increased in width. Instead, additional rehabilitation measures, such as relief wells, were considered to be required in addition to the seepage berm. Selection and sizing of rehabilitation measures is discussed in Section 5.0.

For through-seepage, levees were evaluated in consideration of emergence of the phreatic line on the landside levee slope and composition of the levee. Levees shown to have a phreatic line emerging on the landside levee slope, at either the DWSE condition or the HTOL condition, were evaluated for piping potential and potential for through-seepage-induced sloughing of the landside slope. Levees with erodible soils that may be prone to piping or through-seepage-induced sloughing were considered to require rehabilitation.

The evaluation criteria explicitly considers past performance as well as analysis results. If there is reliable documentation of previous underseepage problems (such as major boils) that have not been remediated, then the design team must conclude that the areas where the performance problems occurred do not meet underseepage criteria. This conclusion of

not meeting criteria and needing rehabilitation based on previous levee distress was required even if seepage analyses did not indicate a problem.

4.6.2 Analysis Criteria for Stability Evaluation

For geotechnical analyses for Pre-Design Formulation, the required minimum factors of safety were:

- Landside stability with steady-state seepage condition at DWSE: 1.4
- Landside stability with steady-state seepage condition at HTOL WSE: 1.2
- Waterside rapid drawdown condition: 1.0 to 1.2

As with seepage evaluation, the evaluation criteria for stability explicitly considers past performance as well as analysis results. If there are well-documented levee stability problems (such as slumping of a landside slope during a high-water event), the design team must conclude that slope stability criteria are not met, unless the stability problems have been satisfactorily corrected. This conclusion of not meeting criteria and needing rehabilitation based on previous levee distress was required even if slope stability analyses did not indicate a problem.

5.0 EVALUATION RESULTS

This section of the report presents the results of geotechnical evaluation performed in support of the Pre-Design Formulation. Evaluation results generally are associated with each levee reach. As such, this section of the report is organized into a series of tables presenting information for each reach. The tables include data, evaluation, and results for each reach.

5.1 Reaches for FRWL Pre-Design Formulation

This section outlines the evaluation reaches that were developed in this study, providing the extents and geotechnically-relevant characteristics of the reaches, and identifying analytical cross sections developed for the reaches. A total of 41 reaches for evaluation were developed and comprise the full length (44 miles) of the FRWL. An overview of the evaluation reaches is shown on Plate 1.

Information characterizing each reach is presented in a series of tables (one table for each reach). Each table presents the rationale for development of the reach and its characteristic transverse cross section. Characterization of the reaches is presented in Tables 5-1A through 5-41A, describing Reaches 1 through 41 respectively.

Much of the data used to characterize the reaches and cross sections were compiled onto working draft plan views and working-draft profile views showing simplified exploration logs; these working draft drawings are presented in Appendix A. Additionally, working sketches for cross section development are included in Appendix C. Refer to these appendices for more detailed data supporting information presented in the reach characterization tables.

5.2 Analysis Results Under Existing Conditions and with Levee Rehabilitation Measures

This section presents the geotechnical analysis results, for existing conditions (i.e., problem identification) and for alternative levee rehabilitation measures. Findings are presented in a series of tables (one table for each reach). Each table includes:

- Results of analyses for existing conditions;
- Conclusions as to whether analysis results meet or do not meet project criteria;
- Identification of alternative rehabilitation measures, where needed;
- Results of analyses incorporating levee rehabilitation measures, for each levee rehabilitation measure alternative analyzed;
- Approximate dimensions needed (to meet project criteria) for the primary features of levee rehabilitation measures, for each levee rehabilitation measure alternative analyzed; and
- Comments and considerations about the information presented.

Analysis results are presented in Tables 5-1B through 5-41B, corresponding to Reaches 1 through 41 respectively (except for Reach 6, the recently completed setback levee at Star Bend, for which no analyses were performed for this study). Figures depicting analytical models and analysis results are presented for each cross section analyzed; these figures are

presented in Appendix B. Figures are presented in sets for each reach, in numerical order of reaches.

As described in Section 4.1.2 and shown on Figure 4-1, a step-by-step process was used to analyze existing conditions (i.e., problem identification) for each reach. For each analysis performed, the results are presented in the corresponding reach table and a figure is presented in Appendix B. For analysis of existing conditions, figure numbers in Appendix B correspond to the step of the process being presented:

- E1 identifies seepage analysis for the DWSE
- E2 identifies seepage analysis for the HTOL
- E3 identifies landside stability analysis for the DWSE
- E4 identifies landside stability analysis for the HTOL
- E5 identifies waterside rapid drawdown analysis

Every reach (except Reach 6, Star Bend) has an E1 figure, showing the results of seepage analysis at the DWSE. If the analysis shows the levee does not meet seepage criteria for the DWSE, then no more analyses are performed and the E1 figure will be the only figure presenting existing conditions results for that reach. If the analysis shows the levee meets criteria, then an E2 figure is also included, and so on in accordance with the process shown in Figure 4-1. This process differed for Reaches 23 and 30, which have additional figures for existing conditions analyzed at the 100-year WSE (described further below).

For analyses of rehabilitation alternatives, each reach analyzed is represented by eight figures: a set of four analyses for each of two rehabilitation alternatives. For each alternative, seepage analysis and landside stability analysis was performed at the DWSE + 1 foot elevation, and seepage analysis and landside stability analysis was performed at the HTOL + 1 foot elevation. For the first rehabilitation alternative, the corresponding figures in Appendix B are identified A1 through A4, respectively; for the second rehabilitation alternative, the corresponding figures are identified A5 through A8, respectively.

As indicated in Section 4.3.2, the design team used a single value of waterside slope (3H:1V) for analysis of rapid drawdown conditions for rehabilitation alternatives. A rapid drawdown analysis incorporating strength parameters for clayey soils (CL) and a 19-foot drop in water level shows that this configuration meets project criteria for rapid drawdown stability (see Figure B42). This result is considered to be directly applicable to, or conservative with respect to, each of the rehabilitation alternative configurations evaluated in this report (i.e., all rehabilitated reach alternatives meet criteria for rapid drawdown). Based on the many field explorations, significant number of laboratory tests, and geomorphologic mapping coverage, soils having lower strength values than used in the analysis may be present in relatively limited areas, but are uncommon and not widespread. Localized areas of weaker soils, if present, can be addressed further in subsequent design stages.

As can be seen in the analysis results tables and the corresponding comments about past performance, the analysis results generally indicated good relationships with past performance problems along the FRWL. However, in a few cases, the analyses do not meet criteria where past performance problems were not found in reviewed documents. It should

be noted that the design WSE at some of these locations are higher than past flood elevations in these reaches. The analysis models are also based on available geologic information which may indicate potential problems that have nearly but not quite manifested in a readily observable manner.

This report will become an appendix to the *FRWL Project Pre-Design Formulation Report*, prepared by HDR in association with other design team members. That report will include discussion of various levee rehabilitation measures, the appropriateness of the measures for addressing various potential problems, the relative benefits and challenges of each, and relative prioritization of the measures for consideration in the FRWL Project. For Pre-Design Formulation, it was intended to evaluate multiple alternatives, and to perform geotechnical analyses for two alternatives for each reach needing rehabilitation. Two general sets of levee rehabilitation alternatives were identified: those that require or occupy roughly the same footprint as the existing levee, and those that require or occupy a much wider footprint than the existing levee. For Pre-Design Formulation, it was intended to, where feasible, select for analysis one rehabilitation measure from each of these two sets.

Among the rehabilitation alternatives considered in this study were those presented in the *Preliminary Problem Identification and Conceptual Alternatives Analysis Report* for Segments 1 through 4 of the FRWL Project. Each of the alternatives presented in that report (e.g., cutoff walls, seepage berms, stability berms, relief trenches, etc.) were considered for applicability and other factors, as described in the *Pre-Design Formulation Report*, on a reach-by-reach basis during the current study. In some cases, the alternatives selected for analysis in the current study were the same alternatives identified in the *Preliminary Problem Identification and Conceptual Alternatives Analysis Report.* In some cases, further evaluation indicated that other rehabilitation alternatives were more appropriate for analysis in support of the Pre-Design Formulation and as a basis for the 30 percent design.

The analysis results tables presented in this report identify the primary potential geotechnical problems for each reach needing rehabilitation, and present rationale for selecting two rehabilitation alternatives for analysis. In some cases, two or more types of rehabilitation measures were combined into a single alternative for consideration and analysis. Additional details of the alternatives are discussed in the *Pre-Design Formulation Report*.

An alternative that is identified and analyzed for certain reaches is filling of a canal or ditch. This alternative is not strictly a levee rehabilitation measure, but for certain reaches along the FRWL, the presence of a landside canal or ditch is the primary source of potential geotechnical problems during a high water event. Landside ditches and canals near the levee often provide the shortest path for underseepage, so have the highest exit gradients. Filling of the ditch or canal can remove this localized condition, but the ditch or canal usually will need to be replaced by either a highline ditch or a relocated ditch away from the levee. Analyses performed for some of the reaches evaluated for this project show that in many cases relocating the ditch at distances of 500 feet or more does not remove the localized high gradients if the underlying thick aquifer is significantly more permeable than the shallow blanket layer. In those cases, we believe that if possible a highline canal option where the base of the canal lies above the surrounding grade is preferable. Note that a highline canal or ditch may not work in some cases due to the hydraulics of the canal or drainage

requirements of the surrounding grade. A highline canal will generally require some additional land due to the higher, and thus wider, slopes for the canal walls and levees.

As a part of the Pre-Design Formulation process, consideration was given to staging or phasing of the project (refer to the *Pre-Design Formulation Report* for further discussion). To support this effort, geotechnical evaluation was conducted to assess whether reaches would meet geotechnical criteria for the 100-year WSE with existing conditions. Some reaches met criteria for existing conditions for the 200-year WSE, and thus meet criteria also for the 100-year WSE. Most reaches along the FRWL do not meet criteria for the 200-year WSE. Additional analyses were performed for many of these reaches to see if they met criteria for the 100-year WSE. Of these reaches, two reaches (Reach 23 and Reach 30) were found to meet criteria at the 100-year WSE. Appendix B includes analysis results figures for 100-year WSE analyses of existing conditions for Reaches 23 and 30. Table 5-42 summarizes the analysis results and evaluation conclusions for 100-year WSE conditions for all reaches.

Please refer to the analysis results tables for further discussion of the findings of this evaluation.

6.0 KEY PARTICIPANTS, LIMITATIONS, AND FUTURE STUDIES

This section identifies entities responsible for and who facilitated preparation of this report, describes limitations of this report, and summarizes the needs for future field investigations and further design analyses.

6.1 Key Participants

This report of geotechnical analysis for Pre-Design Formulation was prepared by URS in association with BCI. Work performed to prepare this report was managed by Derek S. Morley, PE, of URS, geotechnical lead for the FRWL Project. Geotechnical evaluation and analyses were performed under the technical supervision of:

- Robert B. Lokteff, PE, GE (BCI), primary supervision responsibility for Reaches 1 through 7;
- Khaled H. Chowdhury, PE, GE (URS), primary supervision responsibility for Reaches 8 through 17;
- Robert K. Green, PE, GE (URS), primary supervision responsibility for Reaches 18 through 29; and
- Derek S. Morley, PE (URS), primary supervision responsibility for Reaches 30 through 41.

Technical oversight and review was provided by: Dr. Leslie F. Harder, Jr., PE, GE (HDR); Dr. Lelio H. Mejia, PE, GE (URS); Francke Walberg, PE (URS); and John Hess, PE (HDR).

Bill Hampton of LD1 provided key information about historical levee performance and levee improvements, as well as providing valuable logistical assistance and support during subsurface exploration and other field activities.

Project work was facilitated by the provision of geotechnical data and other data sets by DWR; the design team gratefully acknowledges Mike Inamine and Steve Mahnke for providing permission to use these data.

6.2 Limitations

This geotechnical evaluation, associated data collection, and report preparation have been performed in accordance with the standard of care commonly used as the state-of-practice in the engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this area performing the same services under similar circumstances during the same period.

Discussions of subsurface conditions summarized in this report are based on subsurface soil and groundwater conditions at limited exploration locations. Variations in subsurface conditions may exist between exploration locations, and the project team may not be able discern or present all adverse conditions in the levee and its foundation.

No warranty, express or implied, is made in the furnishing of this report, which is the result of geotechnical evaluation services. URS makes no warranty that actual encountered site and

subsurface conditions will exactly conform to the conditions described herein nor that interpretations and recommendations in this report will be sufficient for all construction planning aspects of the work. A sufficient number of additional explorations necessary to verify subsurface conditions should be performed rather than relying solely on the information presented in this report.

URS does not attest to the accuracy, completeness, or reliability of geotechnical borings and other subsurface data by others that are included or referenced in this report. In the preparation of this report, URS has relied upon data and information provided by others, including water surface elevations presented by others as representing specific events and/or governing profiles. URS has not performed independent validation or verification of data by others.

Data presented in this report are time-sensitive in that they apply only to locations and conditions existing at the time of the exploration or collection of the data. Data should not be applied to any other projects in or near the area of this study nor should they be applied at a future time without appropriate verification.

This report is for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk.

This report is a preliminary document describing work completed at the time of preparation and will be supplemented by subsequent reports as additional information becomes available. This report should not to be used as the sole basis for design, construction, remedial action, or major capital spending decisions.

This is a draft version of this report. Additional information and comments from HDR and other reviewers will be incorporated into a final version of this report. This draft version of this report is for review purposes only and should not be relied upon for any other use.

6.3 Future Studies

As described in previous sections of this report, the purpose of the evaluations and analyses presented in this report was to support the Pre-Design Formulation for the FRWL Project. The Pre-Design Formulation is the first phase of the design of the full length of the FRWL Project. The design process will involve multiple phases and design refinements. As such, it was not the intent of this evaluation to address all geotechnical conditions, analytical cases, regulatory requirements, and construction considerations that ultimately will need to be addressed for final design. To address these, additional geotechnical evaluation based on further data collection and analysis will need to be performed in subsequent phases of the FRWL Project. Additional geotechnical evaluation will be needed to address several design concerns, including:

- Confirming existing levee improvement measures;
- Refining the design of selected rehabilitation alternatives;

- Characterizing potential borrow sites; and
- Satisfying regulatory requirements.

At many locations along the FRWL, existing levee improvement measures are believed to be present, but no as-constructed documentation or other clearly reliable evidence has been obtained to confirm the presence of the improvement measures. At many locations, analysis of existing conditions and conclusions regarding the need or lack thereof for levee rehabilitation depends on the presence and proper performance of these improvement measures. Reliable information about the presence of the improvement measures is needed to definitively conclude that levee rehabilitation is not necessary at these locations. Also needed is reliable information about the dimensions of the improvement measure features, the materials used, the quality of placement and conformance to design specifications, and in some cases the current condition of the features.

To date, efforts to obtain as-constructed documents (which would contain most of this information) have been largely unsuccessful, both for this study and for previous studies. For some locations along the FRWL, as-constructed documents are likely to exist, and additional effort should be made to obtain these documents. At other locations, as-constructed documents may not exist. For some such locations, the presence and characteristics of improvement measures may be adequately documented by performing appropriate field exploration, in-situ testing, laboratory testing, surveying, instrumentation and monitoring, and/or other destructive and non-destructive testing.

A number of reaches would benefit from as-constructed documentation or the findings of appropriate additional investigation. For a few reaches, however, this information is key to confirming that the reaches do not need rehabilitation for potential seepage problems. Reaches 12, 14, 15, and 16 will require this information, or they will need to be rehabilitated for potential seepage problems.

As discussed previously in this report, additional information also will be needed to refine the design of rehabilitation measures selected for final design. For example, final design of a seepage berm necessitates explorations distributed over a wide areal extent across the landside field along the levee, and these explorations do not exist for many reaches. For reaches where berms are selected as the preferred rehabilitation alternative, additional field explorations would be needed to complete design. Similar exploration needs would be expected for reaches where filling and relocation of the existing canal is selected for final design. For reaches where a cutoff wall rehabilitation alternative is selected, more densely spaced explorations along the levee crown would be appropriate to complete design.

Exploration and evaluation of potential borrow sites will need to be performed in subsequent phases of the design. As for evaluation of alternative rehabilitation measures, extensive field exploration of potential borrow sites was not performed during the Pre-Design Formulation phase of the design because much of the effort would end up being of little or no use during design and would be an inefficient use of project resources. As needs for borrow material are better defined along the length of the FRWL, exploration and evaluation of potential borrow sites will be needed to identify and confirm the appropriateness and economy of use of the sites as borrow sources.

Regulatory requirements and guidelines outline expectations for explorations and analyses to be performed for levee design and these requirements and guidelines typically are used to guide levee exploration plans. The minimum number of explorations is generally considered to be about 15 explorations per mile, with borings situated at the levee crown, levee toe, and landside field as needed. The significant amount of existing exploration along the FRWL, combined with exploration performed for the current evaluation, meet requirements along the FRWL levee crown. The amount of exploration does not, however, meet requirements with respect to borings along the levee toe or landside field. Initial expectations from regulatory agencies may be a large number of additional borings along the toe and in the field.

Based on site conditions and the expected levee rehabilitation measures to be designed, the design team believes that many of those borings will not be warranted. For example, where a cutoff wall is selected, extensive landside field borings probably are not needed for design. In these cases, it would be appropriate to work with regulators to reduce the number of required explorations. Using existing geophysical data and geomorphic mapping, in combination with the large number of borings and CPTs already performed along most of the FRWL, likely it can be demonstrated that the project should be completed with a significantly reduced number of explorations compared to an initial interpretation of regulatory requirements.

Additional future studies needed to complete analysis and design include characterizing the bathymetry of canals, excavation troughs, etc. that are situated along the waterside toe (or proximity) of the FRWL. These features are common along the southern parts of the FRWL, and also are present at other locations of the project. Depending on rehabilitation measures to be designed, the design and review process may benefit from more complete recent bathymetry of the Feather River (e.g., contiguous contours between bathymetric sections developed by DWR).

7.0 SUMMARY

This section provides a tabulated summary of results of geotechnical analyses for Pre-Design Formulation of the FRWL Project. The summary results are presented in Table 7-1, which includes the key findings for each levee evaluation reach with respect to:

- Whether or not the reach meets project criteria for the design water surface elevations;
- For reaches that do not meet criteria, what two levee rehabilitation alternatives were analyzed; and
- For reaches that do not meet criteria, for each levee rehabilitation alternative, what are the approximate values of the major dimensions characterizing the rehabilitation measure in order to meet project design criteria.

An overview of the evaluation reaches for the FRWL is shown on Plate 1.

8.0 REFERENCES

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TABLES

Table 2-1. Geotechnical Studies of FRWL Prior to 2008
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

Southern Half of FRWL

Resource	Summary
1959 Reinard W. Brandley Report	Reinard W. Brandley, Consulting Civil Engineer, Sacramento, produced a report titled *Foundation Report – Shanghai Bend Levee Cutoff, West Bank-Feather River Sutter County, California*.
1986 Wahler Associates Investigation and Report	Wahler conducted an investigation of flood induced boils in the Star Bend area and produced an Initial Appraisal Report titled *Investigation for Levee Repair, LD-1, Right Bank Feather River, Sutter County, and RD-784, Left Bank Feather River, Yuba County, California*.
1988 Wahler Associates Investigation and Report	Wahler conducted an investigation of approximately 6,000 feet of the landside levee slope in Yuba City and produced a report titled *Levee Investigation, Levee District No. 1, Right Bank Feather River Adjacent to Gilsizer Slough, Yuba City, California*. Wahler conducted an additional boring investigation three months after completion of the initial 1988 investigation (above).
1988-1989 Mark Group Investigations and Reports	In 1988 and 1989, The Mark Group, for USACE, conducted subsurface investigations along 21.8 miles of the right bank levee of the Feather River from the intersection with the left (east) levee of the Sutter Bypass to the intersection with SPRR. In all, 5.19 miles of Maintenance Area 3 levee (LM 0.0 to 5.19) and 16.65 miles of Levee District 1 levee (LM 0.0 to 16.65) were investigated. These investigations were performed as part of an evaluation of the Sutter and Butte County levees for USACE under contract no. DACW05-86-D-0084. Their findings are detailed in: *Geotechnical Report for Subsurface Explorations, Levee Evaluations Sutter and Butte Counties, California*, September 1988, and *Geotechnical Stability Assessments Levee Evaluations, Sutter and Butte Counties, California*, April 1989. See also *Geotechnical Investigation Report, Shanghai Bend Levee Evaluation, Yuba City, California – Levee District No. 1 of Sutter County*, November 1989.
1998 Woodward-Clyde Consultants Investigation and Drawings	Woodward-Clyde Consultants conducted a site investigation of Shanghai Bend as part of an investigation for the construction of a cutoff/setback levee and developed drawings consisting of plan and profile views and boring logs of Shanghai Bend, Yuba City in November 1998.
1992 USACE Report	USACE prepared a report titled *Basis of Design, Geotechnical Evaluation of Levees for Sacramento River Flood Control System Evaluation, Marysville/Yuba City Area*. This report summarizes predominantly The Mark Group 1988 and 1989 (Phase 1) geotechnical investigations along with the 1991 USACE Phase 2 explorations and provides repair recommendations
2004 USACE Report	USACE prepared a report summarizing existing information on the conditions of the Sutter County levees titled *Geotechnical Evaluation of Existing Levees - Sutter County, California Feasibility Study*.
2006 Blackburn Consulting Investigation	Blackburn conducted a geotechnical investigation of the Star Bend area immediately west of the Feather River right levee and produced *Geotechnical Report – Star Bend Setback Levee, Levee District No.1, Sutter County, California*.
USACE Repair Drawings	1957, USACE Sacramento District, Feather River, California, Emergency Levee Repairs, Relief Wells – Right Bank Feather River, Shanghai Bend, Sutter County, California, File 4-4-435. 1960, USACE Sacramento District, Sacramento River, California, Flood Control Project – Right Bank Feather River Levee Stabilization, Levee Districts 1 and 9, File 4-4-508. 1997, USACE Sacramento District, Sacramento River Flood Control Phase II -- Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, and 12), File 50-04-6001. 1997, USACE Sacramento District, Sutter County, California, PL84-99 Phase III, Relief Wells – LD1 Feather River at Star Bend, File 04-04-617. 2000, USACE Sacramento District, Sutter County, California, PL84-99 Cost Shared Added Sites, Sacramento Basin No. 18, Relief Well Improvements, File 04-04-625. 2000, USACE Sacramento District, Sutter County, California, PL84-99 Cost Shared Added Sites, Sacramento Basin No. 18, LD1 Slurry Wall, File 04-25-626.

Northern Half of FRWL

Resource	Summary
DWR Materials	Levee Inspection Logs, listing levee features (ramps, turn-outs, rock revetments and landside levee toe ditches, etc.) and constructed items (gates, poles, embedded pipes, etc.) referenced by levee mile distances in LD9, MA7, and MA16 (Revised 1/05).
1955 USACE Report	*Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit 148, West Levee of the Feather River from North Boundary of Reclamation District 777 to North Boundary of Levee District 1., August 1955,* contains text describing "revisions or additions" to the West Levee of the Feather River Operation and Maintenance O&M Manual with levee "transfer/acceptance" letters and reference to as-constructed drawings of levee modifications.
1957 USACE Report	*Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit 152, West Levee of the Feather River from North Boundary of Reclamation District 777 to the Western Canal Intake (Levee of Drainage District 1), March 1957,* contains text describing "revisions or additions" to the West Levee of the Feather River O&M Manual with levee "transfer/acceptance" letters and reference to as-constructed drawings of levee modifications. In 1957, USACE performed geotechnical investigations to evaluate "excessive seepage" from a landside irrigation ditch near the Sutter/Butte levees. Four borings were drilled and samples were collected for classification testing.
1988-1989 Mark Group Reports	Results from laboratory tests of samples obtained by The Mark Group in 1988 and 1989 are contained in USACE, Division Laboratory, Sausalito, California, *Report of Soil Tests, for Sacramento River Flood Control System Evaluation Marysville/Yuba City Area*, March 1989. *Sacramento River Flood Control System Evaluation, Initial Appraisal Report- Marysville/Yuba City Area*, January 1990, evaluates 134 miles of project levees along the Feather and Yuba Rivers and their tributaries in Butte, Sutter, and Yuba Counties. In 1988, The Mark Group performed geotechnical investigations of the Sutter-Butte levees for USACE and detailed their findings in a report titled *Geotechnical Report for Subsurface Explorations, Levee Evaluations, Sutter and Butte Counties, California, prepared for Sacramento USACE, September 2, 1988.* In 1988 and 1989, The Mark Group performed additional geotechnical investigations of the Sutter-Butte levees for USACE and analyzed stability and seepage conditions. Their findings are detailed in a report titled *Geotechnical Stability Assessments, Levee Evaluations, Sutter and Butte Counties, California, prepared for USACE Sacramento District, 21 April 1989.*
1988 Kleinfelder Corporation Investigation and Report	In 1988, Kleinfelder performed geotechnical investigations of the Sutter-Butte levees for LD9 and detailed their findings in a report titled *Geotechnical Investigation Report, Levee District 9, Sutter County, California*, dated July 19, 1988.
1992 USACE Report	As part of their *Geotechnical Evaluation of Levees for Sacramento River Flood Control System Evaluation, Marysville/Yuba City Area*, February 1992, USACE developed a basis of design document for the proposed levee reconstruction project that included sites in the Sutter/Butte districts. (See Appendix C of Phase II Investigation in January 1993, Volume II of II). Sacramento Flood Control Project, California Marysville/Yuba City Area, Phase II, Design Memorandum, Appendices, Volume II of II (January, 1993). Appendix C presents the *Basis of Design for the Geotechnical Evaluation of Levees* developed in February 1992 by USACE. One section covers the Hamilton Bend Area including MA7, MA16, and LD9.
1997 USACE Investigation and Report	As part of their Yuba River Basin Investigation, USACE performed subsurface investigations of the Sutter-Butte levees in 1997 (not available as of September 2008). As part of their *System Evaluation, Phase 2, Contract 3, Marysville and Yuba City Area*, between 1986 and 1997, USACE designed and constructed levee improvements at three locations (referred to as Sites 1 through 3) in the reach currently under review. At Site 1, located between Stations 39+30 and 65+70 in MA7 (LM 10.2 to 10.5), levee crown and waterside raise were performed. At Site 2, in MA7 between Stations 0+00 and 7+54 (LM 3.0 to 3.2), a waterside slurry cutoff wall was constructed. At Site 3, located between Stations 0+00 to 53+74 in LD9 (LM 4.7 to 5.7), an existing landside irrigation ditch was backfilled.
2006 USACE Investigations	In 2006, USACE performed geotechnical investigations of the Sutter/Butte levees including 10 evenly spaced borings in LD1 and LD9 on the west levee of the Feather River. Four of the borings (numbered 2F-07-07 through 2F-07-10) were in LD9 between approximate LMs 0.0 and 5.0. The maximum boring depth was approximately 92 feet.

Table 2-2. Task Order 1 Subsurface Exploration Summary

Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

Exploration ID	Exploration Type	Location	Depth	Northing	Easting
MA7					
SM0007_001B	Boring	Landside Toe	60	2261186.765	6660618.414
SM0007_002B	Boring	Landside Toe	50	2264827.798	6661259.212
SM0007_003A	Boring	Landside Toe	30	2259681.423	6661193.869
SM0007_004A	Boring	Crest	31.5	2259739.02	6661302.583
SM0007_004B	Boring	Landside Toe	38	2279741.442	6663803.946
SM0007_005A	Boring	Crest	34.5	2270837.068	6666181.298
SM0007_005B	Boring	Landside Toe	50	2282521.297	6662254.216
SM0007_006A	Boring	Crest	40	2284992.45	6661728.653
SM0007_006B	Boring	Landside Toe	32	2284989.342	6661687.818
SM0007_008B	Boring	Landside Toe	43	2289702.419	6662825.484
SM0007_009B	Boring	Crest	5	2291392.024	6663225.51
SM0007_010B	Boring	Crest	40	2292098.146	6663358.838
SM0007_001C	CPT	Landside Toe	30	2255008.654	6665412.789
SM0007_002C	CPT	Landside Toe	23	2270206.843	6667070.169
SM0007_003C	CPT	Landside Toe	26	2273462.944	6664974.875
SM0007_004C	CPT	Landside Toe	27	2275634.967	6664798.251
SM0007_005C	CPT	Landside Toe	33	2241600.437	6665290.759
SM0007_006C	CPT	Landside Toe	12	2285958.263	6661461.681
MA16					
SM0016_001C	CPT	Landside Toe	40	2221019.614	6664501.395
SM0016_003C	CPT	Landside Toe	70	2227344.998	6665507.179
LD9					
SL0009_001B	Boring	Landside Toe	81.5	2191019.367	6668926.035
SL0009_002B	Boring	Crest	86	2200512.498	6666651.527
SL0009_003B	Boring	Landside Toe	45	2215755.749	6664276.099
SL0009_001C	CPT	Landside Toe	53	2194216.108	6669134.511
SL0009_002C	CPT	Landside Toe	55	2208689.832	6666568.052
SL0009_003C	CPT	Landside Toe	70	2212820.334	6665126.325
SL0009_004C	CPT	Landside Toe	50	2216316.757	6664327.517
LD1					
SL0001_001B	Boring	Landside Toe	86	2151351.939	6672938.567
SL0001_002B	Boring	Landside Toe	80	2163559.132	6673391.889
SL0001_001C	CPT	Landside Toe	90	2111059.308	6679469.721
SL0001_002C	CPT	Landside Toe	120	2116124.082	6678408.946
SL0001_003C	CPT	Landside Toe	85	2126774.222	6676056.13
SL0001_004C	CPT	Landside Toe	89	2132319.125	6672516.169
SL0001_005C	CPT	Landside Toe	70	2140726.027	6671942.812
SL0001_007C	CPT	Landside Toe	60	2145436.305	6671981.759
SL0001_008C	CPT	Landside Toe	60	2158448.431	6674473.384
SL0001_009C	CPT	Landside Toe	80	2160230.832	6675030.409
SL0001_010C	CPT	Landside Toe	60	2167494.525	6673212.255
SL0001_011C	CPT	Landside Toe	52	2170522.455	6674490.357
SL0001_012C	CPT	Landside Toe	60	2175969.514	6673515.375
MA3					
SM0003_001C	CPT	Landside Toe	85	2089995.141	6671959.655
SM0003_002C	CPT	Landside Toe	85	2090962.826	6674499.048
SM0003_003C	CPT	Landside Toe	121	2090680.828	6675914.031
SM0003_004C	CPT	Landside Toe	92	2092685.59	6678386.522
SM0003_006C	CPT	Landside Toe	85	2100244.036	6678869.291
SM0003_007C	CPT	Landside Toe	90	2100657.141	6678249.27
SM0003_008C	CPT	Landside Toe	85	2104552.695	6678684.222

Table 2-3. Rationale For Task Order 1 Explorations
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

Exploration ID	SBFCA Station	DWR Station	Location	Depth	Rationale
Maintenance Area 07					
SM0007_001B	1922+91	4089+01	Landside Toe	60	Potential problematic stratigraphy, confirm clean gravel layer.
SM0007_002B	1965+80	4132+00	Landside Toe	50	Potentially critical stratigraphy at low landside elevation. No previous toe exploration in the area.
SM0007_003A	1906+92	4073+01	Landside Toe	30	Confirm stratigraphy at the toe of the levee. No previous toe explorations in the area.
SM0007_004A	1906+90	4072+99	Crest	31.5	Potentially problematic stratigraphy previously identified by the crest sonic boring. Collect samples to develop strength parameters.
SM0007_004B	2211+82	4378+01	Landside Toe	38	Potentially problematic stratigraphy. Historic toe exploration about 2,600 feet away was located at a previous boil site (approx. DWR sta 4352+00).
SM0007_005A	2076+90	4243+00	Crest	34.5	Potentially problematic stratigraphy, previous stability analysis did not meet criteria. Collect samples for strength testing.
SM0007_005B	2250+76	4416+99	Landside Toe	50	Potential problematic stratigraphy, HEM anomaly suggests possible channel, no previous explorations in the area.
SM0007_006A	2276+76	4443+00	Crest	40	Collect samples to develop parameters for a potentially critical section.
SM0007_006B	2276+76	4443+00	Landside Toe	32	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SM0007_008B	2336+87	4503+08	Landside Toe	43	Potentially problematic stratigraphy due to filled pond, exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SM0007_009B	2355+37	4519+95	Crest	5	Potentially problematic stratigraphy, confirm deep gravel layer, develop a complete cross-section.
SM0007_010B	2362+69	N/A	Crest	40	Potentially problematic stratigraphy, confirm deep gravel layer, develop a complete cross-section.
SM0007_001C	1842+85	4009+00	Landside Toe	30	Potentially problematic stratigraphy. HEM anomaly; no previous toe exploration in area.
SM0007_002C	2063+84	4230+00	Landside Toe	23	Potentially problematic stratigraphy. HEM anomaly suggest channel/transition zone.
SM0007_003C	2113+89	4280+00	Landside Toe	26	Potentially problematic stratigraphy. HEM anomaly; no previous toe exploration in area.
SM0007_004C	2149+85	4316+00	Landside Toe	27	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information. Possible transitions zone; no prev toe exploration in area.
SM0007_005C	1698+85	3865+00	Landside Toe	33	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SM0007_006C	2286+75	4452+99	Landside Toe	12	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information; confirm deep gravels.

Table 2-3. Rationale For Task Order 1 Explorations
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

Exploration ID	SBFCA Station	DWR Station	Location	Depth	Rationale
Maintenance Area 16					
SM0016_001C	1476+77	3642+94	Landside Toe	40	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SM0016_003C	1541+83	3707+99	Landside Toe	70	Potentially problematic stratigraphy. HEM anomaly; no previous toe exploration in area.
Levee District 09					
SL0009_001B	1163+75	3329+89	Landside Toe	81.5	Potentially problematic stratigraphy. HEM anomaly.
SL0009_002B	1265+84	3432+00	Crest	86	Potentially problematic stratigraphy. HEM anomaly and location of past performance problems.
SL0009_003B	1423+81	3589+98	Landside Toe	45	Investigate the stratigraphy between levee and canal. The proposed boring is near area of levee distress.
SL0009_001C	1195+85	3361+99	Landside Toe	53	Potentially problematic stratigraphy. HEM anomaly and assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SL0009_002C	1348+34	3514+50	Landside Toe	55	Potentially problematic stratigraphy. HEM anomaly and assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SL0009_003C	1392+82	3559+00	Landside Toe	70	Potentially problematic stratigraphy. HEM anomaly and assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SL0009_004C	1429+45	3595+62	Landside Toe	50	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
Levee District 01					
SL0001_001B	734+85	2901+00	Landside Toe	86	Investigate data gap at potentially critical location; Collect samples to develop parameters; no previous toe exploration in the area.
SL0001_002B	867+20	3033+37	Landside Toe	80	Potentially problematic stratigraphy. HEM anomaly; past CPT borings available, but need boring
SL0001_001C	306+35	2462+58	Landside Toe	90	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SL0001_002C	359+02	2515+24	Landside Toe	120	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information; historic seepage area and where levee previously cracked
SL0001_003C	468+46	2624+67	Landside Toe	85	Investigate the depth of sand deposit in historic seepage area where previous borings were not deep enough.
SL0001_004C	538+93	2705+03	Landside Toe	89	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SL0001_005C	626+37	2792+51	Landside Toe	70	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.

Table 2-3. Rationale For Task Order 1 Explorations
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

Exploration ID	SBFCA Station	DWR Station	Location	Depth	Rationale
SL0001_007C	674+00	2840+15	Landside Toe	60	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SL0001_008C	809+03	2975+19	Landside Toe	60	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information, no previous toe exploration in the area.
SL0001_009C	827+86	2994+01	Landside Toe	80	Exploration at landside toe to assist in developing a transverse geologic cross-section with landside toe data including blanket information for existing cutoff wall evaluation
SL0001_010C	906+84	3073+01	Landside Toe	60	Exploration at landside toe to assist in developing a transverse geologic cross-section with landside toe data including blanket information to analyze the effectiveness of existing relief wells.
SL0001_011C	939+85	3106+01	Landside Toe	52	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information; no previous toe explorations at wall gap; potential HEM anomaly.
SL0001_012C	998+12	3164+34	Landside Toe	60	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information. Investigate/confirm that existing wall does not bottom-out in sand.
Maintenance Area 03					
SM0003_001C	29+08	2185+28	Landside Toe	85	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SM0003_002C	58+38	2214+62	Landside Toe	85	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SM0003_003C	74+25	2230+49	Landside Toe	121	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information. Investigate the depth of sand deposit.
SM0003_004C	106+30	2262+56	Landside Toe	92	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information. Investigate the depth of sand deposit.
SM0003_006C	190+80	2347+02	Landside Toe	85	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information.
SM0003_007C	198+47	2354+70	Landside Toe	90	Exploration at landside toe to investigate a potentially critical section in 1997 "boil" area; historic maps indicate old pond feature adjacent to levee toe
SM0003_008C	239+44	2395+64	Landside Toe	85	Exploration to assist in developing a transverse geologic cross-section with landside toe data including blanket information. Confirm depth of deep sand deposit.

Table 2-4. Design Water Surface Elevations
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

FEATHER RIVER WEST LEVEE REHABILITATION PROJECT
MAXIMUM WATER SURFACE PROFILES
October 26, 2010

Feather River Reach	HEC-RAS River STA	100yr Max WSE (NAVD88-ft)	200yr Max WSE (NAVD88-ft)	500yr Max WSE (NAVD88-ft)	DWR 1957 (NAVD88-ft)	Wood Rodgers Design STA
Upper	58.51	129.82	131.48	139.08	132.14	235748.95
Upper	58.26	129.39	131.08	139.07	130.88	233625.38
Upper	57.95	127.43	128.91	137.19	129.32	232796.18
Upper	57.7	124.99	126.24	132.7	128.05	231347.46
Upper	57.45	122.63	123.71	129.69	126.84	230491.75
Upper	57.17	120.24	121.32	127.59	125.70	226547.44
Upper	56.94	118.97	120.1	126.56	124.95	223836.90
Upper	56.61	117.66	118.82	125.38	123.87	222092.63
Upper	56.43	116.96	118.15	124.81	123.28	221068.16
Upper	56.2	115.55	116.82	123.65	122.52	220516.06
Upper	56.02	114.65	115.95	122.78	121.93	220057.97
Upper	55.8	113.07	114.25	120.24	121.18	219786.54
Upper	55.55	112.34	113.53	119.33	120.17	219191.24
Upper	55.35	110.94	112.04	117.07	119.31	216984.11
Upper	55.03	110.1	111.1	115.62	117.92	214664.25
Upper	54.45	109.02	109.95	114.44	115.41	212925.66
Upper	54.2	108.67	109.64	114.11	114.33	210158.47
Upper	54.04	108.63	109.61	114.11	113.64	209562.52
Upper	53.84	107.98	108.97	113.5	112.77	208499.74
Upper	53.52	107.21	108.13	112.38	111.39	205714.05
Upper	53.22	106.24	107.13	111.06	110.18	204265.70
Upper	52.89	104.42	105.32	109.34	109.40	202757.11
Upper	52.6	102.76	103.63	107.63	108.90	201183.88
Upper	52.21	101.94	102.79	106.71	108.23	199618.97
Upper	51.95	101.7	102.54	106.39	107.78	198775.45
Upper	51.35	100.89	101.83	105.93	106.73	197882.65
Upper	51.1777	100.97	101.87	105.89	106.00	195736.74
Upper	51.04	100.94	101.83	105.81	105.38	193817.41
Upper	50.84	100.54	101.47	105.57	104.23	192085.50
Upper	50.7	100.18	101.22	105.41	103.61	191278.99
Upper	50.59	99.34	100.57	105.08	102.93	190705.90
Upper	50.498	99.27	100.41	104.89	102.55	190230.79
Upper	50.496	99.26	100.39	104.85	102.54	190218.72
Upper	50.489	99.28	100.31	104.82	102.52	190176.83
Upper	50.487	99.33	100.35	104.84	102.51	190166.78
Upper	50.2	98.53	99.52	104.02	101.47	188470.72
Upper	50.06	97.9	98.86	103.41	100.96	187822.66
Upper	49.78	96.68	97.63	102.33	99.97	186662.60
Upper	49.58	95.64	96.6	101.37	99.36	185293.60
Upper	49.38	94.78	95.72	100.55	98.77	184138.90
Upper	49.21	94.19	95.15	100.06	98.27	183514.21
Upper	48.99	93.73	94.7	99.68	97.62	183056.49
Upper	48.85	93.24	94.22	99.24	97.21	182753.69
Upper	48.66	92.89	93.85	98.86	96.65	181801.88
Upper	48.39	92.46	93.42	98.44	95.85	180454.16
Upper	48.21	92.02	92.97	97.98	95.32	179460.20
Upper	48.07	91.42	92.38	97.49	95.00	179109.34
Upper	47.7	90.59	91.6	96.91	94.57	176933.60
Upper	47.55	89.97	91.06	96.62	94.39	175967.91
Upper	47.2	89.51	90.61	96.25	93.85	174102.82
Upper	47.04	89.29	90.4	96.14	93.54	173345.89
Upper	46.69	88.57	89.75	95.85	92.86	172499.41
Upper	46.53	88.22	89.45	95.69	92.55	171792.00
Honcut to Jack	46.45	88.22	89.45	95.69	92.40	171454.59

Honcut to Jack	46.2	88.02	89.25	95.48	92.00	171127.62
Honcut to Jack	45.98	87.77	89.01	95.26	91.82	170521.00
Honcut to Jack	45.71	87.22	88.5	94.86	91.60	169330.99
Honcut to Jack	45.58	86.95	88.25	94.64	91.49	168312.33
Honcut to Jack	45.44	86.78	88.09	94.49	91.37	166923.76
Honcut to Jack	45.26	86.55	87.87	94.28	91.22	165726.12
Honcut to Jack	45.03	86.39	87.71	94.13	91.03	164732.57
Honcut to Jack	44.76	86.17	87.51	93.94	90.81	163250.84
Honcut to Jack	44.6326	86.09	87.43	93.86	90.70	161213.76
Honcut to Jack	44.5	85.92	87.27	93.7	90.59	160088.12
Honcut to Jack	44.23	85.7	87.05	93.49	90.35	159311.39
Honcut to Jack	43.46	85.1	86.54	93.12	89.56	158271.13
Honcut to Jack	43.34	84.85	86.32	92.95	89.38	157627.58
Honcut to Jack	43.28	84.75	86.22	92.93	89.38	157373.66
Honcut to Jack	43.23	84.61	86.1	92.87	89.32	157104.73
Honcut to Jack	43.12	84.32	85.86	92.76	89.21	156612.83
Honcut to Jack	43.06	84.26	85.81	92.74	89.15	156460.24
Honcut to Jack	43.01	84.21	85.76	92.68	89.10	156249.06
Honcut to Jack	42.65	84.09	85.66	92.58	88.73	153765.90
Honcut to Jack	42.47	83.88	85.46	92.4	88.55	153202.55
Honcut to Jack	42.19	83.58	85.2	92.18	88.27	152912.23
Honcut to Jack	42.01	83.56	85.18	92.17	88.13	152695.48
Honcut to Jack	41.61	83.28	84.94	91.98	87.81	152341.44
Honcut to Jack	41.55	83.17	84.85	91.91	87.76	151907.71
Honcut to Jack	41.2	82.92	84.67	91.76	87.49	150600.52
Honcut to Jack	40.7	82.75	84.54	91.65	87.09	150271.92
Honcut to Jack	40.49	82.5	84.34	91.46	86.93	149590.33
Honcut to Jack	40.19	82.3	84.19	91.32	86.71	148995.18
Honcut to Jack	39.45	81.77	83.81	90.95	86.23	147001.01
Honcut to Jack	39.23	81.47	83.59	90.71	86.09	145807.70
Honcut to Jack	38.94	81.15	83.35	90.47	85.90	144368.14
Honcut to Jack	38.71	80.92	83.18	90.29	85.75	143106.13
Honcut to Jack	38.45	80.77	83.08	90.17	85.58	141664.04
Honcut to Jack	38.27	80.66	82.99	90.07	85.46	140631.21
Honcut to Jack	37.95	80.5	82.88	89.93	85.28	138661.68
Honcut to Jack	37.68	80.34	82.76	89.79	85.13	137779.55
Honcut to Jack	37.45	80.18	82.64	89.64	85.00	136973.90
Honcut to Jack	37.29	80.05	82.54	89.49	84.91	136058.20
Honcut to Jack	36.45	79.52	82.17	89.07	84.43	134783.46
Honcut to Jack	36.35	79.36	82.07	88.96	84.37	134645.65
Honcut to Jack	36.24	79.17	81.95	88.84	84.30	134561.14
Honcut to Jack	35.78	78.72	81.66	88.5	83.99	132247.58
Honcut to Jack	35.5	78.59	81.56	88.38	83.88	130647.35
Honcut to Jack	35.25	78.51	81.51	88.3	83.77	130422.24
Honcut to Jack	34.8	78.44	81.46	88.25	83.58	129991.41
Honcut to Jack	34.5	78.39	81.42	88.2	83.46	128407.23
Honcut to Jack	34.07	78.32	81.38	88.14	83.28	127995.61
Honcut to Jack	33.5	78.25	81.33	88.08	83.03	126794.65
Honcut to Jack	33.25	78.15	81.26	87.99	82.90	125934.45
Honcut to Jack	33	78.04	81.18	87.89	82.77	124547.32
Honcut to Jack	32.75	77.91	81.09	87.77	82.65	123335.94
Honcut to Jack	32.5	77.82	81.03	87.67	82.52	122068.05
Honcut to Jack	32.25	77.74	80.97	87.6	82.39	121462.67
Honcut to Jack	32	77.57	80.85	87.43	82.26	121023.94
Honcut to Jack	31.75	77.33	80.68	87.19	82.13	119945.84
Honcut to Jack	31.5	77.12	80.52	86.95	81.98	118882.16
Honcut to Jack	31.25	76.91	80.37	86.74	81.80	117232.05
Honcut to Jack	31	76.68	80.21	86.51	81.63	115835.54
Honcut to Jack	30.75	76.49	80.09	86.32	82.65	115369.28
Honcut to Jack	30.5	76.36	80	86.19	82.03	114410.61

Honcut to Jack	30.25	76.25	79.92	86.08	81.08	113317.84
Honcut to Jack	30	76.03	79.76	85.83	80.84	111356.97
Honcut to Jack	29.828	75.84	79.62	85.83	80.67	110812.54
Honcut to Jack	29.826	75.86	79.64	85.83	80.67	110802.45
Honcut to Jack	29.822	75.8	79.62	85.81	80.67	110784.75
Honcut to Jack	29.821	75.82	79.64	85.81	80.66	110774.66
Honcut to Jack	29.75	75.83	79.65	85.72	80.60	109217.11
Honcut to Jack	29.5	75.74	79.6	85.67	80.36	107965.48
Jack Sl - Yuba R	29.25	75.74	79.6	85.67	80.12	106938.36
Jack Sl - Yuba R	29	75.72	79.59	85.68	79.88	105627.60
Jack Sl - Yuba R	28.75	75.45	79.31	85.31	79.65	104417.55
Jack Sl - Yuba R	28.5	75.26	79.11	85.02	79.33	103521.79
Jack Sl - Yuba R	28.324	75.14	78.96	84.82	78.95	102627.46
Jack Sl - Yuba R	28.322	75.14	78.95	84.82	78.94	102615.67
Jack Sl - Yuba R	28.309	75.15	78.97	84.86	78.91	102537.51
Jack Sl - Yuba R	28.307	75.15	78.97	84.85	78.91	102527.14
Jack Sl - Yuba R	28.25	75.09	78.89	84.74	78.79	102281.40
Jack Sl - Yuba R	28	74.88	78.61	84.35	78.51	100798.76
Jack Sl - Yuba R	27.971	74.78	78.46	84.11	78.49	100749.02
Jack Sl - Yuba R	27.963	74.76	78.42	84.04	78.48	100696.07
Jack Sl - Yuba R	27.956	74.73	78.37	83.98	78.48	100684.10
Jack Sl - Yuba R	27.952	74.71	78.33	83.96	78.47	100652.33
Jack Sl - Yuba R	27.75	74.59	78.17	83.75	78.31	99512.10
Jack Sl - Yuba R	27.5	74.2	77.62	82.95	78.10	98174.47
Jack Sl - Yuba R	27.251	73.59	76.7	81.56	77.90	97016.29
Jack Sl - Yuba R	27.25	73.58	76.7	81.56	77.90	97011.08
Yuba R - Bear R	27	73.58	76.7	81.56	77.71	95787.83
Yuba R - Bear R	26.999	73.58	76.7	81.56	77.71	95782.80
Yuba R - Bear R	26.75	73.14	76.24	81.07	77.55	94705.78
Yuba R - Bear R	26.5	72.53	75.66	80.51	77.39	93495.05
Yuba R - Bear R	26.25	72.06	75.21	80.1	77.23	92095.83
Yuba R - Bear R	26	71.68	74.85	79.75	77.07	90634.01
Yuba R - Bear R	25.75	71.33	74.53	79.44	76.91	89136.87
Yuba R - Bear R	25.5	71.04	74.24	79.14	76.74	87728.16
Yuba R - Bear R	25.25	70.73	73.92	78.81	76.49	86208.17
Yuba R - Bear R	25	70.08	73.3	78.2	76.17	84613.00
Yuba R - Bear R	24.75	69.5	72.7	77.59	75.86	84085.03
Yuba R - Bear R	24.5	69.17	72.34	77.22	75.55	83744.43
Yuba R - Bear R	24.25	68.81	71.94	76.81	75.23	83076.25
Yuba R - Bear R	24	68.54	71.7	76.59	74.92	82269.01
Yuba R - Bear R	23.75	68.12	71.3	76.21	74.61	80891.65
Yuba R - Bear R	23.5	67.85	71.04	75.95	74.25	79494.60
Yuba R - Bear R	23.25	67.45	70.67	75.58	73.87	78032.72
Yuba R - Bear R	23	67.03	70.26	75.17	73.49	76810.25
Yuba R - Bear R	22.75	66.71	69.94	74.83	73.11	75345.95
Yuba R - Bear R	22.5	66.24	69.47	74.35	72.73	74107.24
Yuba R - Bear R	22.25	65.83	69.07	73.93	72.35	72852.32
Yuba R - Bear R	22	65.55	68.79	73.63	71.97	71497.68
Yuba R - Bear R	21.75	65.14	68.4	73.24	71.41	70018.45
Yuba R - Bear R	21.5	64.8	68.07	72.9	70.82	68712.35
Yuba R - Bear R	21.25	64.39	67.68	72.52	70.23	67330.45
Yuba R - Bear R	21	64.08	67.38	72.2	69.77	66047.23
Yuba R - Bear R	20.75	63.85	67.15	71.95	69.30	64675.51
Yuba R - Bear R	20.5	63.65	66.94	71.72	68.83	63332.45
Yuba R - Bear R	20.25	63.45	66.74	71.49	68.37	61977.06
Yuba R - Bear R	20	63.27	66.54	71.27	67.90	60460.00
Yuba R - Bear R	19.75	63.08	66.36	71.08	67.74	58852.41
Yuba R - Bear R	19.5	62.94	66.22	70.94	67.58	56862.66
Yuba R - Bear R	19.25	62.82	66.1	70.81	67.37	55516.59
Yuba R - Bear R	19	62.72	66	70.7	67.15	54713.04

Yuba R - Bear R	18.75	62.55	65.83	70.52	66.93	53622.77
Yuba R - Bear R	18.5	62.45	65.73	70.41	66.71	52897.52
Yuba R - Bear R	18.25	62.33	65.61	70.28	66.45	51890.28
Yuba R - Bear R	18	62.12	65.39	70.03	66.19	49704.43
Yuba R - Bear R	17.75	61.95	65.23	69.85	65.93	49399.72
Yuba R - Bear R	17.5	61.78	65.05	69.66	65.67	49114.25
Yuba R - Bear R	17.25	61.56	64.83	69.43	65.41	48794.83
Yuba R - Bear R	17	61.1	64.39	68.97	65.16	48556.49
Yuba R - Bear R	16.75	60.82	64.11	68.67	64.90	48094.20
Yuba R - Bear R	16.5	60.54	63.81	68.33	64.39	47013.16
Yuba R - Bear R	16.25	60.34	63.6	68.1	63.87	46228.38
Yuba R - Bear R	16	60.04	63.28	67.73	63.36	45101.47
Yuba R - Bear R	15.75	59.47	62.64	66.99	62.85	43356.36
Yuba R - Bear R	15.5	58.98	62.1	66.34	62.33	41613.14
Yuba R - Bear R	15.25	58.59	61.67	65.85	61.82	40305.41
Yuba R - Bear R	15	58.17	61.2	65.28	61.31	39102.69
Yuba R - Bear R	14.75	57.78	60.8	64.84	60.60	37817.10
Yuba R - Bear R	14.5	57.4	60.37	64.33	59.88	36319.37
Yuba R - Bear R	14.25	56.83	59.73	63.55	59.24	34904.17
Yuba R - Bear R	14	56.51	59.38	63.17	58.89	33507.55
Yuba R - Bear R	13.75	56.15	58.96	62.64	58.53	32270.43
Yuba R - Bear R	13.5	55.68	58.44	62.01	58.17	31239.13
Yuba R - Bear R	13.25	55.32	58.05	61.55	57.82	29977.40
Yuba R - Bear R	13	55.19	57.92	61.43	57.46	28644.35
Yuba R - Bear R	12.75	55.01	57.73	61.21	57.11	27255.90
Yuba R - Bear R	12.5	54.93	57.65	61.14	56.82	26065.40
Yuba R - Bear R	12.25	54.68	57.4	60.89	56.59	24642.20
Reach 35	12	54.68	57.4	60.89	56.37	23313.05
Reach 35	11.75	54.54	57.27	60.76	56.15	21993.69
Reach 35	11.599	54.5	57.23	60.71	56.02	21069.77
Reach 35	11.5	54.37	57.1	60.59	55.93	20354.66
Reach 35	11.25	54.15	56.87	60.32	55.71	18182.41
Reach 35	11	53.82	56.51	59.93	55.44	16871.48
Reach 35	10.75	53.67	56.36	59.76	55.01	15547.88
Reach 35	10.5	53.41	56.08	59.44	54.57	14278.44
Reach 35	10.25	52.96	55.57	58.83	54.13	13850.18
Reach 35	10	52.74	55.34	58.59	53.69	12847.13
Reach 35	9.75	52.51	55.08	58.29	53.27	11597.74
Reach 35	9.5	52.1	54.62	57.74	52.91	10595.55
Reach 35	9.278	52.19	54.75	57.93	52.59	9814.09
Reach 35	9.265	51.71	54.16	57.16	52.56	9758.91
Reach 35	9.2	51.61	54.05	57.04	52.39	9164.29
Reach 35	9	51.26	53.66	56.58	51.55	8445.84
Reach 35	8.75	50.5	52.84	55.61	50.44	7531.76
Reach 35	8.5	50.14	52.48	55.23	49.34	6548.71
Reach 35	8.25	49.89	52.25	55	48.23	3573.02
Reach 35	8	49.11	51.46	54.1	47.12	2528.45
Reach 35	7.75	47.97	50.32	52.72	46.02	1733.43
Reach 35	7.55	46.82	49.11	51.05	44.98	1275.43

Source: Design Criteria and Technical Approach Memorandum, Feather River West Levee Improvements, Sutter Butte Flood Control Agency, Yuba City, California, Draft, November 30, 2010

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

1. The locations of the distress and existing improvement measures were obtained from the available documents. The locations are approximate.

2. The stations were estimated from "Levee Miles", as presented in the reviewed documents.

ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
1	Levee Stabilization	1963	10+03 to 280+77 [2166+00 to 2437+00]	1,2,3	Maintenance Area 03 (MA03)	0.0 - 5.13		Levee stabilization construction (USACE Specification 2783, File Drawing 4-4-531)	No	Blackburn Consulting
2	Seepage	1997	10+93 [2167+13]	1	MA 03	0.01	Light seepage was observed.			726
3	Seepage	1997	29+13 [2185+34]	1	MA 03	0.36	Light seepage was observed.			726
4	Erosion	1997	35+85 to 60+50 [2192+06 to 2216+73]	1	MA 03	0.49 - 0.96	Severe sloughing due to wave erosion along approximately 1800 feet on waterside slope.			726
5	Erosion	1997	40+52 to 43+88 [2196+79 to 2200+03]	1	MA 03	0.58 - 0.64	Erosion along the waterward levee slope with a vertical face of 6 to 12 inches, half way up the levee.			275
6	Levee Breach/ Levee Cut	1955	48+00 to 53+21 [2204+22 to 2209+44]	1	MA 03	0.72 - 0.82	Levee cut to dewater the flooded area in December 1955			2863
7	Erosion	1997	69+94 [2226+15]	1	MA 03	1.14	An area where levee turns sharply to an east-west direction was eroded for about 150 feet.			726
8	Erosion/Sinkhole	1986	73+02 [2229+26]	1	MA 03	1.2	A sinkhole approximately 30 feet long, ten feet wide, and ten feet deep right at the waterside toe of the levee. This hole was discovered after the 1986 high water receded. There was no landside evidence of this sinkhole during high water.	The hole was repaired by backfilling with gravel.	No	3920
9	Erosion	2006	98+06 [2254+30]	1	MA 03	1.68	Waterside erosion	Emergency repair made.	No	P1GDR
10	Toe Berm with Drain	1962-63	129+76 to 190+41 [2286+00 to 2346+55]	2	MA 03	2.28 - 3.43		Landside toe berm with 15 feet deep drain present (constructed as part of 1962-63 USACE levee stabilization project).	No	Blackburn Consulting
11	Seepage	Previous Flood Events	130+27 to 181+83 [2286+46 to 2338+04]	2	MA 03	2.3-3.3	This site is located between Sacramento Avenue and Laurel Avenue. Excessive seepage occurs at this site during high water. (F.R. Site A)			314
12	Heavy Seepage	1997	132+87 [2289+07]	2	MA 03	2.35	Heavy seepage, running clear.			275
13	Heavy Seepage	1997	139+46 [2295+67]	2	MA 03	2.48	Heavy seepage, running clear.			275
14	Heavy Seepage	1997	144+63 to 146+73 [2300+84 to 2302+92]	2	MA 03	2.58 - 2.62	Heavy seepage, running clear.			275
15	Heavy Seepage	1997	163+88 [2320+07]	2	MA 03	2.95	Heavy seepage, running clear.			275

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

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ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
16	Heavy Seepage	1997	175+60 [2331+79]	2	MA 03	3.18	Heavy seepage, running clear.			275
17	Heavy Seepage	1997	178+72 [2334+92]	2	MA 03	3.24	Heavy seepage around tree, running clear.			275
18	Heavy Seepage	1997	183+40 [2339+60]	2	MA 03	3.33	Heavy seepage, running clear.			275
19	Heavy Seepage	1997	193+16 to 194+70 [2349+37 to 2350+92]	2	MA 03	3.52 - 3.55	Heavy seepage, running clear.			275
20	Boil	1997	197+97 [2354+07]	2	MA 03	3.61	Boil 200 feet landward of the levee toe, water was clear and did not carry material.			275
21	Heavy Seepage	1997	201+92 [2358+13]	2	MA 03	3.68	Heavy seepage, running clear.			275
22	Boil	1986	198+42 [2354+62]	2	MA 03	3.62	A landside boil occurred in a landside drainage ditch near the levee toe during the 1986 flood. (F.R. Site B).			314
							An area of boils appearing at the landside toe and away from the toe. There appears to be swale or old slough at this location. Ditches were reported to be excavated on both sides of the levee to explore for the cause of the boils, but no explanation was found.			3920
23	Levee Breach	Unknown	203+77 to 218+79 [2360+00 to 2375+00]	2,3	MA 03	3.72 - 4.0	Old levee breach. Interview with Bill Hampton of LD1 in November 2010.			Interview with Bill Hampton (LD1) in November 2010
24	Levee Reconstruction at Levee Breach Area	Unknown	203+77 to 218+79 [2360+00 to 2375+00]	2,3	MA 03	3.72 - 4.0		Levee reconstruction in breach area. Interview with Bill Hampton of LD1 in November 2010.	No	Interview with Bill Hampton (LD1) in November 2010
25	Heavy Seepage and Sloughing	1997	206+15 to 242+00 [2362+13 to 2398+27]	2,3	MA 03	3.76 - 4.45	Heavy seepage into existing ditch caused sloughing of the bank and the levee slope, rock and geo-textile fabric was placed in the ditch and covered with dirt.			275
26	Sloughing and Seepage	1997	206+15 to 242+00 [2362+13 to 2398+27]	2,3	MA 03	3.76 - 4.45	During the 1997 flood, the drainage ditch was sloughing and heavy but clear seepage was entering the ditch. (F.R. Site B)			314

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

1. The locations of the distress and existing improvement measures were obtained from the available documents. The locations are approximate.

2. The stations were estimated from "Levee Miles", as presented in the reviewed documents.

ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
27	Emergency Stability Berm	1998	206+29 to 241+93 [2362+13 to 2398+27]	2,3	MA 03	3.76 - 4.45		During the 1997 flood, an emergency stability berm was constructed of sandbags placed on a geotextile within the drainage ditch. Later that year, the ditch was converted to a pervious toe drain. (F.R. Site B)	No	314
28	Toe Drain and Berm	1998	190+34 to 198+79 [2346+55 to 2355+00 and 2355+41 to 2366+00 (A gap from 2355+00 to 2355+41)]	2	MA 03	3.46 - 3.83 (a 41 feet gap at LM 3.62)		In 1998, a permanent seepage/stability berm was constructed at the site under the Marysville/Yuba City Levee Reconstruction Project. (F.R. Site B)	No	314
								Site 11: Toe drain and berm from LM 3.46 to LM 3.83. There is a 41 foot gap in the toe drain and berm at LM 3.62. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	No	3045
29	Toe Berm		218+31 to 298+97 [2375+00 to 2455+00]	2,3	MA 03	4.0 - 5.52		Drain consists of fabric wrapped gravel placed in exiting ditch and then backfilled. Concrete lined landside ditch on slightly elevated berm.	No	Blackburn Consulting
30	Bank Erosion in Pond	Previous Flood Events	253+70 to 257+92 [2410+00 to 2414+00]	3	MA 03	4.0 - 5.52	Waterlevel in landside pond rises with increasing waterlevel in the river, which leads to bank erosion in the pond.			Interview with Bill Hampton (LD1) in November 2010
31	Crack	1986	359+42 [2515+65]	4	LD 01	1.5	The site is located 2.4 miles south of Star Bend (LM 1.5). During the 1986 flood, a crack formed in the levee. (F.R. Site C)			314
32	Seepage	1997	362+10 to 370+02 [2518+29 to 2526+22]	4	LD 01	1.55 - 1.70	During the 1997 flood, seepage occurred at the site (same location of 1986 crack). (F.R. Site C)			314
							Heavy seepage			
33	Toe Drain and Seepage/Stability Berm	1998	354+50 to 364+44 [2510+73 to 2520+67]	4	LD 01	1.4 - 1.59		A pervious toe drain and seepage/stability berm have been constructed at this site under a PL 84-99 action. (F.R. Site C)	No	314
34	Boils	1997	425+33 [2581+57]	5	LD 01	2.75	Boil at landside toe			233

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Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

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2. The stations were estimated from "Levee Miles", as presented in the reviewed documents.

ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
	Boil	1997	449+03 to 478+14 [2605+31 to 2634+38]	5	LD 01	14-15.5	Yuba City constructed a berm along the landside toe as an emergency action. A permanent seepage/stability berm was later constructed from the Fifth Street Bridge extending northward to about 2500 feet beyond the 10th Street Bridge. An impermeable cuto			314 and 3920
35	Boils and Seepage	1986	467+47 to 495+72 [2623+92 to 2650+22]	5,6	LD 01	3.55 - 4.05	The site is located just south of Star Bend at approximate River Mile 17.8 (Levee Mile 3.8). During the 1986 flood, boils carrying soil formed near the landside toe of the levee in a half mile stretch. The ground within approximately 100 feet of landside toe was very soft and wet. The peak floodwater was 5-6 feet below the top of the levee at this location. LD1 personnel constructed sandbag rings around three of the worst boils. (F.R. Site D)			314
							Site 4: This location at Star Bend suffered serious boils during the 1986 high water. The area was subsequently repaired by excavating a trench and installing drain material over filter fabric.			3920
36	Boils	1997	467+47 to 495+72 [2623+92 to 2650+22]	5,6	LD 01	3.20 - 3.75	Six boils at landside toe of levee			233
37	Levee Raise	1998	480+83 to 509+66 [2637+50 to 2675+50]	6	LD 01	3.81 - 4.52		In 1998 the levee was raised 1-foot and a pervious toe drain and seepage/stability berm was installed at the landside levee toe under the Marysville/Yuba City Levee Reconstruction Project. (F.R. Site D)	No	314
	Toe Drain and Berm							Site 10: Levee raise, repair of existing toe drain and toe berm construction from LM 3.81 to LM 4.52. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	No	3045

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

1. The locations of the distress and existing improvement measures were obtained from the available documents. The locations are approximate.

2. The stations were estimated from "Levee Miles", as presented in the reviewed documents.

ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
38	Setback Levee with Cutoff Wall	2008	478+78 to 510+25 [2635+00 to 2676+00]	6	LD 01	3.76 - 4.58		Setback levee with SB cutoff wall was constructed in 2008. Tie-ins are SCB wall and extend 125 feet north into the existing levee and 150 feet south into the existing levee. The SB wall is 40 to 45 feet deep at the north tie-in and 62 to 67 feet deep at the south tie-in.	Yes	Blackburn Consulting
39	Seepage	1995	510+69 to 556+04 [2677+06 to 2722+50]	7	LD 01	4.56 - 5.42	The site is located between Star Bend Road and Abbott Road at approximate River Mile 18.1 and 19.0 (LM 4.1 to 5.0). During the 1995 flood, clear seepage exited the levee toe and the ground beyond the levee toe while the river level was approximately 12 to 15 feet below the top of levee. (F.R. Site E). **Note: The levee segment between Star Bend Road and Abbott Lake are between LM 4.56 and 5.42**			314
40	Boils and Seepage	1997	510+87 to 556+25 [2677+06 to 2722+50]	7	LD 01	4.56 - 5.42	During the 1997 flood, numerous boils occurred in a 200 linear foot stretch. Sandbag rings were constructed around the boils that were moving material. The following day, the sandbagged boils were flowing clear. (F.R. Site E).			314
41	Boils	1997	521+50 [2687+62]	7	LD 01	4.76	Boil at landside toe			233
42	Boils	1997	532+61 [2698+72]	7	LD 01	4.97	Two boils at landside toe of levee			233
43	Boils	1997	534+71 [2700+83]	7	LD 01	5.01	Three boils at landside toe of levee			233
44	Boils	1997	540+02 [2706+13]	7	LD 01	5.11	Three boils at landside toe of levee			233
45	Boils	1997	543+20 to 547+58 [2709+28 to 2713+51]	7	LD 01	5.17 - 5.25	Seventeen (17) boils at landside toe of levee			233
46	Toe Berm		510+87 to 555+88 [2677+00 to 2722+00]	7	LD 01	4.56 - 5.42		Toe berm from the north end of Star Bend Road to the south end of Abbott Lake Road. Project plans entitled "PL 84-99 Phase III, Relief Wells - LD 1, Feather River at Star Bend, dated 8/18/1997. USACE File No. 04-04-617"	No	3912

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

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ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
47	Relief Wells	1997	526+72 to 542+10 [2692+50 to 2708+20]	7	LD 01	4.85 - 5.16		In 1997, the Corps of Engineers installed relief wells in this area to reduce seepage and instability of the levee under a PL 84-99 contract. (F.R. Site E)	No	314
								A total of 25 relief wells from 1550 feet north of the north end of the Star Bend Road to 1380 feet south of the south end of Abbott Lake Road. Project plans entitled "PL 84-99 Phase III, Relief Wells - LD 1, Feather River at Star Bend, dated 8/18/1997. USACE File No. 04-04-617"	No	3912
48	Heavy Seepage and Boil	2006	510+87 to 555+88 [2677+00 to 2722+00]	7	LD 01	4.56 - 5.42	Heavy seepage and boils were observed during the 2006 flood. Relief wells were present during 2006 flood in this area			Interview with Bill Hampton (LD1) in November 2010
49	Waterside Slope Instability	1997	563+00 to 568+76 [2729+00 to 2735+00]	7	LD 01	5.55 - 5.66	Waterside slope instability due to rapid drawdown when levee breach occurred on east bank of Feather River (in RD 784)			Interview with Bill Hampton (LD1) in November 2010
50	Waterside Slope Repair	After 1997 Flood	563+05 to 568+74 [2729+00 to 2735+00 with an approximately 120 feet gap]	7	LD 01	5.55 - 5.66		Waterside slope repair by USACE after the 1997 flood. A gap of about 120 feet was left unrepaired		Interview with Bill Hampton (LD1) in November 2010
51	Erosion	1986	592+34 [2758+48]	7	LD 01	6.1	This site is located at LM 6.1 near Abbott Lake, north of O'Banion Road at approximately River Mile 19.7. During the 1986 flood, holes appeared at the top of waterside levee berm. It is believed that the holes were result of small trees growing on the berm. The berm slope down to natural ground was eroded. The water was within 5 feet of the top of the levee. (F.R. Site F)			314
52	Sinkhole (waterside)	1997	602+88 to 640+32 [2769+01 to 2806+45]	8	LD 01	6.30 - 7.01	Twenty-six (26) sinkholes on waterside berm of levee. According to bill Hampton of LD1, these sinkholes were 3 feet to 6 feet deep and 2 feet to 4 feet diameter and formed on the waterside berm, which was the original levee before it was raised.	After the flood these sinkholes were repaired by compacting soil.		233 and Interview with Bill Hampton (LD1) in November 2010
	Erosion	2006	655+54 to 679+16	9	LD 01	6.30 - 7.01	Twenty-six (26) sinkholes on waterside berm of levee			233

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

1. The locations of the distress and existing improvement measures were obtained from the available documents. The locations are approximate.

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ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
53	Erosion	Unknown	655+57 [2821+72]	9	LD 01	7.72	Scour on waterside berm of levee.			233
54	Erosion	Unknown	655+57 to 279+10 [2821+72 to 2845+25]	9	LD 01	7.3 - 7.75	The site is located near Messick Road at approximate River Mile 21.2 (LM 7.3). Waterside bank erosion encroaching on the levee section. (F.R. Site G)			314
55	Scour	1997	677+72 [2843+88]	9	LD 01	7.72	Scour on waterside berm of levee			233
56	Erosion	1986	692+50 [2858+65]	9	LD 01	8	This site is at the Boyd Pump Boat Ramp at LM 8, between Messick Road and Oswald Avenue at approximate RM 21.7. During the 1986 flood, portions of the boat ramp parking lot and subgrade and portions of the levee toe were eroded. (F.R. Site H)			314
57	Erosion	1997	699+35 [2865+51]	9	LD 01	8.13	Bank erosion at pump structure at waterside levee			233
58	Toe Drain and Seepage/Stability Berm	1998	655+83 to 706+50 [2820+78 to 2872+50]	9	LD 01	7.28 - 8.25		In 1998 the Corps raised the levee 1-foot and installed a pervious toe drain and seepage/stability berm at the site under the Marysville/Yuba City Levee Reconstruction Project. (F.R. Site H)	No	314
								Site 9: Toe drain and berm from LM 7.28 to LM 8.26. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	No	3045
59	Boil	1997	812+50 [2978+75]	11	LD 01	10.3	A boil developed around a tree. Clean water was coming out.			Interview with Bill Hampton (LD1) in November 2010
60	Seepage	Previous Flood Events	834+39 [3000+39]	12	LD 01	10.8	The site is located at Shanghai Bend at approximate River Mile 25.0 (LM 10.8). Seepage occurs at this site during high water. (F.R. Site I)			314
61	Seepage/Stability Berm	After 1986 flood	834+13 [3000+39]	12	LD 01	10.8	A seepage/stability berm was designed and constructed by LD1 after the 1986 flood. (F.R. Site I)			314
62	Seepage and Boil	1995	834+49 [3000+39]	12	LD 01	10.8	Seepage and a boil occurred just beyond the berm toe during the 1995 high water. (F.R. Site I)			314

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

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ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
63	Cutoff Wall and Setback Levee	1999	829+85 to 845+25 [2996+00 to 3011+50]	11,12,13	LD 01	10.81 - 11.10		Shanghai Bend setback levee with cutoff wall. Additional site investigation report and Star Bend borrow site report for the Project "PL 84-99 Cost Shared, Basin No. 18, Feather River, Shanghai Bend, dated 1999. USACE Drawing File No. 4-4-620" are available during preparation of this report. According to Bill Hampton of LD1, excess material during construction was placed on waterside, which created a waterside berm. .	No	2285
64	Levee Break	1909, 1911, and 1955	839+71 to 908+21 [3005+86 to 3074+31]	12,13	LD 01	11.0 - 12.4	The site is located between Shanghai Bend and Yuba City Airport between approximate River Miles 25.1 and 26.5 (LM 11.0 and 12.4). The levee broke in this area during the 1909, 1911, and 1955. (F.R. Site J).			314
65	Levee Reconstruction and Relief Wells	1957	842+52 to 926+79 [3008+61 to 3092+65]	12,13	LD 01	11.1 - 12.75		In 1957, the Corps of Engineers reconstructed the levee to the landside of it's previous location and installed a row of relief wells near the landside levee toe. Water from the relief wells is pumped to the Feather River. (F.R. Site J). Note: The actual LMs for this improvement measures are from LM 11.3 to LM 12.8. These original relief wells were 200 feet apart.	No	314
								Relief wells at 200 feet intervals. Plans are available in the document entitled "Emergency Levee Repairs, Relief Wells - Right Bank Feather River, Shanghai Bend, Sutter County, California, USACE File 4-4-435"	No	1671
66	Boils	1986	845+71 to 926+51 [3012+00 to 3092+65]	13	LD 01	11.1 - 12.75	During the 1986 flood, volunteers sandbagged several boils in this area. (F.R. Site J)			314
							Site 3: At the downstream of Shanghai Bend, an area of concentrated seepage produced boils during the 1986 high water. These boils were controlled with sack rings.			3920
67	Heavy Seepage and Boil	1997	845+01 [3011+37]	13	LD 01	11.2	Heavy seepage and boils near landside toe of levee at Shanghai bend			233

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

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68	Seepage	1986	845+69 to 926+32 [3012+00 to 3092+65]	13	LD 01	11.1 - 12.75	Site 3: According to LD 1 Engineer Mr. Von Geldern, Relief wells in Shanghai Bend area produced 3 gallons per minute during the 1986 high water. Additional seepage occurred in fields adjacent to the levee. Seepage appeared in this area up to several hundred feet away from the levee toe.			3920
69	Seepage Interceptor and Relief Wells	1990	845+61 to 926+15 [3012+00 to 3092+65]	13	LD 01	11.11 - 11.90		In 1990, the City of Yuba City installed a seepage interceptor system in the southern part of this site. The interceptor system consists of a perforated pipeline and filter 12-18 feet below ground surface to extract shallow seepage, and relief wells placed between the 1957 relief wells to extract deeper seepage. All water collected is pumped into the Feather River separately from the water collected by the 1957 relief wells. (F.R. Site J). Note: The exact location of this interceptor system was unknown during preparation of this report. The relief well spacing is approximately 100 feet after installation of these new wells.	No	314
70	Perforated Plastic Pipeline Replacement by Perforated Clay Pipeline	1993	845+61 to 926+15 [3012+00 to 3092+65]	13	LD 01	11.1 - 12.75		In 1993, and inspection of the shallow drain perforated pipeline discovered unacceptable deflections over large portions of the pipeline. The deformed plastic pipeline was removed and replaced with a perforated clay pipeline. (F.R. Site J). The exact location of this repair is unknown.	No	314
71	Heavy Seepage	1997	893+89 to 902+77 [3060+16 to 3069+06]	13	LD 01	12.13 - 12.30	Heavy seepage near landside toe of levee south of Burns Drive			233
72	Relief Well Rehabilitation	2001	829+44 to 926+50 [3058+59 to 3092+65]	11,12,13	LD 01	12.1 - 12.75		In 2001, the Corps of Engineers rehabilitated the original 1957 relief wells under a PL 84-99 contract. (F.R. Site J).	No	314
								Project plans entitled "PL 84-99 Cost Shared Added Sites Sacramento Basin No. 18 Relief Well Improvements," dated 7/31/2000. USACE Design File No. 4-04-625.	No	145

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

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73	Seepage	Previous Flood Events	971+00 [3137+19]	16	LD 01	13.6	The site is located near the Yuba City Airport at approximate River Mile 27.0 (LM 13.6). Seepage occurs at the site during high water. (F.R. Site K)			314
74	Cutoff Wall, Toe Drain and Berm	1998 (?)	3073+78 to 3181+40	13,14,15, 16	LD 01	See the following 3 rows for location		An impermeable cutoff wall has been constructed in this area. The cutoff wall slightly overlaps the relief wells. Deep seepage interceptor system at F.R. Site J, extends through the site, and ends 800 feet upstream of the Fifth Street Bridge in F.R. Site L. The southern portion of the cutoff wall was constructed under the Marysville/Yuba City Levee Reconstruction Project. The northern portion of the cutoff wall was constructed under a PL 84-99 contract. (F.R. Site K)	No	314
75	Cutoff Wall	1998 (?)	927+08 to 968+31 [3093+19 to 3170+25]	14,15	LD 01	12.76 - 13.28		Site 8: Slurry walls from LM 12.76 to LM 13.28. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	No	3045
76	Toe Drain and Berm	1998 (?)	3066+97 to 3135+62	13,14,15, 16	LD 01	12.26 - 13.57		Site 8: Toe drain and berm from LM 12.26 to LM 13.57. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. **However, during a site visit in November 2010, no berm was found on landside in this section. According to Bill Hampton of LD1, a cutoff wall was installed in this section.**	No	3045 and Interview with Bill Hampton (LD1) in November 2010

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77	Cutoff Wall	1998 (?)	968+35 to 1020+28 [3134+56 to 3186+49]	Different for ULE vs. SBFCA Stationing	LD 01	LM 13.55 - LM 14.37 and LM 14.40 - LM 14.54. A gap from LM 14.37 to LM 14.40 for Union Pacific Railroad and Bridge Street		Site 8: Slurry wall from LM 13.54 to LM 14.25, and LM 14.28 to LM 14.42. A gap in slurry wall from LM 14.25 to LM 14.28 for Union Pacific Railroad and Bridge Street. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	No	3045
78	Cutoff Wall		1016+62 to 1073+86 [3182+85 to 3240+00] An approximately 260 feet wide gap in HWY-20.	16	LD 01	LM 14.56 to LM 15.68. An approximately 260 feet wide gap in HWY-20.		Slurry wall from LM 14.56 to LM 15.68. Plans entitled "PL 84-99 Cost Shared/Added Sites Sacramento Basin No. 18 LD1 Slurry Wall, undated, USACE Design File No. 4-25-625." Note: Based on Doc. 3045 and 946, an approximately 135 feet gap between slurry walls from two projects. PL 84-99 calls for an overlap between the slurry walls. As-built documents of these slurry walls were not available during preparation of the SGDR.	No	946
79	Seepage	1955	991+94 to 1070+74 [3158+16 to 3236+83]	16	LD 01	14.0 - 15.5	The site is located in Yuba City from Garden Highway north to the Drive-In Cinema between approximate River Miles 27.4 to 29.3 (LM 14.0 to LM 15.5). During the 1955 flood, seepage was observed near the 10th Street Bridge. (F.R. Site L)			314
80	Through-Seepage and Slope Instability	1986	991+96 to 1070+69 [3158+16 to 3236+83]	16	LD 01	14.0 - 15.5	During the 1986 flood, the landside slope became saturated and unstable and bulged slightly in the area of the Corporation Yard. Water also flowed up through cracks in the parking lot pavement and the floor slab of an auto body shop on Teegarden Avenue. (F.R. Site L)			314
							Site 1: This is a reach of levee extending 4000 feet through downtown Yuba City. During the 1986 flood, this area showed considerable wetness on landside slope.			3920
81	Heavy Seepage and Boils	1997	1041+99 to 1073+59 [3208+07 to 3239+44]	16	LD 01	14.95 - 15.55	Heavy seepage north of 10th Street Bridge. Heavy seepage near two City drainage pipes.			233

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82	Permanent Seepage/Stability Berm	After 1986 flood	991+96 to 1025+84 [3158+16 to 3224+00]	16	LD 01	14.0 - 15.25		Yuba City constructed a berm along the landside toe as an emergency action. A permanent seepage/stability berm was later constructed from the Fifth Street Bridge extending northward to about 2500 feet beyond the 10th Street Bridge. An impermeable cutoff wall was also constructed in this area (See F.R. Site K). (F.R. Site L). Note: Plans or as-built documents of the permanent seepage/stability berm was not available during preparation of this report.	No	314
								Temporary toe drain/berm: Site 1: In 1986, this area was upgraded by placing a landside berm on the slope with an internal drain protected by filter fabric which extends into the toe. Drainage from this system can be monitored at drain pipes.	No	3920
83	Erosion	1986	1006+04 to 1021+87 [3172+25 to 3188+10]	16	LD 01	14.27 - 14.57	Erosion of the waterside levee toe occurred in the areas immediately upstream and downstream of the Fifth Street Bridge. (F.R. Site L)			314
84	Erosion	1997	1005+95 to 1021+87 [3172+25 to 3188+10]	16	LD 01	14.27 - 14.57	Site 2: This is an area of waterside erosion which extends for several hundred feet upstream and downstream of the Fifth Avenue Bridge. This erosion occurred mostly low down on the slope and had cut into the levee section causing a steepening of the lower levee slope.			3920
							Bank and levee erosion south of the 5th Street Bridge			233
85	Rock Protection	1998	1005+70 to 1021+90 [3172+25 to 3188+10]	16	LD 01	14.27 - 14.57		In 1998, rock protection was added to the waterside eroded area around the Fifth Street Bridge. (F.R. Site L)	No	314
86	Erosion	1997	1030+96 to 1034+65 [3197+08 to 3200+76]	16	LD 01	14.74 - 14.81	Bank erosion between 5th Street Bridge and 10th Street Bridge			233

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87	Area of Concern	1998	1375+38 to 1428+49 [3541+48 to 3594+67]	21	LD 09	4.63 - 5.64		The Corps relocated an open drainage ditch away from the toe of the levee at the north end of the site under the Marysville/Yuba City Levee Reconstruction Project. (F.R. Site M).	No	314
								Site 3: Proposed backfill of irrigation ditch from LM 4.63 to LM 5.64. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	No	3045
88	Seepage	1996	1135+00 to 1214+24 [3299+00 to 3380+44]	18,19	LD 09		Seepage reported during storms of late 1996			P1GER
89	Sinkhole	1966	1136+32 [3302+46]	18	LD 09	0.10	Sinkhole observed on riverside toe in Winter 1966, repaired in Spring 1966			8600
90	Sinkhole	1966	1137+24 [3303+38]	18	LD 09	0.12	Sinkhole observed on riverside toe in Winter 1966, repaired in Spring 1966			8600
91	Sinkhole	1966	1145+22 [3311+36]	18	LD 09	0.27	Sinkhole observed on riverside toe in Winter 1966, repaired in Spring 1966			8600
92	Sinkhole	1966	1146+32 [3312+46]	18	LD 09	0.29	Sinkhole observed on riverside toe in Winter 1966, repaired in Spring 1966			8600
93	Sinkhole	1966	1147+38 [3313+52]	18	LD 09	0.31	Sinkhole observed on riverside toe in Winter 1966, repaired in Spring 1966			8600
94	Sinkhole	1966	1151+68 [3317+82]	18	LD 09	0.39	Sinkhole observed on riverside toe in Winter 1966, repaired in Spring 1966			8600
95	Sinkhole	1966	1153+14 [3319+28]	18	LD 09	0.42	Sinkhole observed on riverside toe in Winter 1966, repaired in Spring 1966			8600
96	Sinkhole	1986	1173+78 [3339+92]	18	LD 09	0.81	Sinkhole			3920
97	Seepage	Unknown	1259+63 to 1267+66 [3425+73 to 3433+88]	19	LD 09	2.437 - 2.59	LD9 maintenance personnel reported that "Two “humps” in the levee are locations where the levee was fortified with additional rock due to “heavy saturation”, and levees turning to “mush”".			8597
98	Boils	1997	1288+24 to 1296+34 [3454+40 to 3462+52]	19	LD 09	2.979 - 3.132	Pinhole Boils - 1997. Letter to USACE - Subject: Sacramento River Flood Control Project, Marysville/Yuba City Area, Phase II, Levee District 9	Drained toe reconstruction by USACE in 1998. Concrete V-ditch observed at repair location.	No	P1GDR

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

1. The locations of the distress and existing improvement measures were obtained from the available documents. The locations are approximate.

2. The stations were estimated from "Levee Miles", as presented in the reviewed documents.

ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
99	Seepage	Unknown	1316+46 to 1320+70 [3482+64 to 3486+88]	20	LD 09	3.514 - 3.595	LD9 maintenance personnel reported that "Two “humps” in the levee are locations where the levee was fortified with additional rock due to “heavy saturation”, and levees turning to “mush”".			8597
100	Heavy Seepage	1997	1131+08 to 1199+60 [3297+21 to 3365+74]	18	LD 09	0.0 - 1.3	Heavy seepage on landside. Some boils were observed up to tens of feet from toe in adjacent orchards. The amount of seepage along this levee was estimated to be significantly higher than previous floods by LD 9 Superintendent, Mr. David Schmidl.			No ID - Subset of 530 (Phase III Basin Reports, Final Emergency Levee Repairs, Left Bank of Sutter Bypass and Right Bank of Feather River Levees, Sutter County, California, by USACE, Dated June 4, 1997)
101	Boil	1955	1242+86 [3409+01]	19	LD 09	2.12	Boil and piping - 1955	Landward half of levee excavated and recompacted with gravel filter	No	8598
102	Riprap	1974	1266+45 to 1269+18 [3432+60 to 3435+35]	19	LD 09	2.57 - 2.62		Bank protection placed by USACE, 1974		3390
103	Revetment	1974	1271+00 [3437+17]	19	LD 09	2.66		Levee rock slope protection		690
104	Heavy Seepage	1997	1278+82 to 1293+07 [3444+99 to 3459+25]	19	LD 09	2.80 - 3.07	Heavy seepage and boils on landside. At LM 3.0, a boil was running clear water, but it was not sandbagged. LD 9 Superintendent considered that this amount was never seen before. Water levels in the Feather River were estimated to be close to the 3-feet freeboard level.			No ID - Subset of 530 (Phase III Basin Reports, Final Emergency Levee Repairs, Left Bank of Sutter Bypass and Right Bank of Feather River Levees, Sutter County, California, by USACE, Dated June 4, 1997)
105	Boil	1955	1321+07 [3487+25]	20	LD 09	3.60	Boil and piping - 1955	Landward half of levee excavated and recompacted with gravel filter	No	8598
106	Seepage and Boil	1986	1328+73 [3495+06]	20	LD 09	3.75	Seepage			3920
							Boil 1986 (Site 1) - "An irrigation ditch approximately 8 feet deep lies with in 50 feet from levee toe." Recommendation: "that the ditch be backfilled with except for right next to the existing pump, or relocate the ditch so that it is at least 50 feet away from the levee toe".			2953

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

1. The locations of the distress and existing improvement measures were obtained from the available documents. The locations are approximate.

2. The stations were estimated from "Levee Miles", as presented in the reviewed documents.

ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
107	Heavy Seepage and Boils	1997	1368+41 to 1410+63 [3534+58 to 3576+80]	20,21	LD 09	4.50 - 5.30	Heavy seepage was observed. Boils near adjacent outbuilding about 20 feet from the levee toe.			No ID - Subset of 530 (Phase III Basin Reports, Final Emergency Levee Repairs, Left Bank of Sutter Bypass and Right Bank of Feather River Levees, Sutter County, California, by USACE, Dated June 4, 1997)
108	Boil	1986	1401+55 [3567+71]	21	LD 09	LM 5.128	Boil 1986 (Site 2) - "An irrigation ditch approximately 8 feet deep lies with in 50 feet from levee toe." Recommendation: "that the ditch be backfilled with except for right next to the existing pump, or relocate the ditch so that it is at least 50 feet away from the levee toe".			2953
109	Heavy Seepage	1997	1417+95 to 1429+03 [3584+13 to 3595+20]	21	LD 09	5.44 - 5.65	Heavy seepage was observed. A serious condition of sloughing near the levee toe due to heavy seepage, along the occurrence of a longitudinal crack of undetermined length along that toe, promoted the rapid backfilling of an existing irrigation canal parallel to the levee as a preventive measure against slope instability. The irrigation canal is about 30 feet wide and 6 feet deep, and about 900 feet of canal was backfilled with crushed rock and coarse gravel. Through Contract III, Site 3, the water conveyed by the canal will be rerouted into a pipeline, which will be placed at some distance from the levee.			No ID - Subset of 530 (Phase III Basin Reports, Final Emergency Levee Repairs, Left Bank of Sutter Bypass and Right Bank of Feather River Levees, Sutter County, California, by USACE, Dated June 4, 1997)
110	Seepage and boil	Previous Flood Events	1336+73 to 1410+70 [3502+94 to 3576+80]	20,21	LD 09	3.9 - 5.3	This site is located around Koch Lane between approximate River Miles 35.6 and 37.6 (LM 3.9 and LM 5.3). During high water, seepage and boils occur near the landside levee toe. (F.R. Site M)			314
111	Seepage	1957	1375+34 to 1390+17 [3541+54 to 3556+37]	21	LD 09	4.63 - 4.91	Seasonal seepage noted in 1957 by L.D.. 9			8597
112	Boil	1955	1385+01 [3551+17]	21	LD 09	4.82	Boils	Relief well installed on landward side of levee in 1955	No	5116

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

1. The locations of the distress and existing improvement measures were obtained from the available documents. The locations are approximate.

2. The stations were estimated from "Levee Miles", as presented in the reviewed documents.

ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
113	Animal Burrows	2010	1433+83 to 1459+77 [3600+00 to 3626+00]	22	LD 09		Severe animal burrows in levee; extremely severe burrowing at north end of LD-9			Observation from site visit 18 Nov 2010
114	Riprap	1968	1515+63 to 1527+32 [3681+80 to 3693+49]	23	MA 16	LM 1.05 - 1.27		Grouted rip-rap placed by USACE in 1968 for bank protection (Contract Site #12)	No	1821
115	Revetment	1965	1516+02 to 1534+67 [3682+19 to 3700+84]	23	MA 16	LM 1.06 to LM 1.413		Bank protection	No	1821
116	Erosion	1991	1521+05 to 1532+55 [3687+24 to 3698+82]	23	MA 16	LM 1.15 - 1.37	Levee erosion noted by citizens in 1991			P1GDR
117	Stability	2010	1689+87 [3856+00]	26	MA 07		Sloughing and oversteepening of canal slope at landside toe of levee			Observation from site visit 18 Nov 2010
118	Seepage		1677+84 to 1721+90 [3843+98 to 3888+07]	26,27,28	MA 07	LM 0.03 - 0.88	Waterside seepage observed during irrigation season	Bentonite-tire slurry wall installed in 1999 at [3873+25 to 3887+75]	No	P1GDR
119	Boil	1955	2303+95 to 2353+40 [4470+00 to 4519+38]	39,40	MA 07	LM 0 - 0.94	Boils			8602
120	Boil	1986	1819+79 [3986+00]	30	MA 07	2.7	The levee in this area runs between two sewer ponds. During the 1986 high water, a boil developed on the landside sewer pond at the toe of the levee. The boil was controlled by building a ring of imported material. After the 1986 flood, a trench was excavated through the length of the waterside sewer pond and the trench was backfilled with imported clay. There has been no information on what effect this work has had on the boil. Note: The report was prepared in 1989.			233
121	Area of Concern	1998	1815+15 to 1822+44 [3981+32 to 3988+61]	30	MA 07	2.68 - 2.82		Site 2: Proposed slurry wall from LM 2.68 to LM 2.82. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	No	3045
121	Boil	1986	1870+91 [4037+06]	30	LD 09	3.75	Boil 1986 (Site 1) - "An irrigation ditch approximately 8 feet deep lies with in 50 feet from levee toe."			2953

Table 3-1. Identified Past Performance Problems And Levee Improvement Measures

Feather River West Levee Rehabilitation Early Implementation Project Task Order 1

Note:

1. The locations of the distress and existing improvement measures were obtained from the available documents. The locations are approximate.

2. The stations were estimated from "Levee Miles", as presented in the reviewed documents.

ID	DISTRESS/ IMPROVEMENT TYPE	DATE	SBFCA STATION [DWR Station]	Reach Number	Maintenance Area/ Levee District/ Agency	Approximate Levee Mile (LM)	DESCRIPTION OF DISTRESS	DESCRIPTION OF EXISTING IMPROVEMENT MEASURES	As-Built Document Availability during Preparation of the Report (Yes/No)	DOC ID from DWR NULE Database
122	Area of Concern	1998	2190+11 to 2216+23 [4356+32 to 4382+43]	35	MA 07	9.89 - 10.39		Site 1: Levee raise LM 9.89 to LM 10.39. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	No	3045
123	Boil	1986	2185+79 [4351+98]	35	MA 07	9.808	Boil 1986 - "The foundation soils are susceptible to seepage and piping".			2953
124	Rebuilt of Levee	1986	2185+85 [4351+98]	35	MA 07	9.808		"Rebuilt 300' levee section"	No	2953
125	Levee Raise and Widening	1946-47	2303+91 to 2326+37 [4469+98 to beyond project boundaries]	39,40	MA 07	RM 57.3 - 60.8		Levee raising, setback, and reconstruction	No	541
126	Area of Concern	1955	2303+73 to 2353+76 [4469+79 to 4519+95]	39,40	MA 07	LM 12.06 - 12.95	Levee breach - 1955		No	8602

Table 4-1. Water Surface Elevations Used for Seepage and Stability Analyses
Feather River West Levee Rehabilitation Eearly Implementation Project - Task Order 1

Levee Condition	WSE Condition	FRWL Project Area	Water Surface Elevation
Existing Conditions	DWSE	North of Sta 461+00	200-year
		South of Sta 461+01	100-year
	HTOL	North of Sta 461+00	lower of 200-year plus 3 feet, 500-year, or top of levee
		South of Sta 461+01	lower of 100-year plus 3 feet, 500-year, or top of levee
With Rehabilitation Measures	DWSE + 1foot	North of Sta 461+00	200-year plus 1 foot
		South of Sta 461+01	100-year plus 1 foot
	HTOL + 1foot	North of Sta 461+00	lower of 200-year plus 4 feet, 500-year, or top of levee
		South of Sta 461+01	lower of 100-year plus 4 feet, 500-year, or top of levee

WSE = water surface elevation
DWSE = design water surface elevation
HTOL = hydraulic top of levee
Sta = station

Table 4-2. Hydraulic Conductivity Values
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

Material Type	Soil Description	Kh (cm/sec)	Kv/Kh	Kv (cm/sec)	Layer Color	Material Number for SEEP/W
Slurry Wall	SCB or CB	1.0E-06	1	1.0E-06	Violet	**1**
	SB	1.0E-07	1	1.0E-07		**2**
Clay (CL, CH)	New Compacted Clay Levee	1.0E-06	0.25	2.5E-07	Indigo	**3**
	Existing Clay Levee	1.0E-06	0.25	2.5E-07		**28**
	New Compacted Clay Berm	1.0E-06	0.25	2.5E-07		**4**
	Clay Layer over 20 feet below ground surface	1.0E-06	0.25	2.5E-07		**5**
	Clay Blanket	1.0E-05	0.25	2.5E-06		**6**
Silt	Silt or Plastic Silt 80-100% fines content, or >50% fines content and PI > 4	1.0E-05	0.25	2.5E-06	Blue	**7**
	Sandy Silt 50-79% fines content	3.0E-05	0.25	7.5E-06		**8**
	Regrade Fill	3.0E-05	0.25	7.5E-06		**27**
Clayey Sand to Sand (SC, SP-SC, SW-SC, SP, SW)	30-49% fines content	1.0E-05	0.25	2.5E-06	Pink	**9**
	13-29% fines content	1.0E-04	0.25	2.5E-05		**10**
	8-12% fines content	1.0E-03	0.25	2.5E-04		**11**
	3-7% fines content	1.0E-02	0.25	2.5E-03	Yellow	**12**
	0-2% fines content	3.0E-02	0.25	7.5E-03		**13**
Silty Sand to Sand (SM, SP-SM, SW-SM, SP, SW)	30-49% fines content	1.0E-04	0.25	2.5E-05	Green	**14**
	13-29% fines content	1.0E-03	0.25	2.5E-04		**15**
	8-12% fines content	5.0E-03	0.25	1.3E-03	Yellow	**16**
	3-7% fines content	1.0E-02	0.25	2.5E-03		**17**
	0-2% fines content	3.0E-02	0.25	7.5E-03		**18**
Clayey Gravel to Sandy Gravel (GC, GP-GC, GW-GC, GP, GW)	30-49% fines content	1.0E-05	0.25	2.5E-06	Pink	**19**
	13-29% fines content	1.0E-04	0.25	2.5E-05		**20**
	8-12% fines content	1.0E-03	0.25	2.5E-04		**21**
	0-7% fines content	3.0E-02	0.25	7.5E-03	Yellow	**22**
Silty Gravel to Sandy Gravel (GM, GP-GM, GW-GM, GP, GW)	30-49% fines content	1.0E-04	0.25	2.5E-05	Orange	**23**
	13-29% fines content	5.0E-03	0.25	1.3E-03		**24**
	8-12% fines content	1.0E-02	0.25	2.5E-03	Yellow	**25**
	0-7% fines content	3.0E-02	0.25	7.5E-03		**26**

Table 4-3. Strength Parameter Values
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

SOIL STRENGTH PARAMETERS FOR SLOPE STABILITY ANALYSIS

SOIL TYPE	Soil Group Description	SOIL STRENTH PARAMETERS FOR SLOPE STABILITY ANALYSIS	
		OCR > 2, or LI ≤ 0.6	OCR < 2, or LI > 0.6
Group 1 Soils Foundation Layers	CL, CH, and MH with Liquid Limit (LL) less than 60 (LL ≤ 60)	c' = 100 psf and $\phi' = 31^0$	c' = 0 psf and $\phi' = 30^0$
Group 1 Soils Embankment Layers		c' = 100 psf and $\phi' = 31^0$	c' = 0 psf and $\phi' = 30^0$
Group 2 Soils Foundation Layers	CH and MH with Liquid Limit Greater than 60 (LL ≥ 60)	c' = 75 psf and $\phi' = 30^0$	c' = 0 psf and $\phi' = 29^0$
Group 2 Soils Embankment Layers		c' = 75 psf and $\phi' = 30^0$	c' = 0 psf and $\phi' = 29^0$
Group 3 Soils Embankment and Foundation Layers	Organic Soils (OL and OH), excluding peat		
Group 4 Soils Foundation Layers	Inorganic Silts, ML,and Clayey Silts CL-ML with Plasticity Index (PI) Lower than 7 (PI < 7), and MH Soils with Liquid Limits (LL) between 25 and 60 (25 < LL < 60)	c' = 50 psf and $\phi' = 32^0$	c' = 0 psf and $\phi' = 32^0$
Group 4 Soils Embankment Layers		c' = 50 psf and $\phi' = 32^0$	c' = 0 psf and $\phi' = 32^0$
SAND and GRAVEL		$\phi' = (20N_{60})^{0.5} + 15$ (Note $\phi' < 35^0$ for embankment and $\phi' < 36^0$ for foundation; Reference:Ohsaki 1959)	

Table 4-4. Seepage Gradient Criteria
Feather River West Levee Rehabilitation Early Implementation Project - Task Order 1

Levee Condition	Location	WSE Condition	Maximum Average Exit Gradient
Existing Conditions	Landside levee toe	DWSE	0.5
		HTOL	0.6
	Bottom of empty ditch at landside toe	DWSE	0.5
		HTOL	0.6
	Bottom of ditch and landside field between toe and 150 feet from toe	DWSE	linear interpolation between 0.5 and 0.8
		HTOL	linear interpolation between 0.6 and 0.9
With Rehabilitation Measures	Landside levee toe, without berm (e.g., with cutoff wall)	DWSE + 1 foot	0.5
		HTOL + 1 foot	0.6
	Landside levee toe with relief wells	DWSE + 1 foot	0.5
		HTOL + 1 foot	0.6
	Bottom of empty ditch at landside toe (without berm)	DWSE + 1 foot	0.5
		HTOL + 1 foot	0.6
	Bottom of empty ditch ≥ 150 feet from toe, with or without berm	DWSE + 1 foot	0.8
		HTOL +1 foot	0.9
	Bottom of ditch between toe and 150 feet from toe, with or without berm	DWSE + 1 foot	linear interpolation between 0.5 and 0.8
		HTOL +1 foot	linear interpolation between 0.6 and 0.9
	Landside levee toe, with berm	DWSE + 1 foot	0.5
		HTOL +1 foot	0.6
	Toe of seepage berm, between landside toe and less than 100 feet from levee toe	DWSE + 1 foot	0.8
		HTOL + 1 foot	does not increase more than 20% from that determined for the DWSE
	Toe of seepage berm between 100 feet and 300 feet from landside levee toe	DWSE + 1 foot	0.8
		HTOL + 1 foot	use engineering judgment
	Toe of seepage berm at or greater than 300 feet from landside levee toe	DWSE + 1 foot	use engineering judgment
		HTOL +1 foot	use engineering judgment

WSE = water surface elevation
DWSE = design water surface elevation
HTOL = hydraulic top of levee

TABLE 5-1A: CHARACTERIZATION OF REACH 1
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
1	SBFCA 10+00 [DWR 2167+00]	SBFCA 129+66 [DWR 2286+00]	2.25	**Toe** CPT – 4 **Crown** CPT – 9 Borings – 6	**Crown Width** • 17 to 20 feet **Landslide Slope** • 1.3H:1V to flatter than 2H:1V **Waterside Slope** • 2.2H:1V to flatter than 3H:1V	• **10+93 (2167+13) 1997:** Light seepage observed. • **29+13 (2185+34) 1997:** Light seepage observed. • **35+85 to 60+50 (2192+06 to 2216+73) 1997:** Severe sloughing due to wave erosion along approximately 1800 feet of waterside slope. • **40+52 to 43+88 (2196+79 to 2200+03) 1997:** Erosion along the waterside levee slope with a vertical face of 6 to 12 inches, half way up the levee. • **48+00 to 53+21 (2204+22 to 2209+44) 1955;** Levee cut to dewater the flooded area in December 1955. • **69+94 (2226+15) 1997:** An area where levee turns sharply to an east-west direction was eroded for about 150 feet. • **73+02 (2229+26) 1986:** A sinkhole approximately 30 feet long, ten feet wide, and ten feet deep right at waterside toe of the levee. This hole was discovered after the 1986 high water receded. There was no landside evidence of this sinkhole during high water. • **98+06 (2254+30) 2006:** Waterside erosion. • Based on DWR's Seepage Area map for the Feather River West Levee area, 100% of Reach 1 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 100% of Reach 1 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **10+03 to 280+77 (2166+00 to 2437+00) 1963**: Levee stabilization construction (USACE Specification 2783, File Drawing 4-4-531). • **73+02 (2229+26) 1986**: Sinkhole at waterside toe filled with gravel. • **98+06 (2254+30) 2006**: Waterside erosion, emergency repair made.	• **Land Side:** Between Stations **10+93 and 54+13 (2167+13 and 2210+33)** Geomorphologic consists of Ra with isolated fingers of Rdc. Station **54+13 (2210+33)** to end of reach consist mainly of Ra with fingers of Hch, Rofc, and Rob. • **Water Side:** Mainly Ra along the levee toe with meandering Rch parallel with waterside ditch.	• **10+93 to 45+80 (2167+13 to 2202+00)**: Low to moderate resistivity within upper 15-20', low to very low resistivity to depth • **45+80 to 106+80 (2202+00 to 2263+00)**: High to very high resistivity (occasionally moderate) within upper 15-25' at 45+80 (2202+00) increasing in depth to greater than 50' between 93+80 (2250+00) and 106+80 (2263+00), possible anomalous deep high resistivity readings at depth from 68+80 (2225+00) to 178+80 (2335+00) on waterside due to bend in levee. • **106+80 to 129+76 (2263+00 to 2286+00)**: Moderate resistivity (occasionally high) within upper 15-25', high to very high below, possible anomalous deep high resistivity readings from 118+80 (2275+00) to 129+80 (2286+00) due to irrigation pipe crossings.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• **Levee Fill:** Consists of variable lenses of clay, silt, sandy silt, silt sand and silty sand. • **Blanket:** Relatively consistent silt, clay, sandy silt and sandy clay blanket with thicknesses ranging from 45 to 60 ft. Isolated lenses (between 1 and 10 ft. thick) of sand and silty sand are shown within the blanket area at different elevations. Below an elevation of -20 ft. MSL, the logs show alternative thin layers of GM/SP/SM/CL.	1) DWR 2262+50 (SBFCA 106+10) = **100-yr, 52.1 ft** 2) Average Head = 13.7 ft	Parallel landside and waterside unlined ditches are present. Near Stations **45+80, 57+80, and 67+80 (2202+00, 2214+00, and 2224+00)** unlined perpendicular ditches tie into parallel ditch. Land side ditch shifts further away from levee toe near Station **57+80 (2214+00)**. Landside ditches ends near Station **67+80 (2224+00)**. Pump Station located in landside ditch near Station **51+80 (2208+00)**. High voltage power pole and line located near Station **72+80 (2229+00)** on waterside. Hwy 99 crosses levee at Station **97+80 (2254+00)**. Sacramento Ave intersects levee road at Station **106+80 (2263+00)**.	SBFCA Station 106+10.50 [DWR Station 2262]	1) WM0003_012B, SM0003_004C, CM0003_004H	Location of potential underseepage problem due to presence of deep sand layers. A ditch is also present at the landside toe, which increases underseepage potential.

TABLE 5-1B: ANALYSIS RESULTS FOR REACH 1
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 1
Analysis Station: 106+11

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.30 to 0.46		0.33 to 0.52	7' above toe	No	The high phreatic breakout point and granular levee fill indicate potential through-seepage issues. Based on stratigraphy and past performance, there may also be isolated areas of shallow underseepage.
100-year + 3 feet	0.35 to 0.55		0.38 to 0.61	8.5' above toe	No	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
100-year	1.36		No	
100-year + 3 feet	1.26		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

For Alternative Analysis, two different models were created using Station 106+11 surface geometry to represent the reach. One model was generated with the existing berm and irrigation ditch and another model was created without the berm or ditch. We show our results for the cross-section without the berm and ditch, because with the berm and ditch in place the toe gradients simply move to the bottom of the ditch due to the close proximity of the toe and ditch. Alternative 1 for Reach 1 is a soil-bentonite cutoff wall extending below relatively shallow silty sand layers into a less permeable clay layer. Alternative 2 for Reach 1 is a drained stability berm and an undrained seepage berm. These alternatives were selected to mitigate through-seepage and shallow underseepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall.

Dimensions of Primary Features: **10+00 to 58+80** Cuttoff Wall Tip Elevation 20ft, **58+80 to 83+00** Cutoff Wall Tip Elevation 18ft, **83+00 to 114+00** Cutoff Wall Tip Elevation 24ft, **114+00 to 129+66** Cutoff Wall Tip Elevation 27ft. Cutoff wall is 3ft wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.31 to 0.49	N/A	0.38 to 0.62	64 ft from Toe	Yes	Results shown on model with berm and ditch removed, which is consistent for portions of the Reach.
100-year + 4 feet	0.37 to 0.57	N/A		Toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.93		Yes	
100-year + 4 feet	1.92		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm.

Dimensions of Primary Features: **10+00 to 129+66**, 8ft tall Drained Stability Berm with 88ft wide Undrained Seepage Berm. Assume 25% of reach will have an undrained seepage berm width extending to 100 ft due to taller levee at some locations. Stability berm is 10ft wide at top, 2ft thick drain, and 3H:1V slope. Seepage Berm thickness - 5ft at levee toe and 3ft at berm toe

Seepage

WSE	Exit Gradient Levee Toe	Stability Berm Toe	Seepage Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot		0.16 to 0.23	0.39 to 0.62	Toe of both berms	Yes	Results shown on model with berm and ditch removed, which is consistent for portions of the Reach.
100-year + 4 feet		0.21 to 0.30	0.44 to 0.72	Toe of both berms	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.90		Yes	
100-year + 4 feet	1.80		Yes	

TABLE 5-2A: CHARACTERIZATION OF REACH 2
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
2	SBFCA 129+66 [DWR 2286+00]	SBFCA 218+66 [DWR 2375+00]	1.69	**Toe** CPT – 9 Borings – 7 **Crown** CPT – 8 Borings – 15 **Field** CPT – 3 Borings – 5	**Crown Width** • 15 to 20 feet **Landslide Slope** • 1.5H:1V to flatter than 2H:1V **Waterside Slope** • 2H:1V to flatter than 3H:1V	• **130+27 to 181+83 (2286+46 to 2338+04) Previous Flood Events:** Excessive seepage occurs during high water between Sacramento Avenue and Laurel Avenue; • **132+87 (2289+07) 1997:** Heavy seepage running clear; • **139+46 (2295+67) 1997:** Heavy seepage running clear; • **144+63 to 146+73 (2300+84 to 2302+92) 1997:** Heavy seepage running clear; • **163+88 (2320+07) 1997:** Heavy seepage running clear; • **175+60 (2331+79) 1997:** Heavy seepage running clear; • **178+72 (2334+92) 1997:** Heavy seepage around tree, running clear; • **183+40 (2339+60) 1997:** Heavy seepage running clear; • **193+16 to 194+70 (2349+37 to 2350+92) 1997:** Heavy seepage running clear; • **197+97 (2354+07) 1986:** Boil 200 feet from landward toe, water was clear and did not carry material; • **201+92 (2358+13) 1997:** Heavy seepage running clear; • **198+42 (2354+62) 1986:** A landside boil occurred in a landside drainage ditch near the levee toe during the 1986 flood, an area of boils appeared at the landside toe and away from the toe, there appears to be a swale or old slough at this location, ditches were reported to be excavated on both sides of the levee to explore for the cause of the boils but no explanation found; • **206+15 to 242+00 (2362+13 to 2398+27) 1997:** Heavy seepage into existing ditch caused sloughing of the bank and the levee slope, clear seepage was entering the ditch. Particularly heavy seepage and sloughing at toe of levee at 2370 to 2374. • **203+77 to 218+79 (2360+00 to 2375+00):** Per B. Hampton of LD-1, this is area of old levee breach and reconstruction. Date unknown. • Based on DWR's Seepage Area map for the Feather River West Levee area, 100% of Reach 2 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 100% of Reach 2 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **129+76 to 190+41 (2286+00 to 2346+55) 1962/1963**: Landside toe berm with 15'-deep drain present (constructed as part of 1962-63 USACE levee stabilization project); • **190+34 to 198+79 (2346+55 to 2355+00 and 2355+41 to 2366+00) 1998**: Toe drain and berm constructed under the Marysville/Yuba City Levee Reconstruction Project (F.R. Site B), 41-foot gap in berm at Laurel Avenue levee ramp access. Also, this is Site 11 (toe drain and berm planned) on project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3" (As-builts?); • **206+29 to 241+93 (2362+13 to 2398+27) 1998**: During 1997 flood, emergency stability berm constructed using sandbags placed on geotextile fabric in drainage ditch, later that year this was converted to a pervious toe drain under the Marysville/Yuba City Levee Reconstruction Project (F.R. Site B).	• **Land Side:** Between Stations **129+76 to 190+41 (2286+00 and 2355+50)** Geomorphology consists of alternating Ra and Rofc. Between Stations **198+79 (2355+00)** and the end of the reach the Geomorphology consists predominantly of Ha with fingers of Rdc. • **Water Side:** Consists of Ra along reach.	• **129+76 to 173+80 (2286+00 to 2330+00)**: Moderate resistivity to depths of 20-40' followed by high resistivity to depths of 100-120'. Moderate resistivity at depths greater than 100-120'; • **173+80 to 218+31 (2330+00 to 2375+00):** Moderate resistivity to depths of 15 to 20 feet (high resistivity zones from **173+80 to 188+80 (2230+00 to 2345+00)** on land/water side), thick very high resistivity zone beneath to depths over 100'.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• **Levee Fill:** Consists of variable lenses of clay, silt, sandy silt, silt sand and silty sand. • **Blanket:** With the exception of two borings at Stations 151+80 and 170+05 (2308+00 and 2326+25), the Reach contains a relatively consistent clay and silty clay blanket between 10 and 25 ft thick. The blanket is overlain and underlain by silty sand and sandy silt of varying thicknesses. At Stations 151+80 and 170+05 (2308+00 and 2326+25) borings indicate levee is underlain by sandy silt to 25 feet below the levee toe elevation. Below an elevation of approximately 0 to 10 ft the borings show interbedded layers of CL/GW-GP/SP/SM/ML to the depths explored.	1) DWR 2337+50 (SBFCA 181+13) = **100-yr, 54.1 ft** 2) Average Head = 16.2 ft	Seepage berm with toe drain located along land side levee toe between Stations **129+76 and 210+30 (2286+00 and 2366+50)**. Irrigation pipe through levee crown at Station **199+80 (2365+00)**. Concrete ditch near end of Reach starting at Station **216+80 (2373+00)** continuing into Reach 3. Audubon Society dirt parking lot and metal structure located near the landslide toe at Station **199+80 (2365+00)**. Water side ditch along entire alignment.	SBFCA Station 181+13 [DWR 2337+50]	1) WM0003_034C, WM0003_035C, WM0003_003A, and WM0003_018C	Presence of sandy layers both in embankment and foundation. Potential thin blanket condition.

TABLE 5-2B: ANALYSIS RESULTS FOR REACH 2
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 2
Analysis Station: 181+13

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.51 to 1.83			4' above toe	No	Results are consistent with past performance of the reach, which consists of significant boils and sloughing at the toe of the levee.
100-year + 3 feet						

Landside Stability

WSE		Performance			Meets Criteria?	
100-year						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 2 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. This alternative was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 2 includes the use of both stability berm with seepage berm and a shallow cutoff wall with a seepage berm. We modeled the seepage berm material type as lean clay, which is similar to the shallow near surface layers. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers and unacceptable gradients through the berm near the levee toe.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall.

Dimensions of Primary Features: **129+66 to 181+00** Cutoff Wall Tip Elevation 20ft, **181+00 to 191+00** Cutoff Wall Tip Elevation (-10ft), **191+00 to 218+66** Cutoff Wall Tip Elevation (-73ft) with full levee de-grade/re-grade. Cutoff wall is 3ft wide and requires 1/2 levee de-grade/re-grade except between station **191+00 and 218+66** where a full levee de-grade/re-grade is required.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.09 to 0.12	N/A		Toe	Yes	
100-year + 4 feet	0.15 to 0.13			Toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.78		Yes	
100-year + 4 feet	1.75		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm and Cutoff Wall with Undrained Seepage Berm

Dimensions of Primary Features: **129+66 to 181+00**, 8ft tall Drained Stability Berm with 100ft wide Undrained Seepage Berm, **181+00 to 218+66** Cutoff Wall Tip Elevation 30ft with 100ft wide Undrained Seepage Berm. Stability berm is 10ft wide at top, 2ft thick drain, and 3H:1V slope. Seepage Berm thickness - 5ft at levee toe and 3ft at berm toe. Cutoff wall is 3ft wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.15	0.57		Intersection Berm/Slope	Yes	Remove thin CL Blanket and underlying SM (4 feet by 200 feet) and replace with Undrained Stability Berm material (CL).
100-year + 4 feet	0.22	0.66		Intersection Berm/Slope	Yes	Remove thin CL Blanket and underlying SM (4 feet by 200 feet) and replace with Undrained Stability Berm material (CL).

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.86		Yes	
100-year + 4 feet	1.81		Yes	

TABLE 5-3A: CHARACTERIZATION OF REACH 3
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
3	SBFCA 218+66 [DWR 2375+00]	SBFCA 300+66 [DWR 2457+00]	1.55	**Toe** CPT – 5 Borings – 9 **Crown** CPT – 9 Borings – 13 **Field** CPT – 3 Borings – 1	**Crown Width** • 17 to 20 feet **Landside Slope** • 1.5H:1V to flatter than 2H:1V **Waterside Slope** • 2H:1V to flatter than 3H:1V	• **206+15 to 242+00 (2362+13 to 2398+27) 1997**: Heavy seepage into existing ditch caused sloughing of the bank and the levee slope, clear seepage was entering the ditch. • **253+70 to 257+92 (2410+00 to 2414+00):** Per B. Hampton with LD-1, water level in landside pond rises with increasing water level behind levee, which leads to bank erosion in the pond. • Based on DWR's Seepage Area map for the Feather River West Levee area, 95% of Reach 3 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 90% of Reach 3 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **206+29 to 241+93 (2362+13 to 2398+27) 1998**: During 1997 flood, emergency stability berm constructed using sandbags placed on geotextile fabric in drainage ditch, later that year this was converted to a pervious toe drain under the Marysville/Yuba City Levee Reconstruction Project (F.R. Site B). • **218+31 to 298+97 (2375+00 to 2455):** Drain consists of fabric-wrapped gravel placed in existing ditch and then backfilled. Concrete lined landside ditch on slightly elevated berm.	• **Land Side:** Geomorphology along levee toe consists of alternating Ha and Rob units. One section of Rcs is shown against the levee toe between Stations **291+05 and 292+80 (2447+25 and 2449+00)**. • **Water Side:** Geomorphology consists of Ra.	• **218+31 to 241+80 (2375+00 to 2398+00)**: Low to moderate resistance throughout profile (low within upper 10-20' of this segment); • **241+80 to 288+80 (2398+00 to 2445+00)**: Alternating high to moderate resistivity zones within the upper 10-20' (waterside mainly high resistivity near-surface) followed by high to very high resistivity to depths of about 100', moderate resistivity below 100'; • **288+80 to 300+80 (2445+00 to 2457+00)**: Primarily high to very high resistivity to a depth of about 50', occasional moderate resistivity zones within the upper 10-20'.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• **Levee Fill:** Consists of variable lenses of clay, silt, sandy silt, silt sand and silty sand. • **Blanket:** ML and CL blanket is present below the levee toe at thicknesses ranging from 10 and 30 ft. The blanket is overlain by thin lenses (less than 5 ft) of silty sand and sand at a few of the boring locations. The blanket is underlain by 10 to 40 ft layers of sand and silty sand. Below an elevation of approximately -20 the borings show interbedded layers of CL/ML/GW/GP//SM to the depths explored.	1) DWR Station 2396+00 (SBFCA Station 239+78) = **100-yr 54.6 ft**, **100-yr + 3ft = 57.5 ft** 2) Average Head 100 yr = 10.6 ft, Average Head 100 yr + 3ft = 13.6 ft	Concrete lined ditch located on land side along entire reach. Pond located on land side near Station **255+80 (2412+00)**. Irrigation pump structure located on water side near Station **298+97 (2455+00)**. Irrigation piping from pump to farm travels through Levee crown near Station **298+97 (2455+00)**. Water side borrow ditch appears to end at Station **265+30 (2421+50)**.	SBFCA Station 239+78 [DWR Station 2396+00]	1) WM0003_022B, WM0003_008C, SM0003_008H	Presence of thin fine-grained blanket layer. The shallow sand and silty layer is about 50 feet thick.

TABLE 5-3B: ANALYSIS RESULTS FOR REACH 3
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 3
Analysis Station: 239+78

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.5	1.7	1.34	Toe	No	Results are consistent with past performance of significant seepage and sloughing at the levee toe.
100-year + 3 feet						

Landside Stability

WSE	FS	Performance			Meets Criteria?	Comments
100-year						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 3 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. This alternative was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 3 consists of a stability berm with a seepage berm. The seepage berm material type is silty sand, which is similar to the shallow near surface layers. Alternative 2 mitigates underseepage and through seepage. Analysis indicates that the 300 ft wide seepage berm could still have high average gradients at the toe of the berm. Therefore, we recommend monitoring the berm toe for future seepage. If boils occur at the toe of the berm, wells or a collection drain will be required.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: **218+66 to 220+00** Cutoff Wall Tip Elevation (-73ft), **220+00 to 230+00** Cutoff Wall Tip Elevation 20ft, **230+00 to 250+00** Cutoff Wall Tip Elevation (-35ft), **250+00 to 289+00** Cutoff Wall Tip Elevation (-20ft), **289+00 to 300+66** Cutoff Wall Tip Elevation 15ft. Cutoff wall is 3ft wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	0.08	0.48		57 ft from Toe	Yes	
100-year + 4 feet	0.11	0.56		57 ft from Toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	1.4		Yes	
100-year + 4 feet	1.4		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm.

Dimensions of Primary Features: **218+66 to 300+66** 8ft tall Drained Stability Berm with 300ft Wide Undrained Seepage Berm with monitoring for seepage at the toe of the Undrained Seepage Berm. Drained Stability Berm is 10ft wide at top, 2ft thick drain, and 3H:1V slope. Undrained Seepage Berm thickness - 5ft at levee toe and 3ft at berm toe

Seepage

WSE	Exit Gradient Levee Toe	Stability Berm Toe	Seepage Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot		0.17	1.31	Toe of both berms	Yes	Monitor seepage at the toe of the Undrained Seepage Berm.
100-year + 4 feet		0.29	1.52	Toe of both berms	Yes	Monitor seepage at the toe of the Undrained Seepage Berm.

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	2.01		Yes	
100-year + 4 feet	2.00		Yes	

TABLE 5-4A: CHARACTERIZATION OF REACH 4
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
4	SBFCA 300+67 [DWR 2457+00]	SBFCA 410+67 [DWR 2567+00]	2.1	**Toe** CPT – 5 Borings – 1 **Crown** CPT – 11 Borings – 5 **Field** CPT - 1	**Crown Width** • 15 to 20 feet **Landslide Slope** • 1.7H:1V to flatter than 2H:1V **Waterside Slope** • 1.5H:1V to flatter than 3H:1V	• **359+42 (2515+65) 1986**: During the 1986 flood, a crack formed in the levee. (F.R. Site C) This site is located 2.4 miles south of Star Bend (LM 1.5). • **362+10 to 370+02 (2518+29 to 2526+22) 1997**: During the 1997 flood, seepage occurred at the site (same location of 1986 crack). (F.R. Site C) • Based on DWR's Seepage Area map for the Feather River West Levee area, 85% of Reach 4 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 80% of Reach 4 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **354+50 to 364+44 (2510+73 to 2520+67) 1998**: Toe Drain and Seepage/Stability Berm constructed. A pervious toe drain and seepage/stability berm have been constructed at this site under a PL 8499 action (F.R. Site C)	• **Land Side:** Between **300+80 and 349+80** (**2457+00 and 2506+00)** Geomorphology consists of alternating Ra, Ha and Rcs. Between **349+80 and 385+80** (**2506+00 and 2542+00)**- Geomorphology consists of alternating Hob and Rcs. Between **385+80** (**2542+00) to the end of the reach** the Geomorphology consists of alternating layers of Rob and Qmu. • **Water Side**: Geomorphology consists of Ra from the **start of the reach to 311+80** (**2468+00)** and consists of Rb from **311+80 (2468+00) to the end of the reach**, with Rofc between Ra and Rb and the water.	• **0 - 10' bgs:** Generally low to moderate resistance crest and land side, high resistance water side. Exceptions: At crest: low resistance from 313+80 to 327+80, 351+80, 353+80, from 408+30 to 411+80 (**2470+00 to 2484+00, 2508+00, 2510+00, from 2564+50 to 2568+00)**; land side: low resistance from 312+80 to 315+30, 312+80 to 410+80 (**2469+00 to 2471+50, 2469+00 to 2567+00)**; water side - low resistance between 323+80 to 334+80 (**2480+00 to 2491+00)** and in between moderate zones at 320+30 to 337+80, 377+80 to 379+80 (**2476+50 to 2494+00, 2534+00 to 2536+00)**. Moderate resistance water side**:** 350+30 (**2506+50) to end of reach** with some high resistance near 393+80 and 406+80 (**2550+00 and 2563+00)**. • **10' - 40' (50' water side):** High resistance from 300+80 to 317+80 (**2457+00 to about 2474+00)** for water, land and crest. 317+80 (**2474+00) to end of reach**, moderate resistance crest and water side, with areas of low resistance along the crest, mainly low resistance land side. • **40' to 150':** moderate resistance for crest, land and water side except areas of low resistance land side from 319+80 to 337+80 and 406+80 to 410+80 (**2476+00 to 2494+00 and 2563+00 to 2567+00)**.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• **Levee** materials generally consist of sandy silt and silty sand with lesser sand and clay layers between 300+80 and 363+80 (2457+00 and 2520+00), then predominately silt and clay between 363+80 and 410+80 (2520+00 and 2567+00). • **Blanket** generally consists of silt and clay that extends 25 to 40 feet below the base of the levee. Local soft layers are present 6 to 10 feet below the base of the levee. Isolated silty sand layers are present within the blanket between approximate 372+80 and 391+80 (2529+00 and 2548+00). Below about elev. 12 ft MSL, soil generally consists of alternating layers/lenses of silty sand, sand, gravel, silt, and clay of varying thickness.	1) DWR 2462+50 (SBFCA 306+33) **100-yr = 54.7 ft, 100 yr + 3 ft = 57.7 ft** 2) Average Head 100 yr = 12.5 ft, Average Head 100 yr + 3ft = 15.5 ft	At about **409+80 (2566+00)**, sump pond located at landside toe and pump station located at riverside toe with associated pipes crossing through levee. Otherwise the area adjacent to the landside levee is used for agricultural purposes.	SBFCA 306+33 [DWR 2462+50]	1) WL0001_023C: SL0001_001C: SL0001_001H	Shallow thin previous layers are present at this section, which is a good representation of this reach.

*SBFCA station numbers based on 2156+20 subtracted from older DWR stations.
**SBFCA station numbers provided by WoodRodgers.

TABLE 5-4B: ANALYSIS RESULTS FOR REACH 4
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 4
Analysis Station: 306+33

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.17 to 0.46	N/A	0.2 to 0.52	5.8' above Toe	No	The high phreatic surface breakout point and granular fill indicate potential through seepage issues. Based on stratigraphy and past performance, there may also be isolated areas of shallow underseepage.
100-year + 3 feet	0.22 to 0.59		0.26 to 0.64	7' above Toe	No	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
100-year		Isolated seepage and failure at the toe.	No	Landside stability criteria not met due to historic seepage and failure at the toe and possible crack in levee.
100-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
100-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 4 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. Alternative 2 for Reach 4 is a stability berm with a seepage berm. Both alternatives were selected to mitigate through-seepage and shallow underseepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall.

Dimensions of Primary Features: **300+66 to 349+00** Cutoff Wall Tip Elevation 15ft, **349+00 to 368+00** Cutoff Wall Tip Elevation 10ft, **368+00 to 410+67** Cutoff Wall Tip Elevation 20ft. Cutoff wall is 3ft wide and requires 1/2 levee de-grade/re-grade.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	See Reach 1				Yes	Subsurface conditions, past performance and Problem Identification seepage results are similar to Reach 1 and therefore mitigation is consistent with Reach 1 results.
100-year + 4 feet	See Reach 1				Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	See Reach 1		Yes	
100-year + 4 feet	See Reach 1		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm

Dimensions of Primary Features: **300+66 to 410+67**, 8ft tall Drained Stability Berm and 100ft wide Undrained Seepage Berm. Stability berm is 10ft wide at top, 2ft thick drain, and 3H:1V slope. Seepage Berm thickness - 5ft at levee toe and 3ft at berm toe

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year + 1 foot	See Reach 1			Intersection Berm/Slope	Yes	Subsurface conditions, past performance and Problem Identification seepage results are similar to Reach 1 and therefore mitigation is consistent with Reach 1 results.
100-year + 4 feet	See Reach 1			Intersection Berm/Slope	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
100-year + 1 foot	See Reach 1		Yes	
100-year + 4 feet	See Reach 1		Yes	

TABLE 5-5A: CHARACTERIZATION OF REACH 5
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)* [DWR ULE STATION]	END STATION (SBFCA)* [DWR ULE STATION]							
5	SBFCA 410+67 [DWR 2567+00]	SBFCA 478+67 [DWR 2635+00]	1.3	**Toe** CPT – 9 Borings – 3 **Crown** CPT – 7 Borings – 4 **Field** CPT - 2	**Crown Width** • 15 to 20 feet **Landslide Slope** • 1.5H:1V to flatter than 2H:1V **Waterside Slope** • 2H:1V to flatter than 3H:1V	• **425+33 to 478+80** (**2581+57 to 2635+00) 1997**: Four boils at landside toe of levee. • **467+47 to 495+72 (2623+92 to 2650+22) 1986**: During the 1986 flood, boils carrying soil formed near the landside toe of the levee. The ground within approximately 100 feet of landside toe was very soft and wet. The peak floodwater was 5-6 feet below the top of the levee at this location. LDI personnel constructed sandbag rings around three of the worst boils. (F.R. Site D) • Based on DWR's Seepage Area map for the Feather River West Levee area, 100% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 100% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation.	• **242+80 to 478+80** (**2581+00 to 2635+00) unknown date**: An undrained stability berm was constructed at landside toe of levee.	• **Land Side:** Between **410+80 (2567+00)** to the end of the reach Geomorphology consists predominantly of Rob with a finger of Qmu. • **Water Side**: Consists of Rb with Rofc between Rb and the water.	• Crest, LS, and WS Profiles similar. **0 - 150' bgs**: Generally alternating moderate to high resistance for entire reach to about 100' depth, high resistance depths greater than 100'. Exceptions: Low resistance noted from **410+80 to 420+80** (**2567+00 to 2577+00)**, and from **435+80 to 439+80** (**2592+00 to 2596+00)** at about 40' to 70' depth landside, and from **443+80 to 457+80** (**2600+00 to 2614+00)** from the ground surface to 10' and dipping to about 50' near **447+80 (2604+00)** landside.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			DWR ULE STATION (SBFCA STATION)		
• **Levee** materials generally consist of silt and clay with lenses of sandy silt at about Sta. 438+80 (2595+00). • **Blanket** generally consists of silt and clay that extends 5 to 20 feet below the base of the levee. A hardpan layer is generally present at a depth of 5 to 9 feet except at 416+80 (2573+00), 427+34 (2583+54), and 466+40 (2622+60). Sand and silty sand layers/lenses 4 to 10 feet thick are present at a depth of 5 to 20 feet below the base of the levee. Sand and gravel layer present at about 30 to 35 feet below the base of the levee that extends to the bottom of 110'- deep explorations.	1) DWR 2633+00 (SBFCA 477+01) **200-yr 64.0 ft** 2) Average Head 200yr = 13.4 ft	No significant constraints or features identified within this Reach. No landside ditches present. The area adjacent to the landside levee is used for agricultural purposes. Significant water-side excavations present along the entire reach.	1) DWR 2633+00 (SBFCA 477+01)	1) WL0001_020C: WL001-059C: WL0001_036C: B5-07 (BCI): B1-06 (BCI): SL0001_003C: SL0001- 003H	A relatively thick layer of sand and silty sand present at about 20 feet below the landside levee toe. The thickness of this layer increases landside based on the toe and field explorations.

TABLE 5-5B: ANALYSIS RESULTS FOR REACH 5
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 5
Analysis Station: 477+01

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.40 to 0.46	0.99 to 1.75		At Toe	No	Results are consistent with historic significant seepage and boils at the toe
Landside Stability						
WSE		Performance			Meets Criteria?	
200-year						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 5 is a soil-bentonite cutoff wall and a soil-benonite cutoff wall with a 200ft seepage berm. Alternative 2 for Reach 5 is a seepage berm. The seepage berm material type is lean clay, which is similar to the shallow near surface layers. The alternative reduces the potential for seepage through shallow near surface sandy layers and unacceptable gradients. Analysis indicated that from 444+00 to 478+67, the 300 ft wide undrained seepage berm could still have high average gradients at the toe of the berm. Therefore, we recommend monitoring the berm toe for future seepage. If boils occur at the toe of the berm, wells or a collection drain will be required.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall and Soil-Bentonite Cutoff Wall with Seepage Berm

Dimensions of Primary Features: **410+67 to 417+00** Cutoff Wall Tip Elevation 20ft, **417+00 to 425+00** Cutoff Wall Tip Elevation 10ft, **425+00 to 456+00** Cutoff Wall Tip Elevation 15ft, **456+00 to 478+68** Cutoff Wall Tip Elevation 15ft with 200ft Wide Undrained Seepage Berm. Cutoff wall is 3ft wide and requires 1/2 levee de-grade/re-grade. Undrained Seepage Berm thickness - 5ft at levee toe and 3ft at berm toe.

Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	Subsurface conditions, past performance and Problem Identification seepage results are similar to Reach 3 and therefore
200-year + 4 feet	See Reach 3				Yes	mitigation is consistent with Reach 3 results.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	
200-year + 4 feet	See Reach 3				Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm

Dimensions of Primary Features: **410+67 to 444+00**, 300ft Wide Undrained Seepage Berm, **444+00 to 478+68**, 300ft Wide Undrained Seepage Berm with monitoring for seepage at the toe of the berm. Undrained Seepage Berm thickness - 5ft at levee toe and 3ft at berm toe.

Seepage						
WSE	Exit Gradient Levee Toe	Seepage Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	Monitor seepage at the toe of the Undrained Seepage Berm.
200-year + 4 feet	See Reach 3				Yes	Monitor seepage at the toe of the Undrained Seepage Berm.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	See Reach 3				Yes	
200-year + 4 feet	See Reach 3				Yes	

TABLE 5-6A: CHARACTERIZATION OF REACH 6
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)*	END STATION (SBFCA)*							
	[DWR ULE STATION]	[DWR ULE STATION]							
6	SBFCA 478+67 [DWR 2635+00]	SBFCA 510+37 [DWR 2676+00]	0.78		3:1 land-side and water-side slopes with minimum 20-foot-wide crown.	• Significant seepage prior to construction of setback levee and slurry wall. • Based on DWR's Seepage Area map for the Feather River West Levee area, 95% of Reach 6 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 95% of Reach 6 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• Setback levee with SB cutoff wall constructed in 2009 within this entire reach. Cutoff wall tie-ins are SCB and extend 125' north into the existing levee and 150' south into the existing levee. The SB cutoff wall is 40 to 45 feet deep at the north tie-in and 62 to 67 feet deep at the south tie-in. • The new levee was constructed of levee fill meeting USACE classification and compaction criteria. • The wall depths and cutoff clay layer depths were confirmed during construction. • Seepage, stability and settlement analyses were performed during design of the setback levee by Blackburn Consulting consistent with USACE criteria and results indicate all criteria was met with regards to seepage gradients, slope stability factors of safety and settlement magnitude.		

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			DWR ULE STATION (SBFCA STATION)		
					New setback levee and SB cutoff wall along entire reach constructed in 2009 in accordance with USACE criteria. This reach will be "certified" under the Star Bend Setback Levee project close-out documentation, which will be referenced in the final FRWL design-level report.

TABLE 5-7A: CHARACTERIZATION OF REACH 7
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT – TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA)* [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA)* [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION – CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
7	SBFCA 510+37 [DWR 2676+00]	SBFCA 598+87 [DWR 2765+00]	1.68	**Toe** CPT – 23 Borings – 11 **Crown** CPT – 30 Borings – 14 **Field** CPT – 4	**Crown Width** • 15 to 20 feet **Landslide Slope** • 2H:1V to flatter than 2H:1V **Waterside Slope** • 3H:1V to flatter than 3H:1V	• **510+69 to 556+25 (2677+06 to 2722+50) 1995:** Seepage -- the site is located between Star Bend Road and Abott Road at approximate River Mile 18.1 and 19.0 (LM 4.1 to 5.0). During the 1995 flood, clear seepage exited the levee toe and the ground beyond the levee toe while the river level was approximately 12 to 15 feet below the top of levee. (F.R. Site E). • **510+69 to 556+25 (2677+06 to 2722+50) 1997:** Boils and seepage. During the 1997 flood, numerous boils occurred in a 200 linear foot stretch. Sandbag rings were constructed around the boils that were moving material. The following day, the sandbagged boils were flowing clear. (F.R. Site E) • **521+50 (2687+62) 1997:** Boil at landside levee toe. • **532+60 (2698+72) 1997:** Two boils at landside levee toe. • **534+71 (2700+83) 1997:** Three boils at landside levee toe. • **540+02 (2706+13) 1997:** Three boils at landside levee toe. • **543+20 to 547+58 (2709+28 to 2713+51) 1997:** Seventeen (17) boils at landside levee toe. • **592+34 (2758+48) 1986:** Erosion, site located at LM 6.1 near Abbott Lake, north of O'Banion Road at approximately River Mile 19.7. During the 1986 flood, holes appeared at the top of waterside levee berm. It is believed that the holes were result of small trees growing on the berm. The berm slope down to natural ground was eroded. The water was within 5 feet of the top of the levee (F.R. Site F) 2006 - Boils reported in 2006 adjacent to and north of the relief well field. • Based on DWR's Seepage Area map for the Feather River West Levee area, 95% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 95% of Reach 7 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• **510+87 to 555+88 (2677+00 to 2722+00) date unknown**: Toe Berm constructed from the north end of Star Bend Road to the south end of Abbott Lake Road. Project Plans entitled "PL 84-99 Phase III, Relief Wells - LD1, Feather River at Star Bend, dated 8/18/1997. USACE File No. 04-04-617" • **526+72 to 542+10 (2692+50 to 2708+20) 1997**: In 1997, the Corps of Engineers installed relief wells in this area to reduce seepage and instability of the levee under PL 84-99 contract. (F.R. Site E). A total of 25 relief wells from 1550 feet north of north end of Star Bend Road to 1380 feet south of the south end of Abbott Lake Road. Project Plans entitled "PL 84-99 Phase III, Relief Wells - LD1, Feather River at Star Bend, dated 8/18/1997. USACE File No. 04-04-617". Significant seepage continued (heavy in 2006) after wells were constructed. Top of wells and collection ditch appear to be too high to mitigate seepage and/or no confining layer present to force near-surface water into wells.	• **Land Side:** Between **510.25 to 568+38** (**2676+00 to 2734+50)** Geomorphology consists of alternating Rcs, Rob, Qmu. From **568+38** (**2734+50) to the end of the reach**, Geomorphology consists of Qmu. • **Water Side**: Geomorphology consists of Rb from the beginning **of the reach to 517+88** (**2684+00)** and then consists of Ra to the end of the reach.	• **0 - 10' bgs:** Generally low resistance from **509+88 to 529+88** (**2676+00 to 2696+00)** with some moderate resistance interspersed. Alternating moderate and high resistance **529+88** (**2696+00) to the end of the reach**. • **10' - 40':** Moderate resistance land and crest, moderate to high resistance water side **509+88 to 535+88** (**2676+00 to 2702+00)**. Exception: low resistance from about **509+88 to 526+88** (**2676+00 to 2693+00)** land side. High resistance **526+88 to 580+88** (**2693+00 to 2747+00) 583+88** (**2750+00 water side)**. Moderate resistance to end of reach. • **40' to 150':** Generally moderate resistance land and water side from **509+88 to 583+88** (**2676+00 to 2750+00)** except areas of low resistance land side from **555+88 to 558+38** (**2722+50 to 2724+50)** at about 120' to 150' depths and water side from **548+88 to 555+88** (**2715+00 to 2722+00)** at about 100' to 150' depths. High resistance water side from **beginning of reach to 528+88 (2695+00)** to depths of 60' and to **519+88** (**2686+00)** at greater depths. Crest - moderate resistance 40' to about 100', low resistance 100' to 150' (moderate resistance from **566+88 to 575+88** (**2733+00 to 2742+00**). From **583+88 to 598+88** (**2750+00 to 2765+00)**, moderate resistance from 40' to about 100' depths, low resistance from 100' to 150' depths.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] DWR ULE STATION (SBFCA STATION)	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• **Levee** materials generally consist of silt and clay with lenses of sandy silt. • **Blanket** generally consists of silt and clay that extends 7 to 10 feet below the base of the levee. A hardpan layer is locally present below the silt and clay. Locally, 1 to 2 foot thick lenses of sand and silty sand are present near the base of the levee. Sand and silty sand layers/lenses 5 to 35 feet thick are present at a depth of 7 to 10 feet below the base of the levee. 1' to 2' thick lenses of very soft, fine grained soil (sometimes organic) within the upper 5' of soil below levee and at the toe. This is likely old lakebed material.	1) DWR 2705+00 (SBFCA 539+30) **200-yr 65.9 ft** 2) Average Head = 18 ft	Landside lined ditch present at levee toe between approximate 511+88 and 555+88 (2678+00 and 2722+00) at levee toe. Relief wells present at levee toe between 526+38 to 542+08 (2692+50 to 2708+20). The area adjacent to the landside levee is used for agricultural purposes. Significant water-side excavation present within 50 to 100 feet of levee toe. Levee was constructed over old lakebed.	1) SBFCA 539+30 (DWR 2705+00)	1) WL0001_084C: WL0001_088B: WL0001_089B: SL0001_004C: SL0001_004H	Blanket layer is approximately 10 feet thick and underlain by sand and silty sand layers.

TABLE 5-7B: ANALYSIS RESULTS FOR REACH 7
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Results for Reach 7
Analysis Station: 539+30

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.55	N/A	2.7	11.5 ft above Toe	No	Results are consistent with significant historic seepage and boils.

Landside Stability

WSE		Performance			Meets Criteria?	
200-year						

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 7 is a soil-bentonite cutoff wall extending below sand/silty sand layers into a less permeable clay/silt layer. This alternative was selected as an in-place alternative to mitigate both through-seepage and underseepage. Alternative 2 for Reach 7 consists of a stability berm with a seepage berm. The seepage berm material type is lean clay, which is similar to the shallow near surface layers. Alternative 2 mitigates underseepage and through seepage. Analysis indicates that the 300 ft wide seepage berm could still have high average gradients at the toe of the berm. Therefore, we recommend monitoring the berm toe for future seepage. If boils occur at the toe of the berm, a collection drain will be required. We recommend the existing wells be abandoned in place. Based on the Corp information, lowering the well discharge point would be an option if a consistent confining layer was present. Due to lack of a consistent confining layer shown in the Army Corp well logs and significant seepage in 2006 after the wells were installed, the wells do not appear to be a viable solution for reuse as part of the repair option for Reach 7.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: **510+37 to 528+00** Cutoff Wall Tip Elevation 15ft, **528+00 to 546+00** Cutoff Wall Tip Elevation (-10ft), **546+00 to 565+00** Cutoff Wall Tip Elevation (-65ft) with Full Levee Degrade, **565+00 to 576+00** Cutoff Wall Tip Elevation (-50ft), **576+00 to 584+00** Cutoff Wall Tip Elevation (-10ft), **584+00 to 598+87** Cutoff Wall Tip Elevation 20ft. Cutoff wall is 3ft wide and requires 1/2 levee de-grade/re-grade except between station **546+00 to 565+00** where a full levee de-grade/re-grade is required.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.05	N/A		Toe	Yes	
HTOL	0.05			Toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.09		Yes	
HTOL	2.09		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Drained Stability Berm with Undrained Seepage Berm

Dimensions of Primary Features: **510+37 to 598+87**, 9.5ft tall, Drained Stability Berm with 300ft Wide Undrained Seepage Berm with monitoring for seepage at the toe of the berm. Drained Stability Berm is 13ft wide at top, 2ft thick drain, and 3H:1V slope. Height of the Undrained Seepage Berm at Levee Toe is 7ft tall due to high gradients across the seepage berm/blanket, 3ft tall at berm toe.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.47	1.39		Stability Berm Toe	No	Monitor seepage at the toe of the Undrained Seepage Berm.
HTOL	0.57	1.53		Stability Berm Toe	No	Monitor seepage at the toe of the Undrained Seepage Berm.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.77		Yes	
HTOL	1.57		Yes	

TABLE 5-8A: CHARACTERIZATION OF REACH 8
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
8	598+84 [2765+00]	654+75 [2821+00]	1.11	Total Number of Explorations = 19; Crest Explorations = 11 (SPT - 5, CPT - 6); Landside Toe Explorations = 6 (SPT - 3, CPT - 3); Landside Field Explorations = 2 (CPT - 2)	**Crown Width :** approximately 20 feet **Landside slope** approximately 2H:1V to flatter than 2H:1V **Waterside Slope** approximately 2H:1V to flatter than 3H:1V	602+88 [2769+01] to 640+32 [2806+45]: Twenty-six (26) sinkholes on waterside berm of levee (1997). According to Bill Hampton of LD1, these sinkholes were 3 feet to 6 feet deep and 2 feet to 4 feet in diameter and formed on the waterside berm, which was the original levee before it was raised. Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 2/3 rd of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 2/3 rd of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	602+88 [2769+01] to 640+32 [2806+45]: After the flood, 26 sinkholes were repaired by compacting soil (1997).	R_{SL} (Recent Slough deposits) R_a (Recent Alluvium) R_{ob} (Recent Overbank)	High resistivity soil layers present at approximately 10 feet below the embankment. The highly resistive layers extends to the ground surface occasionally.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Sand (SP, SM), Silt and Clay **Foundation**: Near Surface layers include Sand (SP), Clay (CL). Landside toe and field explorations indicate shallow Sand layers. Hardpan and soft layers were encountered within shallow foundation layers.	**200 yr WSE** Head = approximately 18.8 feet at the analysis section	Mostly Agricultural. A pond is located on the landside of the levee between Sta. 646+86 [2813+00] and Sta. 648+86 [2815+00].	623+86 [2790+00]	WL0001_049B, WL0001_049C, 2F-91-10 (CREST), WL0001_074C, WL0001_061C, SL0001_005C (LANDSIDE TOE), WL0001_117C, 2F-91-10A, WL0001_110C (FIELD)	Presence of sand in levee embankment may indicate potential for through seepage; shallow sand layers in foundation and relatively thin fine-grained blanket may indicate potential for underseepage; deep sand layers encountered at approximately similar depths as other explorations within this reach.

TABLE 5-8B: ANALYSIS RESULTS FOR REACH 8
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 623+86

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.77	N/A	N/A	1.0	No	The existing levee embankment material is silty sand underlain by approximately 5.2 feet of silty sand and 4.3 feet of clay blanket.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative1 for Reach 8 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 8 is a seepage berm with a shallow cutoff wall. The seepage berm material type is silty sand, which is similar to the shallow near surface layer. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features: 3 feet wide and 45 feet deep cutoff wall starting at Elevation 60 (half levee degrade)						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.90				Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.89				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Seepage Berm and Shallow Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features: Seepage Berm - 130 feet wide berm, 3 feet thick at berm toe and 5 feet thick at levee toe, berm soil type - silty sand Shallow Cutoff Wall - 3 feet wide and 21.5 feet deep cutoff wall starting at Elevation 60 (half levee degrade)						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.27	0.63	N/A	No Breakout	Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	0.34	0.70	N/A	No Breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.86				Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	1.81				Yes	

TABLE 5-9A: CHARACTERIZATION OF REACH 9
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
9	654+75 [2821+00]	706+50 [2872+75]	0.98	Total Number of Explorations = 17; Crest Explorations = 10 (SPT - 5, CPT - 5); Landside Toe Explorations = 6 (SPT - 4, CPT - 2); Landside Field Explorations = 1 (CPT - 1)	**Crown Width :** approximately 10 feet to 20 feet **Landside slope** Approximately 2H:1V or flatter than 2H:1V **Waterside Slope** Approximately 3H:1V to flatter than 3H:1V	• 655+57 [2821+72] to 279+10 [2845+25]: Waterside bank erosion encroaching on the levee section. (F.R. Site G) (Unknown Year). The site is located near Messick Road at approximate River Mile 21.2 (LM 7.3). • 677+72 [2843+88]: Scour on waterside berm of levee (1997) • 692+50 [2858+65]: This site is at the Boyd Pump Boat Ramp at LM 8, between Messick Road and Oswald Avenue at approximate RM 21.7. During the 1986 flood, portions of the boat ramp parking lot and subgrade and portions of the levee toe were eroded. (F.R. Site H) (1986) • 699+35 [2865+51]: Bank erosion at pump structure at waterside levee (1997) Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 1/4 th of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 1/2 of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	655+83 [2820+78] to 706+50 [2872+50]: In 1998, the Corps raised the levee 1-foot and installed a pervious toe drain and seepage/stability berm at the site under the Marysville/Yuba City Levee Reconstruction Project. (F.R. Site H). Site 9: Toe drain and berm from LM 7.28 to LM 8.26. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	R_{SL} (Recent Slough deposits) R_a (Recent Alluvium) R_{ofc} (Recent Overflow Channels) BP (Borrow Pit present in 1937) SP (Spoils present in 1937)	High resistivity soil layers present at approximately 10 ft below the embankment. The resistive layer extends to the ground surface occasionally.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Sand (SP, SM) and Silt (ML). Sand encountered in the entire levee embankment (from levee crown to levee toe) in several explorations. **Foundation**: Near Surface layers include Sand (SP-SM), Clay (CL), and Silt (ML). Thick porous layers are present in multiple layers.	**200 yr WSE** Head = approximately 17.6 feet at the analysis section	Mostly Agricultural. Scattered houses and Sheds observed from aerial maps.	705+84 [2872+00]	WL0001_010S, 2F-91-14 (CREST), WL0001_079C, WL0001_004B, 2F-91-14A (TOE), WL0001_111C (FIELD)	Sand and silty sand in levee embankment may indicate potential for through seepage; sandy foundation layer present near the surface indicate potential for shallow seepage (leaking layer); fine-grained layer below surface sandy layer create potential blanket condition for underseepage; deep sand/gravel layers also present.

TABLE 5-9B: ANALYSIS RESULTS FOR REACH 9
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 705+84

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.59	N/A	N/A	3.7	No	High breakout point, which is an indication of through seepage potential is due to sandy materials in the embankment.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 9 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 9 is seepage berm with shallow cutoff wall. Seepage berm material type is silty sand, which is similar to shallow near surface layers. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 45.5 feet deep cutoff wall starting at Elevation 64.5 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.08	N/A	N/A	At the landside levee toe	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	0.10	N/A	N/A	At the landside levee toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.37		Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	2.28		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Seepage Berm - 110 feet wide berm, 3 feet thick at berm toe and 5 feet thick at levee toe, and berm soil type - silty sand
Shallow Cutoff Wall - 3 feet wide and 29.5 feet deep cutoff wall starting at Elevation 64.5 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.15	0.49	N/A	At the landside levee toe	Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	0.21	0.54	N/A	At the landside levee toe	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.45		Yes	Seepage berm and shallow cutoff wall alternative meets criteria both at levee toe and berm toe.
200-year + 4 feet	2.39		Yes	

TABLE 5-10A: CHARACTERIZATION OF REACH 10
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
10	706+50 [2872+75]	774+00 [2940+25]	1.28	Total Number of Explorations = 20; Crest Explorations = 11 (SPT - 6, CPT - 5); Landside Toe Explorations = 8 (SPT - 5, CPT - 3); Landside Field Explorations = 1 (CPT - 1)	**Crown Width :** approximately 18 feet to 20 feet **Landside Slope** approximately 2H:1V to flatter 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 7/10 th of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 3/5 th of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	No documentation of existing levee improvements were found in the reviewed documents or site walk with LD1 representative.	R_{ob} (Recent Overbank) H_a (Holocene Alluvium) H_{ofc} (Holocene Overflow Channels)	Approximately 60 feet thick, continuous, high resistivity soil layer is present at approximately 10 feet below the embankment from 706+65 [2872+65] to 739+92 [2906+00]. The high resistive layer is not observed beyond Sta. 739+92 [2906+00] to the end of the Reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Sand (SP, SP-SM, SC). Foundation: Near Surface layers include SM, CL, ML. Thick (~ 25 feet) pervious zones was encountered at about 25feet below the embankment in crest explorations. Blanket thins at the toe explorations.	**200 yr WSE** Head = approximately 17.6 feet at the analysis section	Garden highway runs parallel along 1200 feet of this Reach.	733+84 [2900+00]	2F-91-15, CF-88-9, WL0001_057C, WL0001_058C (CREST), 2F-91-15A and SL0001_001B (LANDSIDE TOE)	Sandy layers in levee embankment may indicate potential for through seepage; Location coincide with high resistivity soils shown in HEM differential resistivity profiles; Moderately thick fine-grained blanket layer (about 30 feet thick) encountered in the explorations within this reach in the crest explorations, however blanket thins based on the landside toe explorations.

TABLE 5-10B: ANALYSIS RESULTS FOR REACH 10
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 733+84

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.86	N/A	N/A	5.8	No	High breakout point due to sandy materials in the embankment.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative 1 for Reach 10 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 10 is seepage berm with shallow cutoff wall. Seepage berm material type is silt, which is similar to shallow near surface layers. The shallow cutoff wall reduces the potential for seepage through shallow near surface sandy layers. Exit gradient at the toe of 300 feet wide berm is high. Seepage conditions should be monitored during floods. If needed, a relief well or drainage system may be needed at the toe of the berm.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features: 3 feet wide and 68.5 feet deep cutoff wall starting at Elevation 64.9 (half levee degrade)						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.99				Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.99				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Seepage Berm and Shallow Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features: Seepage Berm - 300 feet wide berm, 3 feet thick at berm toe and 7.2 feet thick at levee toe, and berm soil type - silt Shallow Cutoff Wall - 3 feet wide and 35 feet deep cutoff wall starting at Elevation 65 (half levee degrade)						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.29	0.89	N/A	0	Meets criteria at levee toe. See Comments on berm toe.	Exit gradient at the toe of 300 feet wide berm is high. Seepage conditions should be monitored during floods. If needed, a relief well or drainage system may be needed at the toe of the berm.
200-year + 4 feet	0.38	1.0	N/A	0		
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.00				Yes	
200-year + 4 feet	1.99				Yes	

TABLE 5-11A: CHARACTERIZATION OF REACH 11
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
11	774+00 [2940+25]	830+00 [2996+25]	1.06	Total Number of Explorations = 15; Crest Explorations = 9 (SPT - 6, CPT - 3); Landside Toe Explorations = 4 (SPT - 2, CPT - 2); Landside Field Explorations = 2 (CPT - 2)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** approximately 2H:1V to flatter than 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	812+50 [2978+75]: During 1997 flood, a boil developed around a tree. Clean water was coming out. Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 2/3 rd of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 2/3 rd of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations.	No documentation of existing levee improvements were found in the reviewed documents or site walk with LD1 representative.	R_{ob} (Recent Overbank) R_a (Recent Alluvium)	Approximately 50 feet thick, continuous, high resistivity soil layer is present immediately below the embankment in this Reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: SP, SM, ML, CL **Foundation**: Fine-grained blanket less than 10 feet thick underlain by approximately 10 to 30 feet thick pervious layers.	**200 yr WSE** Head = approximately 14.8 feet at the analysis section	Mostly agricultural with scattered residential houses. Mostly urban in the northern 700 feet (approximately) of the reach (Yuba City)	808+85 [2975+00]	2F-07-01 (CREST), SL0001_008C (TOE), CPT-11 (FIELD)	Thin fine-grained blanket encountered in the boring and CPT underlain by thick pervious layers may indicate potential for underseepage; Approximately 30 feet thick pervious zone (SP layer) below the fine-grained blanket was encountered in both crest and landside toe explorations approximately at the same elevations.

TABLE 5-11B: ANALYSIS RESULTS FOR REACH 11
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 808+85

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.38	N/A	N/A	8.4 feet above LS toe	No	High breakout point due to presence of silt layer in the levee.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative 1 for Reach 11 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 11 is seepage berm with drained stability berm. Seepage berm material type is sandy silt, which is similar to shallow near surface layers. Exit gradient at the toe of 300 feet wide berm is high. Seepage conditions should be monitored during floods. If needed, a relief well or drainage system may be needed at the toe of the berm.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features: 3 feet wide and 73 feet deep cutoff wall starting at Elevation 67.5 (half levee degrade)						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.56				Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.54				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Seepage Berm and Drained Stability Berm						
Dimensions of Primary Features: Seepage Berm - 300 feet wide berm, 3 feet thick at berm toe and 7.2 feet thick at levee toe, berm soil type - sandy silt Drained Stability Berm - 7.5 feet tall, 10 feet wide at top, 2 feet thick drain, and 3H:1V landside slope						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.34	1.41	N/A	0	Meets criteria at levee toe. See Comments on berm toe.	Exit gradient at the toe of 300 feet wide berm is high. Seepage conditions should be monitored during floods. If needed, a relief well or drainage system may be needed at the toe of the berm.
200-year + 4 feet	0.49	1.67	N/A	0		
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.19				Yes	
200-year + 4 feet	1.91				Yes	

TABLE 5-12A: CHARACTERIZATION OF REACH 12
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
12	830+00 [2996+25]	845+00 [3011+25]	0.28	Total Number of Explorations = 7; Crest Explorations = 5 (SPT - 3, CPT - 2); Waterside Field Explorations = 2 (SPT - 2)	**Crown Width :** approximately 20 feet **Landside slope** approximately 2H:1V to flatter 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	834+39 [3009+39]: The site is located at Shanghai Bend at approximate River Mile 25.0 (LM 10.8). Seepage occurred at this site during the previous flood events. (F.R. Site I). 839+71 [3005+86] to 908+21 [3074+31]: The site is located between Shanghai Bend and Yuba City Airport between approximate River Miles 25.1 and 26.5 (LM 11.0 and 12.4). 842+22 [3009+39]: Seepage and a boil occurred just beyond the berm toe during the 1995 high water. (F.R. Site I) Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	829+85 [2996+00] to 846+20 [3012+50]: Shanghai Bend setback levee with cutoff wall. Additional site investigation report and Star Bend borrow site report for the Project "PL 84-99 Cost Shared, Basin No. 18, Feather River, Shanghai Bend, dated 1999. USACE Drawing File No. 4-4-620" were available during preparation of this report.	R_{ob} (Recent Overbank)	High resistivity soil layer is not present for most of this Reach. The high resistivity layer starts towards the northern end 843+61 [3010+00], immediately below the ground surface.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: ML, SC, CL **Foundation**: Shallow Sand layer (potentially cutoff by slurry wall). Deep thick sand layer present approximately 30 feet below embankment.	**200 yr WSE** Head = approximately 16.9 feet at the analysis section	Urban Area (Yuba City)	830+59 [2996+70]	WL0001_064B, WL0001_065C (CREST), SL0001_009C, (LANDSIDE TOE), CPT-11 (FIELD)	Recently built setback levee includes a shallow cutoff wall. Available explorations in the area indicate that the cutoff wall tip embedded within fine-grained soil (fully penetrating cutoff wall); Analysis to evaluate effect of the deep sand and gravel layers.

TABLE 5-12B: ANALYSIS RESULTS FOR REACH 12
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 830+59

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	< 0.1	N/A	N/A	No Breakout	Yes	Shanghai Bend setback levee with cutoff wall. Available explorations indicate that the cutoff wall toe embedded in fine-grained soil layer.
200-year + 3 feet	< 0.1	N/A	N/A	No Breakout	Yes	
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	1.78				Yes	Shanghai Bend setback levee with cutoff wall. Available explorations indicate that the cutoff wall toe embedded in fine-grained soil layer.
200-year + 3 feet	1.78				Yes	
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

TABLE 5-13A: CHARACTERIZATION OF REACH 13
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
13	845+00 [3011+25]	927+00 [3093+25]	1.55	Total Number of Explorations = 70; Crest Explorations = 19 (SPT - 10, CPT - 9); Landside Toe Explorations = 2 (SPT - 1, CPT - 1); Landside Field Explorations = 45 (SPT - 7, CPT - 38); Waterside Field Explorations = 4 (SPT - 4)	**Crown Width** approximately 15 feet to 20 feet **Landside Slope** 1.8 H:1V to flatter than 2H:1V **Waterside Slope** 2.5H:1V to flatter than 3H:1V	839+71 [3005+86] to 908+21 [3074+31]: The site is located between Shanghai Bend and Yuba City Airport between approximate River Miles 25.1 and 26.5 (LM 11.0 and 12.4). The levee broke in this area during the 1909, 1911, and 1955. (F.R. Site J). Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	845+71 [3012+00] to 926+51 [3092+65]: In 1957, the USACE reconstructed the levee to the LS of it's previous loc. and installed a row of relief wells near the LS levee toe. Water from the relief wells is pumped to the Feather River (FR). (F.R. Site J). Note: The actual LMs for this improv. meas. are from LM 11.3 to LM 12.8. Relief wells are spaced at 200 feet intervals. Plans are available in the doc. entitled "Emergency Levee Repairs, Relief Wells - Right Bank FR, Shanghai Bend, Sutter County, Ca, USACE File 4-4-435". 845+71 [3012+00] to 926+15 [3092+65]: In 1990, the City of Yuba City installed a seepage interceptor system in the southern part of this site. The interceptor system consists of a perforated pipeline and filter 12-18 feet below ground surface to extract shallow seepage, and relief wells placed between the 1957 relief wells to extract deeper seepage. All water collected is pumped into the Feather River separately from the water collected by the 1957 relief wells. (F.R. Site J). Note: According to Bill Hampton of LD1, this interceptor system cont. up to 3092+65.	R_{ch} (Recent Channels) Ra (Recent Alluvium) R_{ms} (Channel meander scroll deposits) W_{37} (Water)	Approximately 50 feet thick, continuous, high resistivity soil layer is present immediately below the embankment from 845+71 [3012+00] to 893+90 [3060+00]. Beyond 893+90 [3060+00], the layer is present 10 ft below the foundation.
						845+71 [3012+00] to 926+15 [3092+65]: During the 1986 flood, volunteers sandbagged several boils in this area. (F.R. Site J). Site 3: At the downstream of Shanghai Bend, an area of concentrated seepage produced boils during the 1986 high water. These boils were controlled with sack rings. Site 3: According to LD 1 Engineer Mr. Von Geldern, Relief wells in Shanghai Bend area produced 3 gallons per minute during the 1986 high water. Additional seepage occurred in fields adjacent to the levee. Seepage appeared in this area up to several hundred feet away from the levee toe (1986). 893+89 [3060+16] to 902+77 [3069+06]: Heavy seepage near landside toe of levee south of Burns Drive (1997)	845+71 [3012+00] to 926+15 [3092+65]: In 1993, and inspection of the shallow drain perforated pipeline discovered unacceptable deflections over large portions of the pipeline. The deformed plastic pipeline was removed and replaced with a perforated clay pipeline. (F.R. Site J). 829+44 [3058+59] to 926+50 [3092+65]: In 2001, the Corps of Engineers rehabilitated the original 1957 relief wells under a PL 84-99 contract. (F.R. Site J). Project plans entitled "PL 84-99 Cost Shared Added Sites Sacramento Basin No. 18 Relief Well Improvements," dated 7/31/2000. USACE Design File No. 4-04-625. **During the site visit in November 2010, relief wells at a spacing of 100 feet were observed from station 845+61 [3012+00] to 926+15 [3092+65]**		

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Sand (SP, SP-SM, SM) **Foundation**: Near Surface Layers SM, ML, SC. Thick layers of pervious zones (sand and gravel) present at shallow and deep layers.	**200 yr WSE** Head = approximately 22.3 feet at the analysis section	Urban Area (Yuba City)	861+33 [3027+50]	WL0001_067B, WL0001_067C, B-40 (CREST); CPT 22, CPT 23, SL0001_002B (LANDSIDE TOE); B-33 and B-57 (LANDSIDE FIELD); B-51 and B-52 (WATERSIDE TOE AND FIELD)	Near surface layer consists of sand or sandy layers. Shallow silty sand and sandy silt layer overlying a thick porous zone may create a thin blanket condition and potential for underseepage. HEM differential resistivity profiles indicate presence of thick layer of high resistivity soils from ground surface; Sandy layers in levee embankment may indicate potential for through seepage. Levee embankment at this section have SP-SM materials.

TABLE 5-13B: ANALYSIS RESULTS FOR REACH 13
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 861+33

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.21	N/A	1.38	9.2 feet above LS toe	No	High breakout point due to presence of sand layers (<10% fine contents) in the levee embankment.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 13 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 13 is relief wells with shallow cutoff wall.
Existing relief wells have 100 feet spacing and alternatively 20 feet (installed after 1955 flood) and 50 feet deep (installed in 1990s). Analysis indicated 100 feet wide spacing, however considering presence of existing deep (50 feet deep) relief wells, recommended spacing is 200 feet.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features: 3 feet wide and 97 feet deep cutoff wall starting at Elevation 68.8 (half levee degrade)						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.69				Yes	Fully penetrating (i.e. tip within fine-grained soil) cutoff wall reduces seepage potential.
200-year + 4 feet	1.68				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Shallow Soil-Bentonite Cutoff Wall and Relief Well						
Dimensions of Primary Features: Shallow Cutoff Wall - 3 feet wide and 32 feet deep cutoff wall starting at Elevation 68.8 (half levee degrade) Relief Well - 200 feet Spacing and 65 feet Deep. Existing relief wells have 100 feet spacing and alternatively 20 feet (installed after 1955 flood) and 50 feet deep (installed in 1990s). Analysis indicated 100 feet wide spacing, however considering presence of existing deep (50 feet deep) relief wells, recommended spacing is 200 feet.						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	Shallow cutoff wall and relief well system meet criteria
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.69				Yes	Shallow cutoff wall and relief well system meet criteria
200-year + 4 feet	1.69				Yes	

TABLE 5-14A: CHARACTERIZATION OF REACH 14
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
14	927+00 [3093+25]	954+40 [3120+25]	0.52	Total Number of Explorations = 10; Crest Explorations = 9 (SPT - 2, CPT - 2, TP - 5); Landside Toe Explorations = 1 (CPT - 1)	**Crown Width :** approximately 18 feet to 20 feet **Landside slope** approximately 2H:1V to flatter then 2H:1V **Waterside Slope** approximately 3H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	Site 8: Slurry walls from LM 12.76 to LM 13.28. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001.	R_a (Recent Alluvium)	Approximately 40 feet thick, continuous, high resistivity soil layer is present immediately below the embankment in this Reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Silty sand and silt (SM, ML) **Foundation**: Near Surface layer silty sand and silt (SM, ML). Thick layers of sand and silt sand (SP, SM) and Gravel (GP).	**200 yr WSE** Head = approximately 13.2 feet at the analysis section	Urban Area, Airport (Yuba City)	939+33 [3105+50]	2F-07-02, WL0001_073C (CREST) and SL0001_011C (LANDSIDE TOE)	Based on the design drawings, slurry wall tip in SP/SM layer (potential partially penetrating cutoff wall). Silty sand encountered at toe location at ground surface. However, based on information provided by Bill Hampton of LD1 during a November 2010 site visit the cutoff wall depth varied to embed tipin fine-grained soil. The model is developed using a deeper cutoff wall than depth shown on design drawings. However, specification requirements and as-built documents should be evaluated or excavation should be performed to investigate the depths and conditions of the cutoff walls in this Reach.

TABLE 5-14B: ANALYSIS RESULTS FOR REACH 14
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 939+33

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.07	N/A	0.3 (approximately 55 feet from landside toe)	No Breakout	Yes	The design drawings for this section indicates that the proposed cutoff wall depth is 40 feet. A sensitivity analysis using 40 feet cutoff wall depth did not meet seepage criteria for 200 year and 200+3 feet WSE as the tip of the cutoff wall was in coarse-grained soil layer. Based on discussion with Bill Hampton of LD1 during a site visit in November, 2010, the cutoff wall depths in this area were varied to embed the tip in fine-grained soil layers. Therefore, the analysis model was developed with an assumed cutoff wall depth of approximately 50 feet i.e. cutoff wall tip embedded in fine-grained soil. Specification requirement and as-built drawings should be evaluated or excavation should be performed to investigate the conditions of the cutoff wall. Moreover, a sensitivity study using a $K_h = 10^{-5}$ cm/sec in the top 15 feet of the cutoff wall (for 50 feet deep cutoff wall section) was performed to evaluate effect of potential cracking in the upper portion of the wall. The sensitivity analyses meet criteria.
200-year + 3 feet	0.16	N/A	0.4 (approximately 55 feet from landside toe)	No Breakout	Yes	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	2.0		Yes	
200-year + 3 feet	1.93		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-15A: CHARACTERIZATION OF REACH 15
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
15	954+40 [3120+25]	968+50 [3134+50]	0.27	Total Number of Explorations = 8; Crest Explorations = 3 (SPT - 2, CPT - 1); Landside Toe Explorations = 4 (SPT - 2, CPT - 2); Landside Field Explorations = 1 (CPT - 1)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** 1.5 H:1V to flatter than 2H:1V **Waterside Slope** 1.7H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	Site 8: Toe drain and berm from LM 12.26 to LM 13.57. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. **NOTE: DURING A SITE VISIT ON NOVEMBER 2010, NO BERM WAS FOUND. ACCORDING TO BILL HAMPTON OF LD1, A CUTOFF WALL WAS CONSTRUCTED IN THIS AREA.**	R_a (Recent Alluvium) R_{cs} (Recent Crevasse Splay)	Approximately 40 feet thick, high resistivity soil layer is present immediately below the embankment from 953+80 [3120+00] to 958+80 [3125+00] in this Reach. Beyond this station resistive layer was not observed.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Silty clay, silty sand, and silt (CL, SM, ML) **Foundation**: Near Surface layer consists of silty sand and silt (SM, ML). Sand and Gravel (SP, GM) are present at shallow at deep layers.	**200 yr WSE** Head = approximately 12.4 feet at the analysis section	Urban Area, Airport, Police Station, Baseball Field (Yuba City)	958+83 [3125+00]	WL0001_073C, WL0001_074B, 4F-88-7 (CREST), 2F-88-9A, WL0001_003B, WL0001_103C, WL0001_105C (TOE), and WL0001_108C (LANDSIDE FIELD)	Sand and silty sand in levee embankment may indicate potential for through seepage; Shallow and deep sand/gravel layers may indicate potential for underseepage.

TABLE 5-15B: ANALYSIS RESULTS FOR REACH 15
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 958+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.6	N/A	1.15 (at 25 feet from LS toe)	2.4	No	A toe berm and drain was designed for this section. However, no berm was found during a field visit in November 2010. According to Bill Hampton of LD 1, a cutoff wall was installed in this segment. As-built documents or verification study is needed to investigate the presence and conditions of the cutoff wall.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year	19 feet drop from 200yr WSE	2.14	A drop of 19 feet was estimated from evaluation 0f 1986 and 1997 flood levels at gage station "YUB," which is located near Yuba city. The duration of drop considered was 7 days.	Yes	

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 15 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 15 is a shallow cutoff wall and relief well system. The seepage berm alternative was not considered because this Reach is located near an urban area.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 3 feet wide and 64 feet deep cutoff wall starting at Elevation 73 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No Breakout	Yes	
200-year + 4 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.09		Yes	
200-year + 4 feet	2.07		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Shallow Cutoff Wall and Relief Wells

Dimensions of Primary Features: Relief Wells: 23 feet spacing and 51.5 feet deep.
Shallow Cutoff Wall: 3 feet wide and 36 feet deep cutoff wall starting at Elevation 73 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	Relief wells are modeled to meet an average exit gradient of 0.5 at the center of two relief wells. The head drop at the relief well location and between the relief well and midpoint between relief wells should be higher i.e. gradients should be lower than 0.5. The analyses was performed in accordance with USACE EM 1110-2-1914.
200-year + 4 feet					Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.9		Yes	
200-year + 4 feet	1.87		Yes	

TABLE 5-16A: CHARACTERIZATION OF REACH 16
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
16	968+50 [3134+50]	1080+00 [3246+25]	2.11	Total Number of Explorations = 48; Crest Explorations = 34 (SPT - 24, CPT - 10); Landside Toe Explorations = 4 (SPT - 3, CPT - 1); Landside Field Explorations = 7 (SPT - 7); Waterside Field Explorations = 4 (SPT - 3)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** 1.6 H:1V to flatter than 2H:1V **Waterside Slope** 1.4H:1V to flatter than 3H:1V	Based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps. 971+00 [3137+19] The site is located near the Yuba City Airport at approximate River Mile 27.0 (LM 13.6). Seepage occurs at the site during high water. (F.R. Site K). 991+94 [3158+16] to 1070+74 [3236+83]The site is located in Yuba City from Garden Highway north to the Drive-In Cinema between approximate River Miles 27.4 to 29.3 (LM 14.0 to LM 15.5). During the 1955 flood, seepage was observed near the 10th Street Bridge. (F.R. Site L). 991+94 [3158+16] to 1070+74 [3236+83]: During the 1986 flood, the landside slope became saturated and unstable and bulged slightly in the area of the Corporation Yard. Water also flowed up through cracks in the parking lot pavement and the floor slab of an auto body shop on Teegarden Avenue. (F.R. Site L).	Site 8: 927+08 [3093+19] to 968+31 [3170+25] Slurry walls from LM 12.76 to LM 13.28. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. 1019+75 [3186+85] to 1080+25 [3246+40] with gap in HWY-20: Slurry wall from LM 14.56 to LM 15.68. Plans entitled "PL 84-99 Cost Shared/Added Sites Sacramento Basin No. 18 LD1 Slurry Wall, undated, USACE Design File No. 4-25-625." Note: Based on Doc. 3045 and 946, an approximately 135 feet gap between slurry walls from two projects. PL 84-99 calls for an overlap between the slurry walls.	R_a (Recent Alluvium) R_{cs} (Recent Crevasse Splay) H_{ch} (Holocene Channel) R_{ob} (Recent Overbank) R_{ch} (Recent Channel) (along almost the entire reach - Gilsizer Slough)	High Resistivity soil layers are present intermittently along the Reach, immediately below the embankment.
						991+96 [3158+16] to 1070+69 [3236+83]: Site 1: This is a reach of levee extending 4000 feet through downtown Yuba City. During the 1986 flood, this area showed considerable wetness on landside slope. (1986). 1041+99 [3208+07] to 1073+59 [3239+44]: During the 1997 flood, heavy seepage north of 10th Street Bridge. Heavy seepage near two City drainage pipes. 1005+95 [3172+25] to 1021+87 [3188+10]: During the 1986 flood, Erosion of the waterside levee toe occurred in the areas immediately upstream and downstream of the Fifth Street Bridge. (F.R. Site L). 1005+95 [3172+25] to 1021+87 [3188+10]: During the 1997 flood - this is an area of waterside erosion which extends for several hundred feet upstream and downstream of the Fifth Avenue Bridge (Site 2). This erosion occurred mostly low down on the slope and had cut into the levee section causing a steepening of the lower levee slope. Bank and levee erosion south of the 5th Street Bridge. Bank erosion between 5th Street Bridge and 10th Street Bridge (1997).	991+96 [3158+16] to 1025+84 [3224+00]: Yuba City constructed a berm along the landside toe as an emergency action. A permanent seepage/stability berm was later constructed from the Fifth Street Bridge extending northward to about 2500 feet beyond the 10th Street Bridge. An impermeable cutoff wall was also constructed in this area (See F.R. Site K). (F.R. Site L). 991+96 [3158+16] to 1025+84 [3224+00]: Temporary toe drain/berm: Site 1: In 1986, this area was upgraded by placing a landside berm on the slope with an internal drain protected by filter fabric which extends into the toe. Drainage from this system can be monitored at drain pipes.		

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Silty sand and silt (SM, ML), thin layers of silty clay (CL) **Foundation**: Shallow layers of CL, SM, ML, SC. Sand layers are approximately 10 feet thick and interlayered with CL, ML.	**200 yr WSE** Head = approximately 17.1 feet at the analysis section 993+80 and approximately 21.3 feet at the analysis section 1043+88	Urban Area (Yuba City)	993+80 [3160+00] and 1043+88 [3210+00]	SECTION 993+80: 2F-07-03 (CREST), SL0001_012C (LANDSIDE TOE) SECTION 1043+88: WL0001_081B, WL0001_081C, DH-4C, DH-4A (CREST); DH-4D, DH-4B (LANDSIDE TOE)	Location of mapped old Gilsizer Slough. Location of existing slurry wall.

TABLE 5-16B: ANALYSIS RESULTS FOR REACH 16 (ANALYSIS SECTION 1)
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 993+80

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	<0.1	N/A	N/A	No Breakout	Yes	A sensitivity study using a $K_h = 10^{-5}$ cm/sec in the upper 20 feet of the cutoff wall was performed to evaluate effect of potential cracking in the upper portion of the wall. The sensitivity analyses meet criteria. Specification requirement and as-built drawings should be evaluated or excavation should be performed to investigate the conditions of the existing cutoff walls.
200-year + 3 feet	<0.1	N/A	N/A	No Breakout	Yes	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	1.48		Yes	
200-year + 3 feet	1.47		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year	19 feet drop from 200yr WSE	0.94	A drop of 19 feet was estimated from evaluation 0f 1986 and 1997 flood levels at gage station "YUB," which is located near Yuba city. The duration of drop considered was 7 days.	No	This section does not meet Rapid Drawdown criteria due to a steep waterside slope (~1.6H:1V).

Rationale for Selection of Two Alternatives for Analysis

Typical alternative section with 3H:1V waterside slope and clay embankment satisfies the criteria. Typical section includes 20 feet wide crest, and 3H:1V waterside slope.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-16C: ANALYSIS RESULTS FOR REACH 16 (ANALYSIS SECTION 2)
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1043+88

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	<0.1	N/A	0.4 (280 feet from LS toe)	No Breakout	Yes	A sensitivity study using a $K_h = 10^{-5}$ cm/sec in the upper 20 feet of the cutoff wall was performed to evaluate effect of potential cracking in the upper portion of the wall. The sensitivity analyses meet criteria. Specification requirement and as-built drawings should be evaluated or excavation should be performed to investigate the conditions of the existing cutoff walls.
200-year + 3 feet	<0.1	N/A	0.42 (280 feet from LS toe)	No Breakout	Yes	

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	2.17		Yes	
200-year + 3 feet	2.14		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-17A: CHARACTERIZATION OF REACH 17
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
17	1080+00 [3235+00]	1130+86 [3297+00]	0.96	Total Number of Explorations = 17; Crest Explorations = 8 (SPT - 6, CPT - 2); Landside Toe Explorations = 2 (SPT - 1, CPT - 1); Landside Field Explorations = 5 (SPT - 4, CPT - 1); Waterside Toe Explorations = 1 (CPT - 1); Waterside Field Explorations = 1 (SPT - 1)	**Crown Width :** approximately 15 feet to 20 feet **Landside slope** approximately 1.8H:1V to flatter than 2H:1V **Waterside Slope** approximately 2.5H:1V to flatter than 3H:1V	No documentation of past performance problems were found in the reviewed documents or site walk with LD1 representative. However, based on DWR's Seepage Area map for the Feather River West Levee area, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observations. Based on the same map, approximately 100% of Reach 8 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observations. However, the setback levee was placed after these maps.	No documentation of existing levee improvements were found in the reviewed documents or site walk with LD1 representative.	R_a (Recent Alluvium) R_{ob} (Recent Overbank) BP (Borrow Pit Present in 1937)	High resistivity soil layers are present immediately below the embankment, occasionally.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
Levee Embankment: Silty clay, silty sand, and silt (CL, SM, ML) **Foundation**: Near Surface layer consists of silty sand and silt (SM, ML). Silty sand and silt (SM, ML) are present at shallow at deep layers.	**200 yr WSE** Head = approximately 17.7 feet at the analysis section	Urban Area (Yuba City)	1108+86 [3275+00]	2F-07-05 (CREST), WL0001_003C (WS TOE), WL0001_002C, WL0001_002B (LS TOE), AND WL0001_106C (LANDSIDE FIELD)	A swale or depression is present near the landside toe. Interbedding of ML and CL layers in the levee embankment and foundation. Boring 2F-07-05 encountered sand in foundation.

TABLE 5-17B: ANALYSIS RESULTS FOR REACH 17
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1108+86

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.13	N/A	N/A	5.9	No	
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 17 is soil-bentonite cutoff wall and fill-in of the landside ditch/swale, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 17 is shallow cutoff wall with relief well system. The seepage berm alternative was not considered because this Reach is located near an urban area.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall and fill-in ditch

Dimensions of Primary Features: 3 feet wide and 39 feet deep cutoff wall starting at Elevation 74 (half levee degrade)
Soil type of the ditch/swale fill in - sandy silt

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.46	0.29 (soil filled-in ditch)	N/A	3.0	Yes	Considering the cutoff wall and levee degrade and rebuild criteria, the section meets throughseepage criteria.
200-year + 4 feet	0.58	0.33 (soil filled-in ditch)	N/A	4.1	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.43			
200-year + 4 feet	1.33			

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Relief Wells and Shallow Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Relief wells - 45 feet spacing and 40 feet deep.
Shallow Cutoff Wall - 3 feet wide and 16 feet deep cutoff wall starting at Elevation 74 (half levee degrade)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	Shallow cutoff wall and relief well system meet criteria. Relief wells are modeled to meet an average exit gradient of 0.5 at the center of two relief wells. The head drop at the relief well location and between the relief well and midpoint between relief wells should be higher i.e. gradients should be lower than 0.5. The analyses was performed in accordance with USACE EM 1110-2-1914.
200-year + 4 feet					Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.69		Yes	Shallow cutoff wall and relief well system meet criteria
200-year + 4 feet	1.69		Yes	

TABLE 5-18A : CHARACTERIZATION FOR REACH 18
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
18	1130+86 [3297+00]	1213+85 [3380+00]	1.6	Crest:8 Borings 7 CPTs Landside: 2 Borings 6 CPTs 2 Hand augers Waterside: Not available	Levee Height: 20 feet Crown Width: 22 feet Landside Slope: 2.0H:1V Waterside Slope: 3.0H:1V at analysis section	• Seepage reported during storms of late 1996 from 1135+00 to 1214+24 [3299+00 to 3380+44]. • Sinkholes observed on riverside toe of levee in Winter of 1966 from 1136+32 to 1153+14 [3302+46 to 3319+28], repaired in Spring of 1966. • Sinkhole in 1986 at 1173+78 [3339+92]. • Heavy seepage reported in 1997 from 1131+08 to 1199+60 [3297+21 to 3365+74]. • Based on DWR's Seepage Area map for the Feather River West Levee area, 20% of Reach 18 was mapped as seepage area as indicated on aerial photographs of 4-24-63 in conjunction with field observation. Based on the same map, 25% of Reach 18 was mapped as seepage area as indicated on aerial photographs of 2-10-65 in conjunction with field observation.	• Repair of sinkholes on riverside toe of levee in Spring 1966. Note: As-Constructed Drawings not available.	Rob (Recent Overbank) Qmu (Pleistocene Modesto Formation - Upper) Rofc (Recent Overflow Channel) Ra (Recent Alluvium) Rch (Recent Channel)	Shallow higher resistivity zone near downstream end of reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 19 to 20 feet of sandy silt to lean clay with minor silty sand. • Foundation: 2 to 20 feet of sandy silt to lean clay. • 4 to 27 feet of sand to silty sand with localized silt. • 10 to 40 feet of silty sand to fat clay with minor silty sand and clayey sand. • 3 to 16 feet of poorly-graded gravel to poorly-graded sand with lean clay. • 4 to 23 feet of silty sand to fat clay.	200 Year 13 feet	LS and WS orchards along most of reach, Agricultural buildings at 1179+86 [3346+00]	1138+86 [3305+00]	WL0009_001S (crest), WL0009_008C (crest), WL0009_005C (landside toe), WL0009_004C (landside toe), WL0009_003H (landside), WL009_007A (landside toe)	Thinner blanket over sand layer more susceptible to underseepage.

TABLE 5-18B ANALYSIS RESULTS FOR REACH 18
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1138+86

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	1.32	N/A	N/A	8.0	No	The reach has reported seepage deficiencies including seepage reported in 1965 and 1996, and heavy seepage reported in 1997.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative 1 for Reach 18 is undrained seepage berm with relief wells. Seepage berm material type is silt having similar hydraulic conductivity as the clay blanket. Relief wells and/or a drainage system could be used to reduce high gradient. Alternative 2 for Reach 18 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate underseepage potential. The cutoff wall will block the flow through the existing thick aquifer, and effectively control the underseepage.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Relief Wells						
Dimensions of Primary Features: 300 feet wide seepage berm, seepage berm thickness at the levee toe = 7.0 feet, thickness at the berm toe = 3 feet; Relief wells: depth = 30 feet and spacing = 100 feet.						
Seepage						
WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point above Berm	Meets Criteria?	Comments
200-year + 1 foot	0.38	0.69	1.31	3.2	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Levee prism mainly consists of clayey soils; Drainage berm not required for through seepage.
200-year + 4 feet	0.55	0.89	1.58	6.0	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Levee prism mainly consists of clayey soils; Drainage berm not required for through seepage.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.59				Yes	
200-year + 4 feet	1.23				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Cutoff Wall						
Dimensions of Primary Features: 1130+86 to 1149+50 Cutoff Wall Tip Elevation 0, 1149+50 to 1190+00 Cutoff Wall Tip Elevation 30, 1190+00 to 1213+85 Cutoff Wall Tip Elevation 40.						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.
200-year + 4 feet					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.
200-year + 4 feet					Yes	No separate analysis performed; Alternative 2 of Reach 19 was used in the evaluation; for details see Figures B19-A5 through B19-A8.

TABLE 5-19A : CHARACTERIZATION FOR REACH 19
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
19	1213+85 [3380+00]	1297+83 [3464+00]	1.6	Crest:14 Borings 4 CPTs Landside: 5 Borings 6 CPTs 1 Hand auger Waterside: 1 Boring	Levee Height: 20 feet Crown Width: 18 feet Landside Slope: 2.1H:1V Waterside Slope: 2.9H:1V at analysis section	• Boil and piping observed on landside of levee at 1242+86 [3409+01], landward half of levee excavated and recompacted with gravel filter in 1955. • Heavy levee saturation reported by Levee District 9 from 1259+63 to 1267+66 [3425+73 to 3433+88] (year unknown, awaiting information). • Pinhole boils observed on landside of levee in 1997 from 1288+24 to 1296+34 [3454+40 to 3462+52]. • Heavy seepage and boils on landside at 1278+82 to 1293+07 [3444+99 to 3459+25] in 1997 with river near 3 feet freeboard.	• Landward half of levee excavated and recompacted with gravel filter at 1242+86 [3409+01] in 1955. • Bank protection using rock was placed at 1266+45 to 1269+18 [3432+60 to 3435+35] in 1974. • Levee rock slope protection place at 1271+00 [3437+17] in 1974 • Drained toe berm repair was proposed near 1293+82 [3460+00] in 1998. Note: As-Constructed Drawings not available.	Ra (Recent Alluvium) Rofc (Recent Overflow Channel) Rob (Recent Overbank) Rcs (Recent Crevasse Splay) Qmu (Pleistocene Modesto Formation - Upper)	Shallow higher resistivity zone upstream of 1228+85 [3395+00]. Higher resistivity zone thickest from 1228+85 to 1238+85 [3395+00 to 3405+00].

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 18 to 20 feet of sandy silt to lean clay with minor well-graded gravel and clayey sand lenses. • Foundation: 14 to 46 feet of silty sand to fat clay with minor well-graded sand with silt to clayey sand. • 17 to 63 feet of poorly-graded gravel to poorly-graded sand with silt with minor silty sand and clayey sand. • 6 to 58 feet of silty sand to fat clay.	200 Year 13 feet	LS and WS orchards along much of reach, River at levee toe near 1267+84 [3434+00]	1238+85 [3405+00]	WL009_003S (crest), 2F-88-7 (crest), WL009_016C (landside toe), WL009_009A (landside toe), WL009_014C (landside toe), WL009_008A (landside toe)	Thin blanket over sand layer with underlying gravel susceptible to underseepage, near 1955 seepage area

TABLE 5-19B ANALYSIS RESULTS FOR REACH 19
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1238+85

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	2.32	N/A	N/A	7.0	No	The reach has reported seepage deficiencies including heavy seepage and boils reported in 1997.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative 1 for Reach 19 is undrained seepage berm with relief wells and drained stability berm. Seepage berm material type is silt having similar hydraulic conductivity as the clay blanket. Relief wells provided at the berm toe to reduce high gradient. The drained stability berm is to control through seepage. Alternative 2 for Reach 19 is soil-bentonite cutoff wall, which was selected as an in-place alternative to effectively mitigate both through seepage and underseepage.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Relief Wells, and Drained Stability Berm						
Dimensions of Primary Features: 300 feet wide seepage berm, thickness at the levee toe = 7.0 feet, thickness at the berm toe = 3 feet; Relief wells: depth = 50 feet and spacing = 100 feet; stability berm height = 10 feet above seepage berm.						
Seepage						
WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.36	0.76	2.13	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.
200-year + 4 feet	0.57	1.03	2.59	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.56				Yes	
200-year + 4 feet	2.15				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Cutoff Wall						
Dimensions of Primary Features: 1213+85 to 1224+00 Cutoff Wall Tip Elevation 40, 1224+00 to 1240+00 Cutoff Wall Tip Elevation -27 , 1240+00 to 1269+00 Cutoff Wall Tip Elevation 5, 1269+00 to 1297+83 Cutoff Wall Tip Elevation 35.						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	< 0.05	N/A	N/A	No breakout	Yes	
200-year + 4 feet	< 0.05	N/A	N/A	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.88				Yes	
200-year + 4 feet	1.86				Yes	

TABLE 5-20A : CHARACTERIZATION FOR REACH 20
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
20	1297+83 [3464+00]	1374+33 [3540+50]	1.4	Crest:9 Borings 9 CPTs Landside: 2 Borings 8 CPTs Waterside: 1 CPT	Levee Height: 16 feet Crown Width: 15 feet Landside Slope: 2.1H:1V Waterside Slope: 3.3H:1V at analysis section	• Heavy levee saturation reported by Levee District 9 from 1316+46 to 1320+70 [3482+64 to 3486+88] (year unknown). • Boil and piping observed on landside of levee at 1321+07 [3487+25], landward half of levee excavated and recompacted with fill in 1955. • Seepage and boil observed on landside of levee at 1328+73 [3495+06] in 1986. • Heavy seepage and boils about 20 feet from levee toe in 1997 at 1368+41 to 1410+63 [3534+58 to 3576+80] • Seepage and boils occur near the landside levee toe during high water at 1336+73 to 1410+70 [3502+94 to 3576+80]	• Landward half of levee excavated and recompacted with fill in 1955 at 1321+07 [3487+25].	Rcs (Recent Crevasse Splay) Rofc (Recent Overflow Channel) Qmu (Pleistocene Modesto Formation - Upper) Rob (Recent Overbank)	Shallow higher resistivity zone upstream of 1348+83 [3515+00].

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• Levee: 12 to 18 feet of silty sand to lean clay. • Foundation: 4 to 13 feet of sandy lean clay to lean clay. • 1 to 10 feet of poorly-graded sand with silt to silty sand. • 20 to 43 feet of sandy silt to fat clay with minor poorly-graded sand with silt and silty sand. • 4 to 30 feet of poorly-graded sand with silt to silty sand with minor clayey sand to silt. • 44 to 74 feet of sandy silt to lean clay with minor silty sand and clayey sand.	200 Year 10 feet	Orchards in portions of reach, Agricultural buildings at 1348+33 [3514+50]	1338+83 [3505+00]	WL009_025C (crest), WL009_003A (landside toe), WL009_030C (200 ft landside)	10 feet of silty clayey sand (SC-SM) at toe overlying poorly graded sand with silt (SP-SM) susceptible to underseepage

TABLE 5-20B ANALYSIS RESULTS FOR REACH 20
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1338+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.72	NA	NA	3.0	No	The reach has reported seepage deficiencies including heavy seepage and boils reported in 1986 and 1997, and seepage and boils reported during high water.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 20 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 20 is undrained seepage berm with drained stability berm on Top. Seepage berm material type is SC-SM, which is similar to shallow near surface layer. The drained stability berm is to control through seepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1297+83 to 1359+00 Cutoff Wall Tip Elevation 50, 1359+00 to 1369+00 Cutoff Wall Tip Elevation 40, 1369+00 to 1374+33 Cutoff Wall Tip Elevation 50.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	< 0.05	N/A	N/A	No breakout	Yes	
200-year + 4 feet	< 0.05	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.64		Yes	
200-year + 4 feet	1.64		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Drained Stability Berm on Top

Dimensions of Primary Features: 70 feet wide seepage berm, seepage berm thickness at the levee toe = 5 feet, thickness at the berm toe = 3 feet; 1297+83 to 1309+00 stability berm height = 8.5 feet above seepage berm, 1320+00 to 1374+33 stability berm height = 8.5 feet above seepage berm.

Seepage

WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.14	0.09	0.65	No breakout	Yes	
200-year + 4 feet	0.30	0.20	0.79	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.09		Yes	
200-year + 4 feet	1.90		Yes	

TABLE 5-21A : CHARACTERIZATION FOR REACH 21
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
21	1374+33 [3540+50]	1433+83 [3600+00]	1.1	Crest:5 Borings 9 CPTs Landside: 4 Borings 5 CPTs 2 Hand augers Waterside: 3 Borings	Levee Height: 15 feet Crown Width: 20 feet Landside Slope: 2.1H:1V Waterside Slope: 2.5H:1V at analysis section	• "Seasonal seepage" noted in 1957 by Levee District 9 from 1375+34 to 1390+17 [3541+54 to 3556+37]. • Boil observed on landside of levee in 1986 at 1401+58 [3567+75]. • Landside embankment distress in 1997. • Heavy seepage and boils in 1997 at [3444+99 to 3559+25] • Heavy seepage and sloughing in 1997 at [3584+13 to 3595+20] • Heavy seepage and boils in 1997 at [3534+58 to 3576+80] • Boils in 1955 at 1385+01 [3551+17] • Seepage and boils occur near the landside levee toe during high water at 1336+73 to 1410+70 [3502+94 to 3576+80]	• Corps plans indicate relocation of an open drainage ditch away from the toe of the levee. Plans call for 5374 feet of landside irrigation ditch back-filled from1375+58 to 1429+32 [3541+75 to 3595+49] (Site 3, completion unknown - awaiting construction documents, USACE Plans dated July, 1997). • Relief well on the landward side of the levee at 1385+83 [3552+00]. • Backfilling of irrigation canal with crushed rock and gravel in 1997 as emergency measure at 1417+95 to 1429+03 [3584+13 to 3595+20]. Note: As-Constructed Drawings not available. Canal observed in field at the landside toe of the levee in November 2010.	Ra (Recent Alluvium) Rch (Recent Channel) Qmu (Pleistocene Modesto Formation - Upper) Rcs (Recent Crevasse Splay) Qml (Pleistocene Modesto Formation - Lower)	Shallow higher resistivity in most of reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 10 to 12 feet of silty sand to lean clay with minor silty gravel. • Foundation: 9 to 14 feet of silty sand to lean clay. • 10 to 24 feet of well-graded sand to poorly-graded sand with minor silty and lean clay. • 23 to 36 feet of silty sand to fat clay.	200 Year 10 feet	Orchards on landside, unlined landside ditches	1378+83 [3545+00]	WL009_28C (crest), WL009_006A (landside toe), WL009_004H (260 ft landside), B-3 (crest)	8.5 feet of clay (CL) and silt (ML) at toe over silty sand (SM) and poorly graded sand with silt (SP-SM) susceptible to underseepage

TABLE 5-21B ANALYSIS RESULTS FOR REACH 21
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1378+83

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.17	2.79	1.0	NA	No	The reach has reported seepage deficiencies including heavy seepage and boils reported in 1986 and 1997, and seepage and boils reported during high water.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 21 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through seepage and underseepage potential. Alternative 2 for Reach 21 is undrained seepage berm with relief wells and drained stability berm. Seepage berm material type is silt, which is similar to shallow near surface layer. The drained stability berm is to control through seepage.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1374+33 to 1379+00 Cutoff Wall Tip Elevation 40, 1379+00 to 1389+00 Cutoff Wall Tip Elevation 50, 1389+00 to 1409+00 Cutoff Wall Tip Elevation 60, 1409+00 to 1433+83 Cutoff Wall Tip Elevation 40.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.46	N/A	No breakout	Yes	
200-year + 4 feet	No exit of water	0.46	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.33		Yes	
200-year + 4 feet	2.33		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Relief Wells, and Drained Stability Berm

Dimensions of Primary Features: 300 feet wide seepage berm, seepage berm thickness at the levee toe = 6-1/2 feet, thickness at the berm toe = 3 feet; Relief wells: depth = 20 feet and spacing = 100 feet;
stability berm height = 8 feet above seepage berm.

Seepage

WSE	Exit Gradient Levee Toe	Berm (near berm toe)	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.12	0.23	0.96	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.
200-year + 4 feet	0.32	0.36	1.18	No breakout	No at berm toe; will meet with Relief Wells	The calculated gradient at the berm toe does not meet criteria; Need to provide relief wells to reduce the high gradient at the berm toe; Drainage stability berm controls through seepage.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.88		Yes	
200-year + 4 feet	2.66		Yes	

TABLE 5-22A : CHARACTERIZATION FOR REACH 22
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
22	1433+83 [3600+00]	1503+83 [3670+00]	1.3	Crest:4 Borings 8 CPTs Landside: 1 Boring 2 CPTs Waterside: Not available	Levee Height: 12 feet Crown Width: 15 feet Landside Slope: 2.0H:1V Waterside Slope: 2.7H:1V at analysis section	Severe animal burrows in levee at 1433+83 to 1459+77 [3600+00 to 3626+00]; extremely severe burrowing at north end of LD-9 observed in 2010	• No known mitigation measures.	Qml (Pleistocene Modesto Formation - Lower) Rob (Recent Overbank) Ra (Recent Alluvium) Rch (Recent Channel) Rcs (Recent Crevasse Splay) Rofc (Recent Overflow Channel)	Shallow higher resistivity in most of reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• Levee: 7 to 10 feet of silty sand to lean clay. • Foundation: 0 to 15 feet of silt to lean clay. • 5 to 15 feet of poorly-graded sand with silt to silty sand. • 10 to 15 feet of sandy silt to lean clay. • 25 to 50 feet of silty sand to lean clay.	200 Year 7 feet 10 feet in ditch	Orchards on landside, unlined landside ditch	1468+83 [3635+00]	WM0016_001A (crest), WM0016_008C (crest), WM0016011C (landside toe)	Thin blanket over thick sand layer susceptible to underseepage

TABLE 5-22B: ANALYSIS RESULTS FOR REACH 22
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1468+83

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.27	1.34	NA	1.5	No	The reach has extremely severe burrowing at north end of LD-9 observed in 2010; No other reported deficiencies have been identified; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative1 for Reach 22 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both throughseepage and underseepage potential. Alternative 2 for Reach 22 is fill canal and drained stability berm/levee reconstruction. Fill canal option would mitigate the estimated high gradient at the ditch. The drained stability berm/levee reconstruction is to control through seepage.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Cutoff Wall						
Dimensions of Primary Features: 1433+83 to 1449+00 Cutoff Wall Tip Elevation 40, 1449+00 to 1469+00 Cutoff Wall Tip Elevation 50, 1469+00 to 1503+83 Cutoff Wall Tip Elevation 55 plus full degrade/reconstruct from 1433+83 to 1459+77 due to severe burrowing.						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.18	NA	No breakout	Yes	
200-year + 4 feet	No exit of water	0.24	NA	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.23				Yes	
200-year + 4 feet	2.23				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Fill Canal and Drained Stability Berm						
Dimensions of Primary Features: Fill canal to top (adj grade); stability berm from sta 1459+77 to 1503+83, height = 10 feet; full degrade/reconstruct from sta 1433+83 to 1459+77 due to severe burrowing.						
Seepage						
WSE	Exit Gradient Levee Toe	Filled Ditch	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.34	0.30	N/A	No breakout	Yes	
200-year + 4 feet	0.56	0.53	N/A	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.15				Yes	
200-year + 4 feet	1.79				Yes	

TABLE 5-23A : CHARACTERIZATION FOR REACH 23
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
23	1503+83 [3670+00]	1609.37 [3775+50]	2.0	Crest:7 Borings 7 CPTs Landside: 1 Boring 1 CPT Waterside: Not available	Levee Height: 11 feet Crown Width: 18 feet Landside Slope: 2.2H:1V Waterside Slope: 3.0H:1V at analysis section	• "Levee erosion" noted by citizens at 1521+05 to 1532+55 [3687+24 to 3698+82] in 1991.	• Landside drainage ditch constructed by USACE from 1521+03 to 1532+83 [3687+20 to 3699+00] in 1968. • Grouted rip-rap placed from 1515+63 to 1527+32 [3681+80 to 3693+49] by USACE in 1968 adjacent to levee and in the river channel for bank protection. • Bank protection placed at 1516+02 to 1534+67 [3682+19 to 3700+84] in 1965. Note: As-Constructed Drawings not available.	Qml (Pleistocene Modesto Formation - Lower) Rofc (Recent Overflow Channel) Rob (Recent Overbank) Rcs (Recent Crevasse Splay) Rch (Recent Channel)	Shallow higher resistivity in most of the reach

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• Levee: 7 to 10 feet of silty sand to sandy lean clay. • Foundation: 0 to 25 feet of sandy silt to lean clay. • 5 to 60 feet of poorly-graded sand to silty and clayey sand with significant localized silt to clay.	200 Year 4 feet 10 feet in ditch @ ~250 ft LS of toe	Orchards on both sides, unlined ditch about 200 to 600 feet landside of levee, buildings near 1558+83 [3725+00]	1508+33 [3674+50]	WM0016_011B (crest) SM0016_002C (landside)	Silt to clay levee may be susceptible to through seepage; Thin blanket over sand layer susceptible to underseepage.

TABLE 5-23B: ANALYSIS RESULTS FOR REACH 23
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1508+33

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.32	NA	NA	0.9	Yes	
200-year	0.60	NA	NA	1.8	No	No reported seepage or landside stability deficiencies have been identified; However, the reach has thin clayey blanket underlain by shallow sand aquifer (high potential for underseepage).
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
100-year	2.05		Yes	
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 23 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate underseepage potential. Alternative 2 for Reach 23 is undrained seepage berm. Seepage berm material type is silt, which has similar hydraulic conductivity as the shallow near surface clay blanket layer.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 1503+83 to 1509+00 Cutoff Wall Tip Elevation 55, 1509+00 to 1529+00 Cutoff Wall Tip Elevation 60, 1529+00 to 1566+00 Cutoff Wall Tip Elevation 55, 1566+00 to 1589+00 Cutoff Wall Tip Elevation 60, 1589+00 to 1609+37 Cutoff Wall Tip Elevation 40.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	< 0.05	N/A	N/A	No breakout	Yes	
200-year + 4 feet	< 0.05	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.25		Yes	
200-year + 4 feet	2.23		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm

Dimensions of Primary Features: 60 feet wide seepage berm, seepage berm thickness at the levee toe = 5 feet, thickness at the berm toe = 3 feet.

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Berm Toe	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	0.57	No breakout	Yes	
200-year + 4 feet	0.27	N/A	0.96	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.61		Yes	
200-year + 4 feet	1.36		Yes	

TABLE 5-24A : CHARACTERIZATION FOR REACH 24
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
24	1609.37 [3775+50]	1623+86 [3790+00]	0.3	Crest:1 Boring 1 CPTs Landside: 1 CPT Waterside: Not available	Levee Height: 9 feet Crown Width: 20 feet Landside Slope: 3.2H:1V Waterside Slope: 2.7H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Rch (Recent Channel) Rob (Recent Overbank) Rcs (Recent Crevasse Splay) Qml (Pleistocene Modesto Formation - Lower)	Shallow higher resistivity zone

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 7 to 10 feet sandy silt to lean silty clay. • Foundation: 5 to 10 feet of sandy lean clay with silt. • 10 to 15 feet of well-graded with silt. • 5 to 10 feet of sandy silt to lean clay. • 20 to 25 feet of clayey sand to silty sand.	200 Year 2 feet 7 feet in ditch	LS and WS orchards along most of reach, building at 1610+36 [3776+50]	1615+62 [3781+75]	WL0016_020B (crest) WL0016_006C (landside)	Silt to clay levee; waterside levee toe drops to low elevation; shallow SW-SM acquifer exposed at the bottom of the ditch; wide landside toe ditch, susceptible to through seepage and underseepage

TABLE 5-24B: ANALYSIS RESULTS FOR REACH 24
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1615+62

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.20	4.14	NA	NA	No	No reported seepage or landside stability deficiencies have been identified; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative1 for Reach 24 is fill canal. Fill canal option would mitigate the estimated high gradient at the ditch. Alternative 2 for Reach 24 is cutoff wall plus excavate and place 4.5-foot thick compacted clay fill at the bottom of ditch. The cutoff wall and clayey fill below the bottom of the canal will significantly reduce the flow into the canal and thus reduce the exit gradient at the canal bottom.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Fill Canal						
Dimensions of Primary Features: Fill canal to top (elev 90ft, 40ft wide x 10ft deep).						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	0.38	No breakout	Yes	
200-year + 4 feet	0.27	N/A	0.69	1.0	Yes	Levee prism mainly consists of clayey soils; Drainage berm not required for through seepage.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.95				Yes	
200-year + 4 feet	2.21				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): 1609+37 to 1623+86 Cutoff Wall Tip Elevation 64, plus excavate and place 4.5-foot thick compacted clay fill at the bottom of ditch.						
Dimensions of Primary Features: 30ft-deep cutoff wall.						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.44	N/A	No breakout	Yes	
200-year + 4 feet	No exit of water	0.58	N/A	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.82				Yes	
200-year + 4 feet	1.70				Yes	

TABLE 5-25A : CHARACTERIZATION FOR REACH 25
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
25	1623+86 [3790+00]	1674+37 [3840+50]	1.0	Crest:4 Borings 2 CPTs Landside: Not available Waterside: Not available	Levee Height: 9 feet Crown Width: 23 feet Landside Slope: 1.6H:1V Waterside Slope: 2.5H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Qml (Pleistocene Modesto Formation - Lower) Rch (Recent Channel) Rcs (Recent Crevasse Splay)	Shallow higher resistivity zone

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 5 to 10 feet of sandy silt to lean clay. • Foundation: 10 to 20 feet of sandy silt to lean clay with localized clayey sand. • 0 to 20 feet of poorly-graded sand with silt. • 10 to 20 feet of clayey sand to clayey silty sand. • 0 to 15 feet of well-graded gravel with silt to silty sand.	200 Year 1 foot	Orchards on both LS and WS, building at 1664+37 [3830+50]	1645+86 [3812+00]	WL0016_022S (crest) WL0016_021B (crest)	Silt to clay levee; waterside levee toe drops to low elevation more susceptible to underseepage

TABLE 5-25B: ANALYSIS RESULTS FOR REACH 25
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1645+86

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.15	NA	NA	No breakout	Yes	No reported deficiencies have been identified.
200-year + 3 feet	0.43	NA	NA	1.6	Yes	No reported deficiencies have been identified.; Portion of levee prism below the water surface elevation mainly consists of clay; Drainage berm not required for through seepage.
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	2.25				Yes	No reported deficiencies have been identified.
200-year + 3 feet	1.93				Yes	No reported deficiencies have been identified.
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
N/A

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE					Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

TABLE 5-26A : CHARACTERIZATION FOR REACH 26
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
26	1674+37 [3840+50]	1707+11 [3873+25]	0.6	Crest:1 Boring 3 CPTs Landside: 1 CPT Waterside: Not available	Levee Height: 7 feet Crown Width: 19 feet Landside Slope: 1.5H:1V Waterside Slope: 2.6H:1V at analysis section	• Waterside seepage observed during irrigation season from 1677+84 to 1721+90 [3843+98 to 3888+07]. • Sloughing and oversteepening of canal slope at landside toe of levee observed in 2010 at 1689+87 [3856+00]	• No known mitigation measures.	Rob (Recent Overbank) Ra (Recent Alluvium) Rcs (Recent Crevasse Splay) Rch (Recent Channel) Qml (Pleistocene Modesto Formation - Lower)	Shallow higher resistivity zone

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 5 to 8 feet of sandy silt to lean clay. • Foundation: 5 to 20 feet of sandy silt to lean clay. • 5 to 20 feet of poorly-graded sand to clayey silty sand with localized silt to clay. • 5 to 15 feet of gravel with silt to silty sand.	200 Year 4 feet in ditch	Orchards on both LS and WS, Unlined landside ditch	1698+85 [3865+00]	WM0007_018C (crest)	Silt to clay levee, shallow SP-SM acquifer exposed at the bottom of the ditch; wide landside toe ditch susceptible to underseepage

TABLE 5-26B: ANALYSIS RESULTS FOR REACH 26
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1698+85

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No exit of water	N/A	N/A	NA	No	Waterside seepage observed during irrigation season; Sloughing and oversteepening of canal slope at landside toe of levee observed in 2010; Based on interpreted soil profile, the section has shallow foundation sand layer which leads to through seepage into the canal.
200-year + 3 feet						
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative1 for Reach 26 is fill canal, which would mitigate the through seepage into the canal. Alternative 2 for Reach 26 is cutoff wall and reconstruct the landside slope. The cutoff wall is to block the through seepage into the canal. The reconstruction of the landside slope is to mitigate the steep slopes observed along the canal and thus improve slope instability.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Fill Canal						
Dimensions of Primary Features: Fill canal to top (adj grade, 30ft wide x 5ft deep).						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 1 of Reach 27 was used for evaluation; for details see Figures B27-A1 through B27-A4.

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Cutoff Wall and Reconstruct the Landside Slope						
Dimensions of Primary Features: 1674+37 to 1686+00 Cutoff Wall Tip Elevation 75, 1686+00 to 1707+11 Cutoff Wall Tip Elevation 65; plus Reconstruct the Landside Slope						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B27-A5 through B27-A8.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B27-A5 through B27-A8.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B27-A5 through B27-A8.
200-year + 4 feet					Yes	No separate analysis was performed; Alternative 2 of Reach 27 was used for evaluation; for details see Figures B28-A5 through B27-A7.

TABLE 5-27A : CHARACTERIZATION FOR REACH 27
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
27	1707+11 [3873+25]	1721+60 [3887+75]	0.3	Crest:1 Boring 2 CPTs Landside: Not available Waterside: Not available	Levee Height: 6 feet Crown Width: 20 feet Landside Slope: 1.3H:1V Waterside Slope: 3.0H:1V at analysis section	• Waterside seepage observed during irrigation season from 1677+84 to 1721+90 [3843+98 to 3888+07]. • Large voids behind the apron at the Campbell Weir. • Voids in levee during construction of bentonite-tire slurry wall in 1999 from 1707+11 to 1721+62 [3873+25 to 3887+75]	• Bentonite-tire slurry wall installed in 1999 from 1707+11 to 1721+62 [3873+25 to 3887+75] • Waterside monitoring piezometers installed in 2005. Piezometers indicate continuing seepage after installation of wall. Note: As-Constructed Drawings for Slurry Wall not available. Construction report available.	Rob (Recent Overbank) Ra (Recent Alluvium) Rch (Recent Channel)	Shallow higher resistivity zone

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 4 to 7 feet of lean clay. • Foundation: 10 to 15 feet of lean clay. • 5 to 10 feet of poorly-graded sand to silt. • 25 to 30 feet of clayey sand to fat clay with localized sand and silt.	200 Year 4 feet in ditch	Orchards on both LS and WS, Unlined landside ditch	1708+87 [3875+00]	WM0007_019B (crest), WM0007_019C (crest) WM0007_020C (crest)	Clayey levee; thin CL blanket underlain by SP; wide landside toe ditch; Bentonite-tire slurry wall susceptible to underseepage if wall is not performing well

TABLE 5-27B: ANALYSIS RESULTS FOR REACH 27
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1708+87

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No exit of water	0.57	N/A	No breakout	No	Waterside seepage observed during irrigation season; Voids in levee were observed during construction of cutoff wall in 1999; Based on interpreted soil profile, levee is underlain by soft clay; Note that the existing bentonite-tire slurry cutoff wall was not considered as effective in controlling the flow, and was not modeled in the analyses; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative1 for Reach 27 is fill canal, which would mitigate the high exit gradient at the canal bottom. Alternative 2 for Reach 27 is cutoff wall and reconstruct the landside slope. The cutoff wall is to block the flow into the canal, and reduce the gradient at ditch bottom. The reconstruction of the landside slope is to improve landside slope instability.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Fill Canal

Dimensions of Primary Features: Fill canal to top (adj grade, 30ft wide x 5ft deep).

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.01	N/A	N/A	No breakout	Yes	
200-year + 4 feet	0.16	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.40		Yes	
200-year + 4 feet	1.94		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Cutoff Wall and Reconstruct the Landside Slope

Dimensions of Primary Features: 1707+11 to 1721+60 Cutoff Wall Tip Elevation 65; plus Reconstruct the Landside Slope.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.22	N/A	N/A	No breakout	Yes	
200-year + 4 feet	0.35	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.76		Yes	
200-year + 4 feet	1.68		Yes	

TABLE 5-28A : CHARACTERIZATION FOR REACH 28
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
28	1721+60 [3887+75]	1769+31 [3935+50]	0.9	Crest:3 Borings 5 CPTs Landside: Not available Waterside: Not available	Levee Height: 6 feet Crown Width: 23 feet Landside Slope: 1.4H:1V Waterside Slope: 2.4H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Ra (Recent Alluvium) Qml (Pleistocene Modesto Formation - Lower) Rob (Recent Overbank) Rcs (Recent Crevasse Splay)	Localized shallow higher resistivity zones

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
• Levee: 4 to 8 feet of silt to lean clay. • Foundation: 0 to 20 feet of sandy silt to lean clay with localized clayey sand to silty sand. • 0 to 10 feet of sand to sand with silt. • 10 to 40 feet of silt to lean clay.	200 Year 5 feet in ditch	Orchards on both LS and WS along much of reach, Agricultural buildings at 1738+87 and 1744+87 [3905+00 and 3911+00], Unlined landside ditch	1760+87 [3927+00]	WM0007_024B (crest) WM0007_025C (crest)	Clayey levee; CL blanket underlain by SC/SC-SM; wide landside toe ditch susceptible to underseepage

TABLE 5-28B: ANALYSIS RESULTS FOR REACH 28
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1760+87

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No exit of water	0.38	N/A	No breakout	Yes	No reported deficiencies have been identified; Based on interpreted soil profile, levee is underlain by soft clay; The canal is located at the landside levee toe; For empty ditch condition, the gradient at the bottom of the ditch did not meet criteria.
200-year + 3 feet	No exit of water	0.61	N/A	No breakout	No	
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	1.10				No	
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative1 for Reach 28 is fill canal, which would mitigate the high exit gradient at the canal bottom. Alternative 2 for Reach 28 is cutoff wall and reconstruct the landside slope. The cutoff wall is to block the flow into the canal, and reduce the gradient at ditch bottom. The reconstruction of the landside slope is to improve landside slope instability.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Fill Canal						
Dimensions of Primary Features: Fill canal to top (adj grade, 30ft wide x 5ft deep).						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	
200-year + 4 feet	0.15	N/A	N/A	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.94				Yes	
200-year + 4 feet	1.67				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Cutoff Wall and Reconstruct the Landside Slope						
Dimensions of Primary Features: 1721+60 to 1728+00 Cutoff Wall Tip Elevation 65, 1728+00 to 1749+00 Cutoff Wall Tip Elevation 80, 1749+00 to 1769+31 Cutoff Wall Tip Elevation 45; Plus Reconstruct the Landside Slope.						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	0.16	NA	No breakout	Yes	
200-year + 4 feet	No exit of water	0.23	NA	No breakout	Yes	
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.85				Yes	
200-year + 4 feet	1.80				Yes	

TABLE 5-29A : CHARACTERIZATION FOR REACH 29
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2] START STATION (SBFCA) [DWR ULE STATION]	REACH LIMITS [2] END STATION (SBFCA) [DWR ULE STATION]	LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
29	1769+31 [3935+50]	1813+33 [3979+50]	0.8	Crest:5 Borings 1 CPT Landside: Not available Waterside: Not available	Levee Height: 4 feet Crown Width: 20 feet Landside Slope: 3.5H:1V Waterside Slope: 2.7H:1V at analysis section	• No reported deficiencies have been identified.	• No known mitigation measures.	Ra (Recent Alluvium) Rcu (Recent Crevasse Splay Cutoff Channel) Rob (Recent Overbank)	~ 50 feet thick low resistivity zone below the ground surface

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13] SBFCA STATION [DWR ULE STATION]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
• Levee: 4 to 7 feet of silty sand to lean clay. • Foundation: 0 to 20 feet of sandy silt to lean clay with localized surficial clayey sand to silty sand. • 0 to 25 feet of fat clay. • 0 to 10 feet of clayey sand to silty sand with localized clayey gravel to silty gravel. • 10 to 40 feet of lean sandy silt to lean clay.	200 Year N/A	Orchards on both LS and WS along much of reach, Agricultural buildings at 1782+81 and 1786+81 [3949+00 and 3953+00]	1788+81 [3955+00]	WM0007_026B (crest) WM0007_027S (crest)	Clayey levee; low blowcount SC-SM shallow foundation layer susceptible to underseepage

TABLE 5-29B: ANALYSIS RESULTS FOR REACH 29
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TO-1

Analysis Station: 1788+81

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	N/A	N/A	N/A	N/A	Yes	Water surface elevation is lower than the landside toe elevation; Seepage analysis performed for pore pressure input to slope stability; No reported deficiencies have been identified.
200-year + 3 feet	N/A	N/A	N/A	N/A	Yes	Water surface elevation is lower than the landside toe elevation; Seepage analysis performed for pore pressure input to slope stability; No reported deficiencies have been identified.
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year	4.73				Yes	Short levee with flatter landside slope; No reported deficiencies have been identified.
200-year + 3 feet	3.80				Yes	Short levee with flatter landside slope; No reported deficiencies have been identified.
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
N/A

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s):						
Dimensions of Primary Features:						
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

TABLE 5-30A: CHARACTERIZATION OF REACH 30
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
30	1813+33 [3979+50]	1902+00 [4068+00]	1.68	Total Number of Explorations = 18; Crown Explorations = 12 (Borings-10, CPT-2); Landside Toe Explorations = 4 (Borings-3, CPT-1) Waterside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 15 feet Landside Slope = 2.8H:1V Waterside Slope = 2.4H:1V	At 1871+91 [4037+06], in 1986, a boil appeared on the landslide slope of levee.	After high water receded, approximately 300 feet of levee at this location was excavated to surrounding grade and rebuilt; no evidence of the boil was found during excavation.	Old levee fill mapped meandering along current levee alignment. Ra waterside and landside, with Rcu along landside of old levee fill (which at some locations is just to waterside of and underneath current levee alignment).	High resistivity present, fair correspondence with logs.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee silty sand to silt. Silty sand and silt from native grade to about 20 to 25 feet bgs, underlain by clean gravel to about 40 to 60 feet bgs, underlain by clay, clayey sand, and/or clayey gravel >5 feet thick.	**200 yr WSE** Head = approximately 5.6 feet at analysis section	Predominantly agricultural on landside and on waterside where levee set back from river. From approximately sta 1896+00 [4060+20] to 4068+00 [1902+00] there are homes on the landside of the levee (observed from the aerial map).	1826+94 [3993+10]	WM0007_004S	Section selection based on location that appears most likely to have highest gradient (i.e. underseepage potential).

TABLE 5-30B: ANALYSIS RESULTS FOR REACH 30
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 1826+94

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Phreatic Surface Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
100-year	0.39	NA	NA	0.6	Yes	
200-year	0.48	NA	NA	1.2	Yes	Thin waterside blanket (if extrapolate crown boring) removed for analysis. Toe gradient marginally passes; through-seepage marginal*.
200-year + 3 feet	0.78	NA	NA	2.2	No	Toe gradient clearly does not meet criterion. Through-seepage more clearly not meeting criterion (daylights on slope, erodible material)

* Consistent with past performance, report of one "boil" on the landside slope during 1986 high water event.

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
100-year	1.61		Yes	
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 30 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 30 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1813+33 to 1816+40 Cutoff Wall Tip Elevation 80 , 1816+40 to 1865+90 Cutoff Wall Tip Elevation 40 , 1865+90 to 1877+90 Cutoff Wall Tip Elevation 50, 1877+90 to 1902+00 Cutoff Wall Tip Elevation 30

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Phreatic Surface Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage. Fine-grained layer varies in depth
200-year + 4 feet	No exit of water	N/A	N/A	No breakout	Yes	over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.81		Yes	
200-year + 4 feet	1.78		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm

Dimensions of Primary Features: 1813+33 to 1831+00 seepage berm 300 feet wide, 6.5 feet thick at levee toe, 1831+00 to 1888+00 seepage berm 100 feet wide, 5 feet thick at levee toe, 1888+00 to 1895+00 seepage berm 300 feet wide, 6.5 feet thick at levee toe, 1895+00 to 1902+00 seepage berm 100 feet wide, 5 feet thick at levee toe, for each, thickness at seepage berm toe = 3 feet and stability berm height = 4 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Phreatic Surface Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No Exit of Water	0.86	NA	1.3	Meets criteria at levee toe. See comments on berm toe.	Berm toe exit gradient marginally exceed the criteria. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.
200-year + 4 feet	No Exit of Water	1.14	NA	Top of berm	Meets criteria at levee toe. See comments on berm toe.	No criteria of exit gradient at berm toe greater than 100 feet in width. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	4.72		Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	4.15		Yes	

TABLE 5-31A: CHARACTERIZATION OF REACH 31
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
31	1902+00 [4068+00)	1958+00 [4125+00]	1.06	Total Number of Explorations = 11; Crown Explorations = 9 (Borings-8, CPT-1); Landside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 16 feet Landside Slope = 1.4H:1V Waterside Slope = 2.5H:1V	none documented	none documented	Old levee fill mapped along current levee alignment for much of length (where river adjacent). Ra landside, with Rcs and Rofc at southern end landside River waterside for much of length, with Hch along waterside where levee set back from current river alignment.	High resistivity present, fair correspondence with logs; gap in HEM at upstream end of reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee lean clay, with some SC and ML. Foundation profile partly mostly clay, partly 10 to 15 foot clay blanket over clean gravel, sand, and some silt to 40 to 50 feet below ground surface, underlain by >5 feet clay.	**200 yr WSE** Head = approximately 8 ft above base of canal (no head above levee toe)	Butte Main Canal runs along LS toe of levee. The landside and waterside (where the levee is setback from the river) is mainly agricultural. A canal is located approximately 25 feet away from the landside toe. The canal is about 55 feet wide and 7 feet deep.	1907+91 [4074+00]	WM0007_37S SM0007_003A SM0007_004A	If address canal, reach has potential to meet criteria otherwise, so section selection based on location that appears most likely to have highest gradient (after addressing canal). Note that depth of wall (for cost purposes) controlled by other location (036S, at d/s end of segment).	

TABLE 5-31B: ANALYSIS RESULTS FOR REACH 31
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 1907+91

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	NA	2.3	0.14	5.1	No	High gradient at canal due to thin blanket (canal bottom close to underlying sand). Breakout point measured from bottom of canal.
200-year + 3 feet						No documentation of performance problems occurring in canal during high water events; unknown if canal was empty or full at time

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 31 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. The potential seepage problems, however, are due to the presence of the canal; if the canal were not present, the potential seepage problems would not occur. So Alternative 2 for Reach 31 is filling of the canal (and re-locating the canal a large distance from the levee). Canal fill material type is silt, to be permeability-compatible with underlying material (may use more permeable fill than silt).

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1902+00 to 1916+90 Cutoff Wall Tip Elevation 30, 1916+90 to 1933+90 Cutoff Wall Tip Elevation 75, 1933+90 to 1958+00 Cutoff Wall Tip Elevation 40

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No Exit of Water	0.18	NA	No Breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage. Fine-grained layer varies in depth
200-year + 4 feet	No Exit of Water	0.24	NA	No Breakout	Yes	over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.62		Yes	
200-year + 4 feet	2.58		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Filled Canal

Dimensions of Primary Features: Canal filled up to adjacent grade; 1.4 % slope on top of fill for drainage. The filled canal and its existing embankments effectively become a landside berm, about 100 feet wide.

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No Exit of Water	0.24	NA	No Breakout	Yes	Filled canal and embankments considered a berm, so gradient criterion used at embankment toe is that for berms.
200-year + 4 feet	No Exit of Water	0.51	NA	No Breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	9.61		Yes	Berm condition, with fill up against short landside levee slope, significantly increases stability FS.
200-year + 4 feet	8.10		Yes	

TABLE 5-32A: CHARACTERIZATION OF REACH 32
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
32	1958+00 [4125+00]	1989+00 [4155+00]	0.59	Total Number of Explorations = 7; Crown Explorations = 5 (Borings-4, CPT-1); Landside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 14 feet Landside Slope = 2.1H:1V Waterside Slope = 2.1H:1V	none documented	none documented	H_{ch} (Holocene Channel deposits) R_a (Recent Alluvium) R_{cu} (Recent Cutoff Channel) Rob (Recent Overbank)	Approximately 10ft thick, continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: SM, CL, ML, SC **Foundation**: Near Surface layers include SM, CL, ML. Thick (~ 20ft) pervious zones present at about 30ft below the embankment (GW).	**200 yr WSE** Head = approximately 12.9 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses and sheds were observed from the aerial map.	1965+80 [4132+00]	WM0007_042B WM0007_042S SM0007_002B	Section likely to control gradient, berm design (wall depth ~constant).

TABLE 5-32B: ANALYSIS RESULTS FOR REACH 32
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 1965+80

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.83	NA	NA	4.6	No	High gradient at toe, due to thin blanket over permeable layers, clearly does not meet criteria. Through-seepage a concern (erodible soils).
200-year + 3 feet						No documented problems during floods. Gradient not FS<1, and analyzed WSE higher than floods; analysis and performance consistent

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 32 is soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and under seepage potential. Alternative 2 for Reach 32 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type is modeled as silty sand, which is similar to there more permeable of the shallow near surface layers (some silty sands on the finer blanket layer materials).

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 1958+00 to 1965+80 Cutoff Wall Tip Elevation 40, 1965+80 to 1986+80 Cutoff Wall Tip Elevation 58
1986+80 to 1989+00 Cutoff Wall Tip Elevation 10

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.27	NA	NA	No Breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage.
200-year + 4 feet	0.29	NA	NA	No Breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.65		Yes	
200-year + 4 feet	1.65		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (SM) with stability berm

Dimensions of Primary Features: 1958+00 to 1982+00 seepage berm 120 feet wide, 6 feet thick at levee toe, with stability berm height = 6 feet (on top of seepage berm)
1982+00 to 1989+00 seepage berm 50 feet wide, 5 feet thick at levee toe, with stability berm height = 4 feet (on top of seepage berm)
for each, thickness at seepage berm toe = 3 feet

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.20	0.76	NA	No Breakout	Yes	
200-year + 4 feet	0.30	0.92	NA	No Breakout	Meets criteria at levee toe. See comments on berm toe.	No criteria of exit gradient at berm toe greater than 100 feet in width. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.25		Yes	
200-year + 4 feet	2.16		Yes	

TABLE 5-33A: CHARACTERIZATION OF REACH 33
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
33	1989+00 [4155+00]	2122+00 [4288+00]	2.52	Total Number of Explorations = 22; Crown Explorations = 17 (Borings-14, CPT-3); Landside Toe Explorations = 5 (Borings-2, CPT-3)	At analysis section: Crown width = 16 feet Landside Slope = 3.3H:1V Waterside Slope = 2H:1V	none documented	none documented	Ra (Recent Alluvium) Rcu (Recent Cutoff Channel) DT (Dredge Tailings)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment. Low resistivity observed occasionally. Gap in HEM data intermittently.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: SM, ML **Foundation**: Near Surface layers include ML, SM, SP-SM. Thick (~ 40ft) pervious zones present at about 30ft below the embankment (GP, GW).	**200yr WSE** Head = approximately 4.9 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses and sheds were observed from the aerial map.	2076+90 [4243+00]	WM0007_009S (Crown) WM0007_002C (LS Toe) SM0007_005A (Crown)	Section likely to control gradient, berm design, and wall depth. Previous analyses at this location showed marginal/close to criteria.

TABLE 5-33B: ANALYSIS RESULTS FOR REACH 33
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2076+90

Existing Conditions Problem Identification						
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.55	NA	NA	1.6	No	Gradient at toe does not meet. Dredge tailings (DT) modeled as GM-GP, about 60ft deep. DT has relatively little effect on gradients here.
200-year + 3 feet						No documented performance problems; gradient not much over criterion, though; consistent. Reach has≤90-degree bends (3D effect).
Landside Stability						
WSE	FS	Performance			Meets Criteria?	Comments
200-year						
200-year + 3 feet						
Rapid Drawdown						
WSE - initial	WSE - final	FS	Duration Effect		Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE					

Rationale for Selection of Two Alternatives for Analysis
Alternative 1 for Reach 33 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 33 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1						
Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall						
Dimensions of Primary Features:	1989+00 to 2000+80 Cutoff Wall Tip Elevation 10, 2000+80 to 2026+80 Cutoff Wall Tip Elevation 90 2026+80 to 2036+90 Cutoff Wall Tip Elevation 20, 2036+90 to 2086+90 Cutoff Wall Tip Elevation 35 2086+90 to 2122+00 Cutoff Wall Tip Elevation 90					
Seepage						
WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	NA	NA	No Breakout	Yes	Relatively deep wall needed to tie in to fine-grained layer, mitigate through-seepage and underseepage.
200-year + 4 feet	<0.1	NA	NA	No Breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	1.82				Yes	
200-year + 4 feet	1.81				Yes	

Rehabilitated Levee Alternative 2						
Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm, optionally with relief wells						
Dimensions of Primary Features:	1989+00 to 2020+00 seepage berm 50 feet wide, 5 feet thick at levee toe , 2020+00 to 2028+00 seepage berm 100 feet wide, 5 feet thick at levee toe , 2028+00 to 2037+00 seepage berm 50 feet wide, 5 feet thick at levee toe , 2037+00 to 2050+00 seepage berm 100 feet wide, 6 feet thick at levee toe, 2050+00 to 2065+00 connect berm toe as straight line across bend, 2065+00 to 2087+00 seepage berm 100 feet wide, 6 feet thick at levee toe, 2087+00 to 2102+00 seepage berm 50 feet wide, 5 feet thick at levee toe, 2102+00 to 2106+00 connect berm toe as straight line across bend, 2106+00 to 2122+00 seepage berm 60 feet wide, 5 feet thick at levee toe, for each, thickness at seepage berm toe = 3 feet, stability berm height = 4 feet (on top of seepage berm)					
Seepage						
WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.02	0.72	NA	Top of Berm	Yes	
200-year + 4 feet	0.22	1.05	NA	Top of Berm	Meets criteria at levee toe. See comments on	Berm toe exit gradient exceed the criteria. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.
Landside Stability						
WSE	FS				Meets Criteria?	Comments
200-year + 1 foot	2.96				Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	2.73				Yes	

TABLE 5-34A: CHARACTERIZATION OF FOR REACH 34
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
34	2122+00 [4288+00]	2182+00 [4348+00]	1.14	Total Number of Explorations = 9; Crown Explorations = 8 (Borings-7, CPT-1); Landside Toe Explorations = 1 (Borings-0, CPT-1)	At analysis section: Crown width = 20 feet Landside Slope = 1.6H:1V Waterside Slope = 3.0H:1V	none documented	none documented	Ra (Recent Alluvium) Rcu (Recent Cutoff Channel) DT (Dredge Tailings)	Continuous, High Resistive Soil layers observed immediately below the embankment. Gap in HEM data intermittently.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: SM, ML **Foundation**: Near Surface layers include ML, CL, SM, SP, SW-SM. Thick (~ 20ft) pervious zones present at about 30ft below the embankment (GP, GW).	**200 yr WSE** Head = approximately 1.4 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river).	2138+99 [4305+20] (hinged section)	WM0007_055S (crown)	High ground along this reach, but steep levee LS slopes along parts, so section targeted at characterizing levee LS slope stability.

TABLE 5-34B: ANALYSIS RESULTS FOR REACH 34
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2138+99

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.06	NA	NA	No Breakout	Yes*	Very low WSEs, result is low gradients. Dredge tailings (DT) modeled as GM-GP, about 60ft deep; DT has little effect on results here.
200-year + 3 feet	0.19	NA	NA	1.0	Yes*	* See note below in rationale for selection

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	1.62		Yes	
200-year + 3 feet	1.45		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Most of reach does not require rehabilitation. However, downstream end of reach needs rehabilitation for seepage. Rehabilitation measures for reach 33 should extend 1600 feet into reach 34, as described below. See reach 33 for rationale of rehabilitation measures and analysis results.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Cutoff Wall

Dimensions of Primary Features: 2122+00 to 2138+00 Cutoff Wall Tip Elevation 90
2138+00 to 2182+00 no wall (no rehabilitation required)

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	**					** See Reach 33 for representative analysis results.
200-year + 4 feet	**					

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with Drained Stability Berm on Top

Dimensions of Primary Features: 2122+00 to 2138+00 seepage berm 60 feet wide, 5 feet thick at levee toe, with stability berm height = 4 feet (on top of seepage berm)
2138+00 to 2182+00 no berm (no rehabilitation required)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	**					** See Reach 33 for representative analysis results.
200-year + 4 feet	**					

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-35A: CHARACTERIZATION OF REACH 35
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
35	2182+00 [4348+00]	2224+00 [4390+00]	0.8	Total Number of Explorations = 11; Crown Explorations = 8 (Borings-7, CPT-1); Landside Toe Explorations = 1 (Borings-1, CPT-0) Field Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 16 feet Landside Slope = 3H:1V Waterside Slope = 2.1H:1V	Boil 1986 - "The foundation soils are susceptible to seepage and piping".(1986)	Site 1: Levee raise LM 9.89 to LM 10.39. Project plans entitled "Sacramento River Flood Control Project Phase II, Levee Reconstruction, Contract 3 (Sites 1, 2, 3, 8, 9, 10, 11, & 12)," dated 7/4/1997. USACE Design File No. 50-04-6001. Note: Document 314, which included as-constructed improvement measures did not include this levee raise in the "Sutter County, California Past Problem Sites Map." "Rebuilt 300' levee section" Note: No detail of this rebuilt work was available during preparation of this SGDR. NOTE: AS-BUILT DOCUMENT NOT AVAILABLE TO HDR TEAM.	Ra (Recent Alluvium) Rcu (Recent Cutoff Channel) DT (Dredge Tailings)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment. Gap in HEM data intermittently.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: SM, ML, CL **Foundation**: Near Surface layers include ML, SM, SP-SM. Thick (~ 15ft) pervious zones present at about 30ft below the embankment (GP, GP-GM).	**200 yr WSE** Head = approximately 8.2 feet at analysis section	Predominantly agricultural on the landside. A warehouse is located on the landside of the levee at approximately station 2185+00 [4351+25]	2211+30 [4377+50]	WM0007_062B (Crown) WM0007_062S (Crown) SM0007_004B (Toe)	Section likely to control gradient, berm design, and wall depth. Previous analyses at this location showed marginal/close to criteria.

TABLE 5-35B: ANALYSIS RESULTS FOR REACH 35
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2211+30

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.36	NA	0.57	1.8	Yes	Dredge tailings (DT) modeled as GM-GP, about 40ft deep. Underseepage gradients meet criteria, through-seepage marginal.
200-year + 3 feet	0.50	NA	0.72	3.6	No	Underseepage does not meet the field criterion, nor through-seepage (daylights on slope, erodible materials). Reach has 90-deg bends. A boil reported in 1986 (different location on same reach); consistent with analysis results showing not meeting criteria.

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 35 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 35 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silty sand, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2182+00 to 2224+00 Cutoff Wall Tip Elevation 55

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	NA	0.12	No Breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage.
200-year + 4 feet	<0.1	NA	0.14	No Breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.79		Yes	
200-year + 4 feet	1.79		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Undrained Seepage Berm with and without Drained Stability Berm on Top

Dimensions of Primary Features: 2182+00 to 2199+00 seepage berm 65 feet wide, 5 feet thick at levee toe (no drained stability berm on top)
2199+00 to 2203+00 connect berm toe as straight line across bend (no drained stability berm on top)
2203+00 to 2224+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with drained stability berm height = 5 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.08	0.62	NA	Top of Berm	Yes	Gradients at berm toe same values as in field for ex. conditions, but farther from levee; berm width extended to point where meet criteria.
200-year + 4 feet	0.19	0.78	NA	Top of Berm	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.44		Yes	
200-year + 4 feet	2.15		Yes	

TABLE 5-36A: CHARACTERIZATION OF REACH 36
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
36	2224+00 [4390+00]	2259+00 [4425+00]	0.66	Total Number of Explorations = 7; Crown Explorations = 5 (Borings-4, CPT-1); Landside Toe Explorations = 2 (Borings-2, CPT-0)	At analysis section: Crown width = 8 feet Landside Slope = 3.2H:1V Waterside Slope = 2.9H:1V	none documented	none documented	Generally runs along boundary between DT and Ra, crossing onto and overlying each along part, with Rcu crossing under at several locations. H_{ms} (Holocene meander Scrolls)	Moderate resistivity, gap in HEM in d/s part of reach.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Silt levee. Silty sand, silt, and clay from native grade to about 15 to 20 feet bgs, underlain by clean sand and gravel to about 35 feet bgs, underlain by clay and/or clayey gravel >5 feet thick.	**200 yr WSE** Head = approximately 7.5 ft at analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses and sheds on the landside and waterside were observed from the aerial map.	2250+78 [4417+00]	SM0007_005B (TOE)	Section likely to control gradient, berm design, and wall depth.

TABLE 5-36B: ANALYSIS RESULTS FOR REACH 36
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2250+78

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.94	N/A	N/A	3.4	No	Gradient at toe does not meet. Dredge tailings (DT) modeled as GM-GP, about 40ft deep, about ≥300 feet to waterside of levee.
200-year + 3 feet						No documented performance problems; gradient not much over criterion, though; consistent. Reach has 90-degree bends (3D effect).

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 36 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 36 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as clayey sand, which is similar to shallow near surface layers. Clayey sand may be of higher value for other uses on the project; a more permeable material may be used as berm material.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2224+00 to 2259+00 Cutoff Wall Tip Elevation 75

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	N/A	N/A	No breakout	Yes	Moderate depth wall ties in to fine-grained layer, mitigates through-seepage and underseepage.
200-year + 4 feet	<0.1	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.03		Yes	
200-year + 4 feet	2.00		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (SC) with stability berm

Dimensions of Primary Features: 2224+00 to 2227+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with stability berm height = 5 feet (on top of seepage berm)
2227+00 to 2233+00 connect berm toe as straight line across bend, with stability berm height = 5 feet (on top of seepage berm)
2233+00 to 2259+00 seepage berm 300 feet wide, 7.5 feet thick at levee toe, with drained stability berm height = 4 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	<0.1	0.95	N/A	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Berm toe exit gradient exceeds the criteria. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.
200-year + 4 feet	0.15	1.27	N/A	Top of berm	Meets criteria at levee toe. See comments on berm toe.	No criteria of exit gradient at berm toe greater than 100 feet in width. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	3.19		Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	2.86		Yes	

TABLE 5-37A: CHARACTERIZATION OF REACH 37
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
37	2259+00 [4425+00]	2290+00 [4456+00]	0.59	Total Number of Explorations = 7; Crown Explorations = 5 (Borings-5, CPT-0); Landside Toe Explorations = 2 (Borings-1, CPT-1)	At analysis section: Crown width = 20 feet Landside Slope = 3.1H:1V Waterside Slope = 2.1H:1V	none documented	none documented	Rcu (Recent Cutoff Channel) DT (Dredge Tailings) H_{ms} (Holocene meander Scrolls)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: ML, CL, CL-ML **Foundation**: Near Surface layers include ML, SM, CL-ML. Thick (~ 15ft) pervious zones present at about 20 to 30ft below the embankment (GP, GP).	**200 yr WSE** Head = approximately 6.1 feet at the analysis section	Predominantly agricultural on the landside and waterside (where levee set back from river). Scattered houses were observed from the aerial map.	2276+76 [4443+00]	WM0007_013S SM0007_006A SM0007_006B	Section selected for location where gradient most likely to control fix dimensions for berm or other non-wall fix. Note that depth of wall (for cost purposes) controlled by other location (068S, at u/s end of segment).

TABLE 5-37B: ANALYSIS RESULTS FOR REACH 37
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2276+76

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.49	N/A	N/A	3.6	No	Through-seepage daylights, erodible soil. Underseepage marginal. Dredge tailings modeled on waterside, instead of projecting silt blanket
200-year + 3 feet	0.72	N/A	N/A	4.3	No	At this WSE, underseepage also does not meet criteria. No documented performance problems; consistent with gradients for WSEs

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 37 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 37 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2259+00 to 2290+00 Cutoff Wall Tip Elevation 45

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.11	N/A	N/A	No breakout	Yes	Relatively deep wall needed to tie in to layer with fine-grained material, mitigate through-seepage and underseepage.
200-year + 4 feet	0.14	N/A	N/A	No breakout	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.83		Yes	
200-year + 4 feet	1.8		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm

Dimensions of Primary Features: 2259+00 to 2290+00 seepage berm 65 feet wide, 5.5 feet thick at levee toe, with stability berm height = 6 feet (on top of seepage berm)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.1	0.53	N/A	Top of berm	Yes	
200-year + 4 feet	0.27	0.75	N/A	Top of berm	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.54		Yes	Drained stability berm (for through-seepage) significantly increases stability FS.
200-year + 4 feet	2.33		Yes	

TABLE 5-38A: CHARACTERIZATION OF REACH 38
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
38	2290+00 [4456+00]	2303+00 [4469+00]	0.25	Total Number of Explorations = 1; Crown Explorations = 1 (Borings-1, CPT-0)	At analysis section: Crown width = 29 feet Landside Slope = 2.6H:1V Waterside Slope = 2H:1V	None documented on levee reach. Adjacent "old" levee breached in 1955 event. "Old" levee extends southward, along river, from east end of Reach 38 levee (which runs west-east along Vance Ave). Adjacent levee that extends north from east end of Reach 38 levee is Reach 39 levee, which nearly breached in 1955, with multiple boils and sinkholes and significant flood-fighting to save levee.	none documented	DT (Dredge Tailings) H_{ms} (Holocene meander Scrolls)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment. Gap in HEM data towards the downstream end of the Reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: ML **Foundation**: Thick (~ 30ft) pervious zones present below the embankment (GM, GC, GP, GP-GM), thought to be dredge tailings.	**200 yr WSE** Head = approximately 13.1 feet above berm toe at analysis section	Scattered trees on the landside and waterside of the levee.	2299+69 [4466+00] (hinged section)	WM0007_069B WM0007_069S (CREST)	Section selected to flag anticipated critical gradient, controlling berm dimensions. Note that depth of wall (for cost purposes) controlled by other locations (068S and 070S, at either end of segment).	

TABLE 5-38B: ANALYSIS RESULTS FOR REACH 38
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2299+69

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.17	N/A	N/A	0.7	No	Gradients meet. Through-seepage marginal. Does not meet based on past performance. At east end, adjacent levee to south breached
200-year + 3 feet	0.23	N/A	N/A	1.3	No	adjacent levee to north nearly breached, and those levee/foundation conditions still present at Reach 38 (silt levee built on dredge tailings)

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	2.68		Yes	
200-year + 3 feet	2.56		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Mechanisms of potential failure thought to be present for the Reach 38 levee are associated with the incompatibility of the silty levee material with the gravelly (dredge tailings) foundation soils. Under high head conditions, seepage through the silt and into the gravels, or along the silt/gravel interface, can lead to internal erosion and piping of the silt as the silt particles are carried into/through the gravel. Alternative 1 for Reach 38 is a soil-bentonite cutoff wall, to decrease the internal gradient at the silt/gravel interface and to inhibit the flow of water through the foundation along the silt/gravel interface. Alternative 2 for Reach 38 is a full de-grade and reconstruction of the levee, and a seepage berm with the newly reconstructed levee.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2290+00 to 2303+00 Cutoff Wall Tip Elevation 45

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						Existing gradients already meet criteria (exit gradients not salient for this reach); no need to analyze gradients for improved condition.
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Reconstructed Levee, with Seepage Berm

Dimensions of Primary Features: 2290+00 to 2302+00 De-grade entire levee and reconstruct, with zoned filter at base, and regrade landside to create 300 feet-wide drained seepage berm, 5 feet thick at levee toe, with filter carried out through berm. (2302 to 2303 occupied by berm of Reach 39)

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						Existing gradients already meet criteria (exit gradients not salient for this reach); no need to analyze gradients for improved condition.
200-year + 4 feet						

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot				
200-year + 4 feet				

TABLE 5-39A: CHARACTERIZATION OF REACH 39
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
39	2303+00 [4469+00]	2319+00 [4486+00]	0.3	Total Number of Explorations = 3; Crown Explorations = 3 (Borings-2, CPT-1)	At analysis section: Crown width = 60 feet Landside Slope = Varies, typically nominally 4H:1V Waterside Slope = Varies (as steep as 1H:1V in some places)	Levee nearly breached in 1955. During flood event, numerous boils and sinkholes, with multiple flood-fight crews and dozers pushing gravel into sinkholes.	Levee raising, setback, and reconstruction. **NOTE: AS-BUILT DOCUMENT NOT AVAILABLE TO HDR TEAM.**	DT (Dredge Tailings) H_{ch} (Holocene Channel deposits)	Continuous, Moderate Resistive Soil layers observed immediately below the embankment. Gap in HEM data towards the upstream end of the Reach.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: GP, GM **Foundation**: GM, GC, GP, GP-GM (~ 50ft thick below the embankment). Silt and silty sands layers (ML,SM) observed below the Gravel layer.	**200 yr WSE** Head = approximately 21.5 feet at analysis section	Scattered trees on the landside and waterside of the levee.	2314+91 [4481+00]	WM0007_071B (Crown) WM0007_071S (Crown)	Generally flows through, but projection of GW-GC layer (if acts GC-like) in 071S relative to ground surface profile anticipated to control gradient relationship.	

TABLE 5-39B: ANALYSIS RESULTS FOR REACH 39
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2314+91

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	No Exit of Water	N/A	0.27 (Local Y-grad)	No Breakout	Yes	Gradients meet. This reach nearly breached in 1955, with numerous boils and sinkholes, with multiple flood-fight crews and
200-year + 3 feet	No Exit of Water	N/A	0.3 (Local Y-grad)	No Breakout	Yes	dozers pushing gravel into sinkholes. Levee built on dredge tailings. No documentation of rehabilitation. Levee appears to have been rehabilitated after poor performance event.

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year	3.06		Yes	
200-year + 3 feet	2.62		Yes	

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot			
200-year + 4 feet			

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s):

Dimensions of Primary Features:

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot						
200-year + 4 feet						

Landside Stability

WSE	FS	Meets Criteria?	Comments
200-year + 1 foot			
200-year + 4 feet			

TABLE 5-40A: CHARACTERIZATION OF REACH 40
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA)	END STATION (SBFCA)							
	[DWR ULE STATION]	[DWR ULE STATION]							
40	2319+00 [4486+00]	2359+00 [Old Butte Canal Structure]	0.76	Total Number of Explorations = 6; Crown Explorations = 4 (Borings-4, CPT-0); Landside Toe Explorations = 1 (Borings-1, CPT-0) Waterside Toe Explorations = 1 (Borings-0, CPT-1)	At analysis section: Crown width = 63 feet Landside Slope = 2.1H:1V Waterside Slope = 2.8H:1V	Numerous boils in 1955 event, with significant flood-fighting.	Levee raising, setback, and reconstruction. **NOTE: AS-BUILT DOCUMENT NOT AVAILABLE TO HDR TEAM.**	DT (Dredge Tailings) H_{ch} (Holocene Channel deposits)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.
			GENERALIZED SUBSURFACE CONDITIONS [10]	**DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]**	**NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]**	**TRANSVERSE SECTION FOR EVALUATION [13]** SBFCA STATION [DWR ULE STATION]	**EXPLORATIONS FOR TRANSVERSE SECTION [14]**	**RATIONALE FOR SECTION SELECTION [15]**	
			Levee Embankment: GP, GM, GP-GM, GW-GC **Foundation**: GM, GC, GW, GP, GP-GM intermixed thin layers (~2 to 3ft) of ML, SM.	**200 yr WSE** Head = approximately 10 feet at analysis section	Scattered trees on the landside and waterside of the levee. Some agricultural on the landside of the levee.	2332+91 [4499+00]	WM0007_072S WM0007_014S (CREST) SM0007_008B (FIELD)	Projection of clay layer in 072S relative to ground surface profile at 4499 anticipated to control gradient relationship, dimensions of berm. Depth of wall (for cost purposes) controlled by other location (073S, at u/s end of segment).	

TABLE 5-40B: ANALYSIS RESULTS FOR REACH 40
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2332+91

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.64	N/A	N/A	5.3	No	Does not meet gradient at toe. Past performance: boils/flood-fights. Dredge tailings (DT) modeled as GM-GP, about 40ft deep, waterside
200-year + 3 feet						

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 40 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 40 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: 2319+00 to 2336+90 Cutoff Wall Tip Elevation 50
2336+90 to 2359+00 Cutoff Wall Tip Elevation 20

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	Deep wall needed to tie in to layer with fine-grained material, mitigate through-seepage and underseepage.
200-year + 4 feet	No exit of water	N/A	N/A	No breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.23		Yes	
200-year + 4 feet	2.18		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm, plus relief wells

Dimensions of Primary Features: Fill the large landside pit at 2321+00 to 2332+00 up to el 120,
2321+00 to 2329+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with drained stability berm height = 7 feet (on top of seepage berm)
Fill the large landside pits at 2333+00 to 2343+00
2331+00 to 2346+00 seepage berm 120 feet wide, 5 feet thick at levee toe, with drained stability berm height = 10 feet (on top of seepage berm)
2346+00 to 2359+00 seepage berm 300 feet wide, 5 feet thick at levee toe, with drained stability berm height = 4 feet (on top of seepage berm

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.07	0.78	N/A	Top of berm	Yes	
200-year + 4 feet	0.2	0.82	N/A	Top of berm	Yes	

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.96		Yes	
200-year + 4 feet	2.68		Yes	

TABLE 5-41A: CHARACTERIZATION OF REACH 41
FEATHER RIVER WEST LEVEE REHABILITATION PROJECT - TASK ORDER 1

REACH ID [1]	REACH LIMITS [2]		LENGTH OF REACH (MILES) [3]	NUMBER OF EXPLORATIONS (LOCATION - CREST/TOE/FIELD AND TYPE) [4]	GENERALIZED LEVEE GEOMETRY [5]	DESCRIPTION OF DOCUMENTED PAST PERFORMANCE [6]	SUMMARY OF KNOWN IMPROVEMENT MEASURES [7]	SUMMARY OF SURFICIAL GEOMORPHOLOGIC UNITS [8]	EVALUATION OF DIFFERENTIAL RESISTIVITY PROFILES FROM HEM [9]
	START STATION (SBFCA) [DWR ULE STATION]	END STATION (SBFCA) [DWR ULE STATION]							
41	2359+00 [Old Butte Canal Structure]	2368+00 [Thermalito]	0.17	Total Number of Explorations = 1; Crown Explorations = 1 (Borings-1, CPT-0)	At analysis section: Crown width = 21 feet Landside Slope = 2.6H:1V Waterside Slope = 2H:1V	none documented	none documented	DT (Dredge Tailings) H_{ch} (Holocene Channel deposits)	Continuous, High to Moderate Resistive Soil layers observed immediately below the embankment.

GENERALIZED SUBSURFACE CONDITIONS [10]	DESIGN WSE BASIS (200 YEAR/100 YEAR) AND AVERAGE HEAD FOR DESIGN WSE [11]	NATURAL, PHYSICAL, AND LAND USE CONSTRAINTS OR FEATURES [12]	TRANSVERSE SECTION FOR EVALUATION [13]	EXPLORATIONS FOR TRANSVERSE SECTION [14]	RATIONALE FOR SECTION SELECTION [15]
			SBFCA STATION [DWR ULE STATION]		
Levee Embankment: GP, GM, GP-GM, GW-GC **Foundation**: GM, GC, GW, GP, GP-GM intermixed thin layers (~2 to 3ft) of ML, SM.	**200 yr WSE** Head = approximately 9.2 feet at analysis section	Scattered trees on the landside and waterside of the levee. Some agricultural on the landside of the levee.	2362+70 [None]	SM0007_010B (CREST)	WSE, geometry fairly consistent, so section at only boring location. Note that depth of wall (for cost purposes) expected to deepen d/s of boring (based on d/s reach characterization).

TABLE 5-41B: ANALYSIS RESULTS FOR REACH 41
FEATHER RIVER WEST LEVEE EARLY IMPLEMENTATION PROJECT TASK ORDER 1

Analysis Station: 2362+70

Existing Conditions Problem Identification

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year	0.81	N/A	N/A	4	No	Does not meet gradient at toe. Dredge tailings (DT) modeled as GM-GP, about 60ft deep, waterside of levee, instead of extending blanket
200-year + 3 feet						No documented problems. Gradient not FS<1, analyzed WSE higher than this levee experienced; analysis and performance consistent

Landside Stability

WSE	FS	Performance	Meets Criteria?	Comments
200-year				
200-year + 3 feet				

Rapid Drawdown

WSE - initial	WSE - final	FS	Duration Effect	Meets Criteria?	Comments
200-year + 1 foot	typ. winter WSE				

Rationale for Selection of Two Alternatives for Analysis

Alternative 1 for Reach 41 is a soil-bentonite cutoff wall, which was selected as an in-place alternative to mitigate both through-seepage and underseepage potential. Alternative 2 for Reach 41 is a seepage berm (for underseepage) with a drained stability berm on top (for through-seepage). Seepage berm material type modeled as silt, which is similar to shallow near surface layers.

Rehabilitated Levee Alternative 1

Geotechnical Rehabilitation Measure(s): Soil-Bentonite Cutoff Wall

Dimensions of Primary Features: Cutoff Wall Tip Elevation 20 at 2359+00, constant decrease in depth up to Cutoff Wall Tip Elevation 70 at 2368+00

Seepage

WSE	Exit Gradient Levee Toe	Ditch/Canal	Field	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	No exit of water	N/A	N/A	No breakout	Yes	Deep wall needed to tie in to layer with fine-grained material, mitigate underseepage.
200-year + 4 feet	No exit of water	N/A	N/A	No breakout	Yes	Fine-grained layer varies in depth over length of reach, so wall depth varies over length of reach, as indicated above

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	1.92		Yes	
200-year + 4 feet	1.91		Yes	

Rehabilitated Levee Alternative 2

Geotechnical Rehabilitation Measure(s): Seepage Berm (ML) with stability berm, plus relief wells

Dimensions of Primary Features: 2359+00 to 2368+00 seepage berm 70 feet wide, 5 feet thick at levee toe, with drainage relief trench along berm toe that is 50 feet wide at grade, extending down 12 feet deep, with 1.5:1 backcut and frontcut, filled with drain gravel, with filter zones adjacent in-situ soils

Seepage

WSE	Exit Gradient Levee Toe	Berm Toe	Other	Phreatic Surface Breakout Point	Meets Criteria?	Comments
200-year + 1 foot	0.12	0.76	N/A	Top of berm	Yes	
200-year + 4 feet	0.27	0.98	N/A	Top of berm	Meets criteria at levee toe. See comments on berm toe.	Berm toe exit gradient marginally exceed the criteria. Seepage condition should be monitored during flood. If needed, a relief well or drainage system may be needed at the toe of the berm.

Landside Stability

WSE	FS		Meets Criteria?	Comments
200-year + 1 foot	2.38		Yes	
200-year + 4 feet	2.13		Yes	

Table 5-42: Summary of Geotechnical Analysis for 100 Year WSE

Reach	Design WSE (year)	Rehabilitation Needed for DWSE and or HTOL?	Reach analyzed for 100-year WSE?	Meets geotechnical criteria for 100-year WSE?
1	100	Yes	Yes	No
2	100	Yes	Yes	No
3	100	Yes	Yes	No
4	100	Yes	Yes	No
5	200	Yes	No	No
6	200	No	No	Yes
7	200	Yes	No	No
8	200	Yes	Yes	No
9	200	Yes	Yes	No
10	200	Yes	No	No
11	200	Yes	No	No
12	200	No*	No	Yes*
13	200	Yes	No	No
14	200	No*	No	Yes*
15	200	No*	No	Yes*
16	200	No	No	Yes
17	200	Yes	No	No
18	200	Yes	Yes	No
19	200	Yes	Yes	No
20	200	Yes	Yes	No
21	200	Yes	Yes	No
22	200	Yes	Yes	No
23	200	Yes	Yes	Yes
24	200	Yes	Yes	No
25	200	No	Yes	Yes
26	200	Yes	Yes	No
27	200	Yes	Yes	No
28	200	Yes	Yes	No
29	200	No	Yes	Yes
30	200	Yes	Yes	Yes
31	200	Yes	No	No
32	200	Yes	No	No
33	200	Yes	Yes	No
34	200	Yes	No	No
35	200	Yes	Yes	No
36	200	Yes	No	No
37	200	Yes	Yes	No
38	200	Yes	No	No
39	200	No*	No	Yes*
40	200	Yes	Yes	No
41	200	Yes	Yes	No

NOTE: * = Based on confirmation by receipt of as-constructed drawings or adequate confirmatory investigation.

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
1	10+00	129+66	No	No	Yes	Cutoff Wall	10+00 to 58+80 Cutoff Wall Tip Elevation 20 58+80 to 83+00 Cutoff Wall Tip Elevation 18 83+00 to 114+00 Cutoff Wall Tip Elevation 24 114+00 to 129+66 Cutoff Wall Tip Elevation 27	
						Undrained Seepage Berm with Drained Stability Berm	Drained Stability Berm: 8 feet tall Undrained Seepage Berm : 88 feet wide and 5 feet thick at levee toe.	Assume 25% of reach will have a seepage berm width extending to 100ft due to taller levee at some locations.
2	129+66	218+66	No	No	Yes	Cutoff Wall	129+66 to 181+00 Cutoff Wall Tip Elevation 20 181+00 to 191+00 Cutoff Wall Tip Elevation -10 191+00 to 220+00 Cutoff Wall Tip Elevation -73 with Full Levee Degrade.	191+00 to 220+00 Full Levee Degrade.
						Undrained Seepage Berm with Drained Stability Berm and Cutoff Wall with Seepage Berm	129+66 to 181+00: 8 feet tall Drained Stability Berm on Seepage Berm; Seepage Berm 100 feet wide and 5 feet thick at levee toe 181+00 to 218+66: Cutoff Wall Tip Elevation 30 feet with 100 feet wide Undrained Seepage Berm. Seepage Berm 5 feet thick at berm toe	
3	218+66	300+66	No	No	Yes	Cutoff Wall	218+66 to 220+00 Cutoff Wall Tip Elevation -73 220+00 to 230+00 Cutoff Wall Tip Elevation 20 230+00 to 250+00 Cutoff Wall Tip Elevation -35 250+00 to 289+00 Cutoff Wall Tip Elevation -20 289+00 to 300+66 Cutoff Wall Tip Elevation 15	
						Undrained Seepage Berm with Drained Stability Berm	8 feet tall Drained Stability Berm on 300 feet wide Undrained Seepage Berm with monitoring for seepage at the toe of the berm	Analysis indicates that the 300 feet wide seepage berm could still have high avg gradients at the toe of the berm. Therefore we recommend monitoring the berm toe for future seepage. If boils occur at the toe of berm, wells or a collection drain will be required.
4	300+66	410+67	No	No	Yes	Cutoff Wall	300+66 to 349+00 Cutoff Wall Tip Elevation 15 349+00 to 368+00 Cutoff Wall Tip Elevation 10 368+00 to 410+67 Cutoff Wall Tip Elevation 20	
						Undrained Seepage Berm with Drained Stability Berm	8 feet tall Drained Stability Berm on 100 feet wide Undrained Seepage Berm; Seepage berm 5 feet thick at berm toe.	
5	410+67	478+68	No	No	Yes	Cutoff Wall and Cutoff Wall with Seepage Berm	410+67 to 417+00 Cutoff Wall Tip Elevation 20 417+00 to 425+00 Cutoff Wall Tip Elevation 10 425+00 to 456+00 Cutoff Wall Tip Elevation 15 456+00 to 478+68 Cutoff Wall Tip Elevation 15 with 200 feet wide Undrained Seepage Berm.	
						Undrained Seepage Berm	410+67 to 444+00: 300 feet wide Seepage Berm 444+00 to 478+68: 300 feet wide Seepage Berm with monitoring for seepage at the toe of the berm.	Analysis indicates that from 444+00 to 478+68, the 300ft wide seepage berm could still have high avg gradients at the toe of the berm. Therefore we recommend monitoring the berm toe for future seepage. If boils occur at the toe of berm, wells or a collection drain will be required.

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
6	478+68	510+37	Yes	Yes* (see comments)	No	NA		Star Bend setback levee with cutoff wall. No performance data after the Star Bend improvements were made.
						NA		
7	510+37	598+87	No	No	Yes	Cutoff Wall	510+37 to 528+00 Cutoff Wall Tip Elevation 15 528+00 to 546+00 Cutoff Wall Tip Elevation -10 546+00 to 565+00 Cutoff Wall Tip Elevation -65 with Full Levee Degrade 565+00 to 576+00 Cutoff Wall Tip Elevation -50 576+00 to 584+00 Cutoff Wall Tip Elevation -10 584+00 to 598+87 Cutoff Wall Tip Elevation 20	Abandon the existing wells in place. Based on review of Corp information, lowering the well discharge point would be an option if a consistent confining layer was present. Due to lack of consistent confining layer shown in Army Corp well logs and historical seepage, the wells do not appear to be a viable solution for reuse as part of the repair option for Reach 7. 546+00 to 565+00 Full Levee Degrade.
						Undrained Seepage Berm with Drained Stability Berm	9.5 feet tall, 13 wide at the top, Drained Stability Berm on 300 feet wide Undrained Seepage Berm with monitoring for seepage at the toe of the berm; Berm thickness 7 feet at levee toe	Analysis indicates that the seepage berm could still have high avg gradients at the toe of the berm. Therefore we recommend monitoring the berm toe for future seepage. If boils occur at the toe of berm, wells or a collection drain will be required.
8	598+87	654+75	No	No	Yes	Cutoff Wall	598+87 to 617+00 Cutoff Wall Tip El. +15 617+00 to 630+00 Cutoff Wall Tip El. +15 630+00 to 638+00 Cutoff Wall Tip El. +15 638+00 to 646+00 Cutoff Wall Tip El. +15 646+00 to 654+75 Cutoff Wall El. -15	
						Undrained Seepage Berm and Shallow Cutoff Wall	Shallow Cutoff Wall Tip El. +38 Seepage Berm: 130 feet wide and 5 feet thick at levee toe.	
9	654+75	706+50	No	No	Yes	Cutoff Wall	654+75 to 668+00 Cutoff Wall Tip El. -15 668+00 to 706+00 Cutoff Wall Tip El. +20	
						Undrained Seepage Berm and Shallow Cutoff Wall	Shallow Cutoff Wall Tip El. +35 Seepage Berm: 110 feet wide and 5 feet thick at levee toe.	
10	706+50	774+00	No	No	Yes	Cutoff Wall	706+50 to 745+00 Cutoff Wall Tip El. -5 745+00 to 774+00 Cutoff Wall Tip El. +25	
						Undrained Seepage Berm and Shallow Cutoff Wall	Shallow Cutoff Wall Tip El. +30 Seepage Berm: 300 feet wide and 7 feet thick at levee toe.	

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
11	774+00	830+00	No	No	Yes	Cutoff Wall	774+00 to 784+00 Cutoff Wall Tip El. +25 784+00 to 824+00 Cutoff Wall Tip El. -5 824+00 to 830+00 Cutoff Wall Tip El. +25	
						Undrained Seepage Berm with Drained Stability Berm	Seepage Berm: 300 feet wide and 7 feet thick at levee toe. Drained Stability Berm: 7.5 feet tall	
12	830+00	845+00	Yes	Yes* (see comments)	No	NA		Shanghai Bend setback levee with cutoff wall
						NA		* No performance data available after Cutoff Wall installation
13	845+00	927+00	No	No	Yes	Cutoff Wall	845+00 to 857+00 Cutoff Wall Tip El. -33 857+00 to 927+00 Cutoff Wall Tip El. -28	
						Shallow Cutoff Wall and Relief Wells	Shallow Cutoff Wall Tip El. +35 Relief Wells: 200 feet spacing and 65 feet deep	Existing relief wells have 100 feet spacing and alternatively 20 feet (installed after 1955 flood) and 50 feet deep (installed in 1990s). Analysis indicated 100 feet wide spacing, however considering presence of existing deep (50 feet deep) relief wells, recommended spacing is 200 feet.
14	927+00	954+40	Yes	Yes* (see comments)	No	NA		Cutoff wall previously installed. Design documents of existing cutoff wall available. However, specification and as-built document for existing cutoff wall should be evaluated or in-situ investigation should be performed to evaluate effectiveness. Currently no as-built document is available to the design team. * No Performance Data Available After Cutoff Wall Installation.
						NA		
15	954+40	968+50	No if no wall exists; Yes if wall was constructed and is as modeled in analyses	No if no wall exists; Yes* if wall was constructed	Yes if no wall exists; No if wall was constructed and is as modeled in analyses	Cutoff Wall	954+40 to 960+40 Cutoff Wall Tip El. +9 960+40 to 968+50 Cutoff Wall Tip El. +35	Design drawings of a proposed toe berm and drain are available. However, no berm was installed. Bill Hampton of LD1 indicated that a cutoff wall was installed at this location. **Based on evaluation of presence and effectiveness of a cutoff wall, this reach may not need rehabilitation measure. Currently no as-built document is available to the design team. * No Performance Data Available After Cutoff Wall Installation (if was installed).**
						Shallow Cutoff Wall and Relief Wells	Shallow Cutoff Wall: Tip El. +37 Relief Wells: 23 feet spacing and 51.5 feet deep	

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
16	968+50	1080+00	Yes	Yes* (see comments)	Yes (for Rapid Drawdown and gap closure at 2 bridge crossings)	Waterside slope flattening	At steep waterside slope areas	Cutoff wall previously installed. Design documents of existing cutoff wall available. However, specification and as-built document for existing cutoff wall should be evaluated or in-situ investigation should be performed to evaluate effectiveness. Currently no as-built document is available to the design team. * No Performance Data Available After Cutoff Wall Installation. **Gaps in the existing cutoff walls are present at two bridge locations, which will require mitigation measures.**
						NA		
17	1080+00	1130+86	No	Yes	Yes	Cutoff Wall with Landside Toe Depression Filled In	1080+00 to 1130+86 Cutoff Wall Tip El. +35 Fill-in the landside toe depression (depression is 4 feet deep and 40 feet wide at the analysis section, Sta. 1108+86)	
						Relief Wells and Cutoff Wall	1080+00 to 1130+86 Shallow Cutoff Wall Tip El. +58 Relief Wells: 45 feet spacing and 38.5 feet deep	
18	1130+86	1213+85	No	No	Yes	Cutoff Wall	1130+86 to 1149+50 Cutoff Wall Tip Elevation 0 1149+50 to 1190+00 Cutoff Wall Tip Elevation 30 1190+00 to 1213+85 Cutoff Wall Tip Elevation 40	
						Undrained Seepage Berm with Relief Wells	300 feet wide seepage berm, berm thickness at the levee toe = 7 feet; Relief wells: depth = 30 feet and spacing = 100 feet.	Relief wells added at end of 300 feet wide berm as gradient is very high and factor of safety is below 1 at the berm toe and there was seepage related past performance problems.
19	1213+85	1297+83	No	No	Yes	Cutoff Wall	1213+85 to 1224+00 Cutoff Wall Tip Elevation 40 1224+00 to 1240+00 Cutoff Wall Tip Elevation -27 1240+00 to 1269+00 Cutoff Wall Tip Elevation 5 1269+00 to 1297+83 Cutoff Wall Tip Elevation 35	
						Undrained Seepage Berm with Relief Wells, and Drained Stability Berm	300 feet wide seepage berm, thickness at the levee toe = 7 feet; Relief wells: depth = 50 feet and spacing = 100 feet; stability berm height = 10 feet above seepage berm.	Relief wells added at end of 300 feet wide berm as gradient is very high and factor of safety is below 1 at the berm toe and there was seepage related past performance problems.
20	1297+83	1374+33	No	No	Yes	Cutoff Wall	1297+83 to 1359+00 Cutoff Wall Tip Elevation 50 1359+00 to 1369+00 Cutoff Wall Tip Elevation 40 1369+00 to 1374+33 Cutoff Wall Tip Elevation 50	
						Undrained Seepage Berm with Drained Stability Berm on Top	70 feet wide seepage berm, seepage berm thickness at the levee toe = 5 feet; 1297+83 to 1309+00 stability berm height = 8.5 feet above seepage berm 1320+00 to 1374+33 stability berm height = 8.5 feet above seepage berm	

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
21	1374+33	1433+83	No	No	Yes	Cutoff Wall	1374+33 to 1379+00 Cutoff Wall Tip Elevation 40 1379+00 to 1389+00 Cutoff Wall Tip Elevation 50 1389+00 to 1409+00 Cutoff Wall Tip Elevation 60 1409+00 to 1433+83 Cutoff Wall Tip Elevation 40	
						Undrained Seepage Berm with Relief Wells, and Drained Stability Berm	300 feet wide seepage berm, berm thickness at the levee toe = 6.5 feet; Relief wells: depth = 20 feet and spacing = 100 feet; stability berm height = 8 feet above seepage berm.	Relief wells added at end of 300 feet wide berm as gradient is very high and factor of safety is below 1 at the berm toe and there was seepage related past performance problems.
22	1433+83	1503+83	No	No	Yes	Cutoff Wall	1433+83 to 1449+00 Cutoff Wall Tip Elevation 40 1449+00 to 1469+00 Cutoff Wall Tip Elevation 50 1469+00 to 1503+83 Cutoff Wall Tip Elevation 55 and full degrade/reconstruct from 1433+83 to 1459+77 due to severe burrowing	Full levee reconstruction due to severe burrowing may not be needed for entire LD9 part of reach, but internal levee integrity will need to be observed during construction.
						Fill Canal and Drained Stability Berm/ Levee Reconstruction	Fill canal to top (adj grade); stability berm from sta 1459+77 to 1503+83, height = 10 feet; full degrade/reconstruct from sta 1433+83 to 1459+77 due to severe burrowing.	
23	1503+83	1609+37	No	No	Yes	Cutoff Wall	1503+83 to 1509+00 Cutoff Wall Tip Elevation 55 1509+00 to 1529+00 Cutoff Wall Tip Elevation 60 1529+00 to 1566+00 Cutoff Wall Tip Elevation 55 1566+00 to 1589+00 Cutoff Wall Tip Elevation 60 1589+00 to 1609+37 Cutoff Wall Tip Elevation 40	
						Undrained Seepage Berm	60 feet wide seepage berm, seepage berm thickness at the levee toe = 5 feet	
24	1609+37	1623+86	No	Yes	Yes	Cutoff Wall with Reconfiguration of Canal Bottom	1609+37 to 1623+86 Cutoff Wall Tip Elevation 64, excavate and place 4.5-foot thick compacted clay fill at the bottom of ditch	Analysis results for existing conditions did not meet criteria due to presence of canal near landside toe.
						Fill Canal	Fill canal to top (elev 90 feet, 40 feet wide x 10 feet deep).	
25	1623+86	1674+37	Yes	Yes	No	NA		
						NA		

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
26	1674+37	1707+11	No	No	Yes	Cutoff Wall and Reconstruct the Landside Slope	1674+37 to 1686+00 Cutoff Wall Tip Elevation 75 1686+00 to 1707+11 Cutoff Wall Tip Elevation 65 and reconstruct landside slope	Analysis results for existing conditions did not meet criteria due to presence of canal near landside toe. Landside slope oversteepened at canal.
						Fill Canal	Fill canal to top (adj grade, 30 feet wide x 5 feet deep).	
27	1707+11	1721+60	No	No	Yes	Cutoff Wall and Reconstruct the Landside Slope	1707+11 to 1721+60 Cutoff Wall Tip Elevation 65 and reconstruct landside slope	Analysis results for existing conditions did not meet criteria due to presence of canal near landside toe. Landside slope oversteepened at canal. Existing tire-bentonite wall was interpreted to be not providing adequate cutoff based on piezometer measurements after installation.
						Fill Canal	Fill canal to top (adj grade, 30 feet wide x 5 feet deep).	
28	1721+60	1769+31	No	Yes	Yes	Cutoff Wall and Reconstruct the Landside Slope	1721+60 to 1728+00 Cutoff Wall Tip Elevation 65 1728+00 to 1749+00 Cutoff Wall Tip Elevation 80 1749+00 to 1769+31 Cutoff Wall Tip Elevation 45 and reconstruct landside slope	Analysis results for existing conditions did not meet criteria due to presence of canal near landside toe. Landside slope oversteepened at canal.
						Fill Canal	Fill canal to top (adj grade, 30 feet wide x 5 feet deep).	
29	1769+31	1813+33	Yes	Yes	No	NA		
						NA		
30	1813+33	1902+00	No	No	Yes	Cutoff Wall	1813+33 to 1816+40 Cutoff Wall Tip Elevation 80 1816+40 to 1865+90 Cutoff Wall Tip Elevation 40 1865+90 to 1877+90 Cutoff Wall Tip Elevation 50 1877+90 to 1902+00 Cutoff Wall Tip Elevation 30	
						Undrained Seepage Berm with Drained Stability Berm on Top	1813+33 to 1831+00 seepage berm 300 feet wide, 6.5 feet thick at levee toe 1831+00 to 1888+00 seepage berm 100 feet wide, 5 feet thick at levee toe 1888+00 to 1895+00 seepage berm 300 feet wide, 6.5 feet thick at levee toe 1895+00 to 1902+00 seepage berm 100 feet wide, 5 feet thick at levee toe for each, stability berm height = 4 feet (on top of seepage berm)	

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
31	1902+00	1958+00	No	Yes	Yes	Cutoff Wall	1902+00 to 1916+90 Cutoff Wall Tip Elevation 30 1916+90 to 1933+90 Cutoff Wall Tip Elevation 75 1933+90 to 1958+00 Cutoff Wall Tip Elevation 40	Analysis results for existing conditions did not meet criteria due to presence of canal near landside toe.
						Fill Canal	Fill canal to top (adj grade)	
32	1958+00	1989+00	No	Yes	Yes	Cutoff Wall	1958+00 to 1965+80 Cutoff Wall Tip Elevation 40 1965+80 to 1986+80 Cutoff Wall Tip Elevation 58 1986+80 to 1989+00 Cutoff Wall Tip Elevation 10	
						Undrained Seepage Berm with Drained Stability Berm on Top	1958+00 to 1982+00 seepage berm 120 feet wide, 6 feet thick at levee toe, with stability berm height = 6 feet (on top of seepage berm) 1982+00 to 1989+00 seepage berm 50 feet wide, 5 feet thick at levee toe, with stability berm height = 4 feet (on top of seepage berm)	
33	1989+00	2122+00	No	Yes	Yes	Cutoff Wall	1989+00 to 2000+80 Cutoff Wall Tip Elevation 10 2000+80 to 2026+80 Cutoff Wall Tip Elevation 90 2026+80 to 2036+90 Cutoff Wall Tip Elevation 20 2036+90 to 2086+90 Cutoff Wall Tip Elevation 35 2086+90 to 2122+00 Cutoff Wall Tip Elevation 90	This reach has bends in the levee alignment (in plan view) which are 90 degrees or tighter, which may exacerbate seepage conditions due to three-dimensional effects. 90-degree bends are an important factor for berm design/dimensions (less so for walls). 90-degree bends are important, though, for constructability considerations of slurry cutoff walls.
						Undrained Seepage Berm with Drained Stability Berm on Top	1989+00 to 2020+00 seepage berm 50 feet wide, 5 feet thick at levee toe 2020+00 to 2028+00 seepage berm 100 feet wide, 5 feet thick at levee toe 2028+00 to 2037+00 seepage berm 50 feet wide, 5 feet thick at levee toe 2037+00 to 2050+00 seepage berm 100 feet wide, 6 feet thick at levee toe 2050+00 to 2065+00 connect berm toe as straight line across bend 2065+00 to 2087+00 seepage berm 100 feet wide, 6 feet thick at levee toe 2087+00 to 2102+00 seepage berm 50 feet wide, 5 feet thick at levee toe 2102+00 to 2106+00 connect berm toe as straight line across bend 2106+00 to 2122+00 seepage berm 60 feet wide, 5 feet thick at levee toe for each, stability berm height = 4 feet (on top of seepage berm)	
34	2122+00	2182+00	No	Yes	Yes	Cutoff Wall	2122+00 to 2138+00 Cutoff Wall Tip Elevation 90 2138+00 to 2182+00 no wall (no rehabilitation required)	
						Undrained Seepage Berm with Drained Stability Berm on Top	2122+00 to 2138+00 seepage berm 60 feet wide, 5 feet thick at levee toe, with stability berm height = 4 feet (on top of seepage berm) 2138+00 to 2182+00 no berm (no rehabilitation required)	
						Cutoff Wall	2182+00 to 2224+00 Cutoff Wall Tip Elevation 55	This reach has bends in the levee alignment (in plan view) which are 90 degrees, which may exacerbate seepage conditions due to three-

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

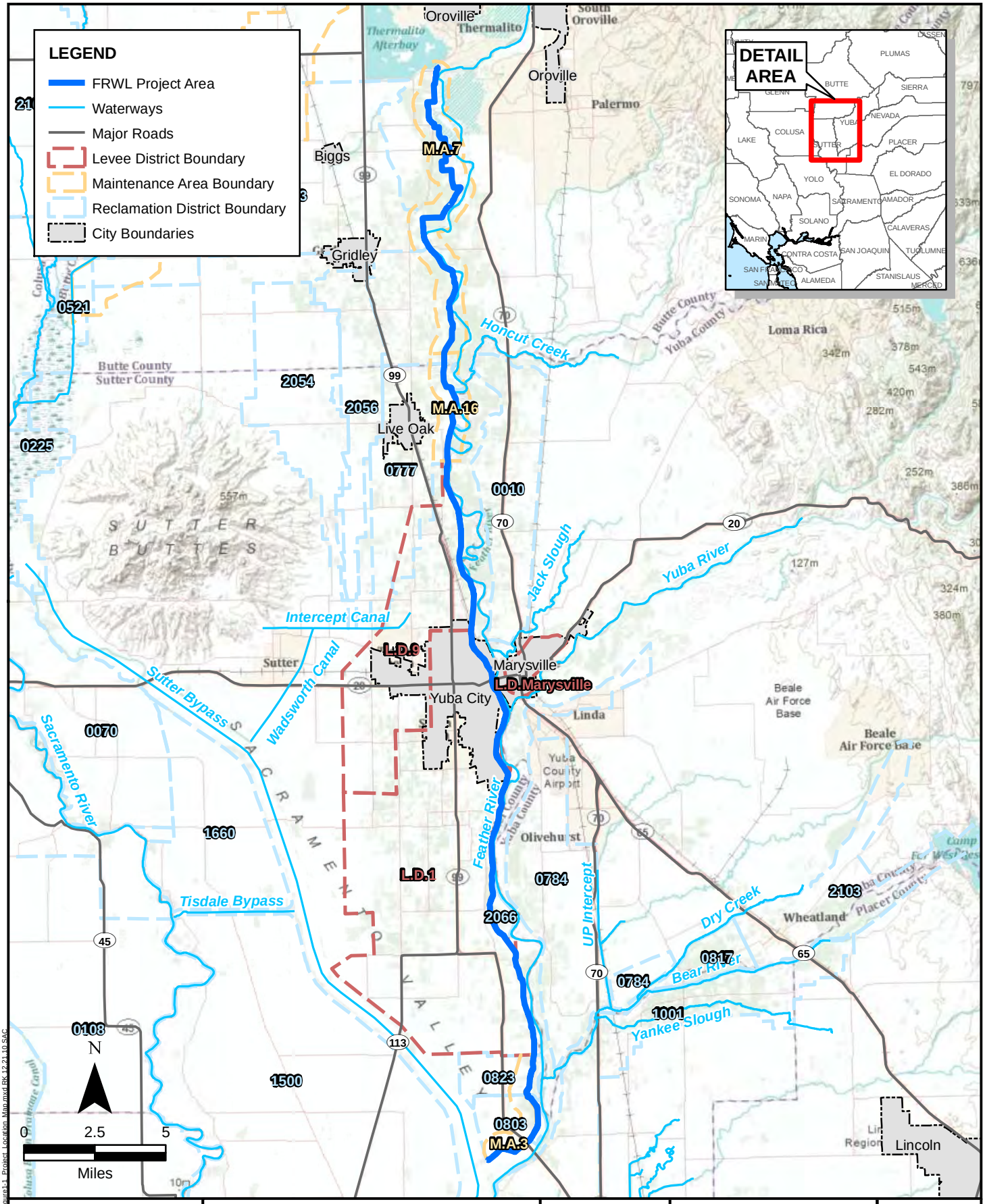
Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
35	2182+00	2224+00	No	No	Yes	Undrained Seepage Berm with and without Drained Stability Berm on Top	2182+00 to 2199+00 seepage berm 65 feet wide, 5 feet thick at levee toe (no drained stability berm on top) 2199+00 to 2203+00 connect berm toe as straight line across bend (no drained stability berm on top) 2203+00 to 2224+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with drained stability berm height = 5 feet (on top of seepage berm)	exacerbate seepage conditions due to three-dimensional effects. 90-degree bends are an important factor for berm design/dimensions (less so for walls). 90-degree bends are important, though, for constructability considerations of slurry cutoff walls.
36	2224+00	2259+00	No	Yes	Yes	Cutoff Wall	2224+00 to 2259+00 Cutoff Wall Tip Elevation 75	This reach has bends in the levee alignment (in plan view) which are 90 degrees, which may exacerbate seepage conditions due to three-dimensional effects. 90-degree bends are an important factor for berm design/dimensions (less so for walls). 90-degree bends are important, though, for constructability considerations of slurry cutoff walls.
						Undrained Seepage Berm with Drained Stability Berm on Top	2224+00 to 2227+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with stability berm height = 5 feet (on top of seepage berm) 2227+00 to 2233+00 connect berm toe as straight line across bend, with stability berm height = 5 feet (on top of seepage berm) 2233+00 to 2259+00 seepage berm 300 feet wide, 7.5 feet thick at levee toe, with drained stability berm height = 4 feet (on top of seepage berm)	
37	2259+00	2290+00	No	Yes	Yes	Cutoff Wall	2259+00 to 2290+00 Cutoff Wall Tip Elevation 45	
						Undrained Seepage Berm with Drained Stability Berm on Top	2259+00 to 2290+00 seepage berm 65 feet wide, 5.5 feet thick at levee to, with stability berm height = 6 feet (on top of seepage berm)	
38	2290+00	2303+00	Yes	No	Yes	Cutoff Wall	2290+00 to 2303+00 Cutoff Wall Tip Elevation 45	Levee founded on dredge tailings.
						Levee Reconstruction and Drained Seepage Berm	2290+00 to 2302+00 De-grade entire levee and reconstruct, with zoned filter at base, and regrade landside to create 300 feet-wide drained seepage berm, 5 feet thick at levee toe, with filter carried out through berm. (2302 to 2303 occupied by berm of Reach 39)	

TABLE 7-1. SUMMARY OF GEOTECHNICAL ANALYSES RESULTS FOR PRE-DESIGN FORMULATION
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT - TASK ORDER 1

Evaluation Reach ID	Reach Limits		Existing Conditions Meet Analytical Criteria?	Existing Conditions Meet Performance Criteria?	Levee Rehabilitation Needed?	Rehabilitation Alternative	Approximate Dimensions of Primary Features	Comments
	Start Station	End Station						
39	2303+00	2319+00	Yes	Yes	No	NA		Levee founded on dredge tailings.
						NA		
40	2319+00	2359+00	No	No	Yes	Cutoff Wall	2319+00 to 2336+90 Cutoff Wall Tip Elevation 50 2336+90 to 2359+00 Cutoff Wall Tip Elevation 20	
						Undrained Seepage Berm with Drained Stability Berm on Top with Landside Pits Filled	Fill the large landside pit at 2321+00 to 2332+00 up to el 120 2321+00 to 2329+00 seepage berm 65 feet wide, 5 feet thick at levee toe, with drained stability berm height = 7 feet (on top of seepage berm) Fill the large landside pits at 2333+00 to 2343+00 2331+00 to 2346+00 seepage berm 120 feet wide, 5 feet thick at levee toe, with drained stability berm height = 10 feet (on top of seepage berm) 2346+00 to 2359+00 seepage berm 300 feet wide, 5 feet thick at levee toe, with drained stability berm height = 4 feet (on top of seepage berm)	
41	2359+00	2368+00	No	Yes	Yes	Cutoff Wall	Cutoff Wall Tip Elevation 20 at 2359+00, constant decrease in depth up to Cutoff Wall Tip Elevation 70 at 2368+00	
						Undrained Seepage Berm with Relief Trench at Berm Toe	2359+00 to 2368+00 seepage berm 70 feet wide, 5 feet thick at levee toe, with drainage relief trench along berm toe that is 50 feet wide at grade, extending down 12 feet deep, with 1.5:1 backcut and frontcut, filled with drain gravel, with filter zones adjacent in-situ soils	

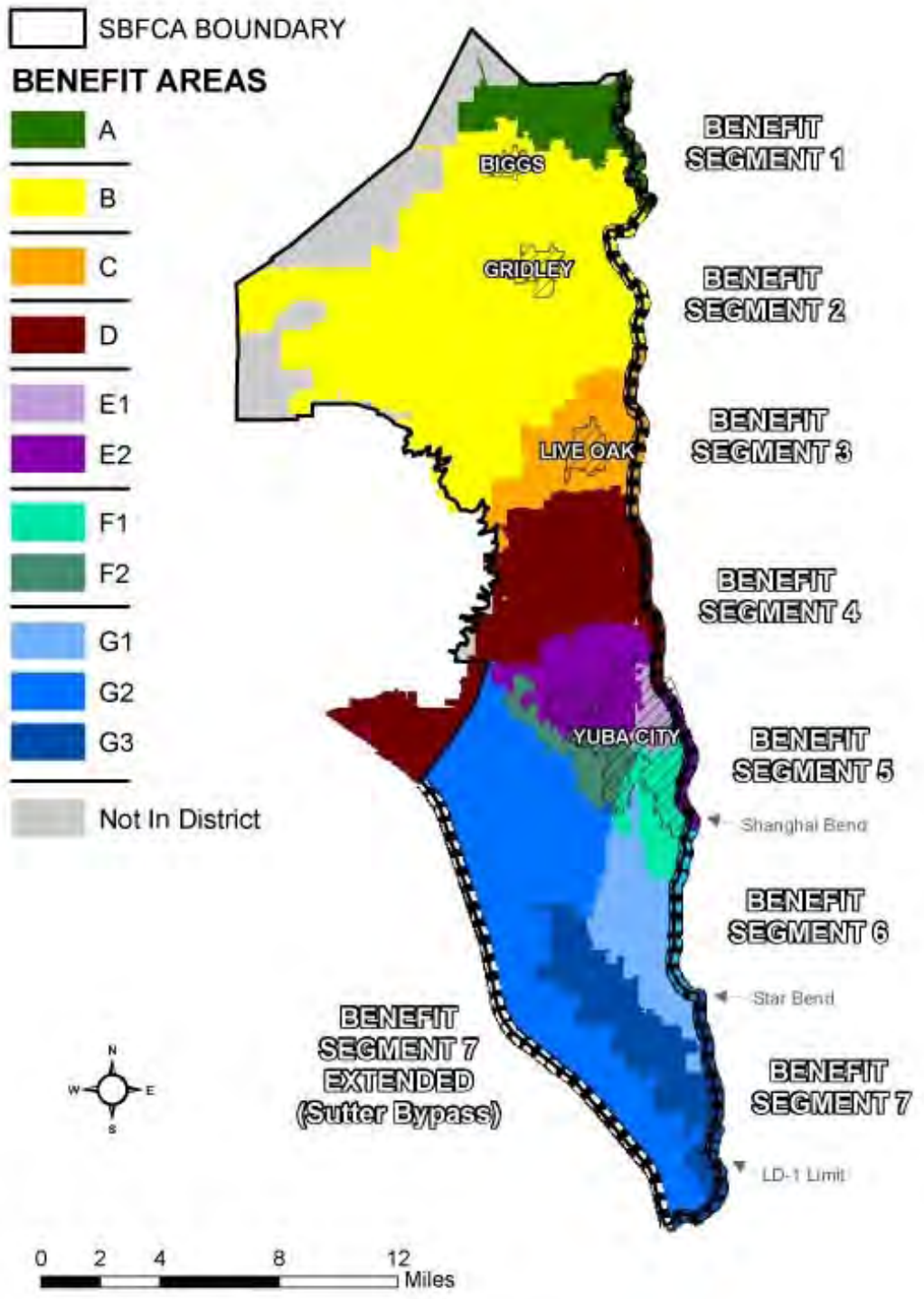
Notes:
1. Berm thicknesses are to the nearest 0.5 foot.
2. Unless otherwise specified:
    1) Cutoff wall is 3 feet thick, de-grade/re-grade is 1/2 levee height.
    2) Seepage berm thickness at the berm toe is 3 feet; berm width is measured from existing levee toe location.
    3) Stability berm slope is 3H:1V, with top-bench 10 feet wide, and 2 feet of cover over 2 feet wide drain.
3. Dimensions are nominal minimum dimensions from a geotechnical standpoint; other requirements may dictate higher minimum values.
4. Current no as-built document is available to the design team. As-built documents and/or adequate confirmatory investigation of the existing berm would be required to confirm that no further rehabilitation is required.

FIGURES

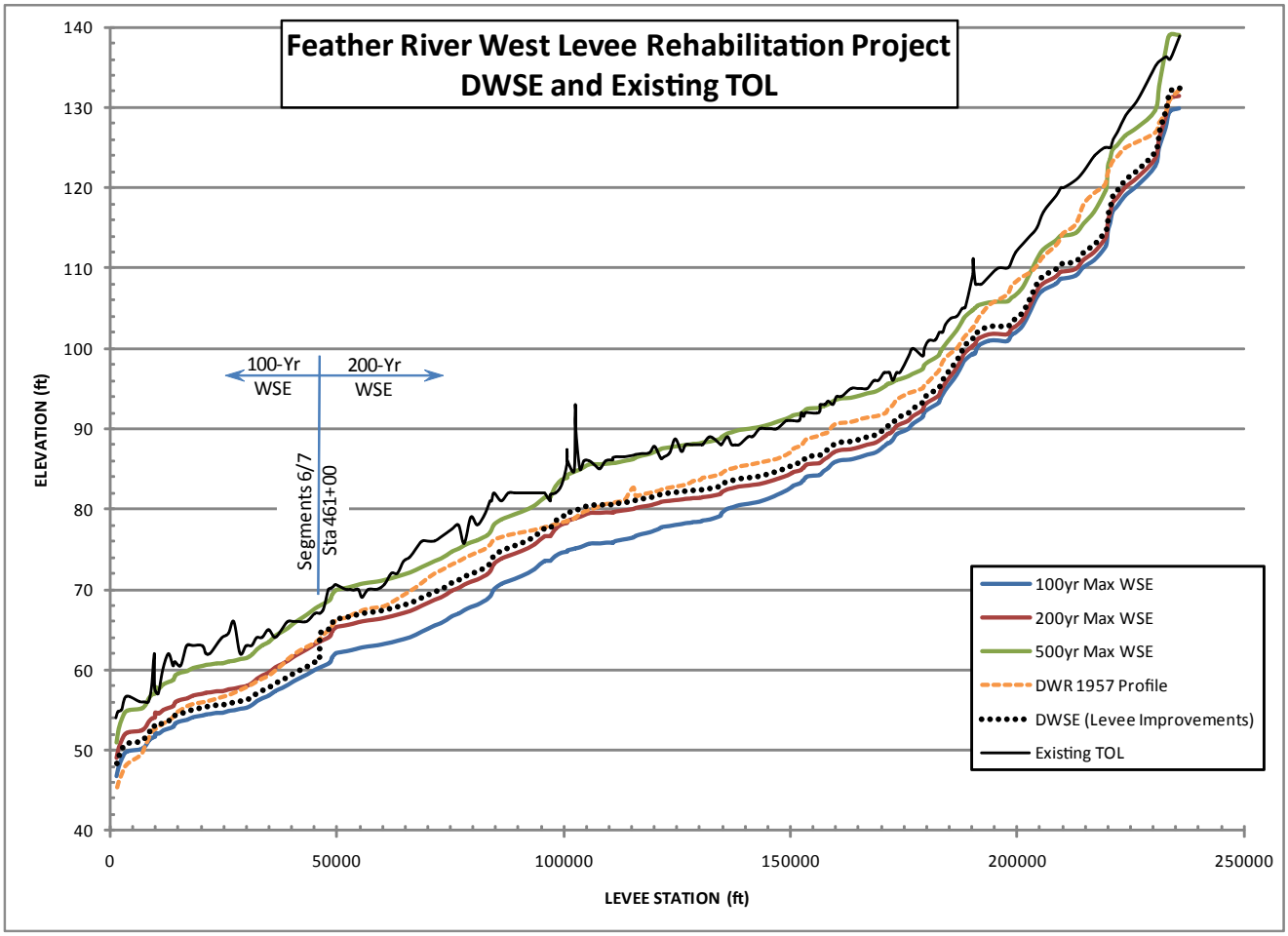


Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation	URS *in association with:* blackburn consulting	**Project Location**	**Figure 1-1**

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Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation	URS *in association with:* blackburn consulting	**FRWL Project Segments**	**Figure 1-2**



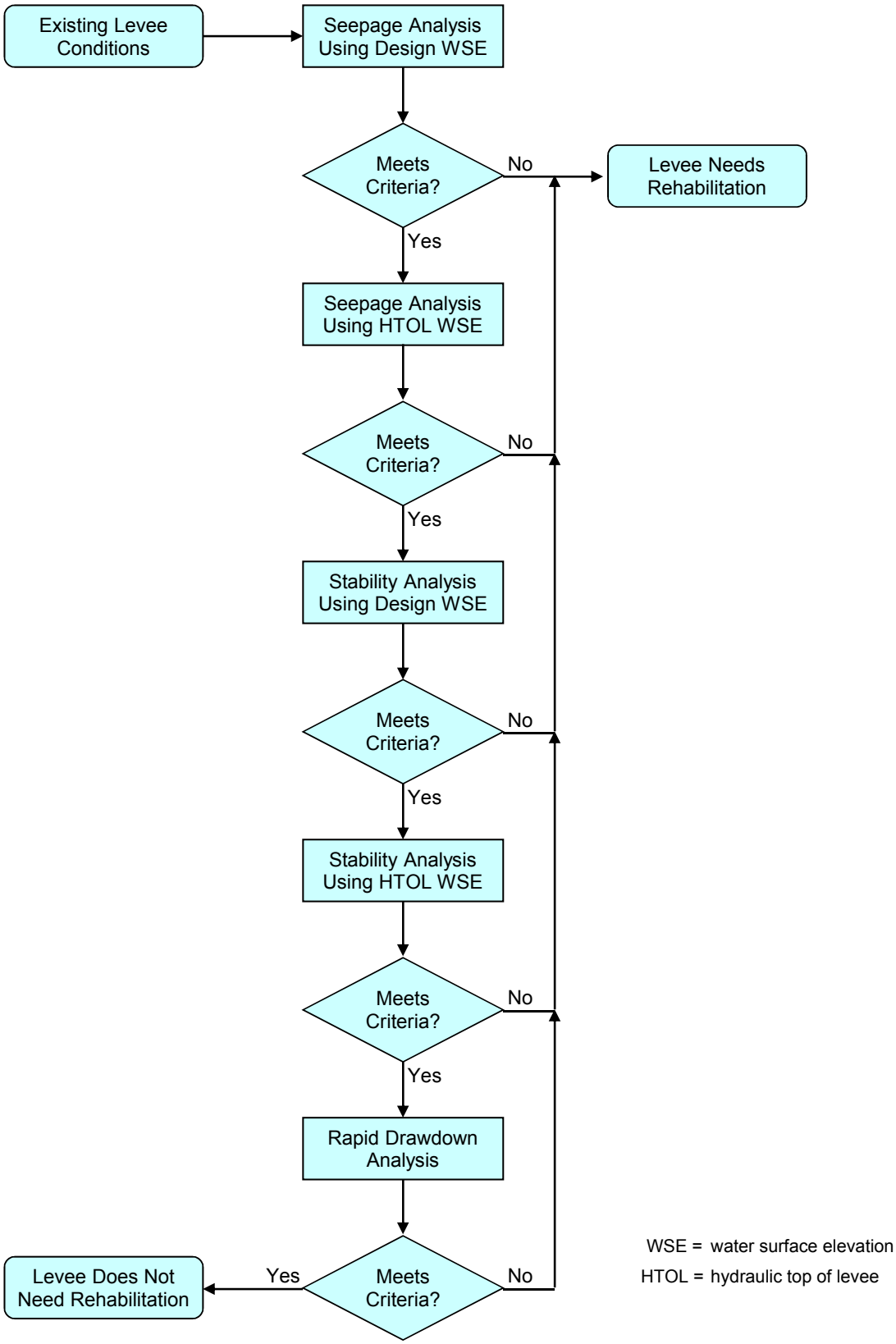
Source: Design Criteria and Technical Approach Memorandum, Feather River West Levee Improvements, Sutter Butte Flood Control Agency, Yuba City, California. Draft. November 30, 2010.

Notes

Elevation datum is 1988 North American Vertical Datum (NAVD88).

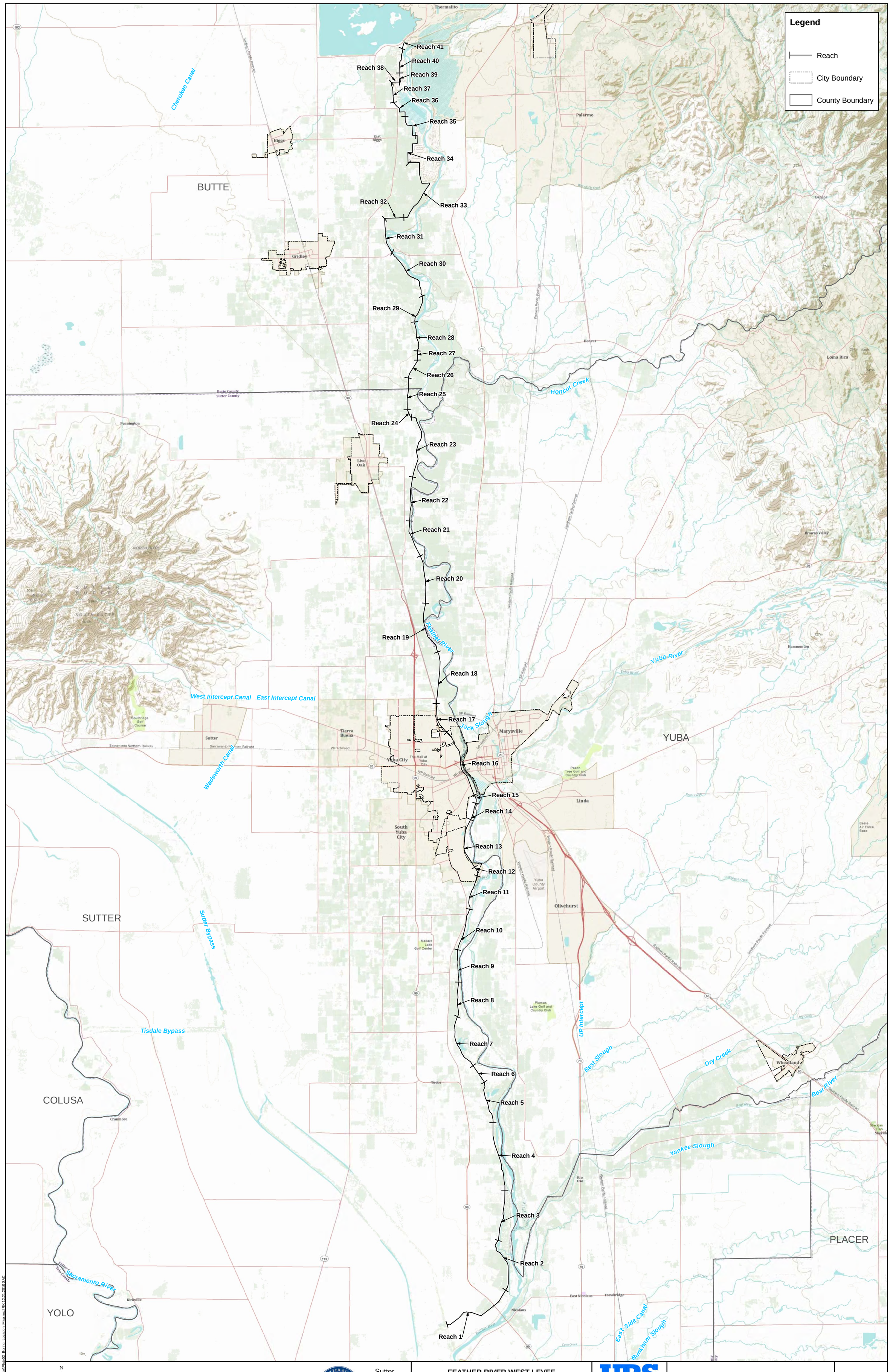
WSE water surface elevation
DWSE design water surface elevation
TOL top of levee
Sta station

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation	URS *in association with:* blackburn consulting	**Water Surface Elevations**	**Figure 2-1**



Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation	URS *in association with:* blackburn consulting	**Problem Identification Process**	**Figure 4-1**

PLATES


Legend
Reach
City Boundary
County Boundary
Reach 41
Reach 40
Reach 38
Reach 39
Reach 37
Reach 36
Reach 35
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Reach 5
Reach 4
Reach 3
Reach 2
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BUTTE
SUTTER
YUBA
COLUSA
YOLO
PLACER
Cherokee Canal
Honcut Creek
Feather River
Yuba River
Jack Slough
Wadsworth Canal
West Intercept Canal
East Intercept Canal
Sutter Bypass
Tisdale Bypass
UP Intercept
Best Slough
Dry Creek
Bear River
Yankee Slough
East Side Canal
Bunkham Slough
Sacramento River
Butte County
Sutter County
Thermalito
Palermo
Biggs
East Biggs
Gridley
Pennington
Live Oak
Honcut
Loma Rica
Bangor
Browns Valley
Hammonton
Wheatland
Tierra Buena
Marysville
Yuba City
South Yuba City
Linda
Olivehurst
Tudor
Cranmore
Kirkville
Sutter
Nicolaus
East Nicolaus
Trowbridge
Rio Oso
Southridge Golf Course
Peach Tree Golf and Country Club
Plumas Lake Golf and Country Club
Mallard Lake Golf Center
Yuba County Airport
Beale Air Force Base
Western Pacific Railroad
Southern Pacific Railroad
Sacramento Northern Railway
WP Railroad
SP Railroad
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Feet
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT
Geotechnical Analyses for Pre-Design Formulation
URS
in association with:
blackburn consulting
Evaluation Reaches
Plate 1
L:\Projects\SBFCA\ArcMaps\Plate02_Boring_Location_Map.mxd RK 12.21.2010 SAC

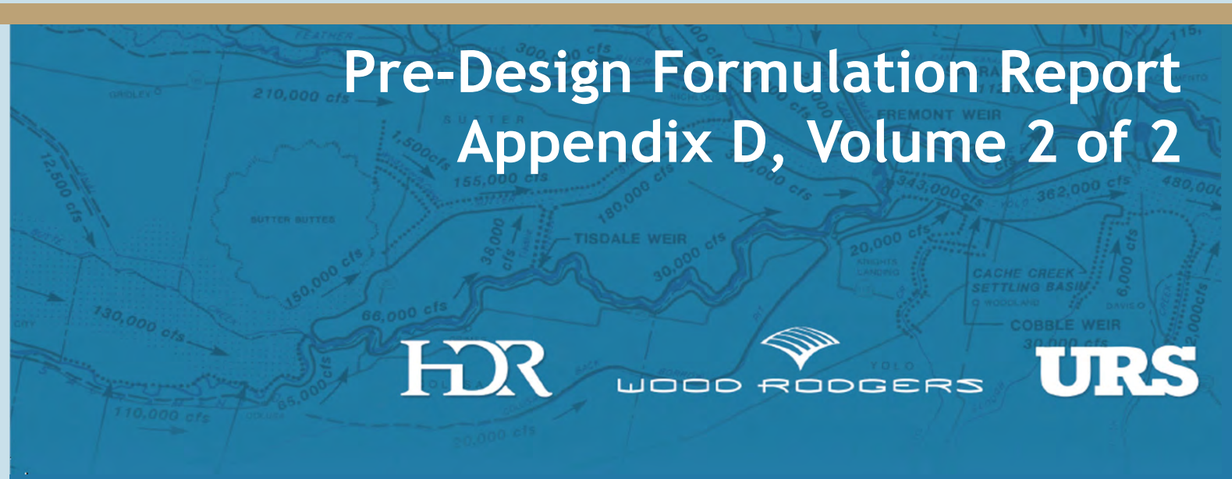
February 2011



Feather River West Levee Improvement Program

Sutter Butte Flood Control Agency

Pre-Design Formulation Report
Appendix D, Volume 2 of 2



HDR WOOD RODGERS URS

APPENDIX A

Working Draft Plan View and Stick Logs

INDEX LEGEND

- Feather River North
- Feather River South
- Sutter Bypass
- Wadsworth Canal
- 2 — Plan Frame width and Sheet Number

DETAIL AREA

YUBA CO.

BUTTE CO.

SUTTER CO.

GLENN CO.

COLUSA CO.

Yuba River

Jack Slough

Honcut Creek

Feather River

Dry Creek

Bear River

Yankee Slough

Best Slough

UP Intercept

East Side Canal

Upham Slough

Feather River North

Feather River South

Sutter Bypass

Wadsworth Canal

West Intercept Canal

East Intercept Canal

Tisdale Bypass

Sacramento River

Cherokee Canal

Butte Creek

L.D.Marysville

L.D.6

L.D.1

RD 2103

RD 0784

RD 1001

RD 0783

RD 0782

RD 0783

RD 0777

RD 2056

RD 2054

RD 0783

RD 1500

RD 1660

RD 0776

RD 0784

RD 2102

RD 0784

RD 2102

RD 0784

RD 0784

RD 0784

PLAN LEGEND

- SBFCA FRWL Project Boring
- SBFCA FRWL Project CPT
- HistoricalULE Boring
- Historical ULE CPT
- Historical ULE Hand Auger
- Other Historical Boring
- Levee Miles
- Canal
- SBFCA FRWL Project Levee Stationing
- DWR ULE Levee Stationing
- Analysis Cross-Section
- Reach
- Levee District Boundary
- Maintenance Area Boundary
- Reclamation District Boundary

Existing Improvement Measure, Known or Reported

- Berm
- Revetment
- Toe Drain
- Berm
- Ditch
- Levee Raise
- Levee Raise and Widening
- Levee Reconstruction
- Relief Well
- Revetment
- Riprap
- Seepage Interceptor System
- Slurry Cutoff Wall
- Toe Drain
- Waterside Slope Repair

Documented Historical Levee Distress

- Boil
- Cracking
- Erosion
- Seepage
- Sinkhole
- Area of Concern
- Boil
- Breach, Levee Failure
- Burrow
- Erosion
- Seepage
- Sinkhole
- Slope Instability

SURFICIAL GEOLOGY LEGEND (Source: DWR, 2010a)

Surfical Geology was mapped at 1:20,000.

Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain; solid contacts within 30' of line shown on map.

W 1911 Water bodies, circa 1911

W 1937 Water bodies, circa 1937

BP Borrow pits present in 1937

GEOLOGIC UNITS*

Historical

- L Levee; Culturally deposited
- SP Spoils pile; Artificial fill, circa 1937
- DT Dredge tailings; Spoils material from gold dredge operations
- 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
- Rdc Distributary channel deposits; Distributary channel deposits, trace gravel, sand, silt, and clay; channelized flow conducting sediment to floodplain
- Rofc Overflow channels; Vertically stratified sand, silt and clay in channels occupiedwhen high-stage water overtops channel banks
- Rsl Slough deposits; Sand, silt and clay, fining upward facies, low-energy channel deposit
- Rcu Crevasse splay deposits; Cut off channel (chute); occurs on insides of meander bends within the river channel; on flood plain -- entrenchment of overflow channels into hydraulic mining debris
- Rch Channel deposits; Sorted sands and silts; fining upward (Rch 1911: channels as shown on historic topo)
  - Rb Channel bar deposits; fine gravel, sand, and silt deposited in or along channel lateral margins
  - Rms Channel meander scroll deposits; Sand, silt and clay from lateral channel migration
- Ra Alluvial deposits, undifferentiated; sand, silt, and minor lenses of fine gravel

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 clay 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
- Ha Alluvial deposits undifferentiated; Sand, silt, and minor lenses of gravel; under cultivation in 1937
- Hch Channel deposits; Sorted sands and silts; fining upward
  - Hb Channel bar deposits; Fine gravel, sand, and silt deposited in or along channel lateral margins
  - Hms Channel meander scroll deposits; Sand, silt and clay from lateral channel migration
- Hdc Distributary channel deposits, sand, silt, and clay
- Hsl Slough deposits; sand, silt and clay, fining upward facies, low-energy channel deposit
- Hfy Alluvial fan deposits; Well graded gravel, sand, silt and clay; volcanic lithologies
- Qa Alluvial deposits undifferentiated; Sand, silt, and minor lenses of fine gravel, under urbanization in 1937
- Qn Basin deposits; Fine sand, silt and clay, dark yellow to dark yellowish brown, under cultivation in 1937
- Qs Marsh deposits; Silt and clay, likely organic-rich; perennially or seasonally submerged

Pleistocene

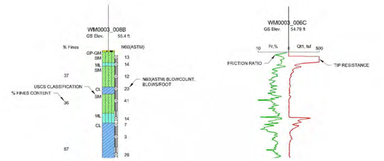
- Qmu Modesto Formation; upper member; Unconsolidated gravel, sand, silt, and clay
- Qml Modesto Formation; lower member; Unconsolidated to semi-consolidated gravel, sand, silt and clay
- Qru Riverbank Formation; upper member; Semi-consolidated to consolidated gravel, sand, silt and minor clay
- Qrl Riverbank Formation; lower member; Consolidated gravel, sand, silt, and clay, generally associated with strong duripan soil horizon

Pliocene / Pleistocene

- QTm Tuff breccia; Volcanic tuff breccia (andesitic and rhyolitic) from Sutter Buttes, latest Pliocene

PROFILE LEGEND

- Levee Crest
- Landside Levee Toe
- Waterside Levee Toe



GROUP SYMBOLS AND NAMES

Graphic	Group Names	Graphic	Group Names	Graphic	Group Names	Graphic	Group Names
	Lean Clay (CL)		Lean Clay with Sand (CL)		Lean Clay with Gravel (CL)		Sandy Fat Clay (CH)
	Sandy Lean Clay (CL)		Sandy Lean Clay with Gravel (CL)		Gravelly Lean Clay (CL)		Sandy Clayey Silt (ML/CL)
	Gravelly Lean Clay with Sand (CL)		Fat Clay (CH)		Fat Clay with Sand (CH)		Sandy Elastic Silt (MH)
	Silty Clay (CL-ML)		Silty Clay with Sand (CL-ML)		Sandy Silty Clay (CL-ML)		Poorly Graded Sand with Clay and Gravel (SP-SC)
	Silt (ML)		Silt with Sand (ML)		Sandy Silt (ML)		Silty Gravel (GM)
	Sandy Silt with Gravel (ML)		Gravelly Silt (ML)		Gravelly Silt with Sand (ML)		Clayey Silt (ML/CL)
	Elastic Silt (MH)		Elastic Silt with Sand (MH)		Poorly Graded Sand (SP)		Lean to Fat Clay (CL/CH)
	Poorly Graded Sand with Gravel (SP)		Poorly Graded Sand with Clay (SP-SC)		Poorly Graded Sand with Silty Clay (SP-SC)		Sandy Silty Clay to Clayey Silt (CL/ML)
	Poorly Graded Sand with Silt (SP-SM)		Poorly Graded Sand with Silt and Gravel (SP-SM)		Well-Graded Sand (SW)		Sandy Clayey Silt (ML/CL)
	Well-Graded Sand with Gravel (SW)		Well-Graded Sand with Clay (SW-SC)		Well-Graded Sand with Clay and Gravel (SW-SC)		
	Well-Graded Sand with Silt (SW-SM)		Well-Graded Sand with Silt and Gravel (SW-SM)		Clayey Sand (SC)		
	Clayey Sand with Gravel (SC)		Silty Sand (SM)		Silty Sand with Gravel (SM)		
	Poorly Graded Gravel (GP)		Poorly Graded Gravel with Sand (GP)		Poorly Graded Gravel with Clay (GP-GC)		
	Poorly Graded Gravel with Clay and Sand (GP-GC)		Poorly Graded Gravel with Silt (GP-GM)		Poorly Graded Gravel with Silt and Sand (GP-GM)		
	Well-Graded Gravel (GW)		Well-Graded Gravel with Sand (GW)		Well-Graded Gravel with Clay (GW-GC)		
	Well-Graded Gravel with Clay and Sand (GW-GC)		Well-Graded Gravel with Silt (GW-GM)		Well-Graded Gravel with Silt and Sand (GW-GM)		
	Clayey Gravel (GC)		Clayey Gravel with Sand (GC)		Silty Gravel with Sand (GM)		

OTHER SYMBOLS

- Asphalt
- Boulders and cobbles

Note: Soils were classified in the field in general accordance with ASTM D2488-06, Standard Practice for Description and Identification of Soils (Visual Manual Procedure). Where laboratory testing was performed, classifications were modified in general accordance with ASTM D2487-06, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

Borderline symbols, two group symbols separated by a slash, may be used to reflect visual classification when (1) percentage of fines is estimated to be between 45% and 55%, (2) percentages of sand and gravel are estimated to be about the same, (3) soil could be either well graded or poorly graded, (4) soil could be either a silt or a clay, or (5) fine-grained soil has properties bordering that it is at the boundary between low and high plasticity. Refer to ESRP Soil and Rock Logging, Classification, and Presentation Manual for guidelines in the use of borderline symbols.

SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (1.4 in. ID)
- Standard California (2.5 in. ID)
- Modified California (2.6 in. ID)
- Shelby Tube (2.38 or 2.87 in. ID)
- Punch Core
- Sonic Core
- Dry Core
- Bag Sample

FRWL Project Plan Views and Stick Figures

Plate Index

URS

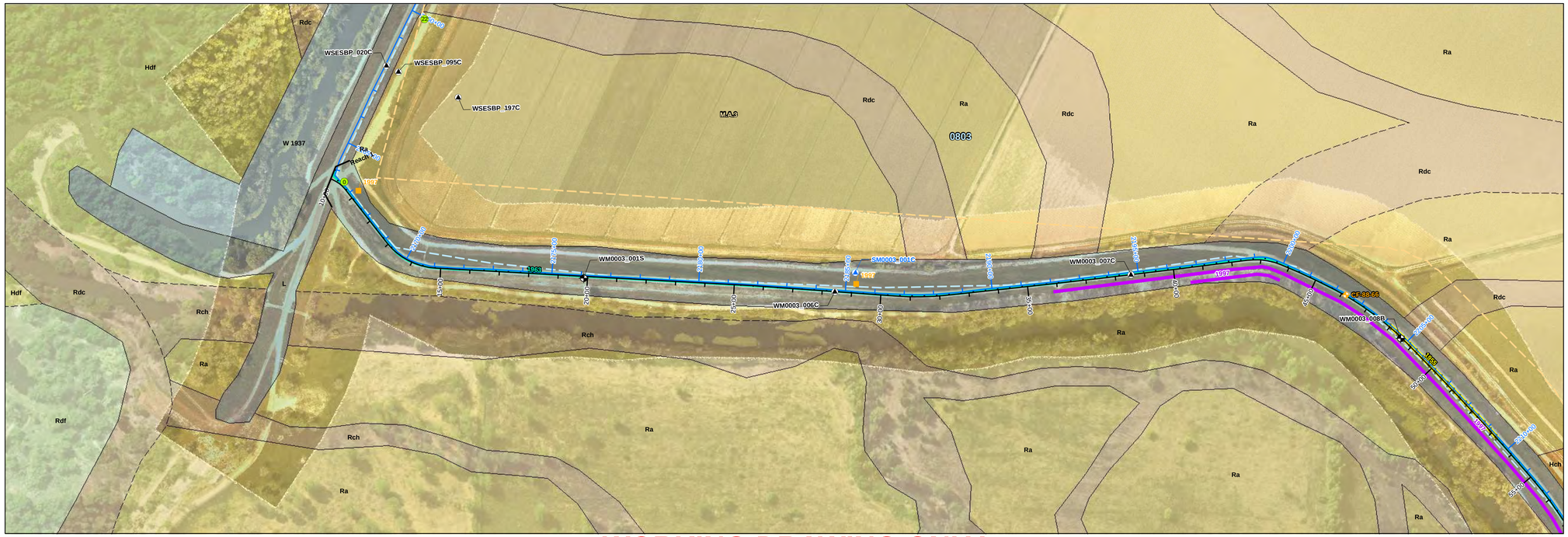
Report of Geotechnical Analyses for Pre-Design Formulation

Sutter Butte Flood Control Agency

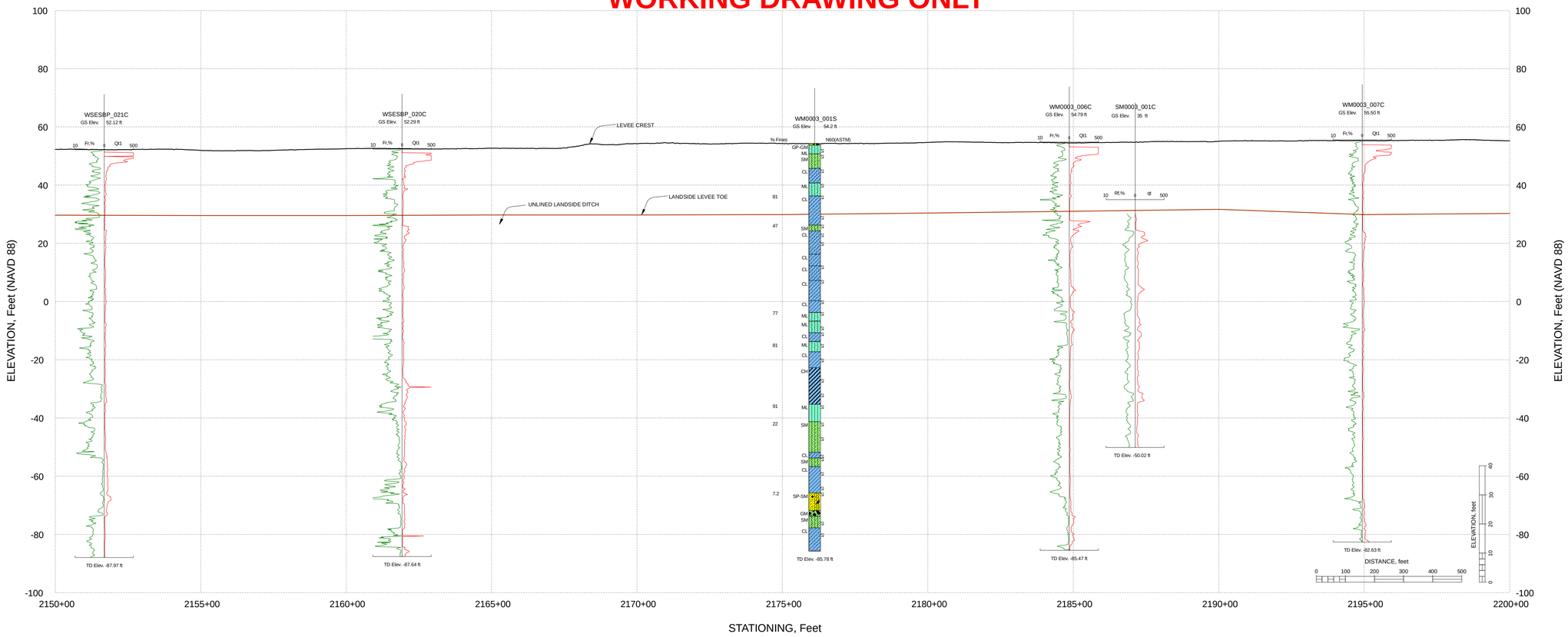
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A2

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WORKING DRAWING ONLY

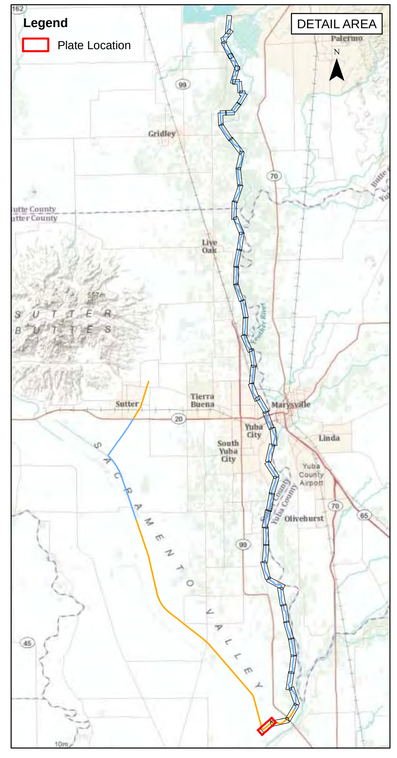


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Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



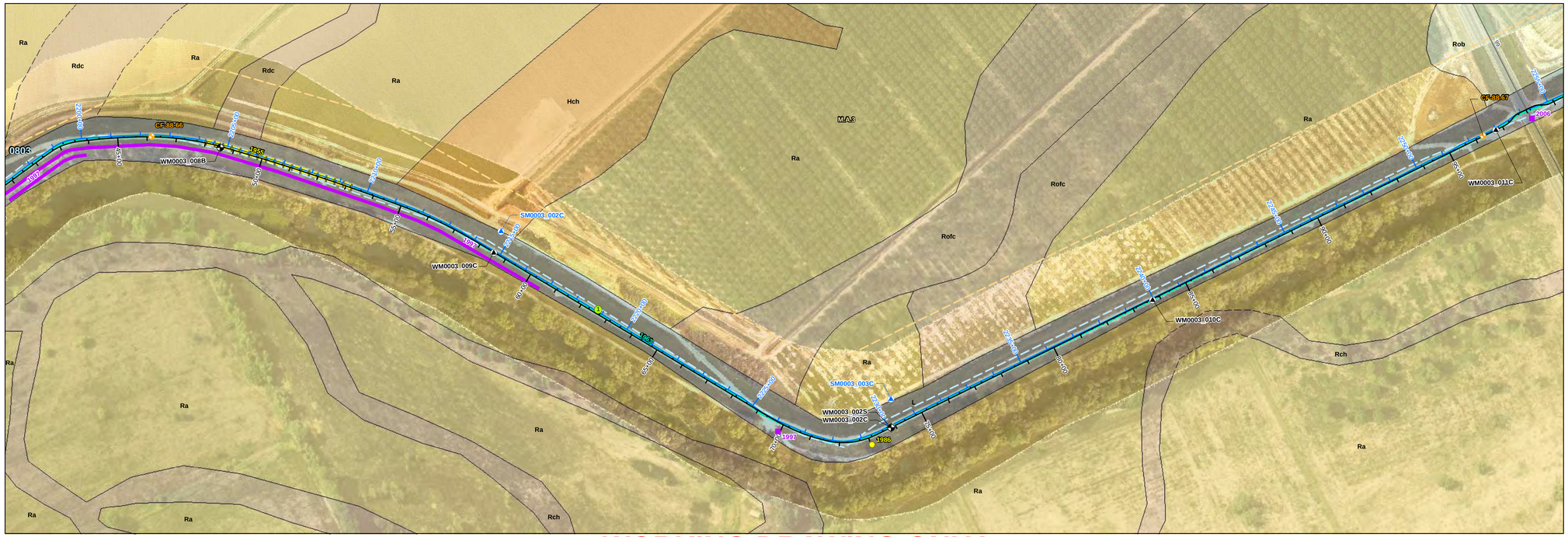
FRWL Project Plan Views and Stick Figures
DWR: Station 2166+00 to Station 2200+00
FRWL Project: Station 10+00 to Station 43+77

URS
Report of Geotechnical Analyses for Pre-Design Formulation

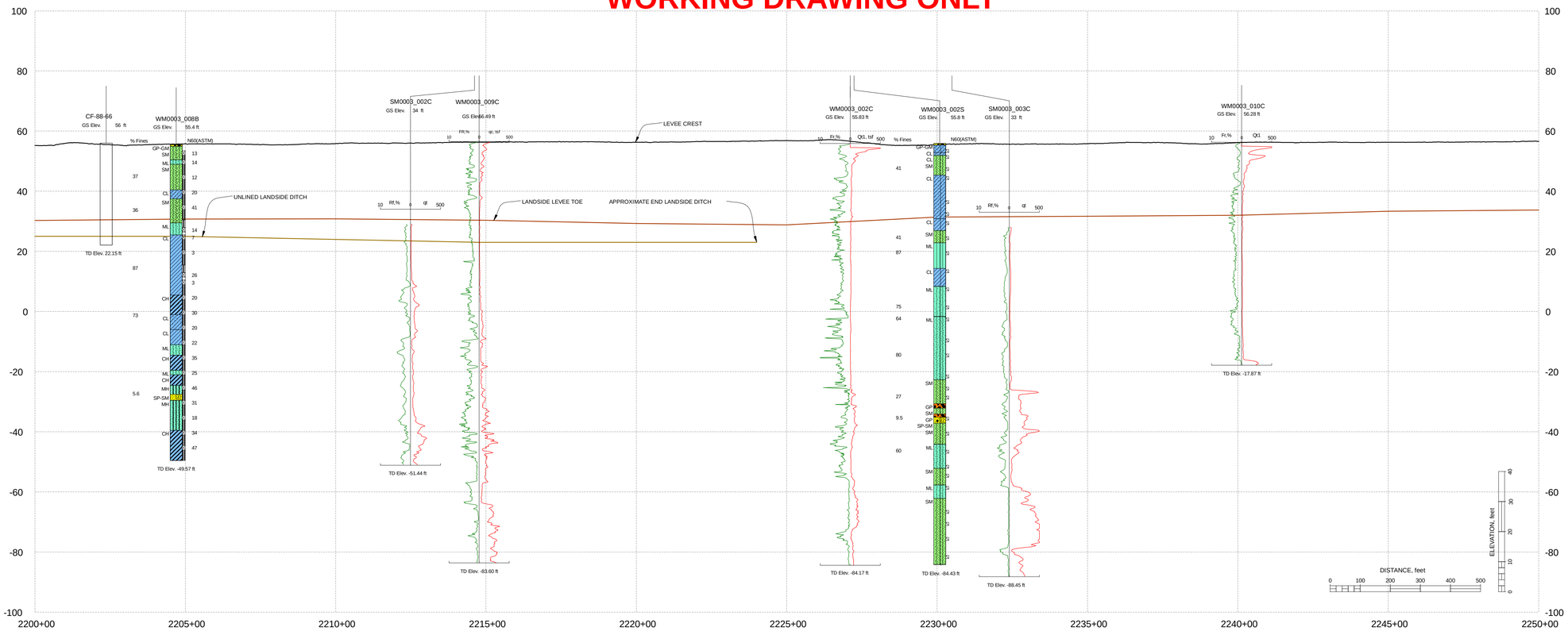
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A3

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WORKING DRAWING ONLY



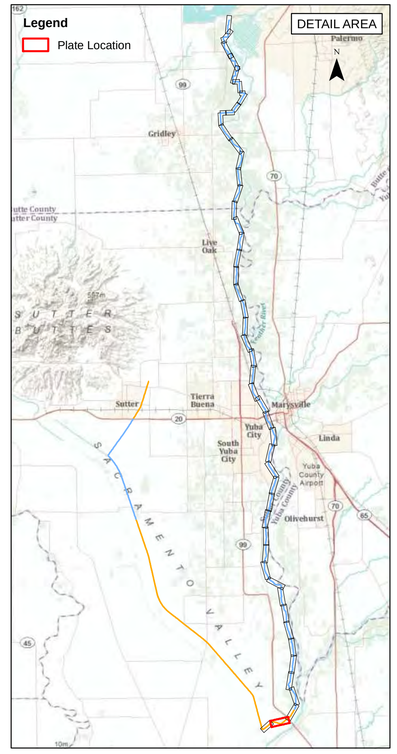
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DRAFT

NOTES:

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FRWL Project Plan Views and Stick Figures
DWR: Station 2200+00 to Station 2250+00
FRWL Project: Station 43+77 to Station 93+76

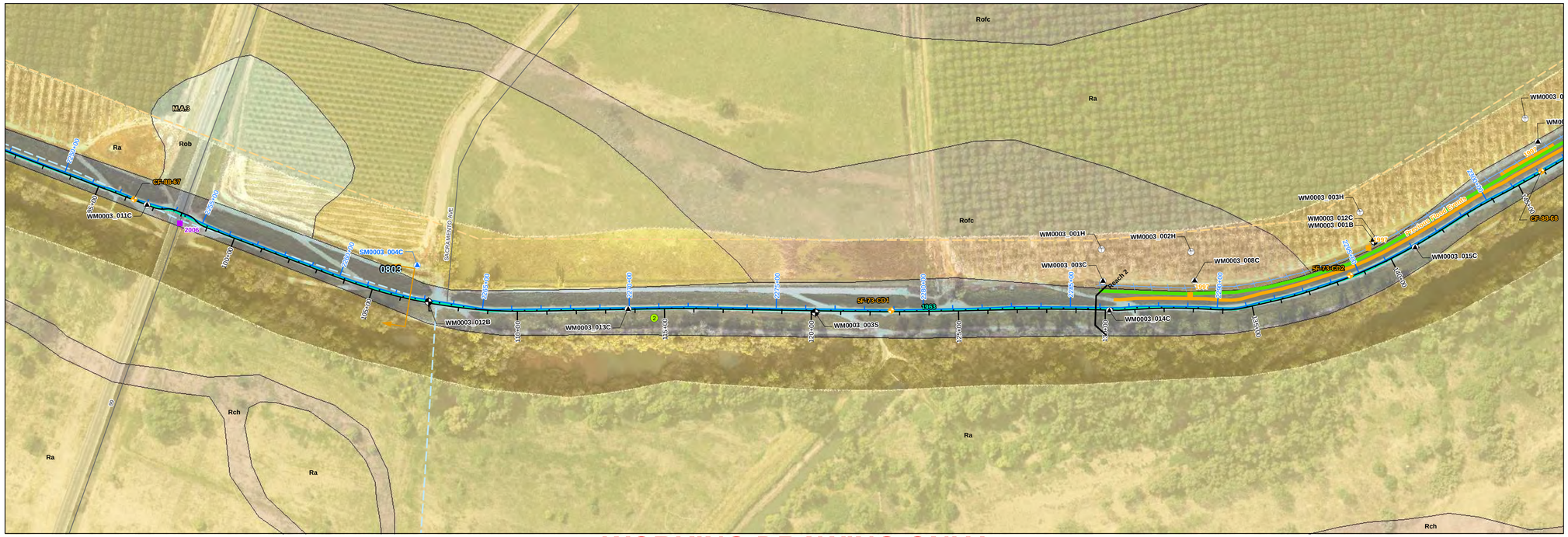
URS

Report of Geotechnical Analyses
for Pre-Design Formulation

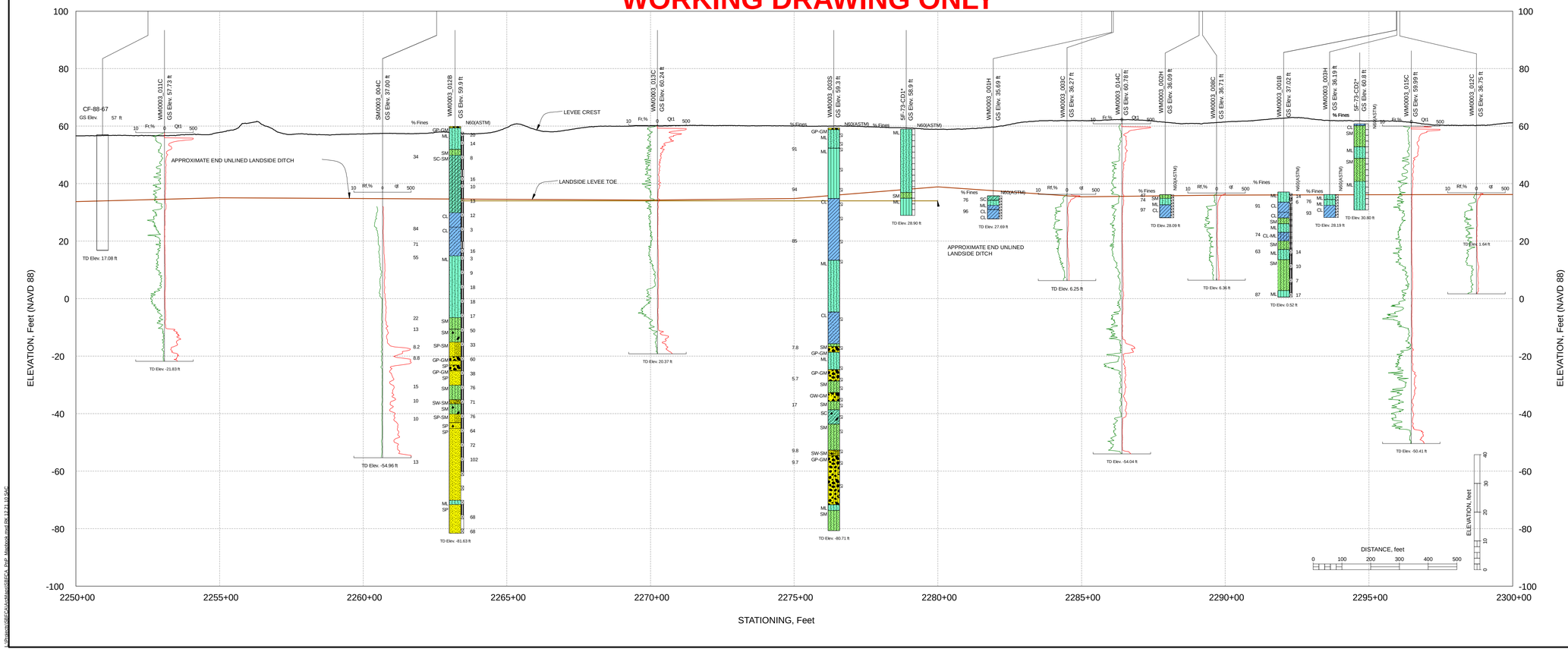
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A4

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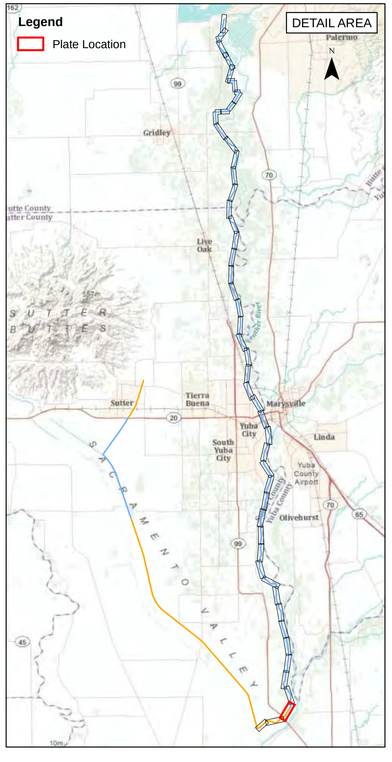
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NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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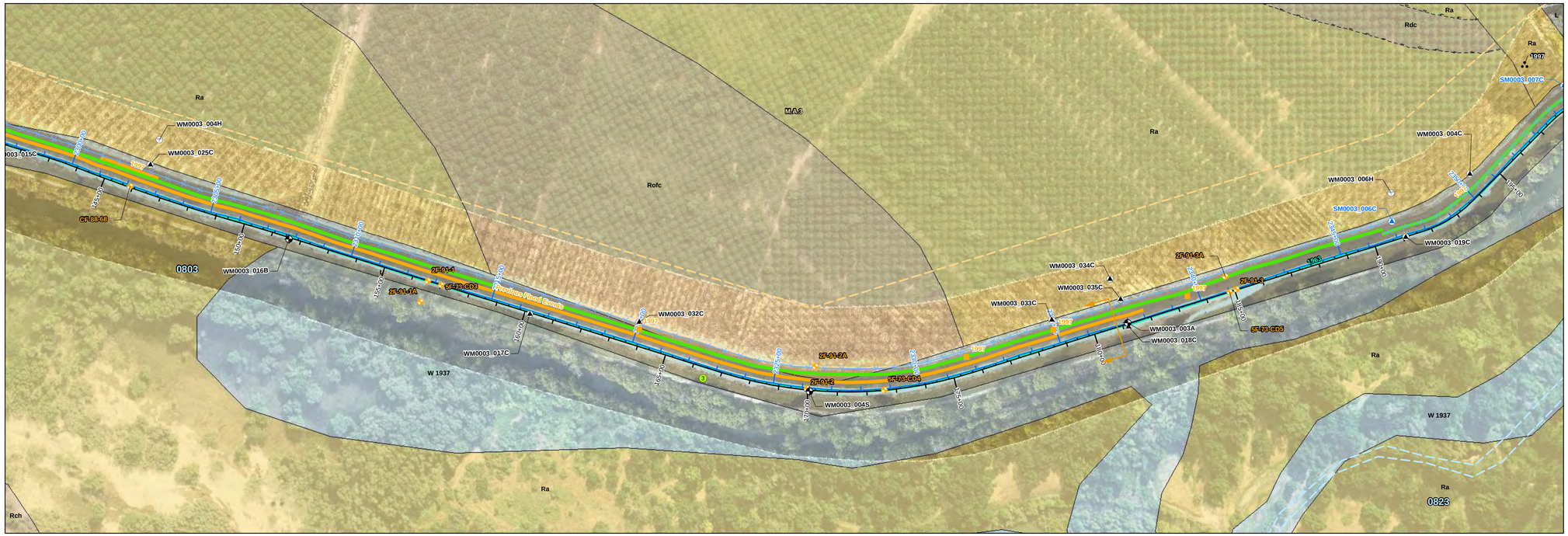
FRWL Project Plan Views and Stick Figures
DWR: Station 2250+00 to Station 2300+00
FRWL Project: Station 93+76 to Station 143+84

URS — Report of Geotechnical Analyses for Pre-Design Formulation

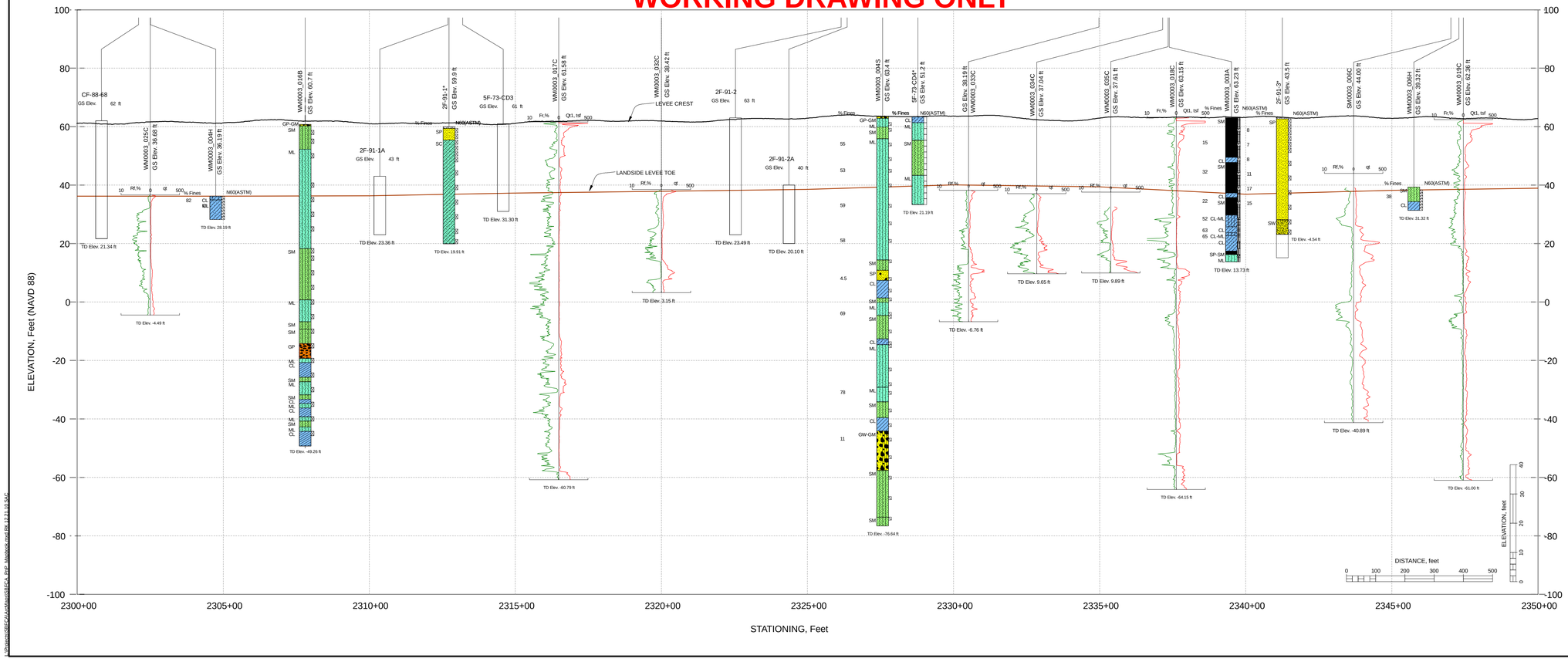
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A5

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WORKING DRAWING ONLY



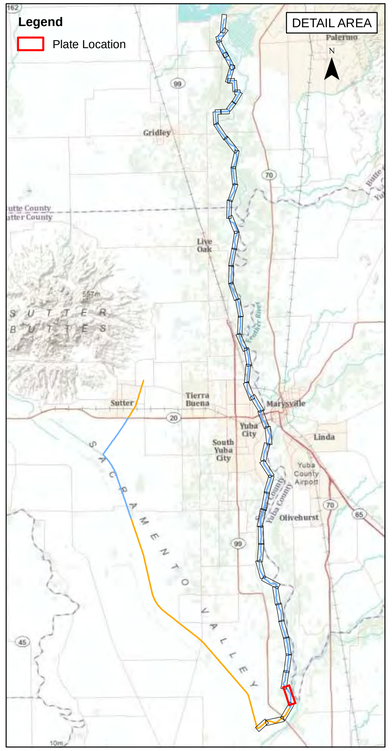
N

0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



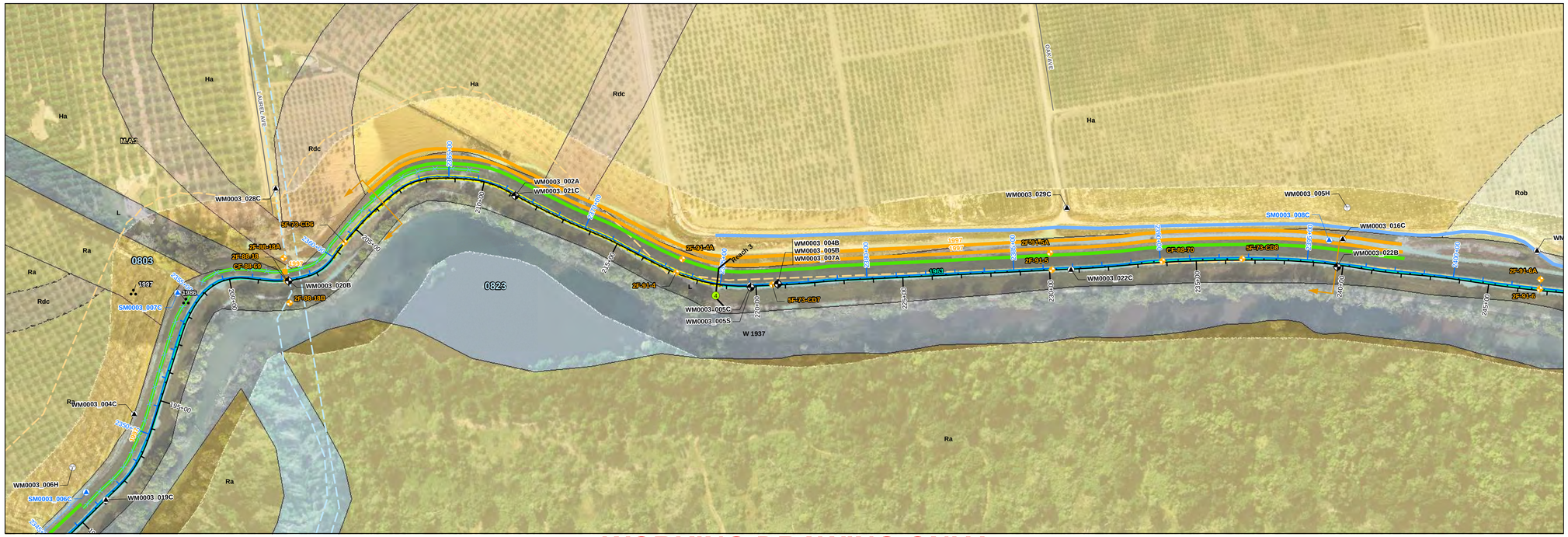
FRWL Project Plan Views and Stick Figures
DWR: Station 2300+00 to Station 2350+00
FRWL Project: Station 143+84 to Station 193+86

URS
Report of Geotechnical Analyses for Pre-Design Formulation

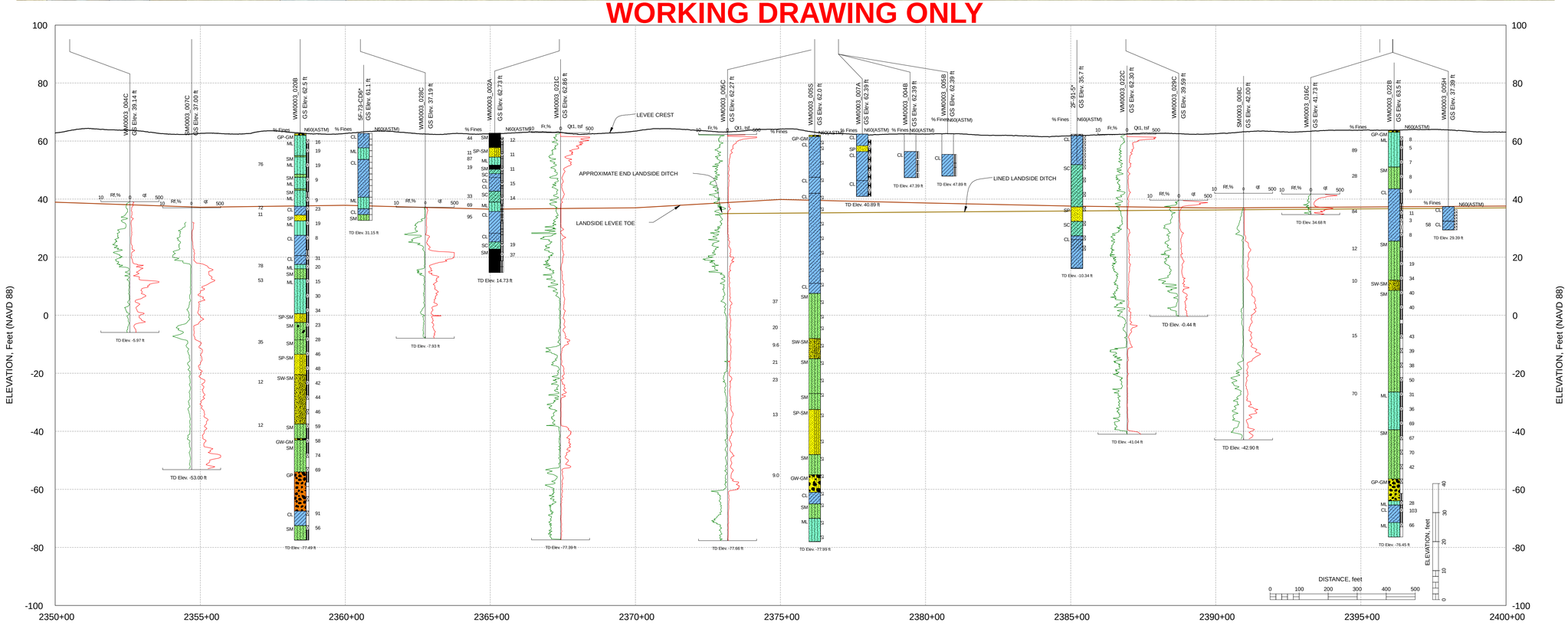
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A6

J:\Projects\SBFCA\Maps\SBFCA_PreP_Maps6.mxd 09.17.21 10:54C



WORKING DRAWING ONLY



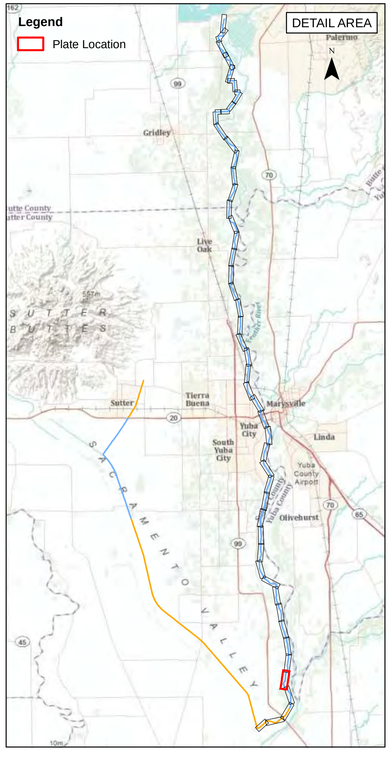
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Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



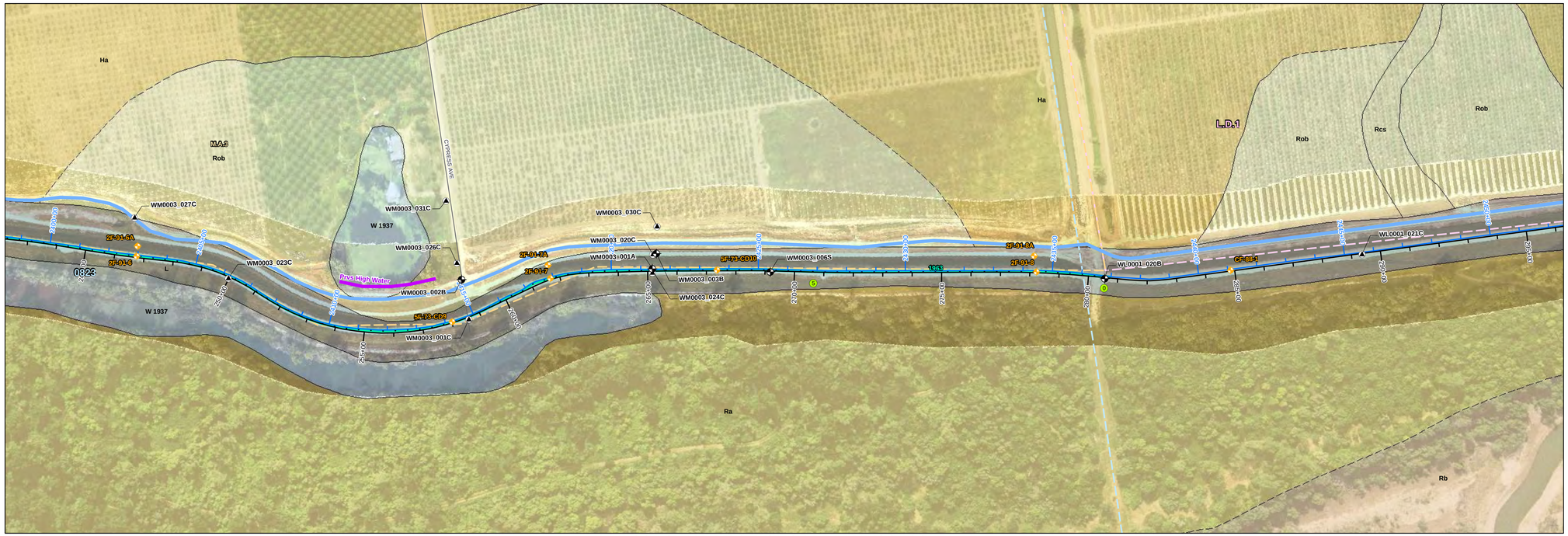
FRWL Project Plan Views and Stick Figures
DWR: Station 2350+00 to Station 2400+00
FRWL Project: Station 193+86 to Station 243+79

URS — Report of Geotechnical Analyses for Pre-Design Formulation

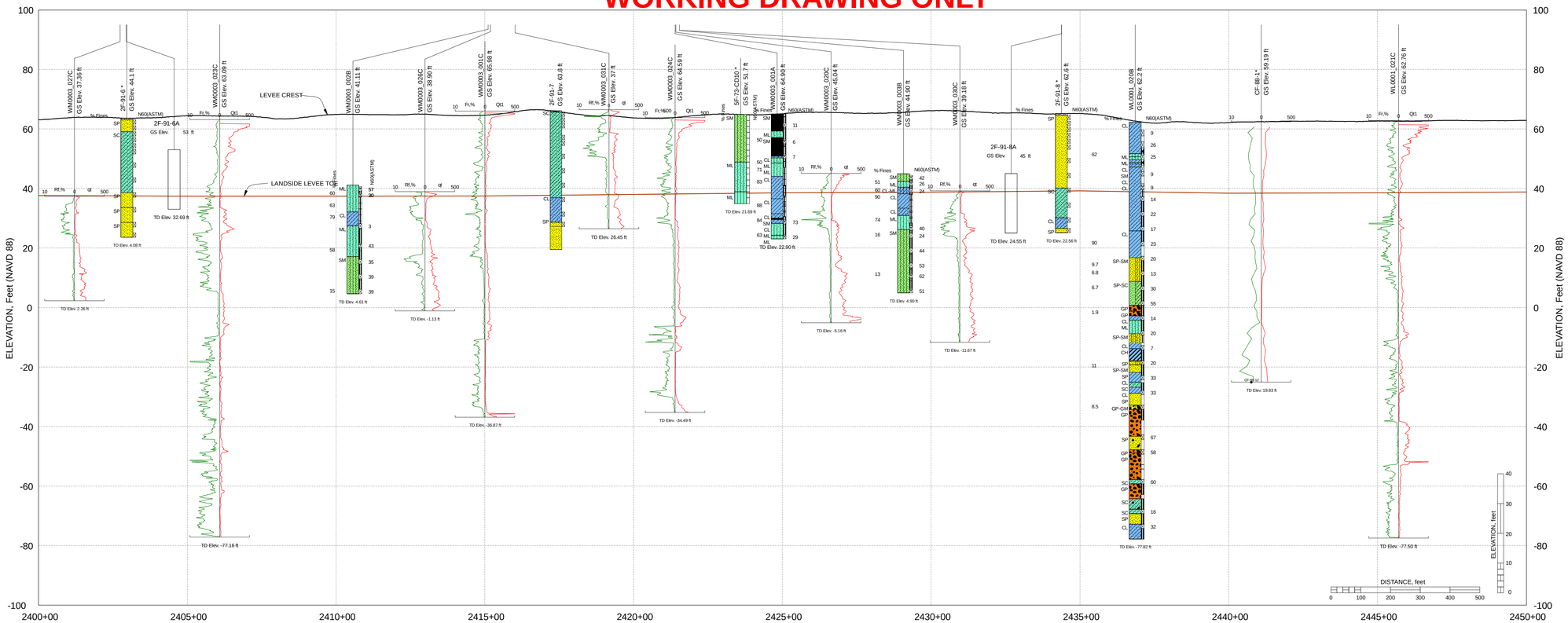
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A7

Plotted:08/FEB/2011 08:10:10 By:Mcdonald, Brad
J:\projects\SBFCA\Maps\SBFCA_PreP_Workbook.mxd



WORKING DRAWING ONLY



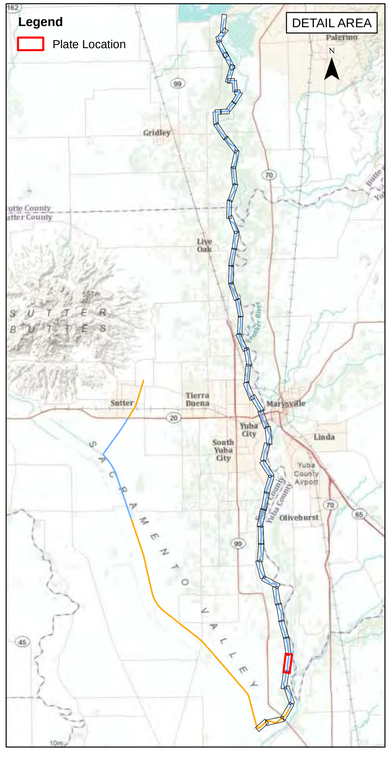
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0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 2400+00 to Station 2450+00
FRWL Project: Station 243+79 to Station 293+78

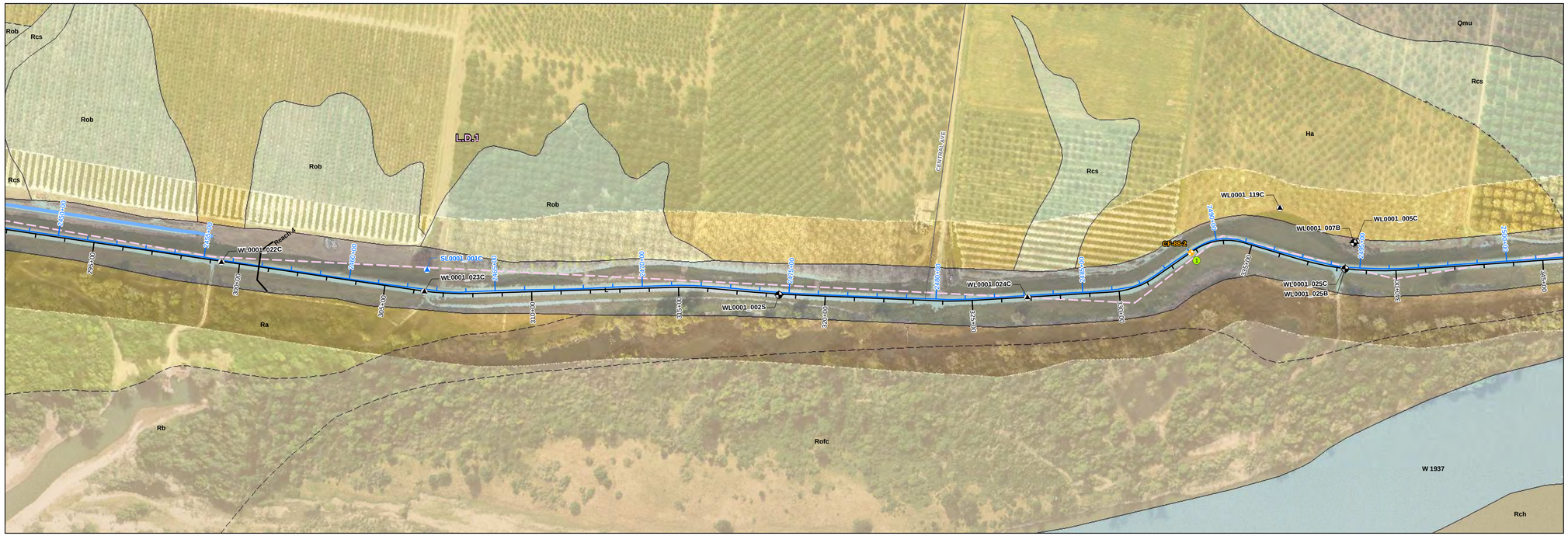
URS

Report of Geotechnical Analyses
for Pre-Design Formulation

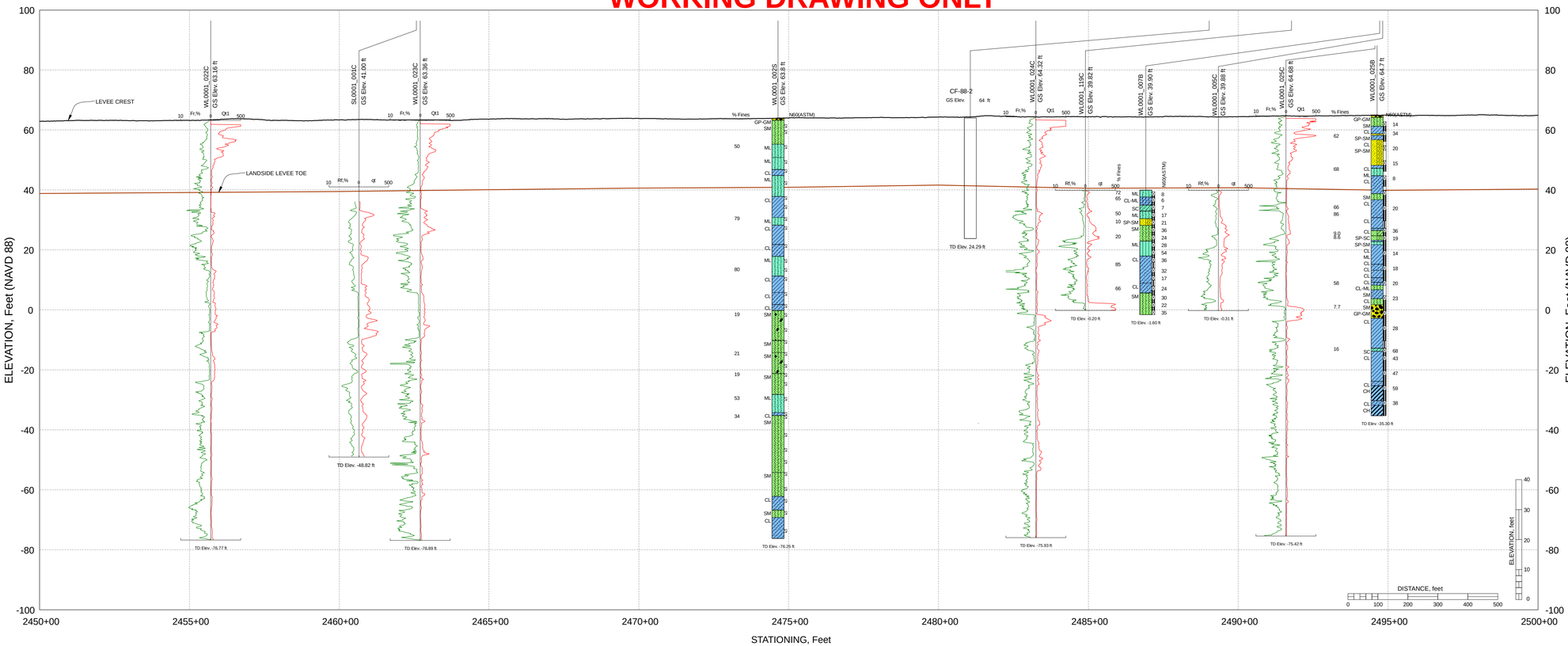
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A8

Plotted:08/24/2011 10:04AM By:Mcdonald, Ryan
Drawing:S:\EFCA\Maps\EFCA_PreP_Workbook.mxd



WORKING DRAWING ONLY



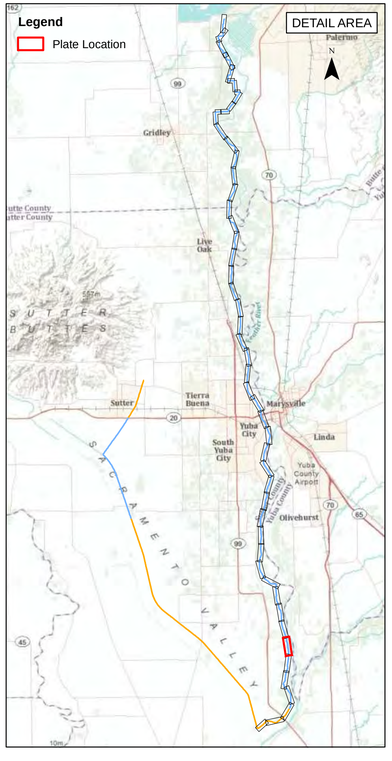
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Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 2450+00 to Station 2500+00
FRWL Project: Station 293+78 to Station 343+78

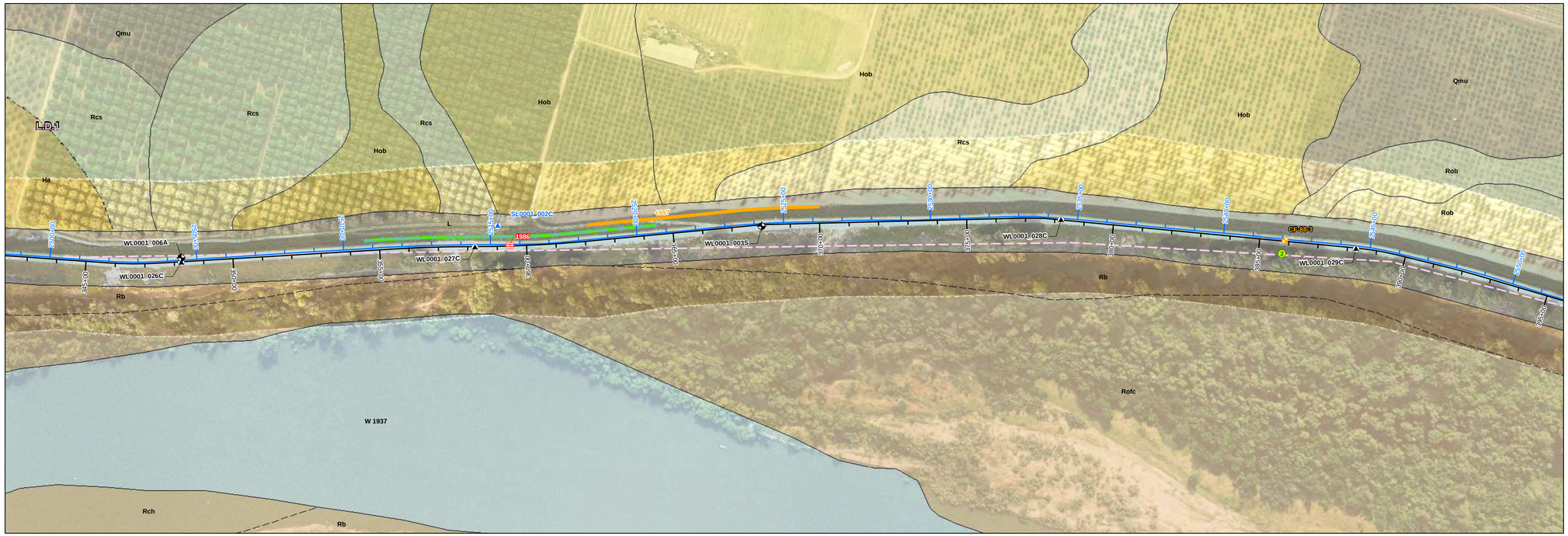
URS

Report of Geotechnical Analyses
for Pre-Design Formulation

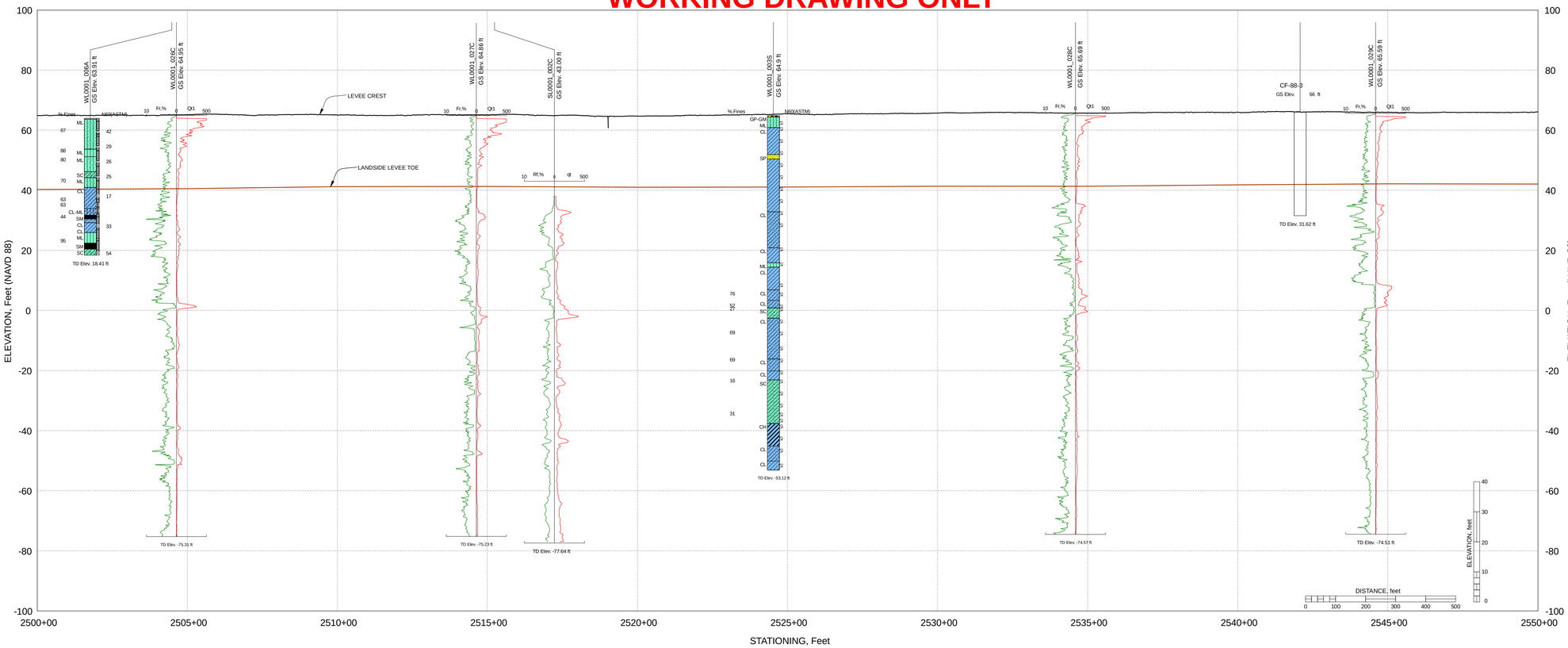
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A9

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WORKING DRAWING ONLY



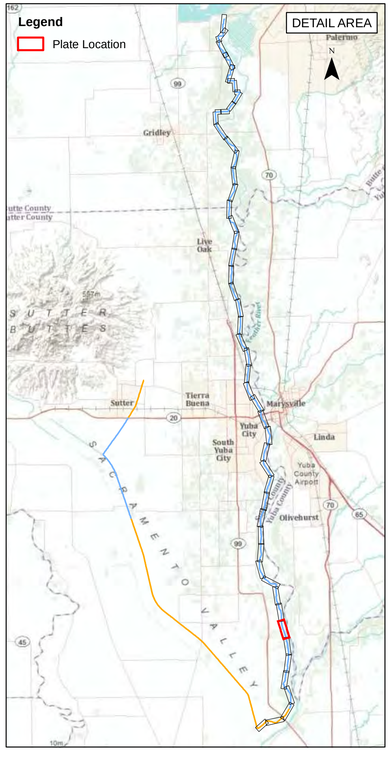
N

0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 2500+00 to Station 2550+00
FRWL Project: Station 343+78 to Station 393+79

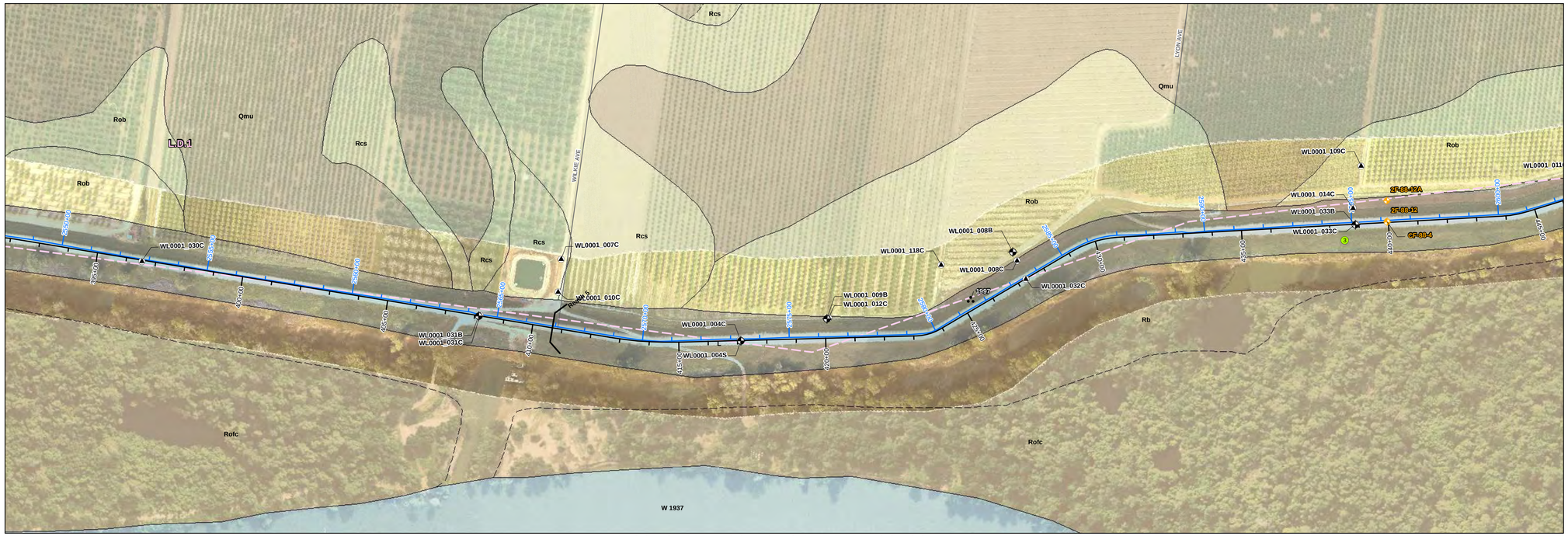
URS

Report of Geotechnical Analyses
for Pre-Design Formulation

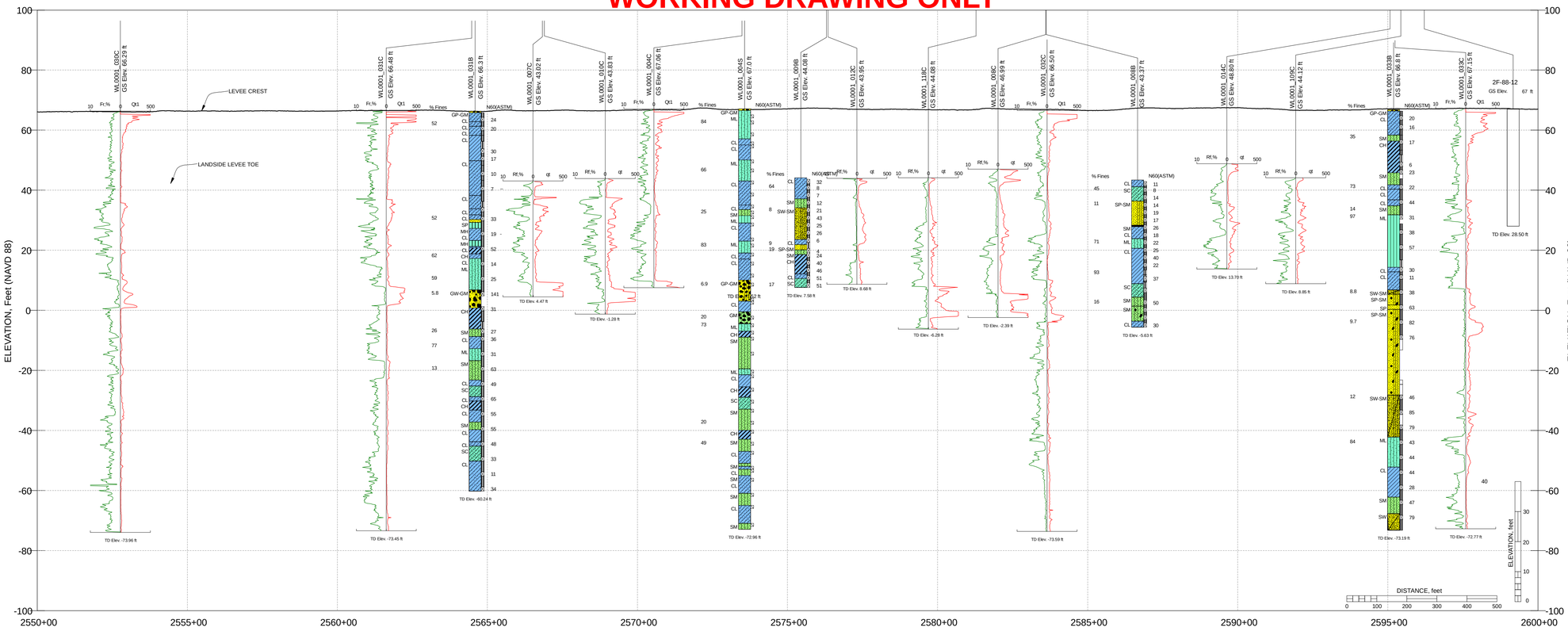
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A10

Plotted:08/14/2014 10:04:49 AM By:Mary Lee
Drawing:G:\EIP\Geotech\Working\Plates\Plate_A10_Working.mxd



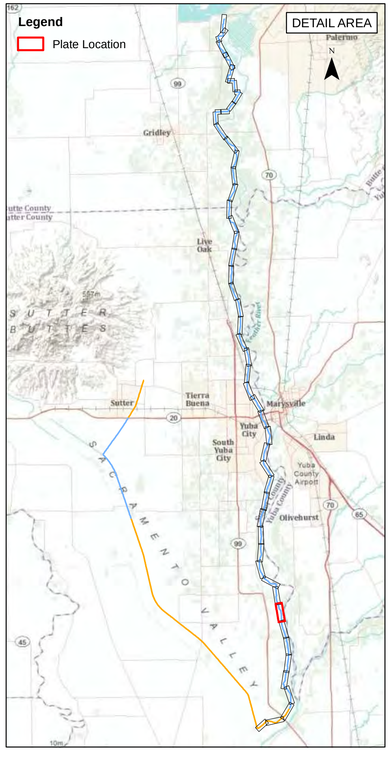
WORKING DRAWING ONLY



DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 2550+00 to Station 2600+00
FRWL Project: Station 393+79 to Station 443+76

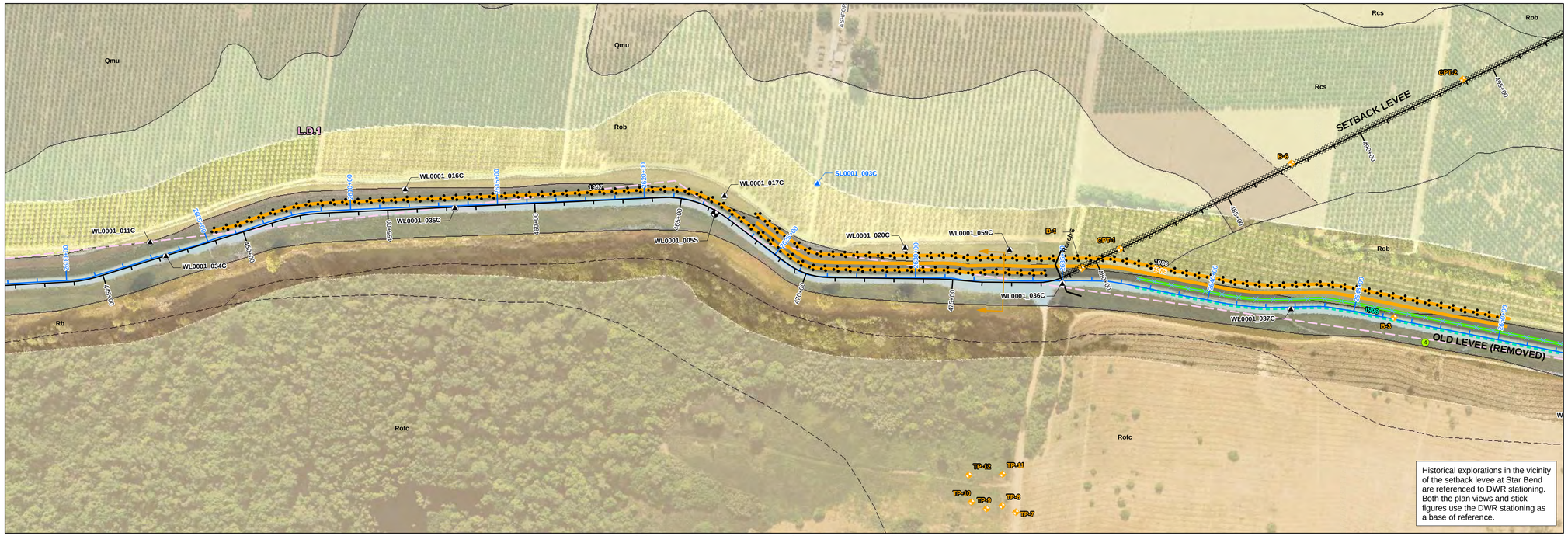
URS

Report of Geotechnical Analyses for Pre-Design Formulation

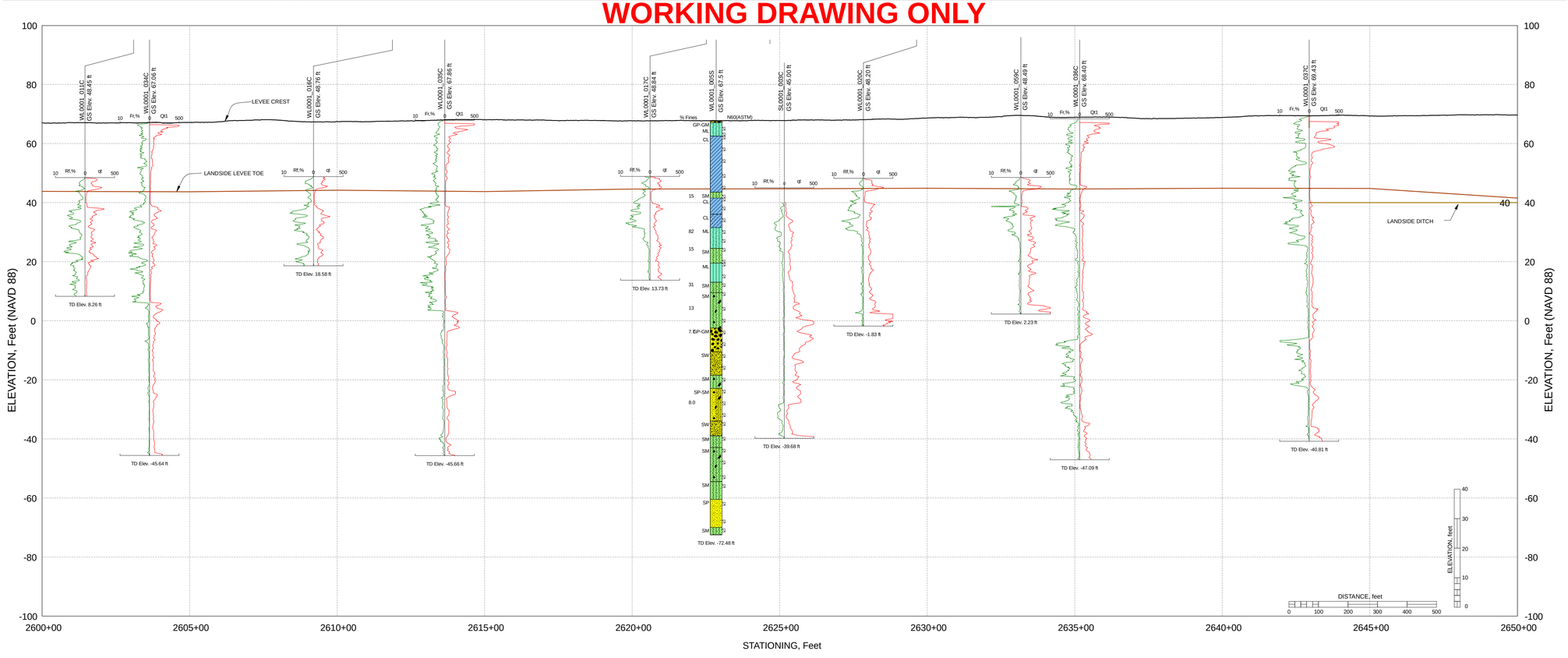
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A11

Plotted:08/04/2011 By:Jeffrey Pyle
Drawing:S:\EIP\CAD\Geotech\FCA_PreP_Workbook.mxd



WORKING DRAWING ONLY



N

0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

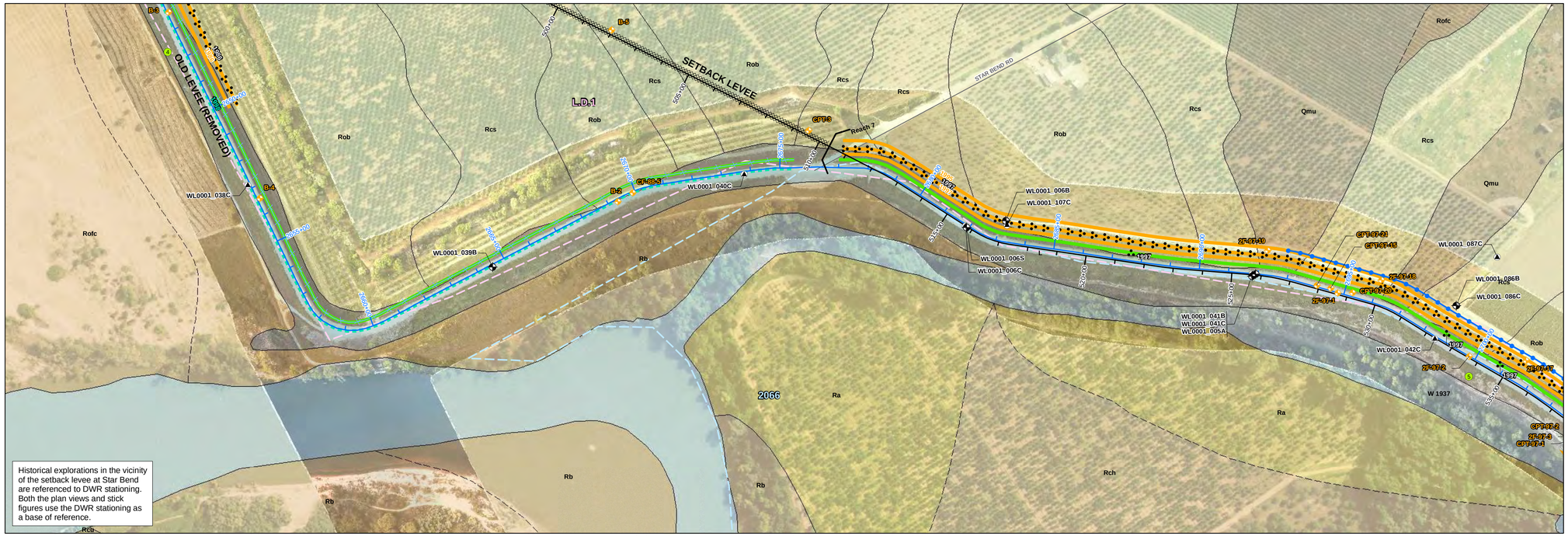
FRWL Project Plan Views and Stick Figures
DWR: Station 2600+00 to Station 2650+00
FRWL Project: Station 443+76 to Station 495+00

URS — Report of Geotechnical Analyses for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A12

Plotted:08/14/2013 By:Mark Lindberg
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Historical explorations in the vicinity of the setback levee at Star Bend are referenced to DWR stationing. Both the plan views and stick figures use the DWR stationing as a base of reference.

WORKING DRAWING ONLY

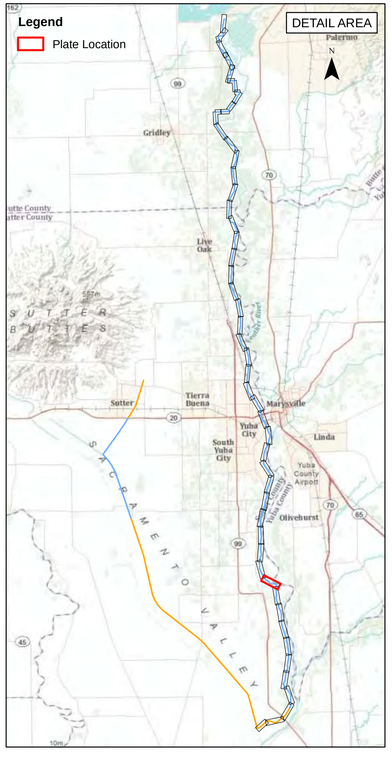
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0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 2650+00 to Station 2700+00
FRWL Project: Station 495+00 to Station 533+89

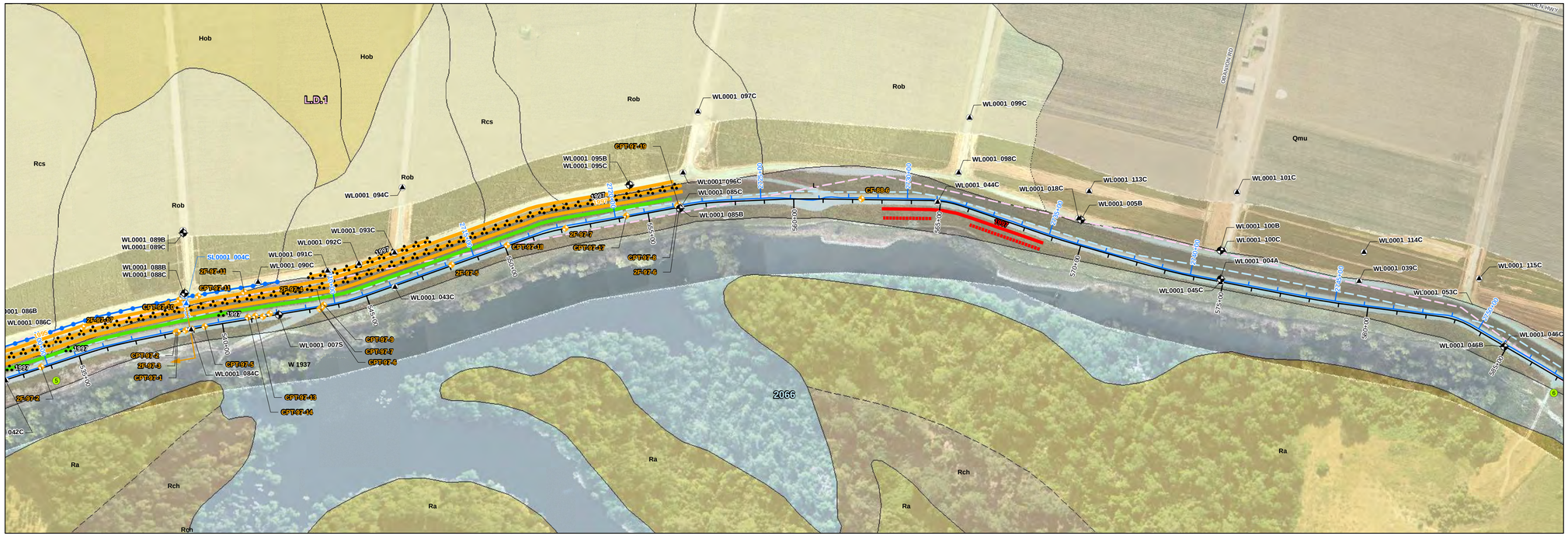
URS

Report of Geotechnical Analyses for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A13

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WORKING DRAWING ONLY

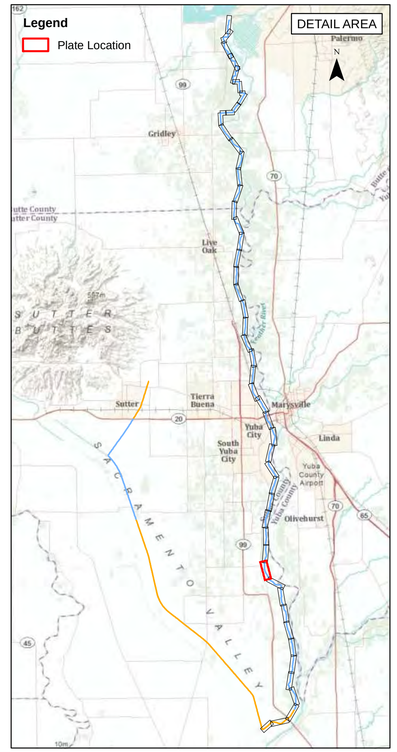
NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

N

0 100 200
Feet

DRAFT



FRWL Project Plan Views and Stick Figures
DWR: Station 2700+00 to Station 2750+00
FRWL Project: Station 533+89 to Station 583+87

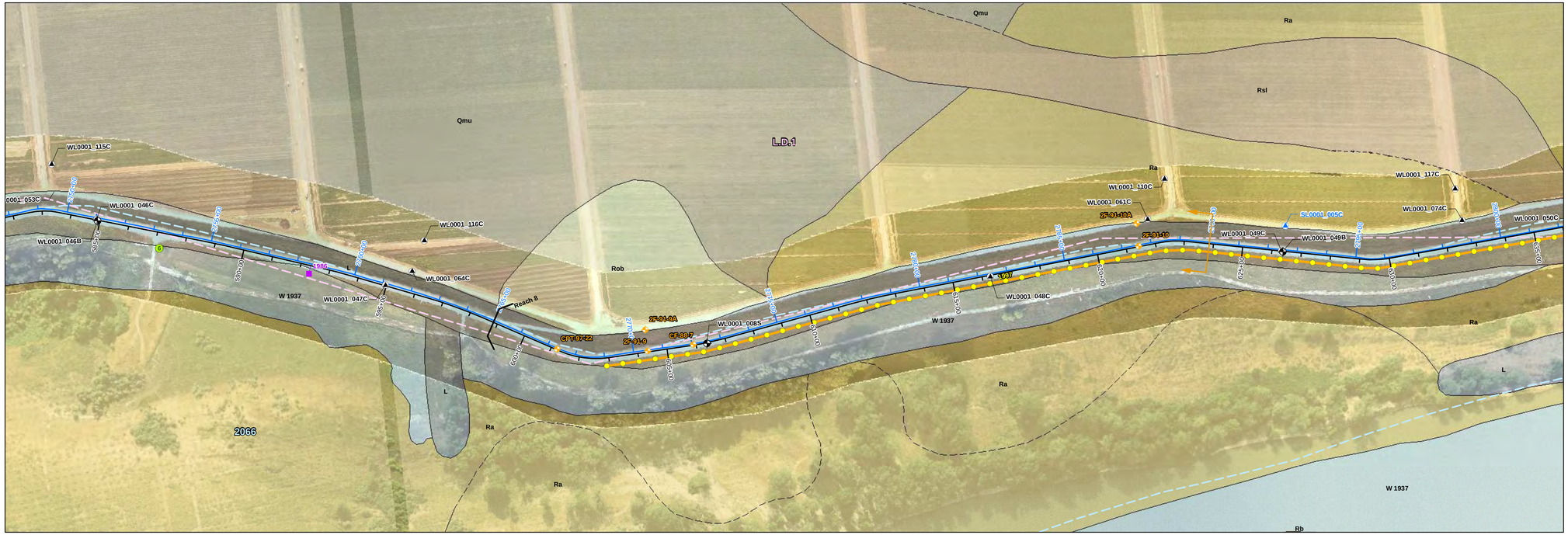
URS

Report of Geotechnical Analyses
for Pre-Design Formulation

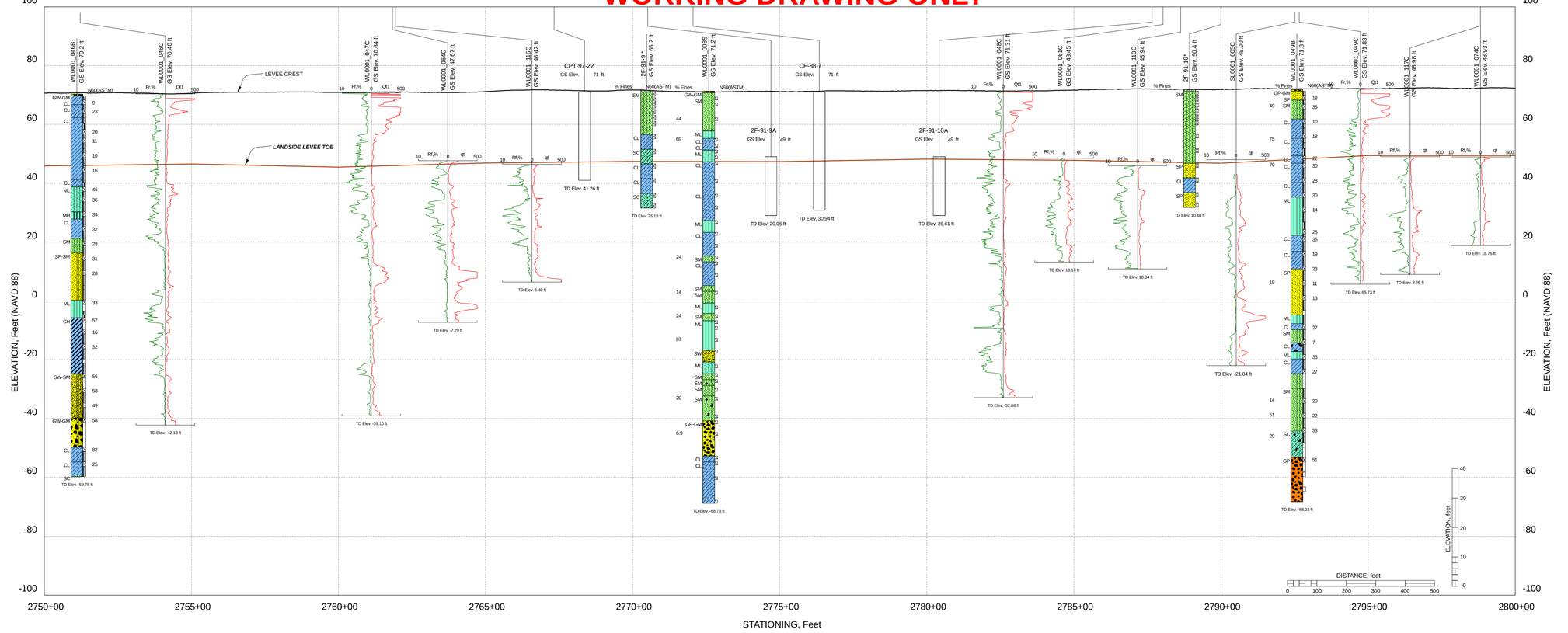
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A14

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WORKING DRAWING ONLY



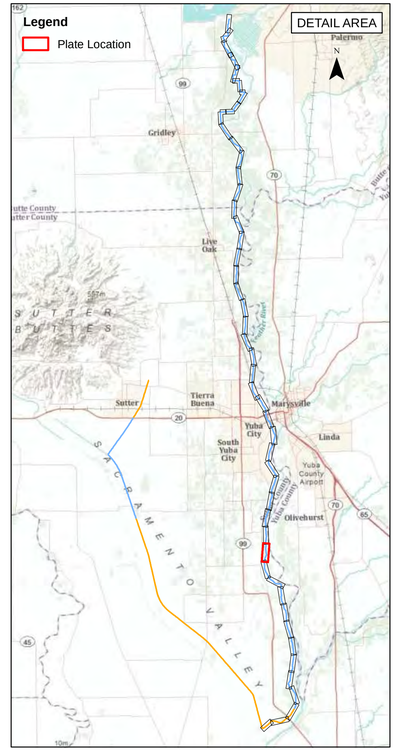
NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

N

0 100 200
Feet

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FRWL Project Plan Views and Stick Figures
DWR: Station 2750+00 to Station 2800+00
FRWL Project: Station 583+87 to Station 633+86

URS
Report of Geotechnical Analyses for Pre-Design Formulation

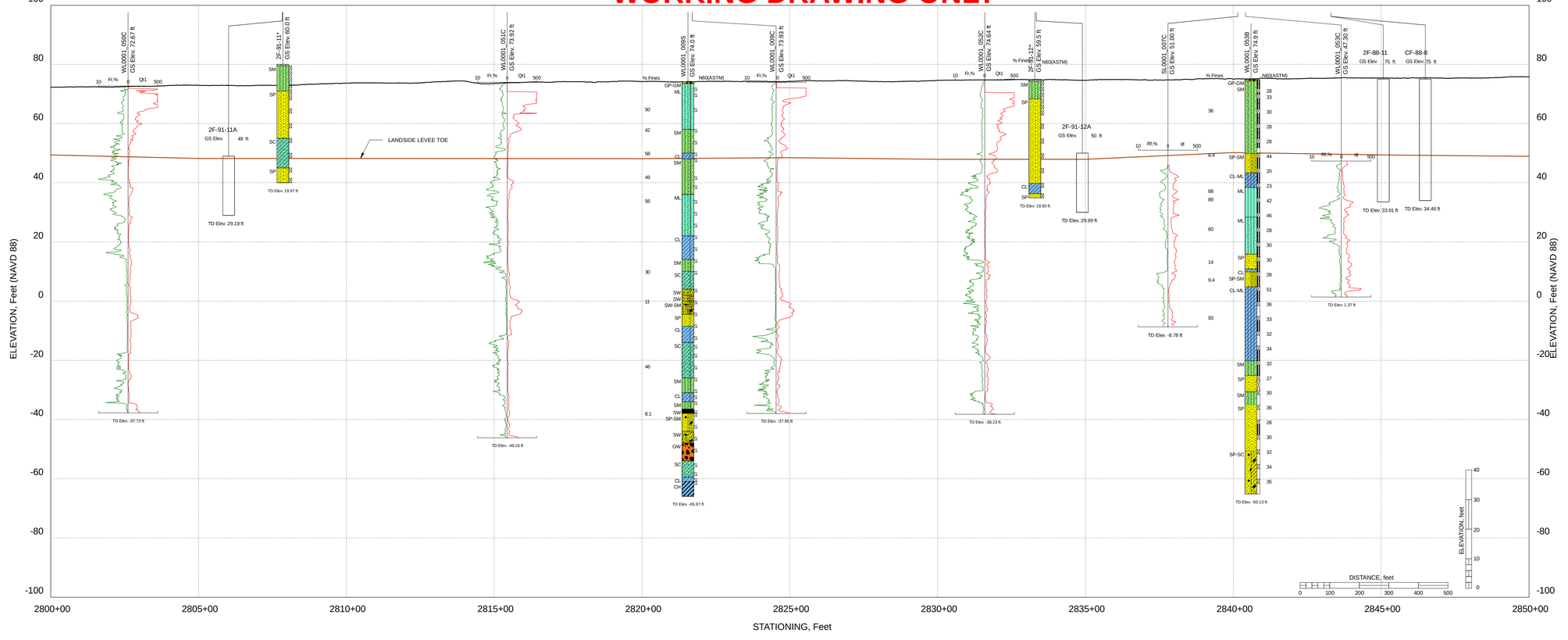
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A15

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WORKING DRAWING ONLY



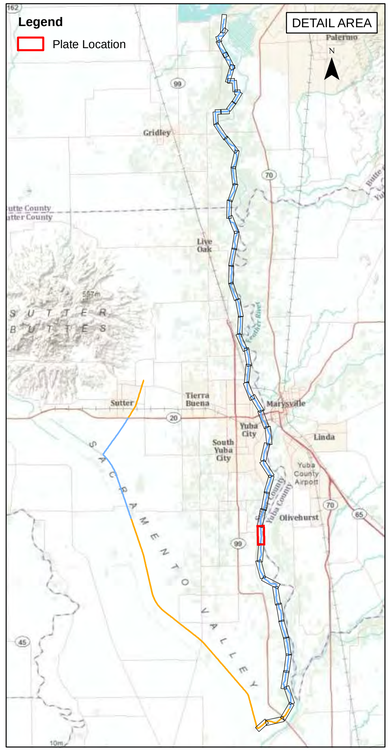
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Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 2800+00 to Station 2850+00
FRWL Project: Station 633+86 to Station 683+86

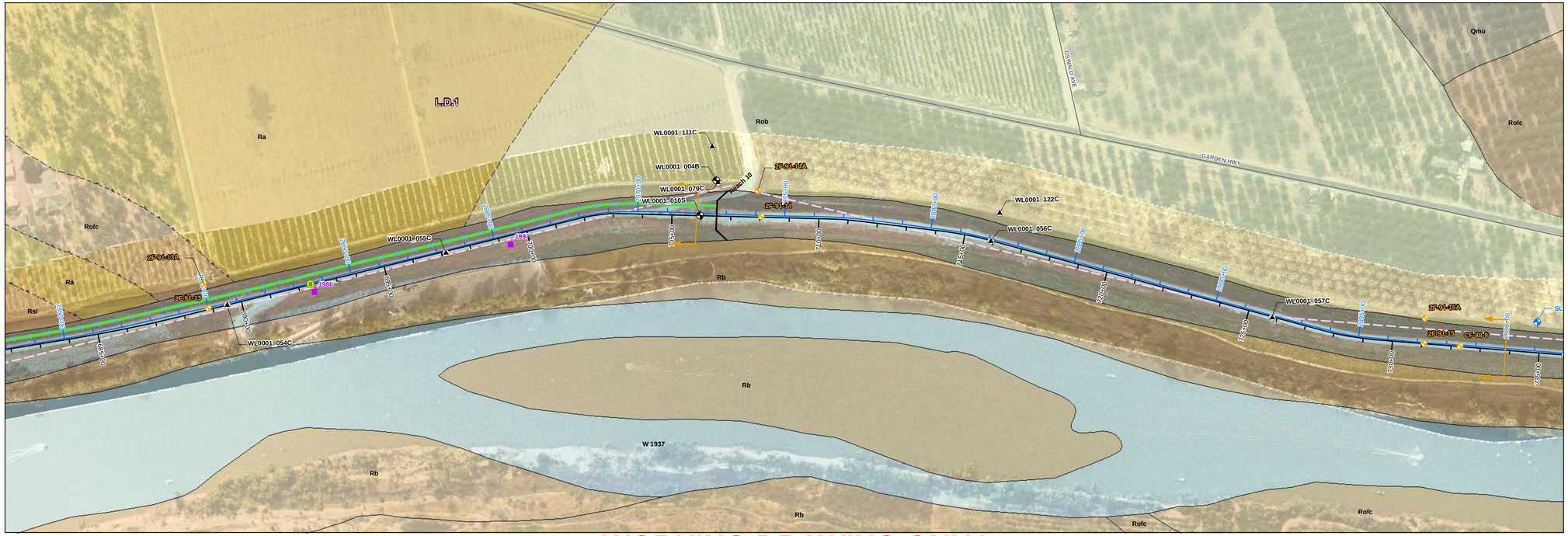
URS

Report of Geotechnical Analyses
for Pre-Design Formulation

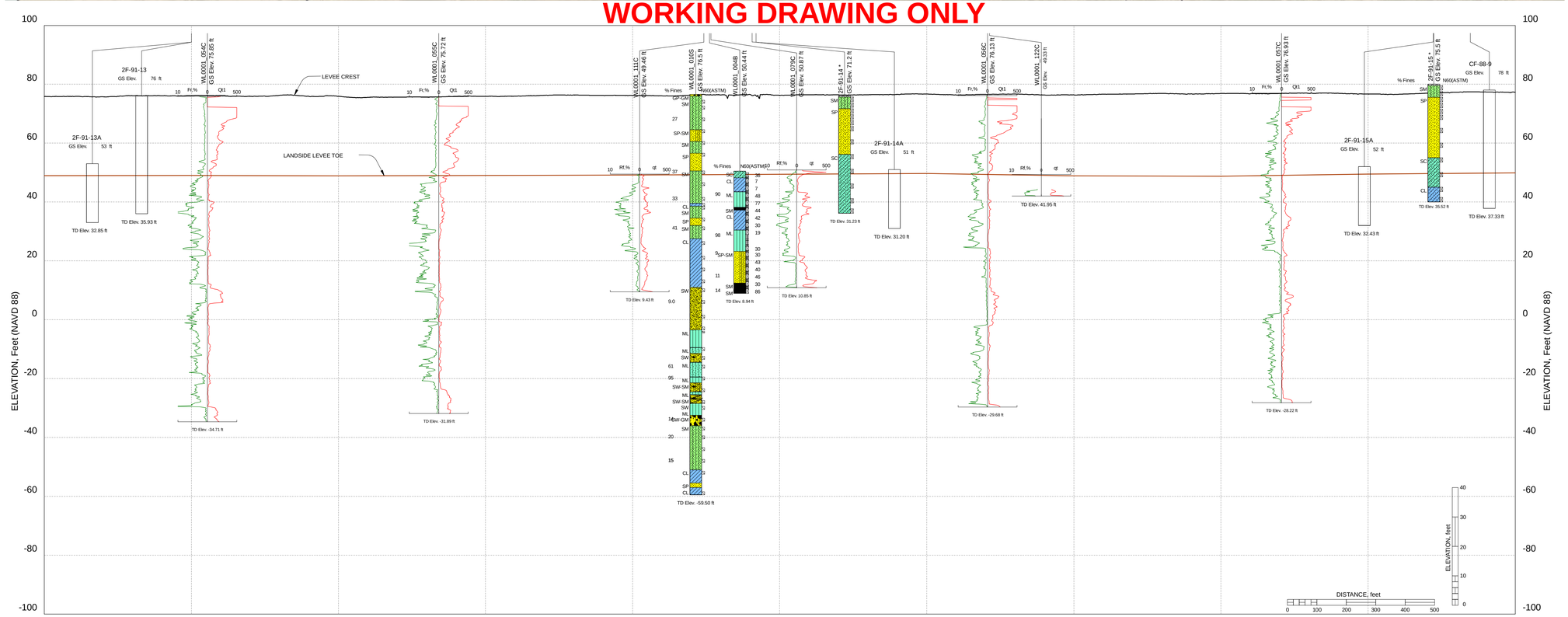
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A16

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WORKING DRAWING ONLY



N

0 100 200
Feet

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NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 2850+00 to Station 2900+00
FRWL Project: Station 683+86 to Station 733+84

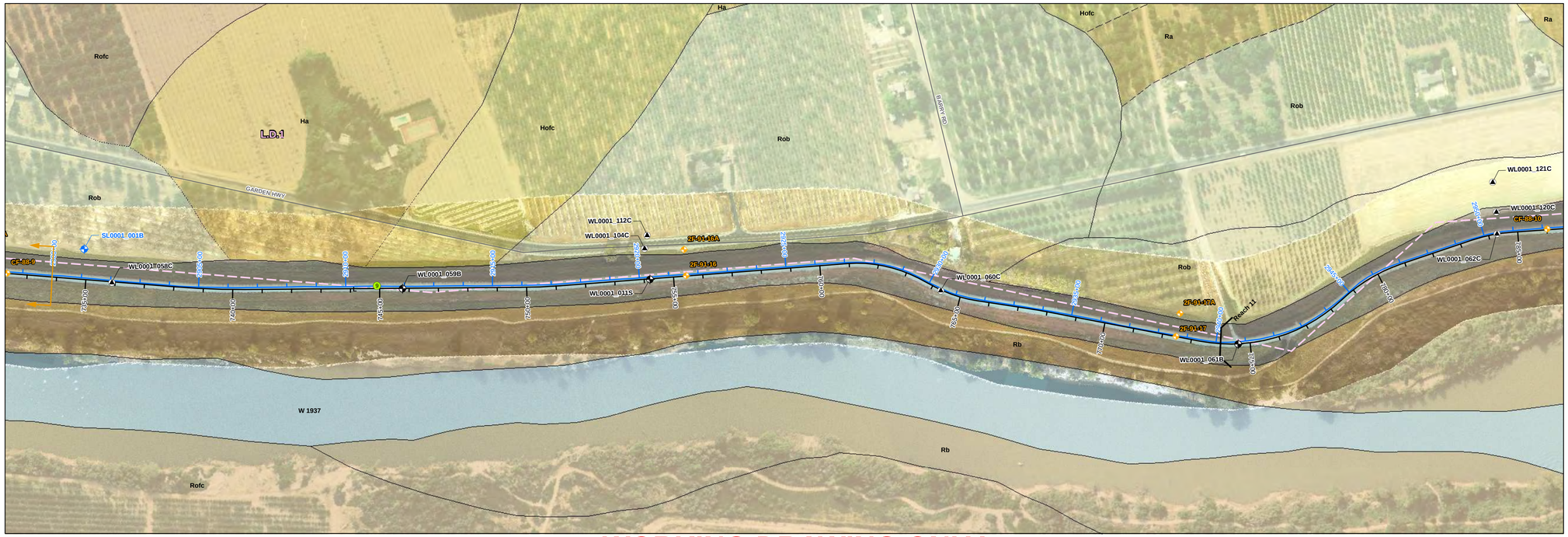
URS

Report of Geotechnical Analyses
for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

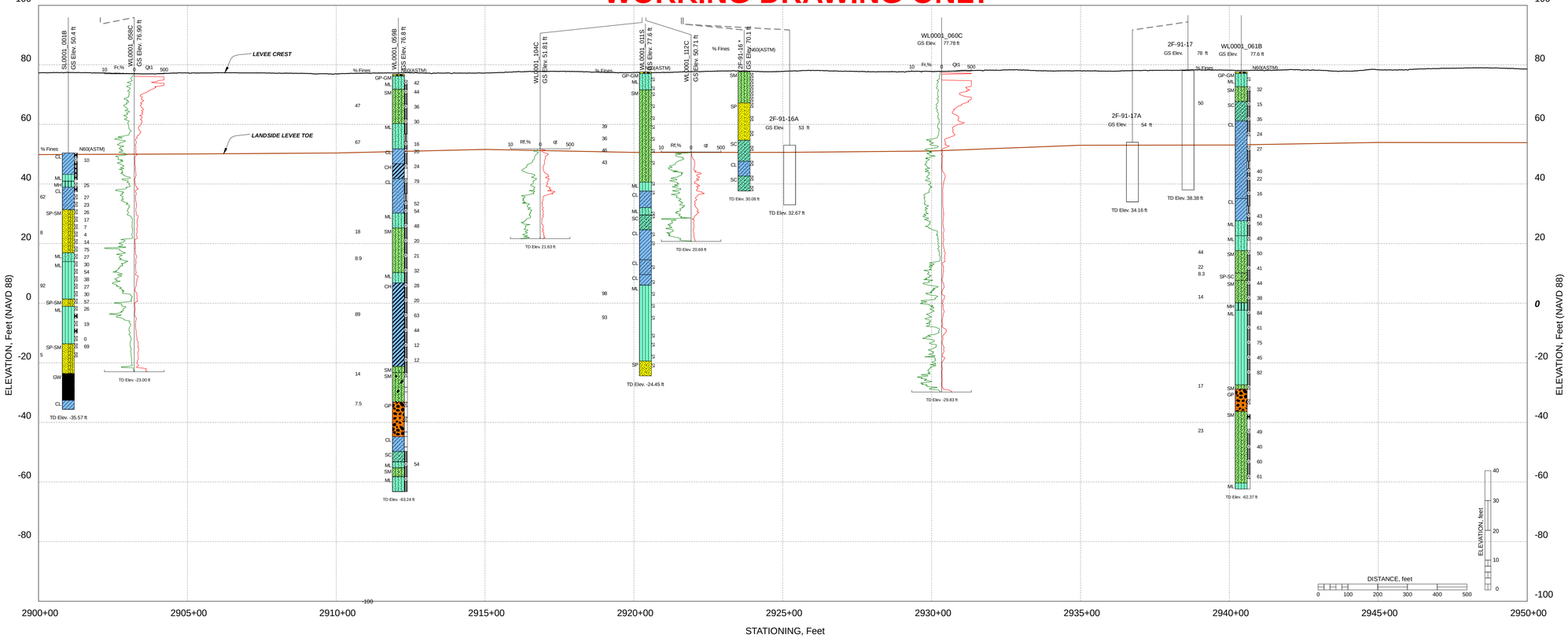
Appendix A17

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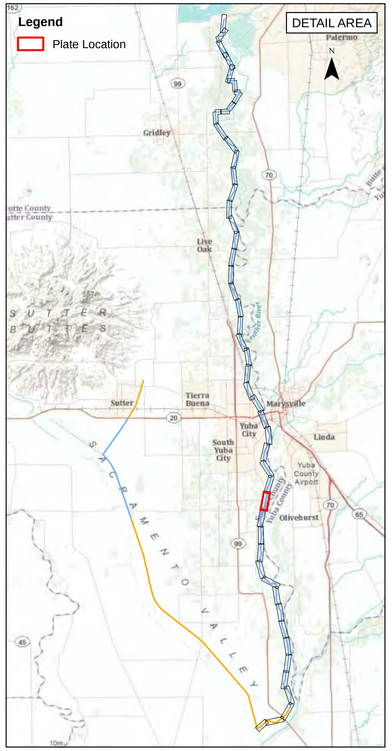
WORKING DRAWING ONLY

READING



NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



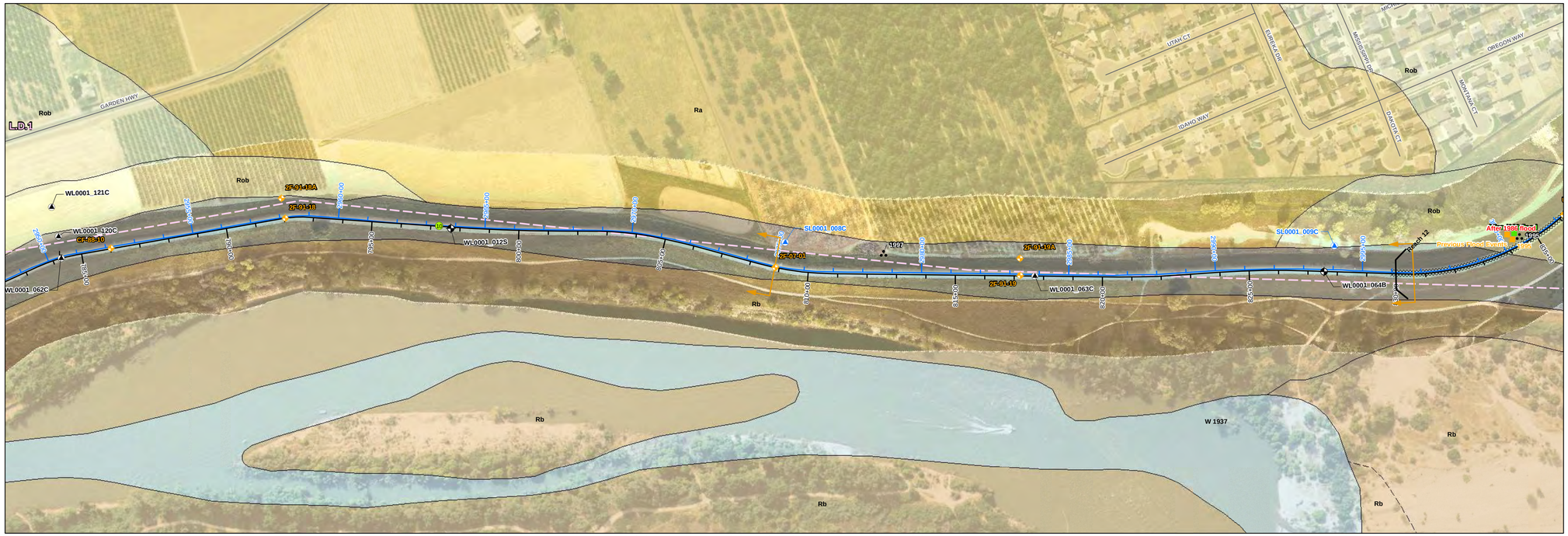
FRWL Project Plan Views and Stick Figures
DWR: Station 2900+00 to Station 2950+00
FRWL Project: Station 733+84 to Station 783+85

URS — Report of Geotechnical Analyses for Pre-Design Formulation

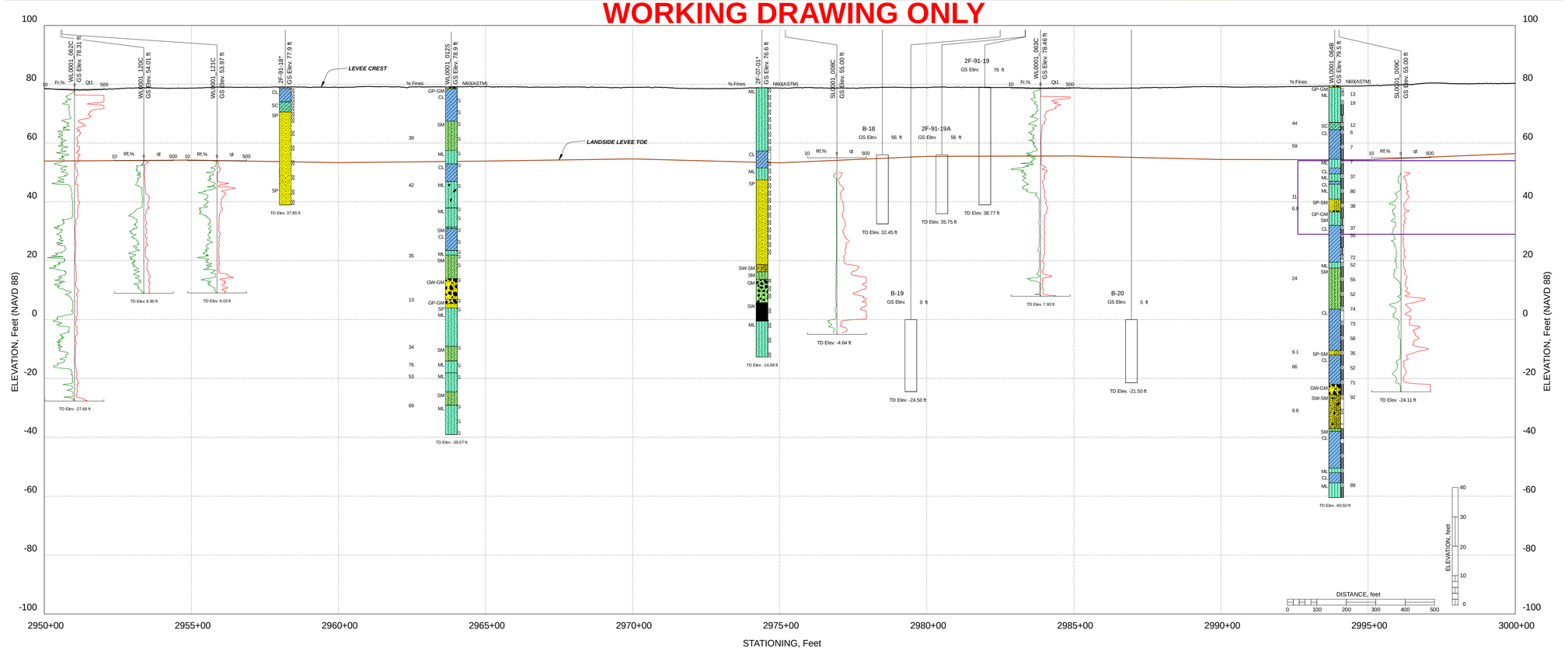
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A18

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WORKING DRAWING ONLY



NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

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Feet

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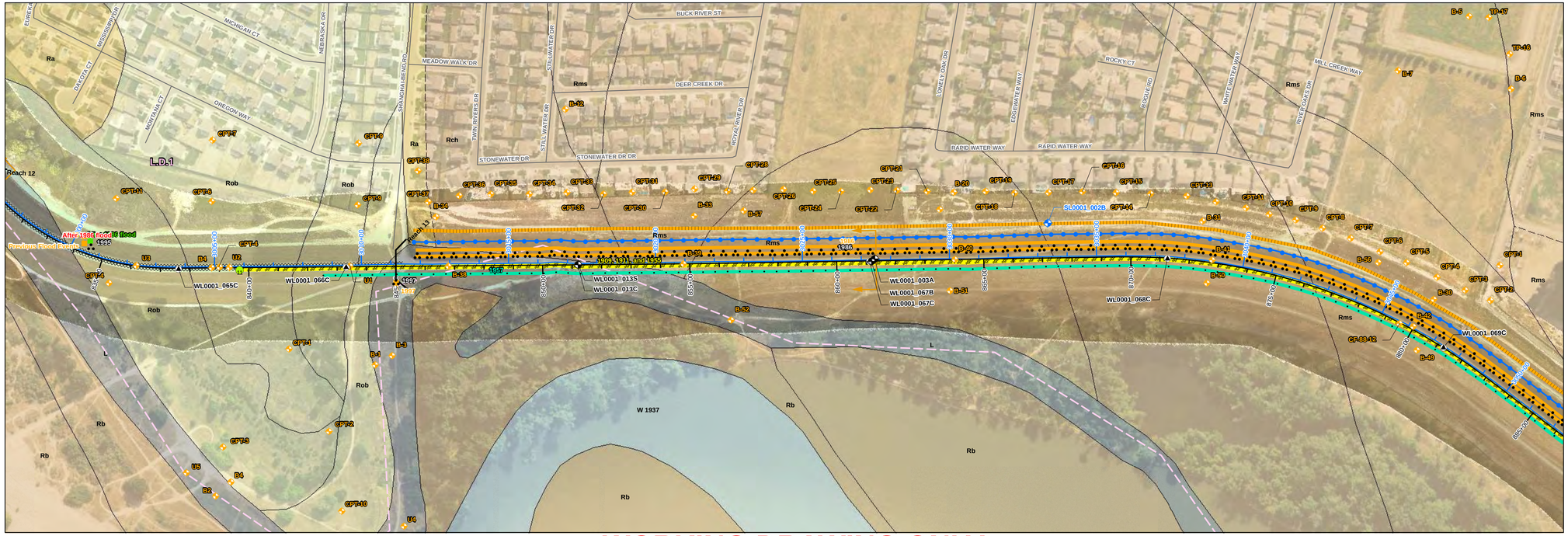
FRWL Project Plan Views and Stick Figures
DWR: Station 2950+00 to Station 3000+00
FRWL Project: Station 783+85 to Station 833+86

URS
Report of Geotechnical Analyses
for Pre-Design Formulation

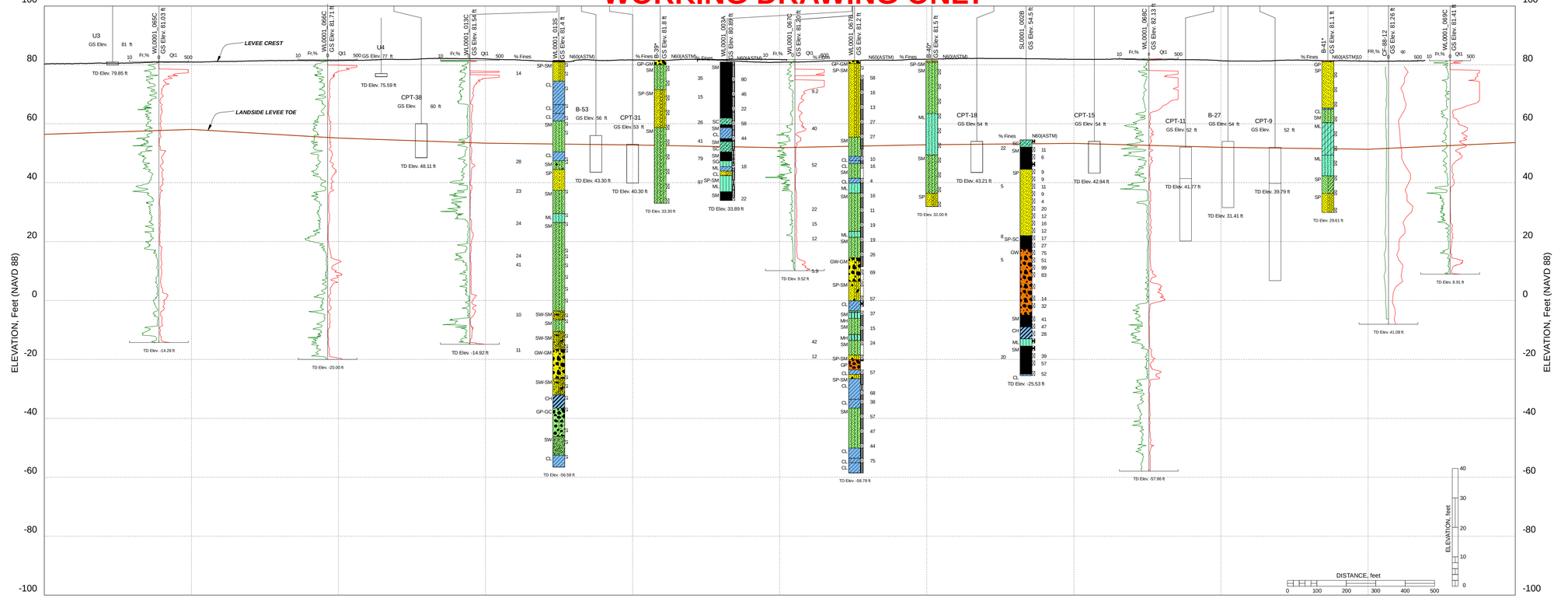
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A19

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WORKING DRAWING ONLY



NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

0 100 200 Feet

DRAFT



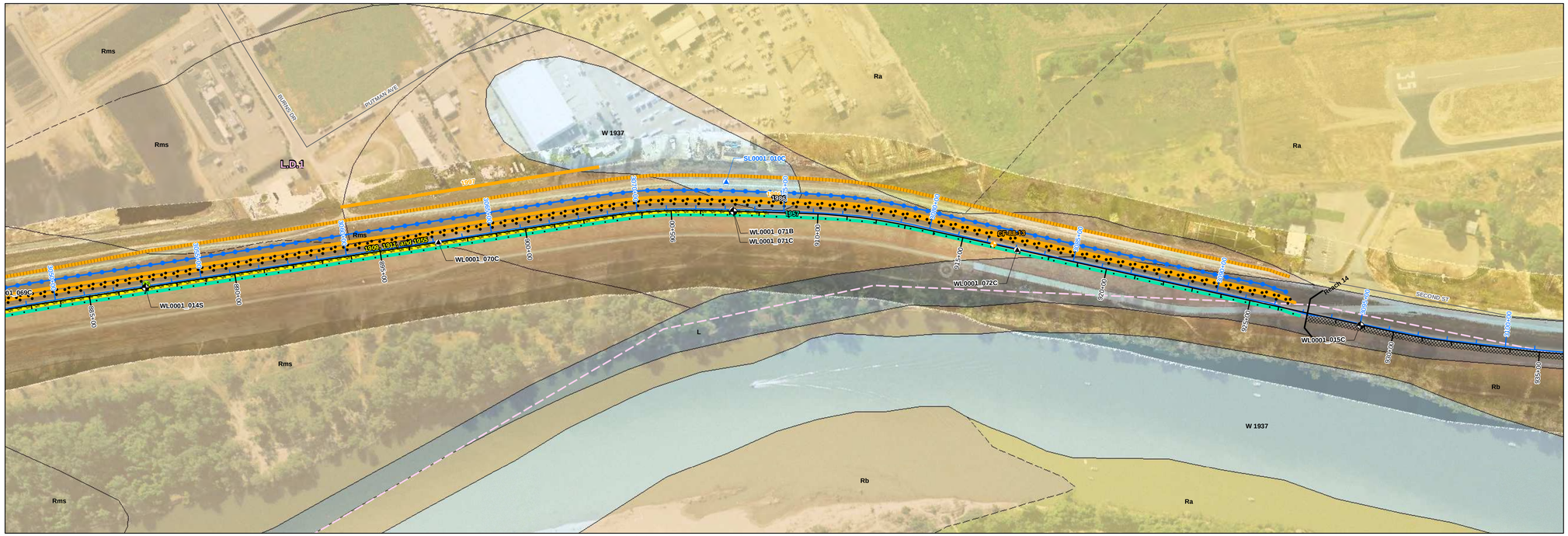
FRWL Project Plan Views and Stick Figures
DWR: Station 3000+00 to Station 3050+00
FRWL Project: Station 833+86 to Station 883+84

URS
Report of Geotechnical Analyses for Pre-Design Formulation

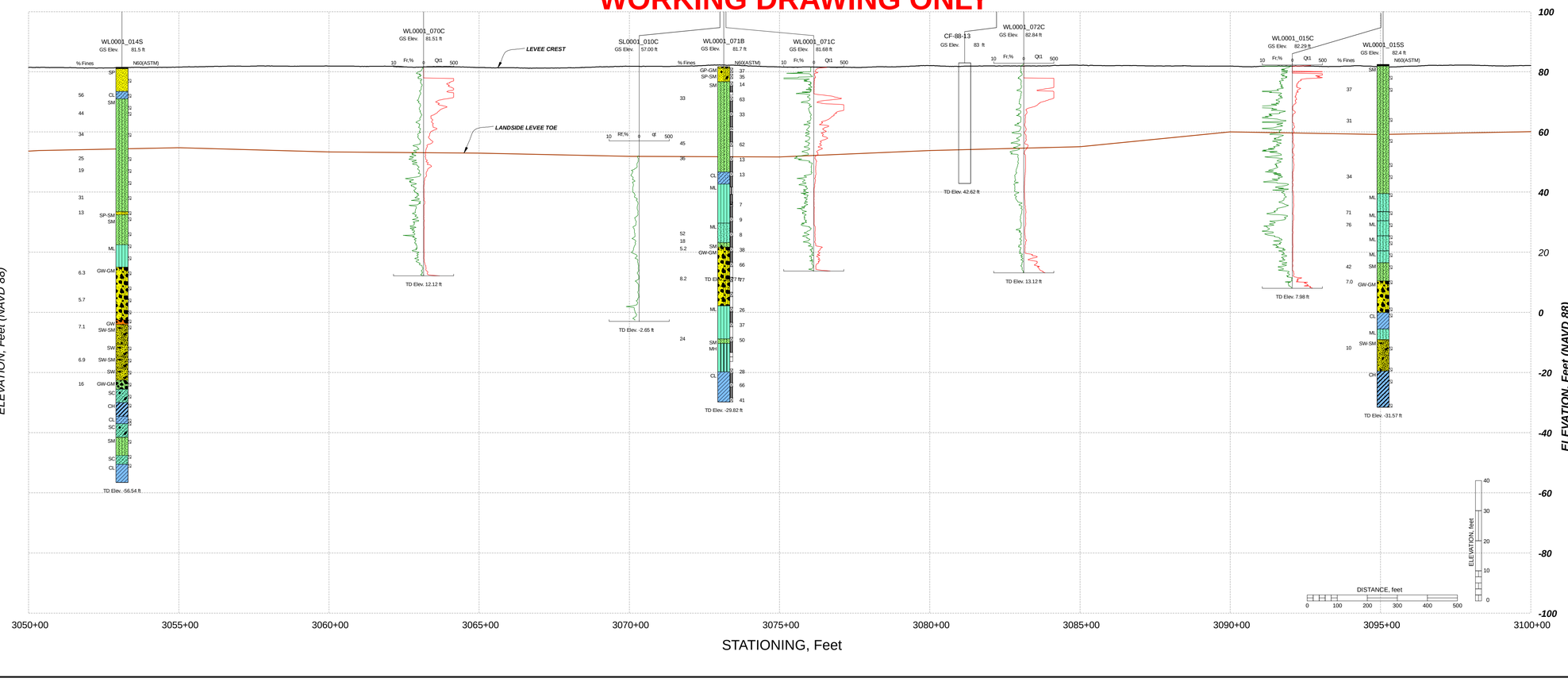
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A20

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WORKING DRAWING ONLY



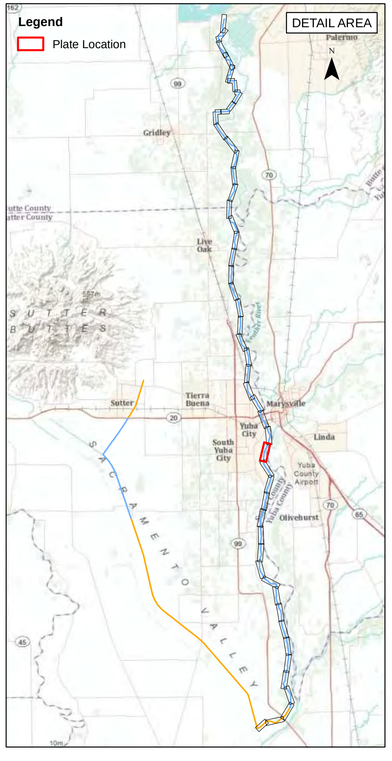
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0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3050+00 to Station 3100+00
FRWL Project: Station 883+84 to Station 933+84

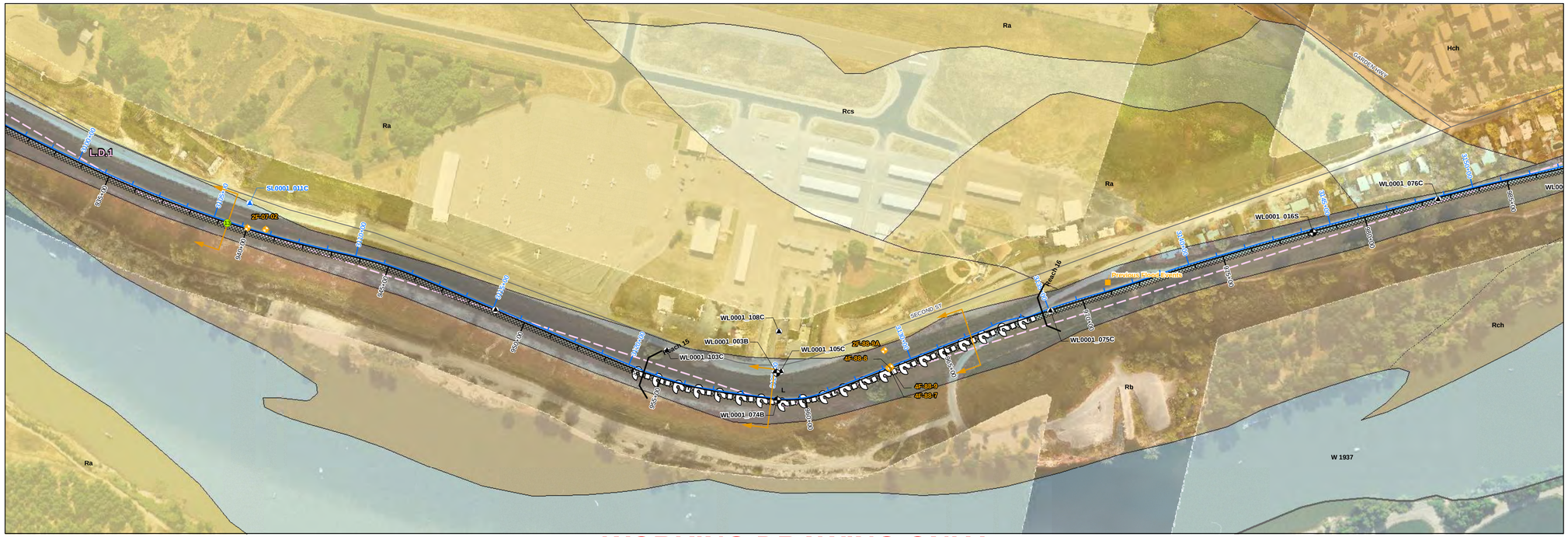
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Report of Geotechnical Analyses
for Pre-Design Formulation

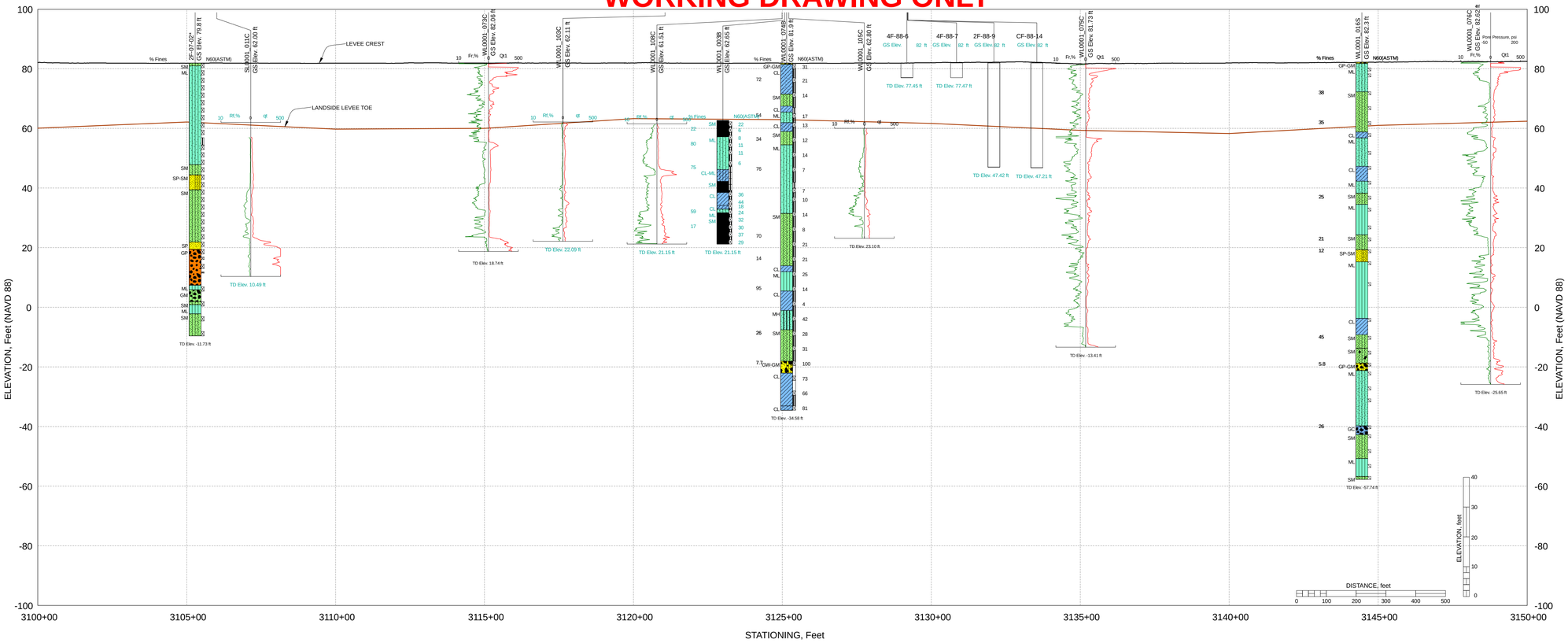
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A21

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WORKING DRAWING ONLY



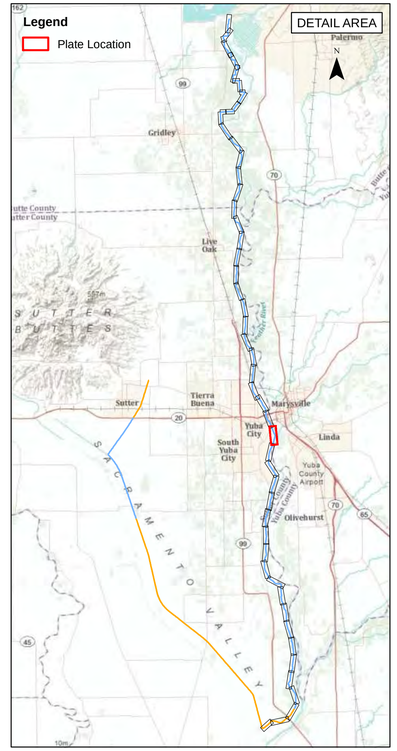
NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

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Feet

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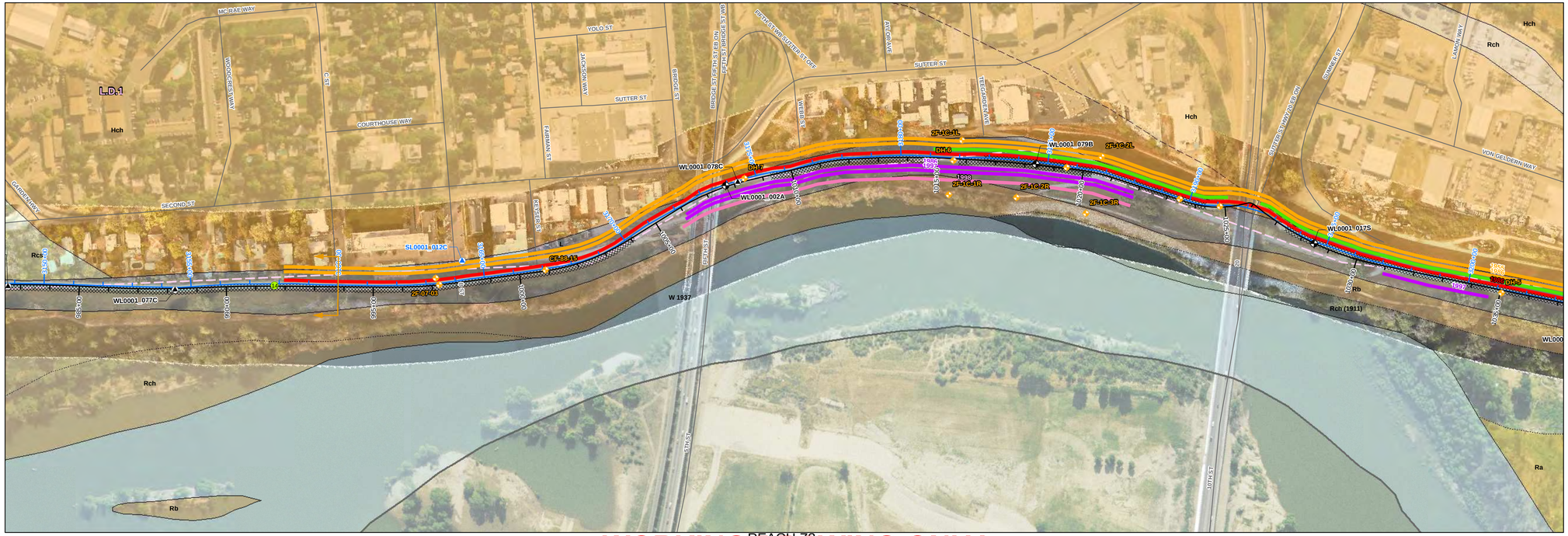
FRWL Project Plan Views and Stick Figures
DWR: Station 3100+00 to Station 3150+00
FRWL Project: Station 933+84 to Station 983+82

URS
Report of Geotechnical Analyses for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

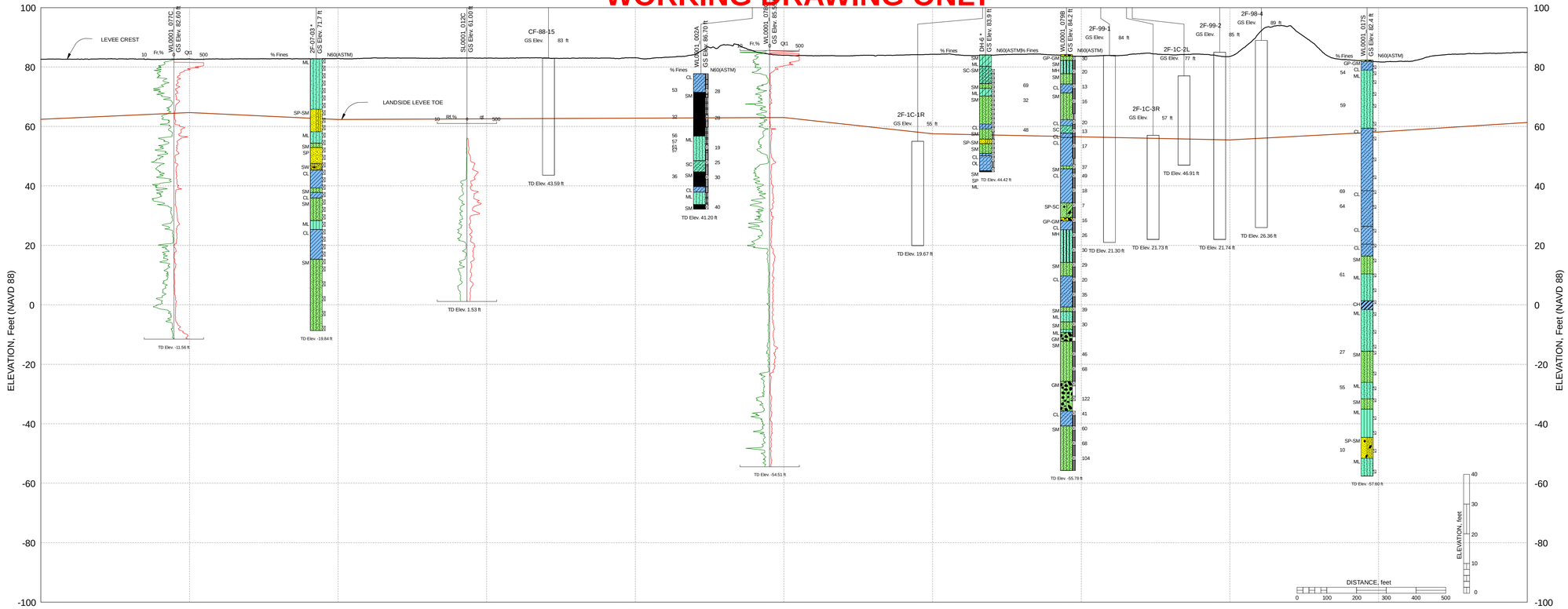
Appendix A22

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REACH 2A

WORKING DRAWING ONLY



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Feet

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NOTES:

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6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3150+00 to Station 3200+00
FRWL Project: Station 983+82 to Station 1033+90

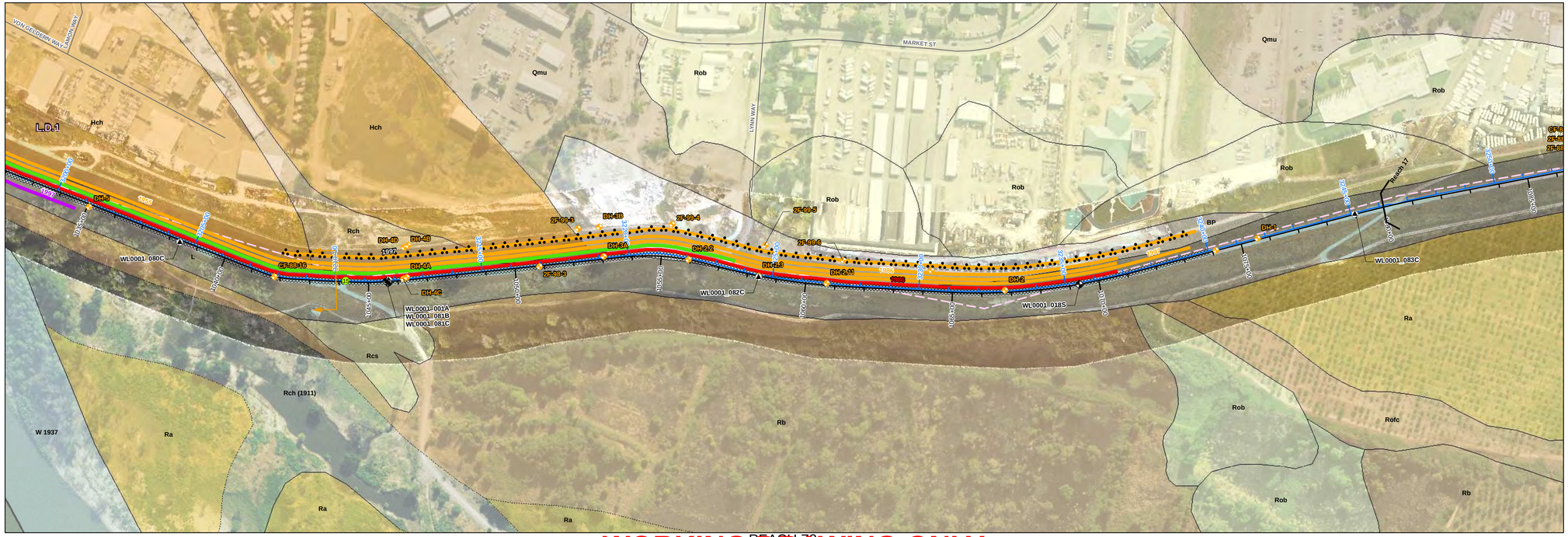
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Report of Geotechnical Analyses
for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

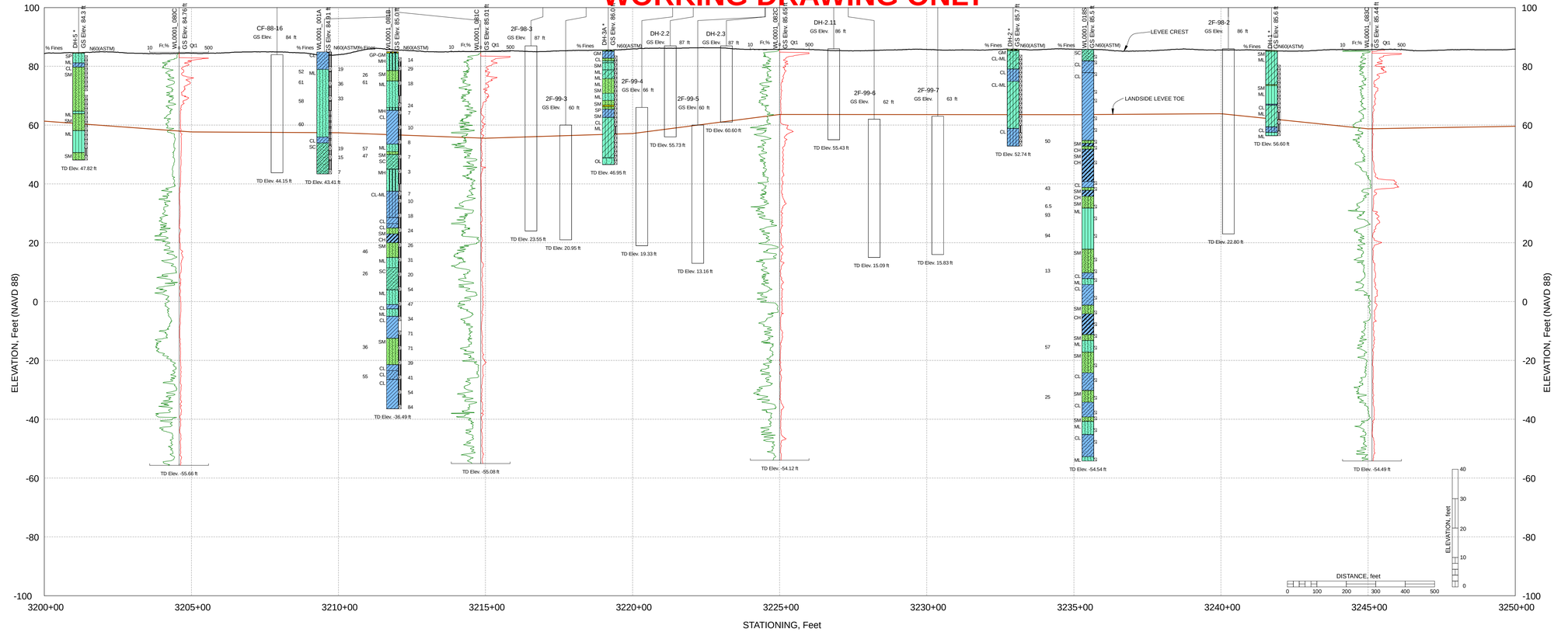
Appendix A23

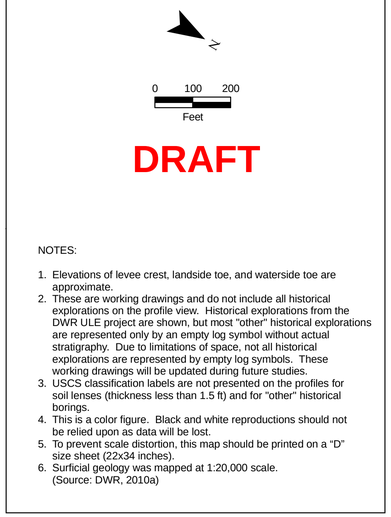
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REACH 73

WORKING DRAWING ONLY

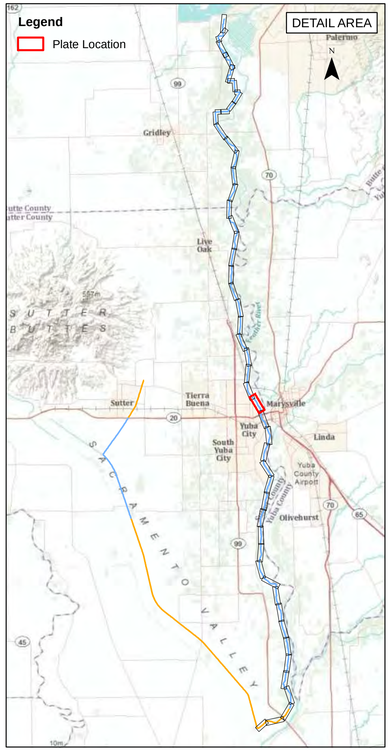




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NOTES:

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5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3200+00 to Station 3250+00
FRWL Project: Station 1033+90 to Station 1083+87

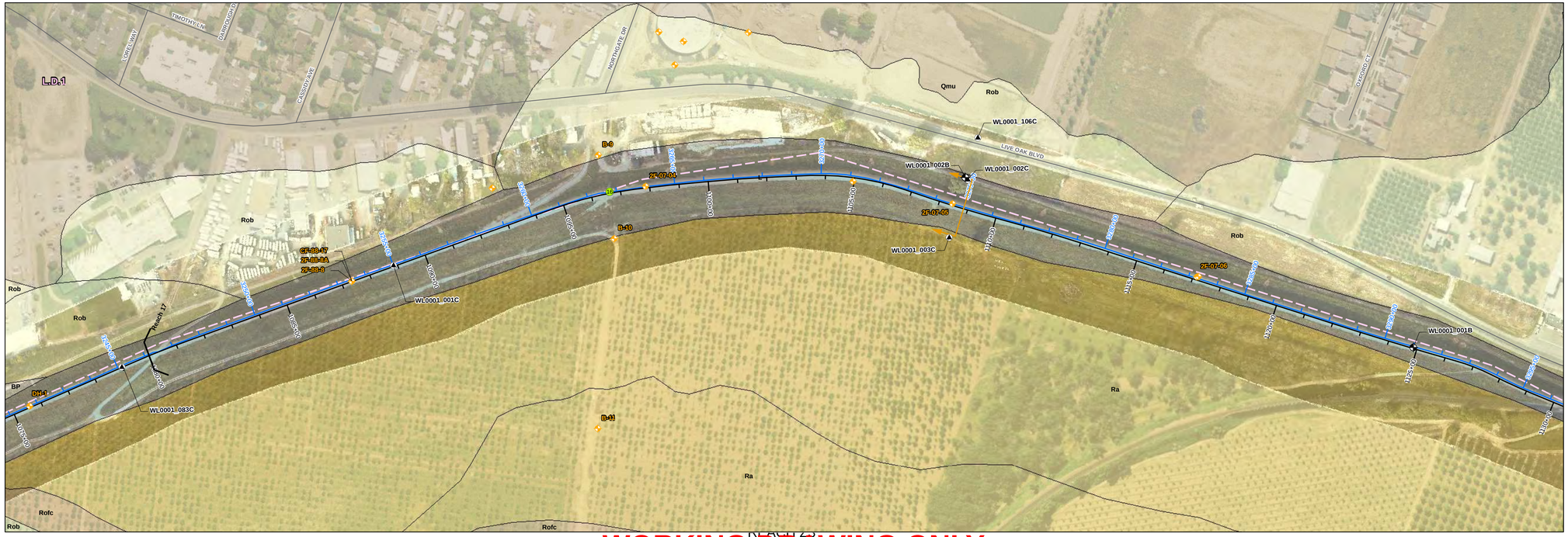
URS

Report of Geotechnical Analyses
for Pre-Design Formulation

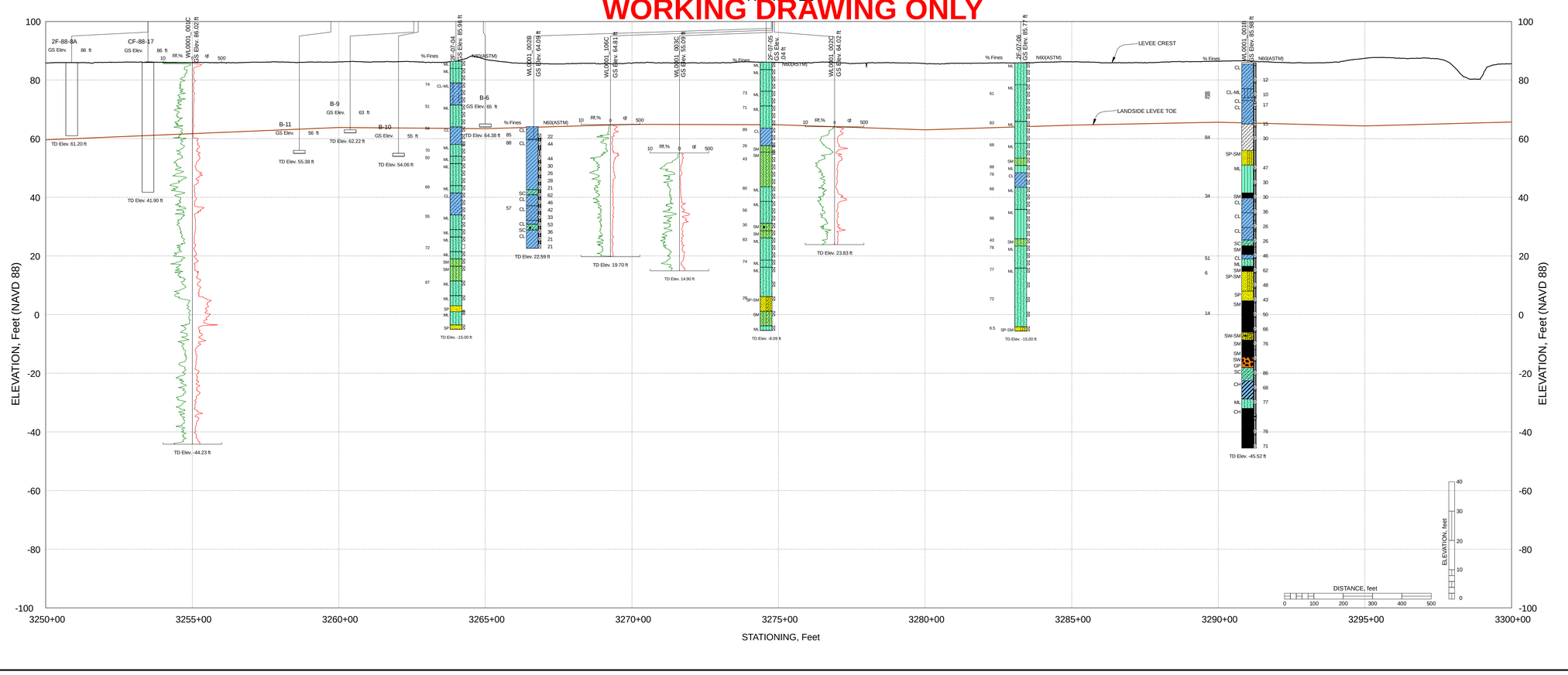
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A24

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WORKING DRAWING ONLY



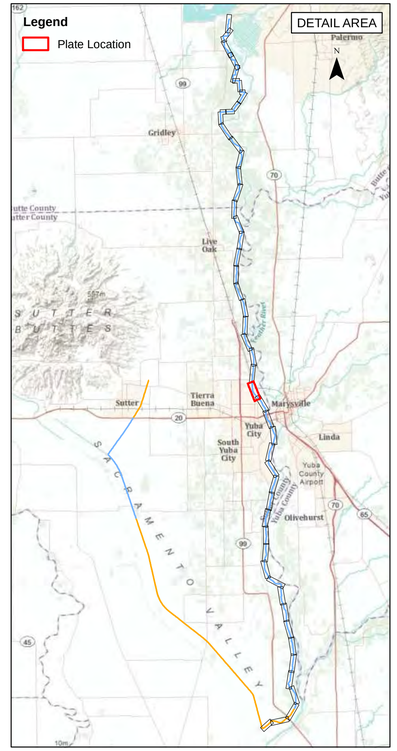
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Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



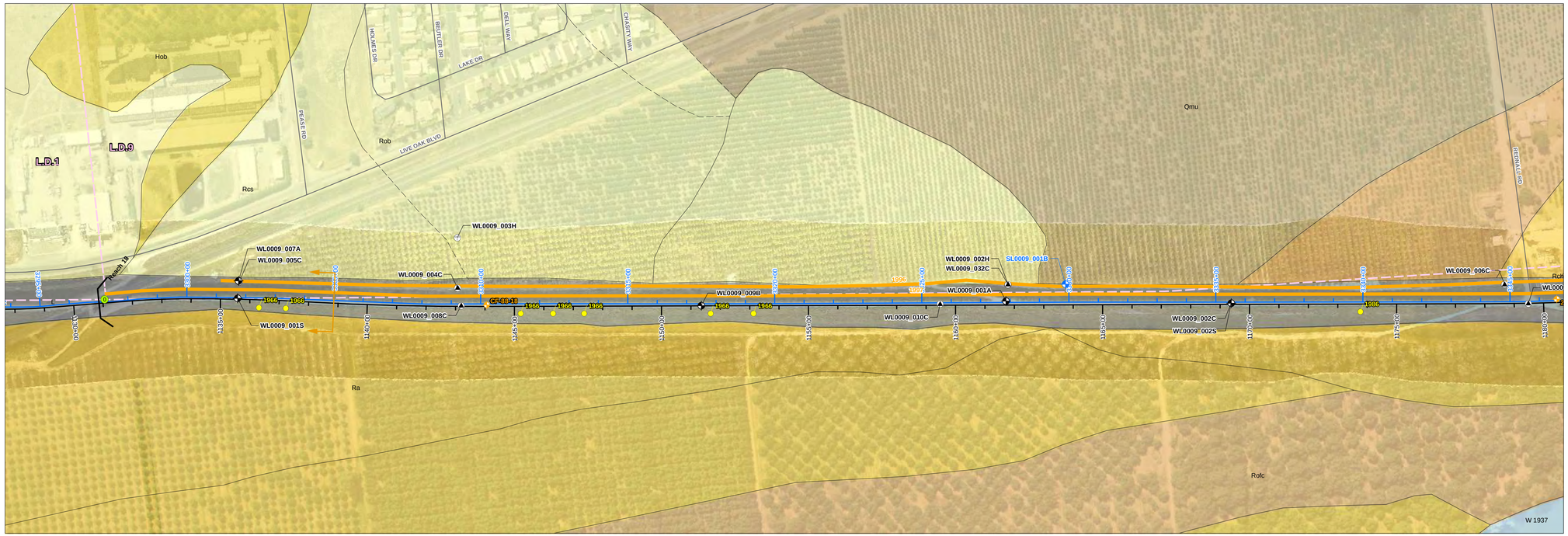
FRWL Project Plan Views and Stick Figures
DWR: Station 3250+00 to Station 3295+59
FRWL Project: Station 1083+87 to Station 1128+88

URS
Report of Geotechnical Analyses for Pre-Design Formulation

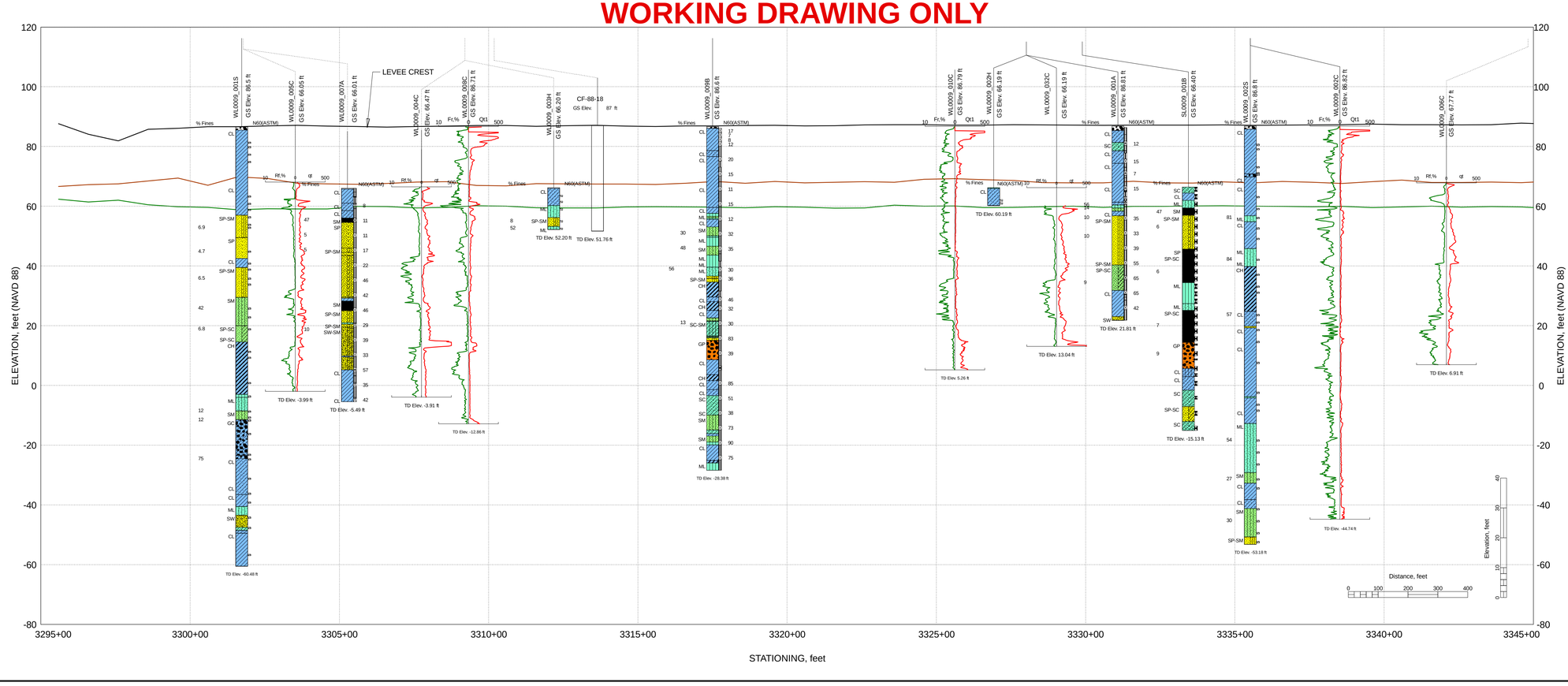
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A25

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WORKING DRAWING ONLY



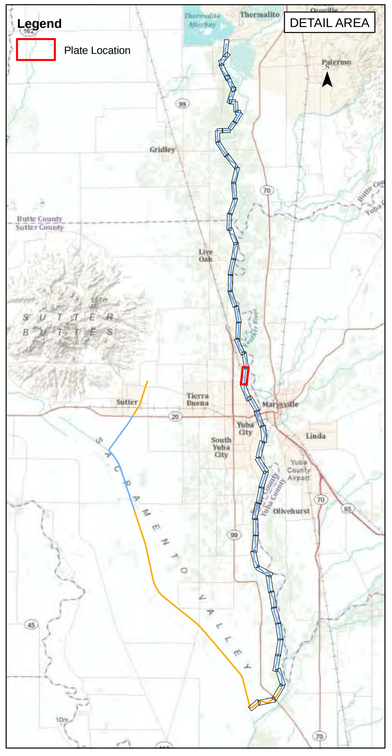
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0 100 200
Feet

DRAFT

NOTES:

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5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



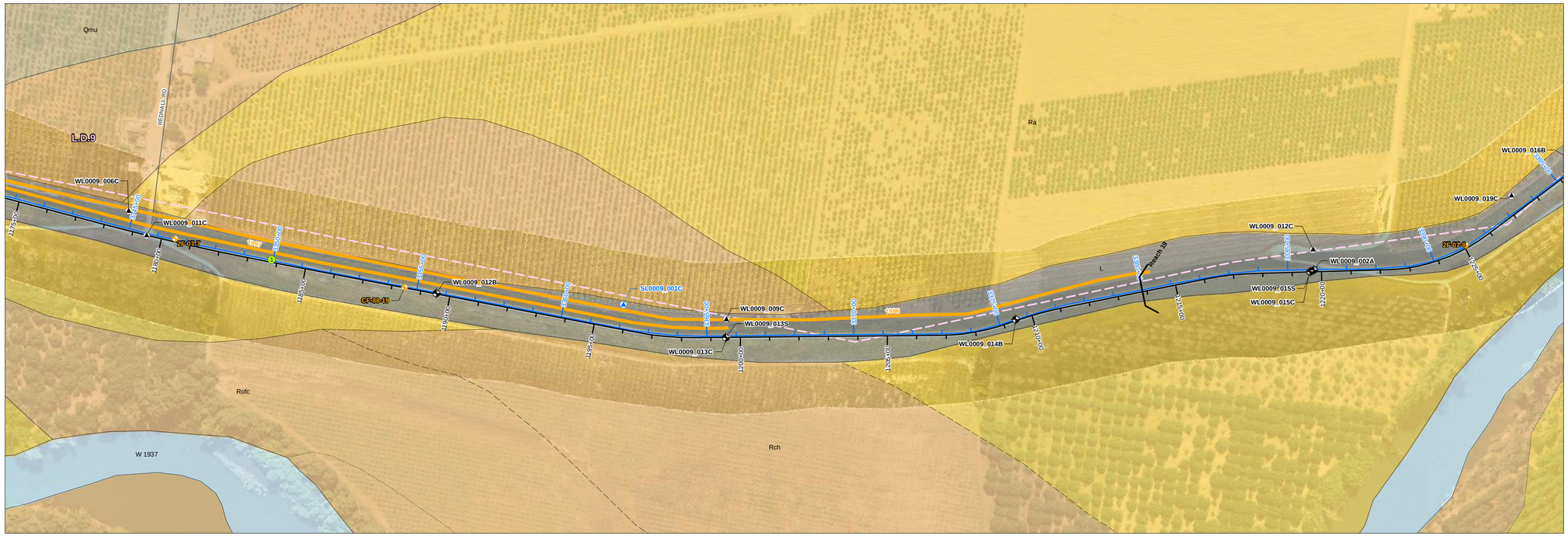
FRWL Project Plan Views and Stick Figures
DWR: Station 3295+00 to Station 3345+00
FRWL Project: Station 1128+88 to Station 1178+87

URS — Report of Geotechnical Analyses for Pre-Design Formulation

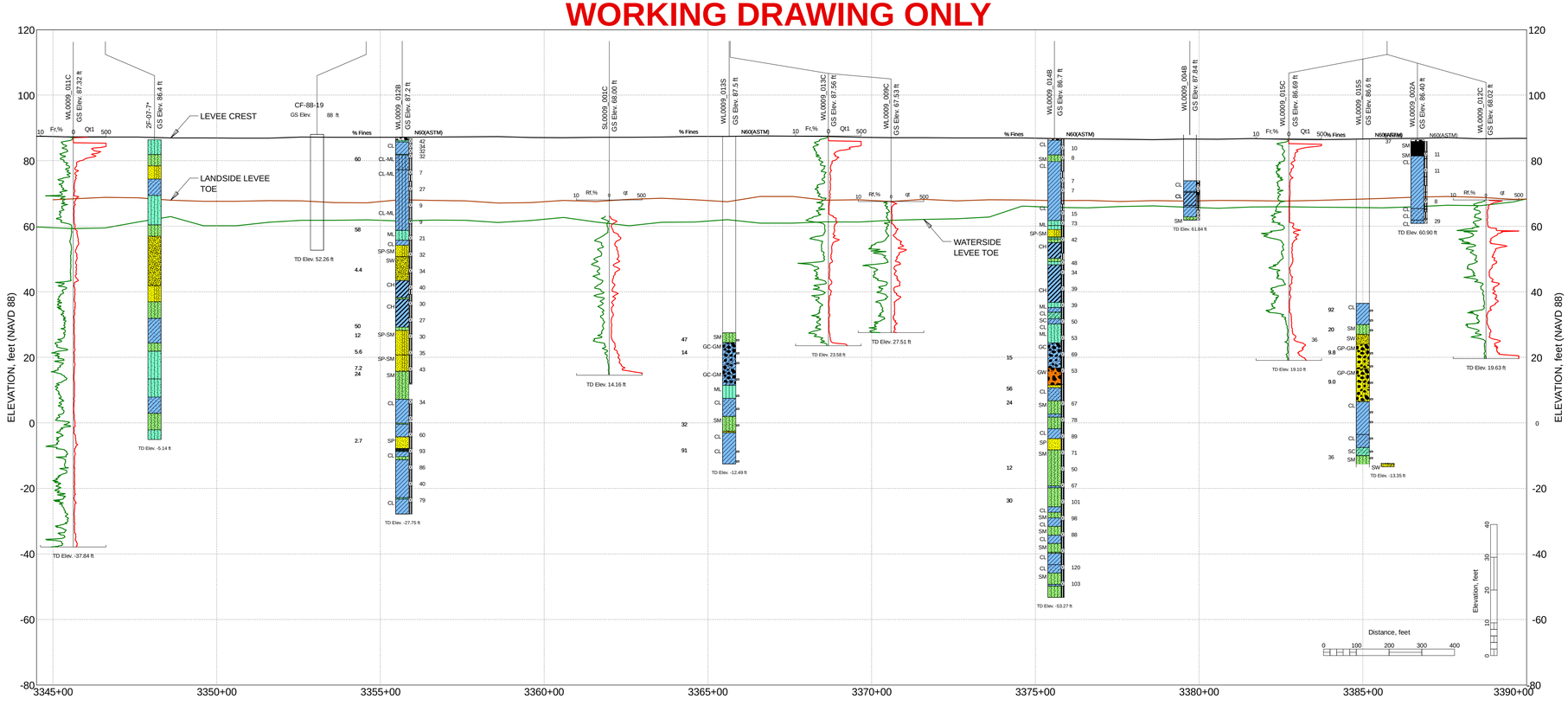
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A26

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WORKING DRAWING ONLY



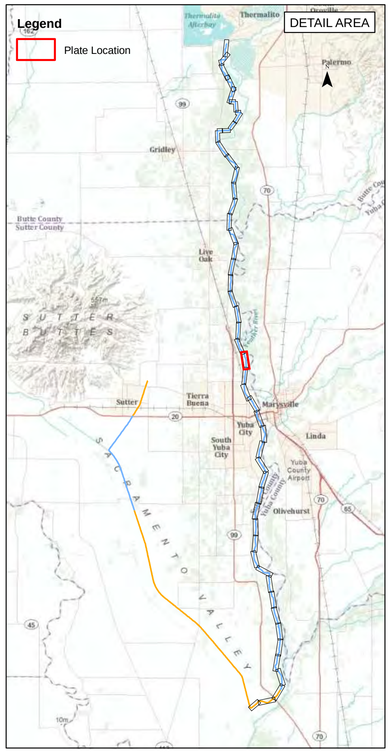
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NOTES:

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FRWL Project Plan Views and Stick Figures
DWR: Station 3345+00 to Station 3390+00
FRWL Project: Station 1178+87 to Station 1223+88

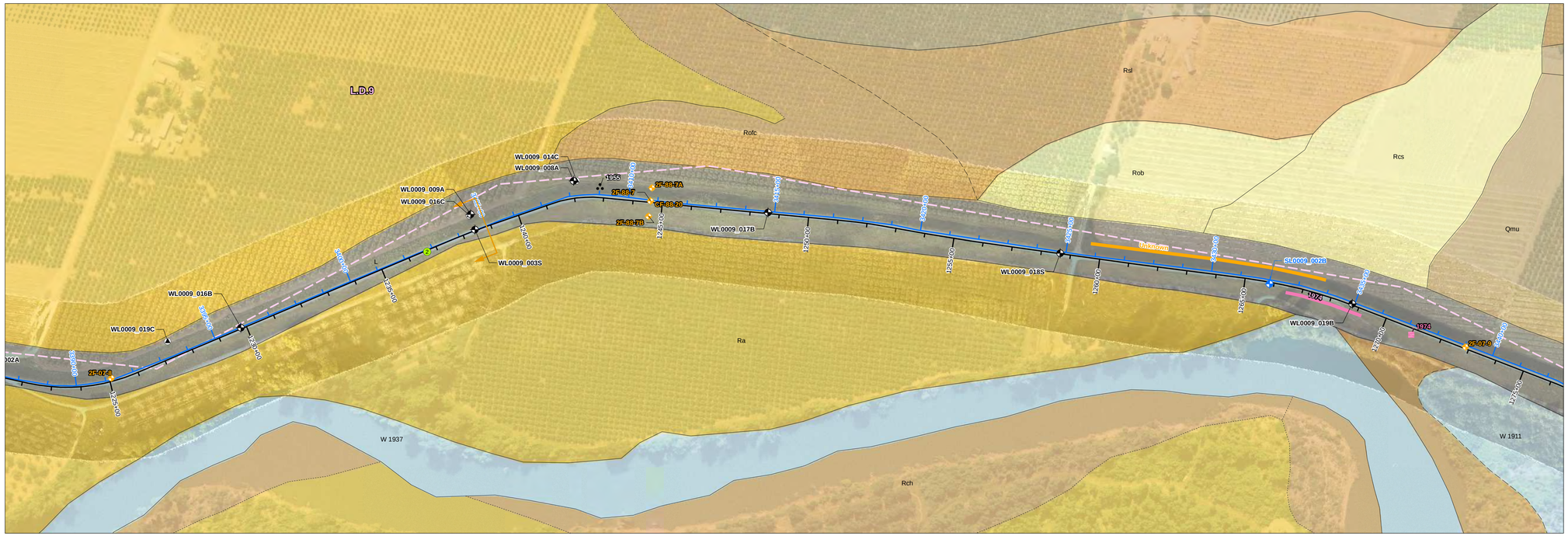
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Report of Geotechnical Analyses
for Pre-Design Formulation

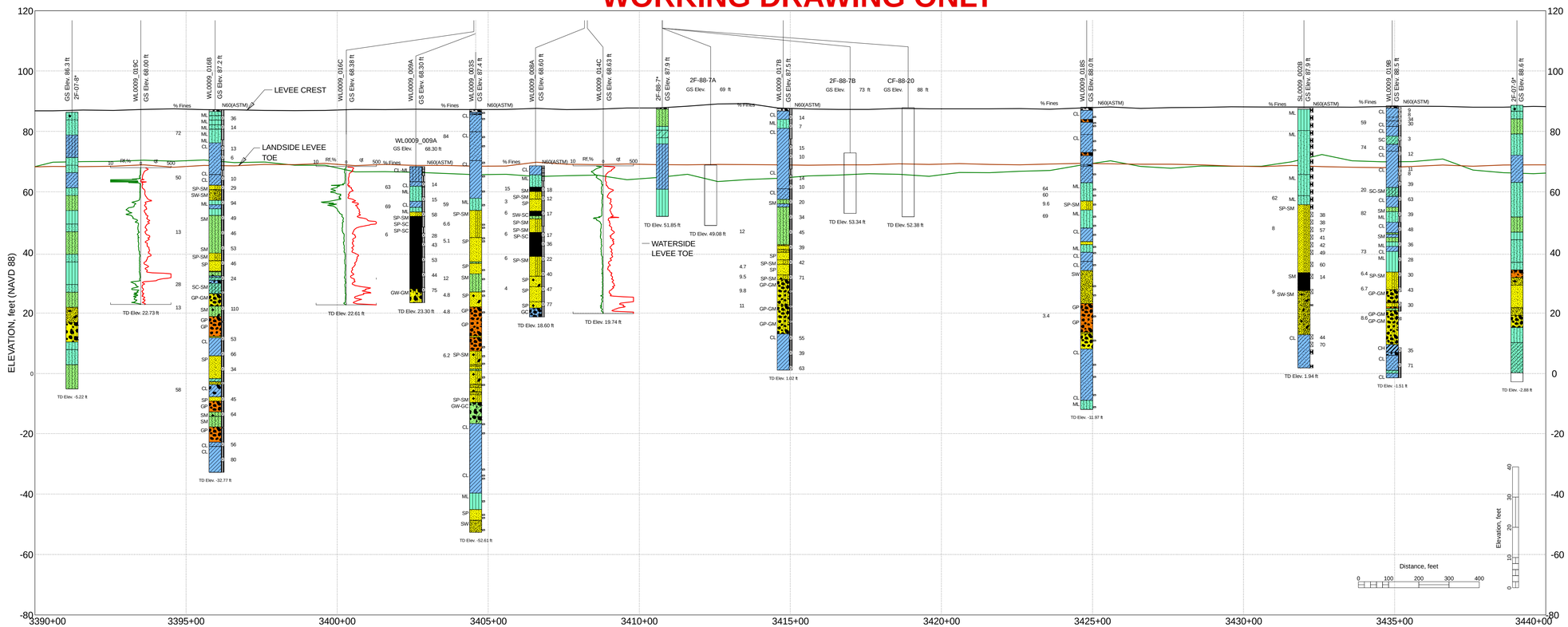
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

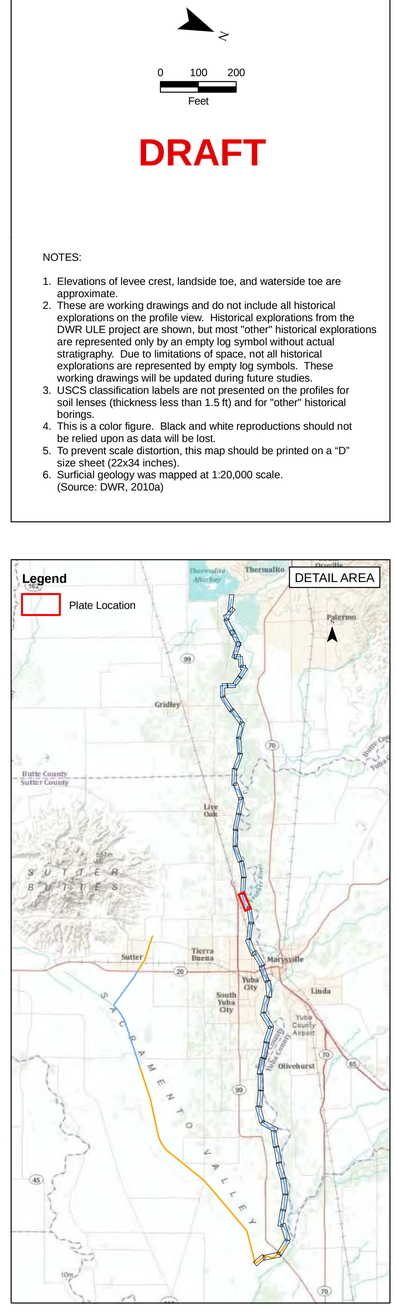
Appendix A27

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WORKING DRAWING ONLY





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NOTES:

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6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

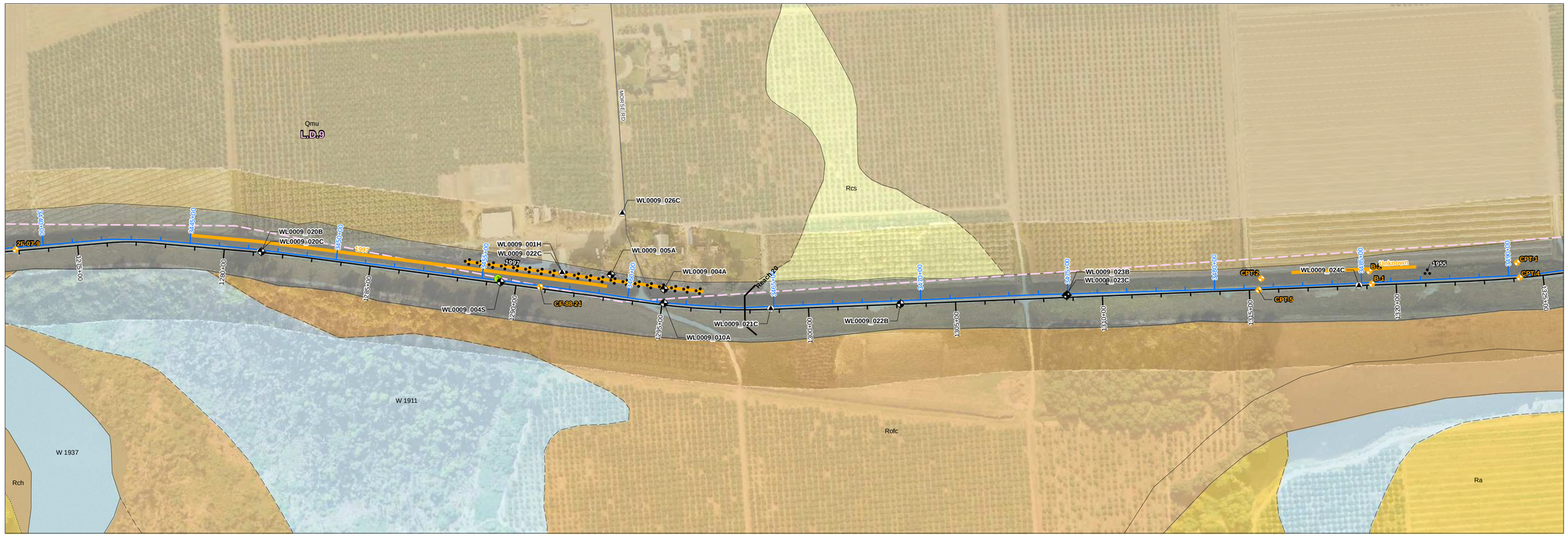
FRWL Project Plan Views and Stick Figures
DWR: Station 3390+00 to Station 3440+00
FRWL Project: Station 1223+88 to Station 1273+83

URS
Report of Geotechnical Analyses for Pre-Design Formulation

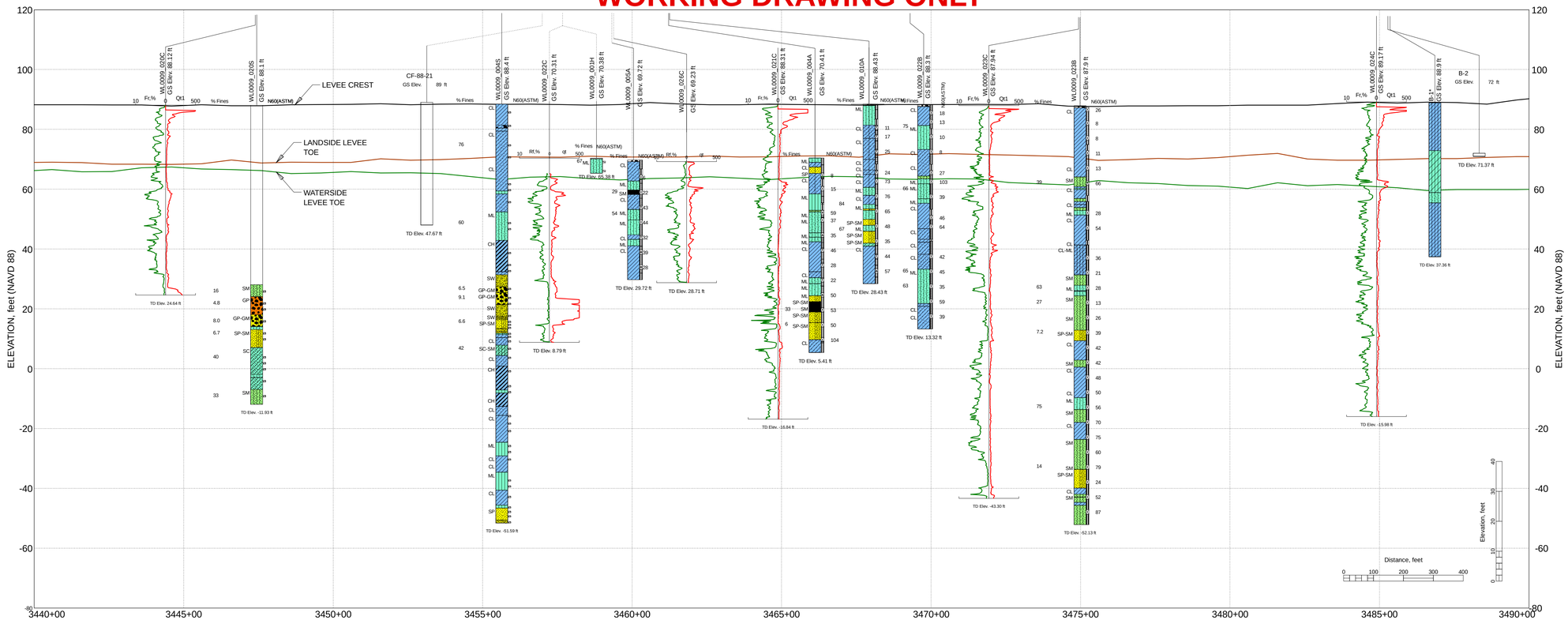
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A28

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WORKING DRAWING ONLY



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Feet

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NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3440+00 to Station 3490+00
FRWL Project: Station 1273+83 to Station 1323+85

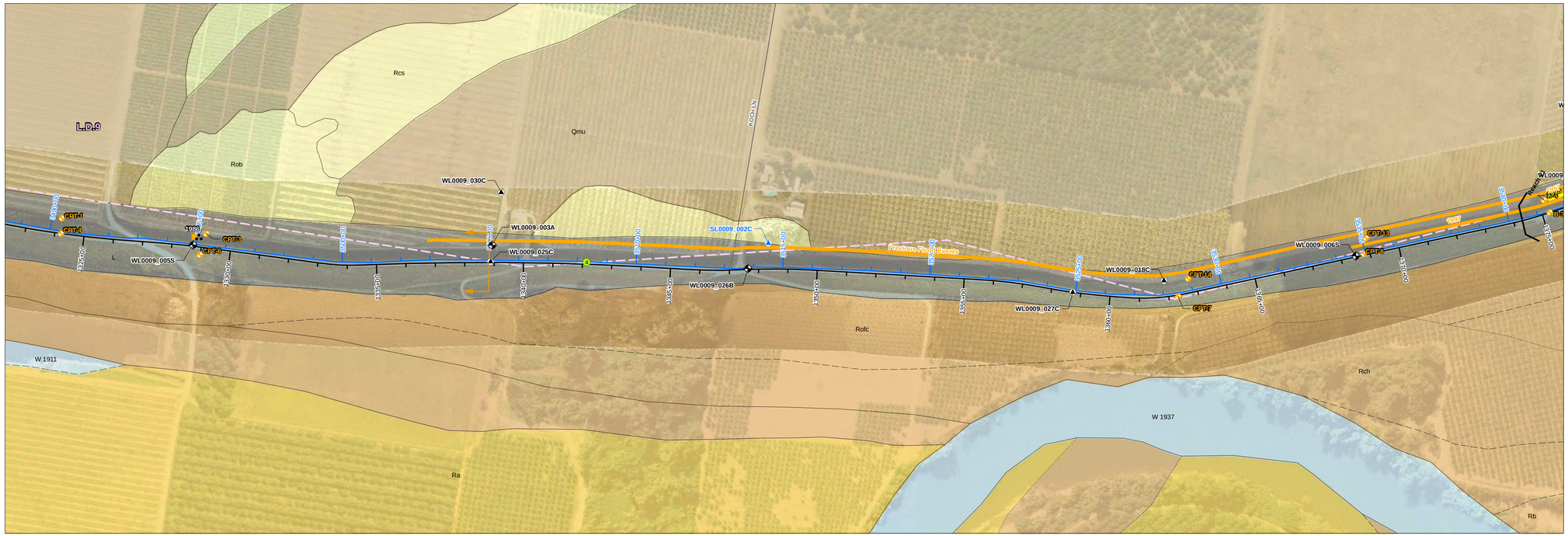
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Report of Geotechnical Analyses for Pre-Design Formulation

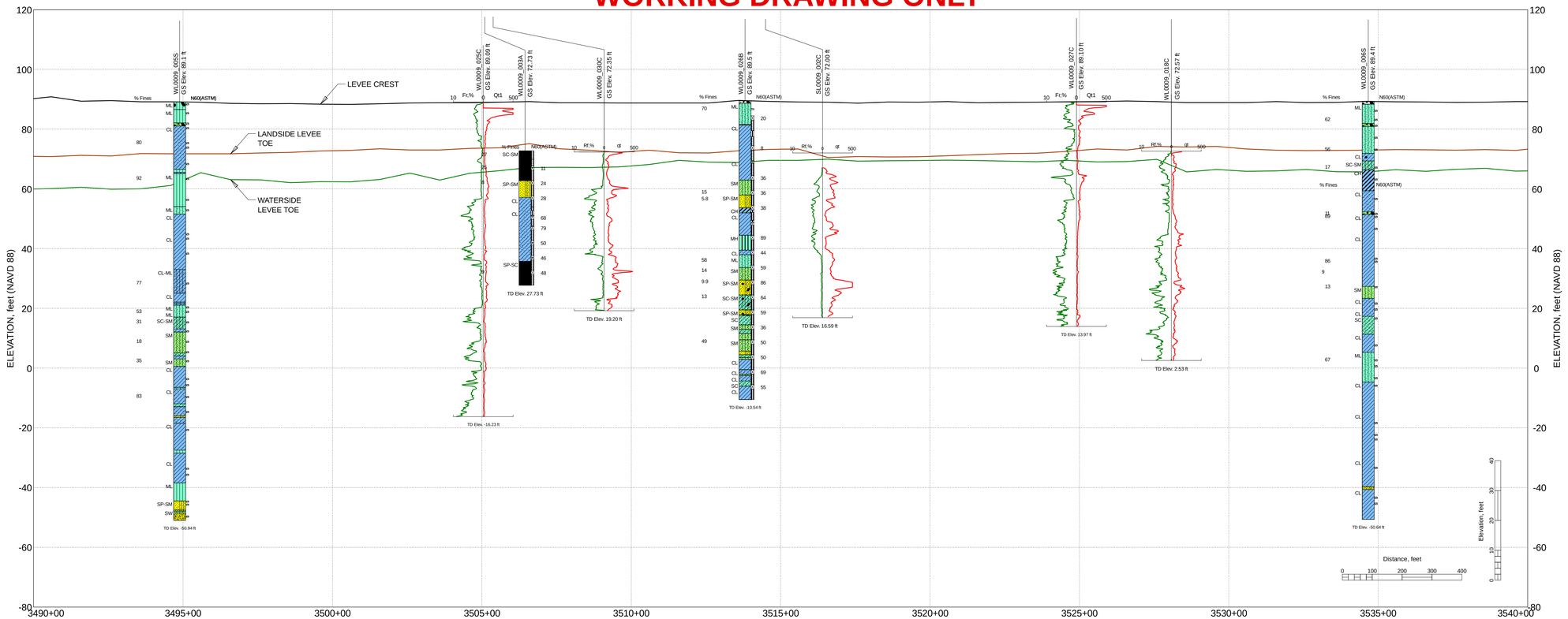
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A29

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WORKING DRAWING ONLY



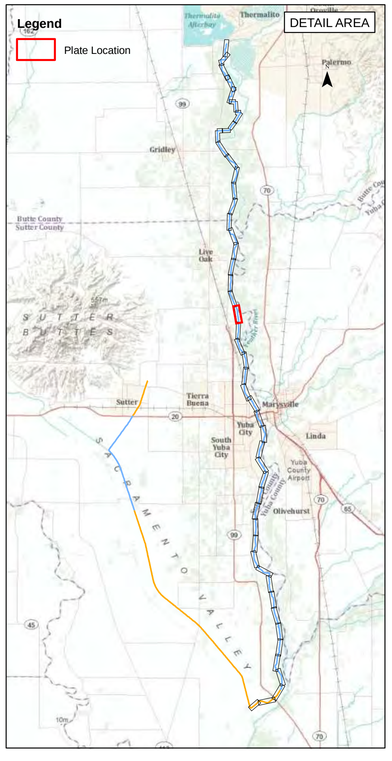
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NOTES:

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6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3490+00 to Station 3540+00
FRWL Project: Station 1323+85 to Station 1373+83

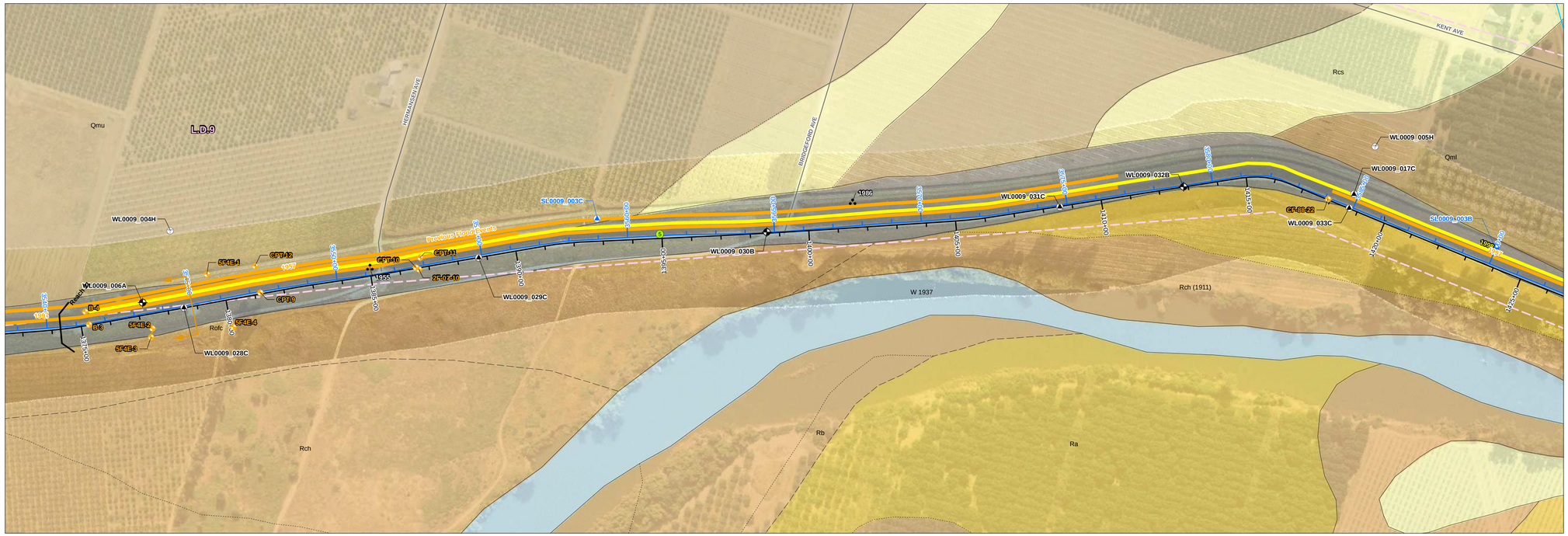
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Report of Geotechnical Analyses
for Pre-Design Formulation

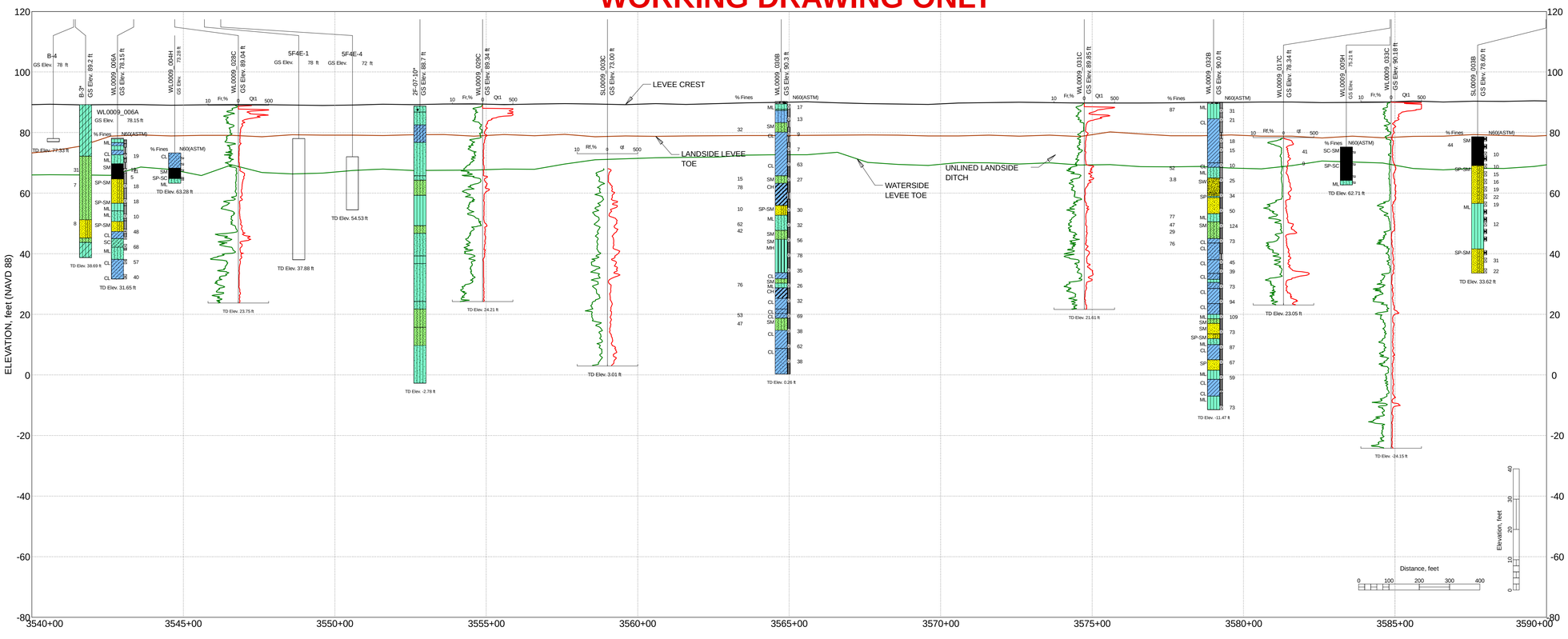
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

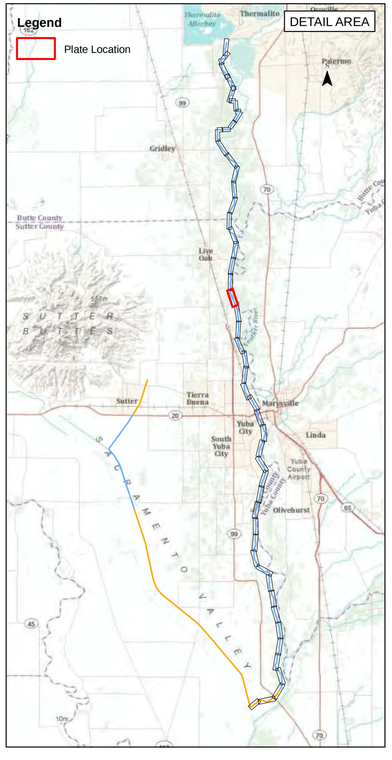
Appendix A30

I:\projects\SBFCA\Maps\RFEA_GR_PrePP_Workbook.mxd 10-23-10 SAC



WORKING DRAWING ONLY





N

0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
3. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft) and for "other" historical borings.
4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

FRWL Project Plan Views and Stick Figures
DWR: Station 3540+00 to Station 3590+00
FRWL Project: Station 1373+83 to Station 1423+87

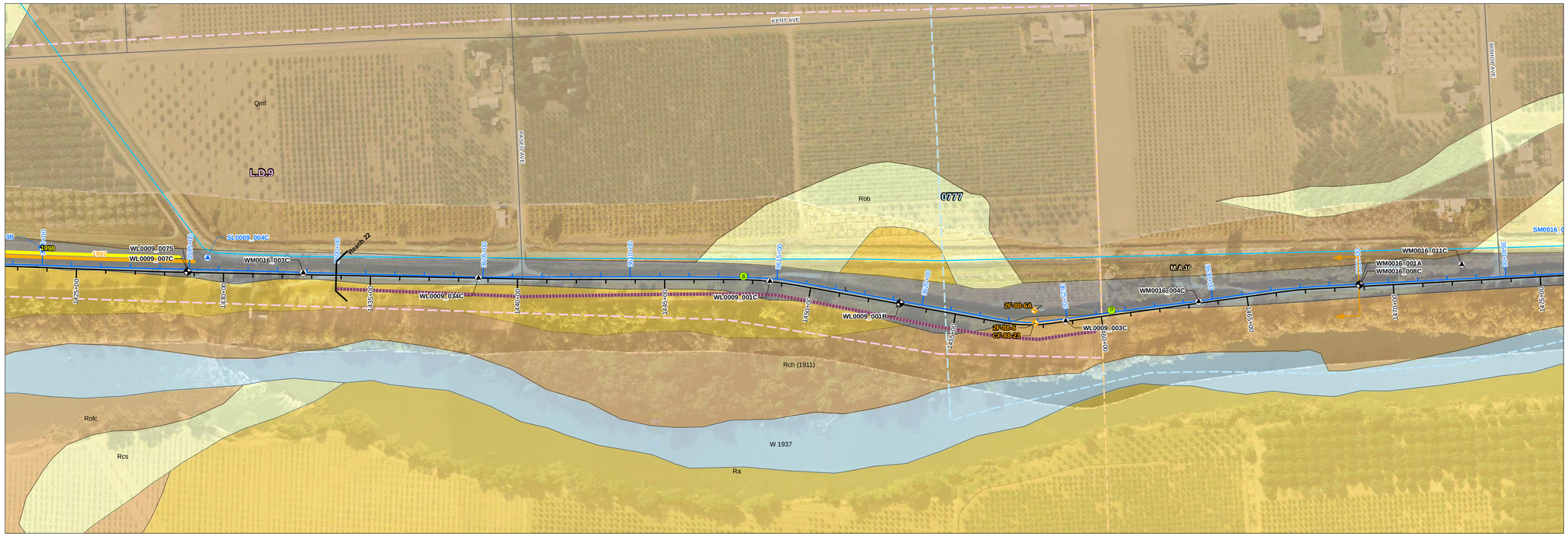
URS

Report of Geotechnical Analyses
for Pre-Design Formulation

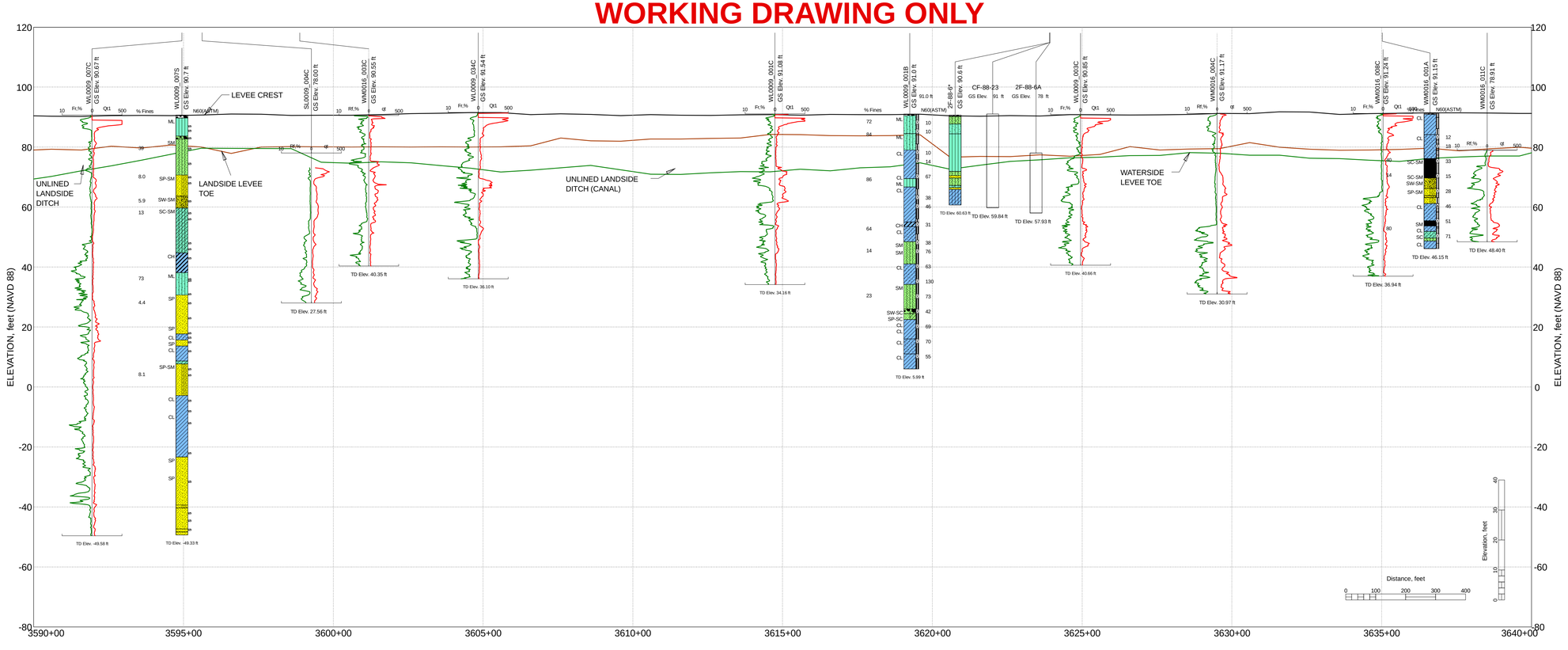
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A31

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WORKING DRAWING ONLY



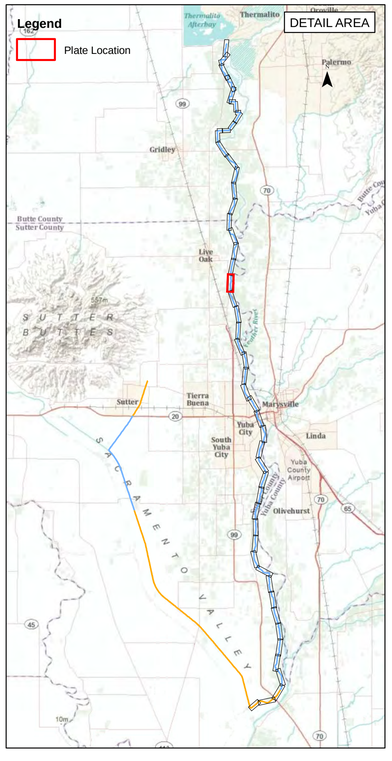
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Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3590+00 to Station 3640+00
FRWL Project: Station 1423+87 to Station 1473+89

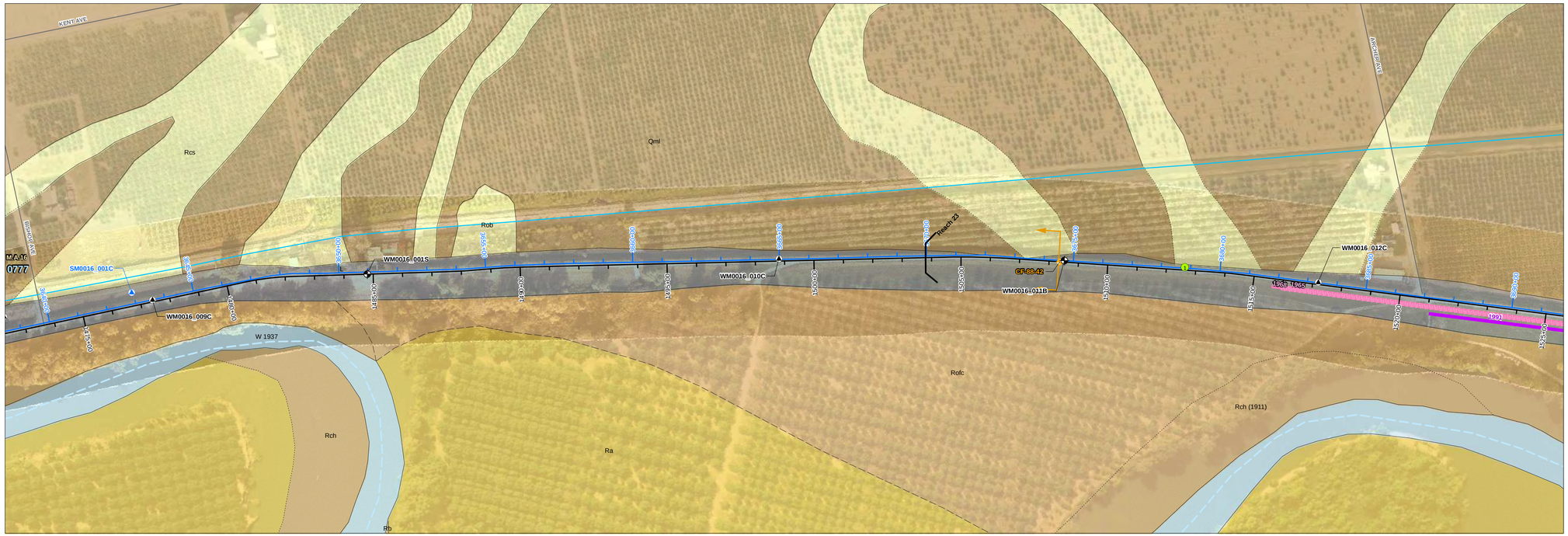
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Report of Geotechnical Analyses
for Pre-Design Formulation

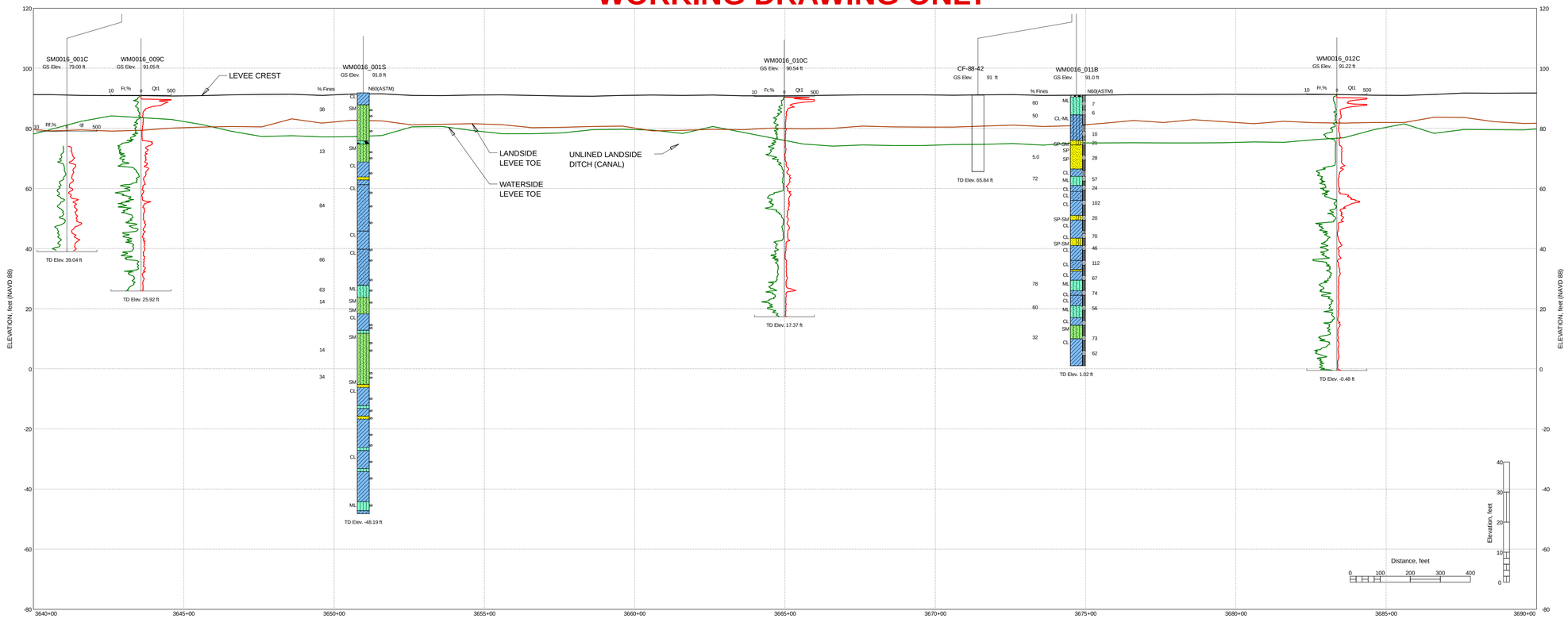
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A32

Projects\SBFCA\Maps\SBFCA_GR_Prof_Map\Book1.mxd 12-21-10 SVC



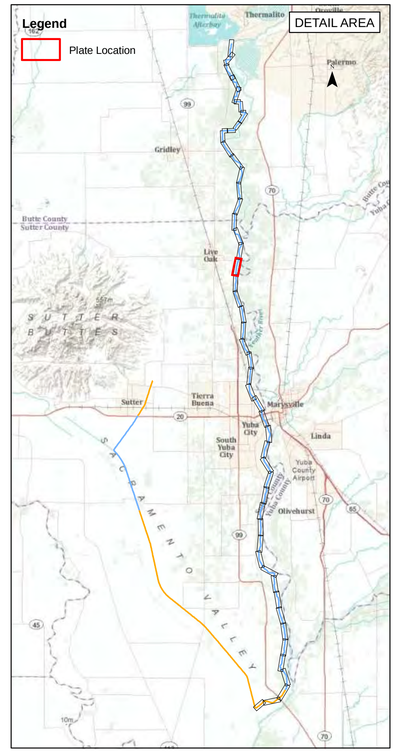
WORKING DRAWING ONLY



DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3640+00 to Station 3690+00
FRWL Project: Station 1473+89 to Station 1523+84

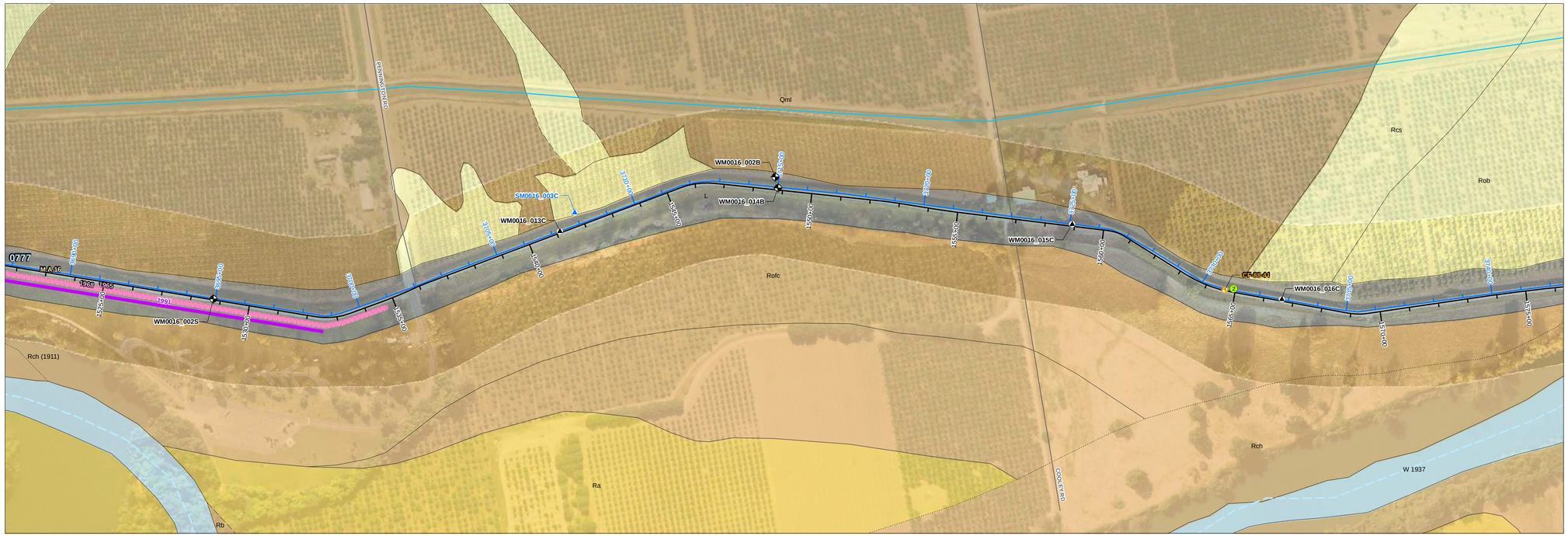
URS

Report of Geotechnical Analyses for Pre-Design Formulation

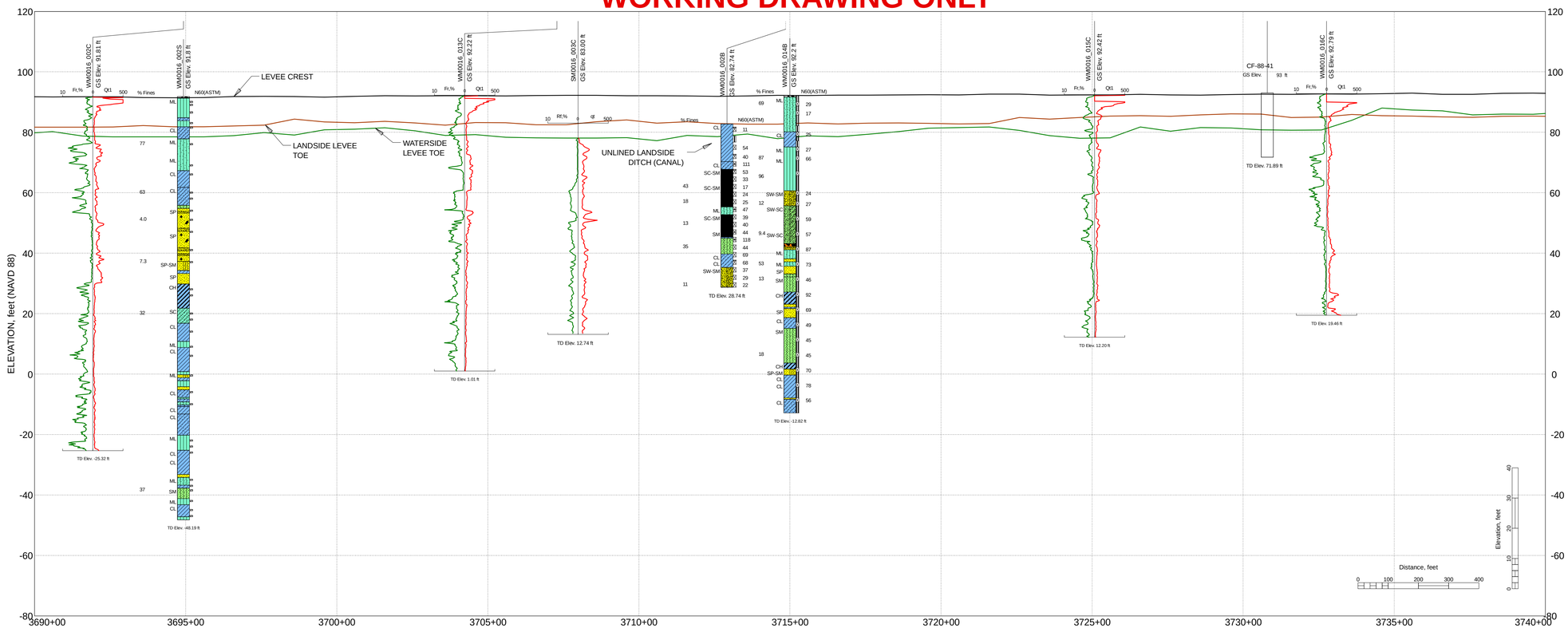
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A33

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WORKING DRAWING ONLY



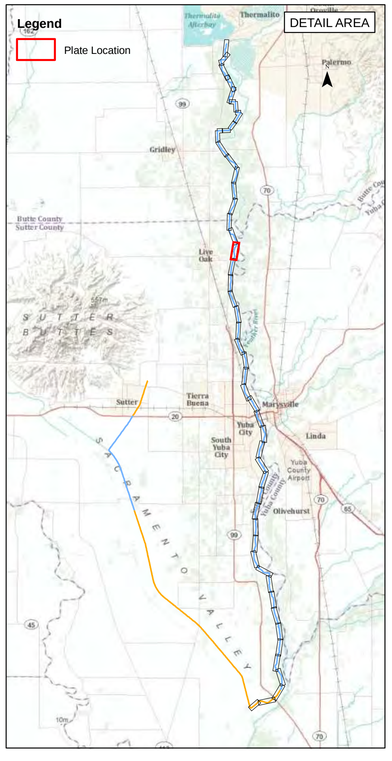
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Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3690+00 to Station 3740+00
FRWL Project: Station 1523+84 to Station 1573+91

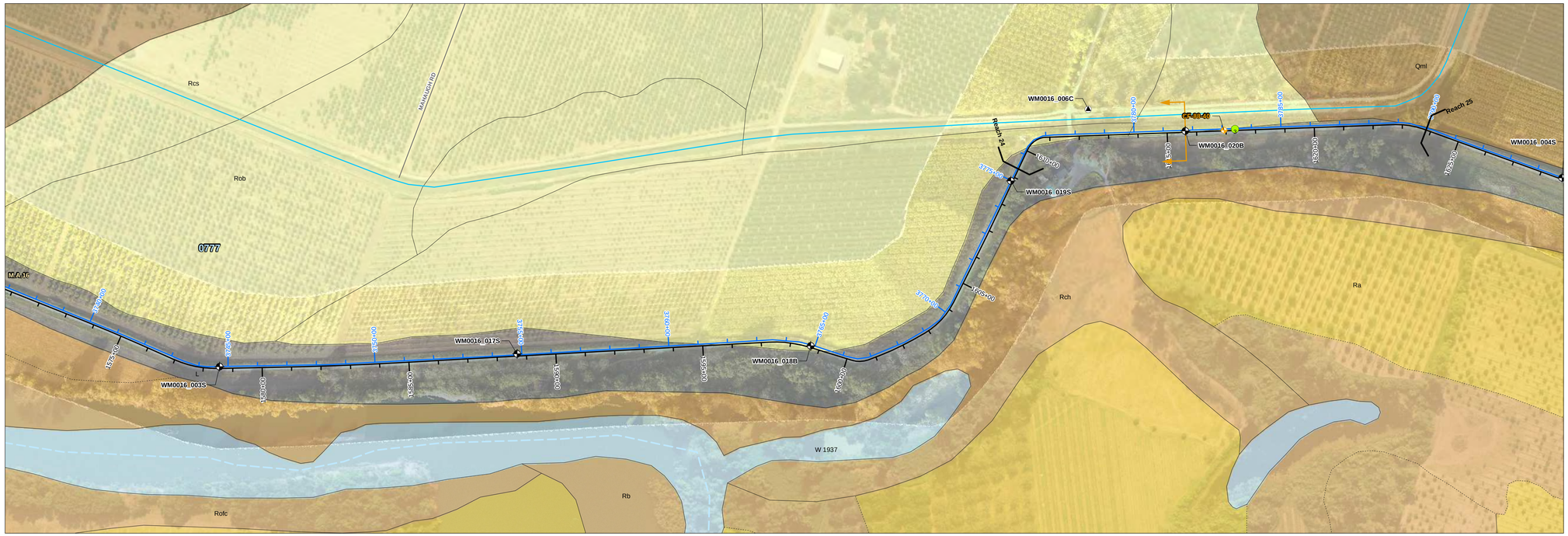
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Report of Geotechnical Analyses
for Pre-Design Formulation

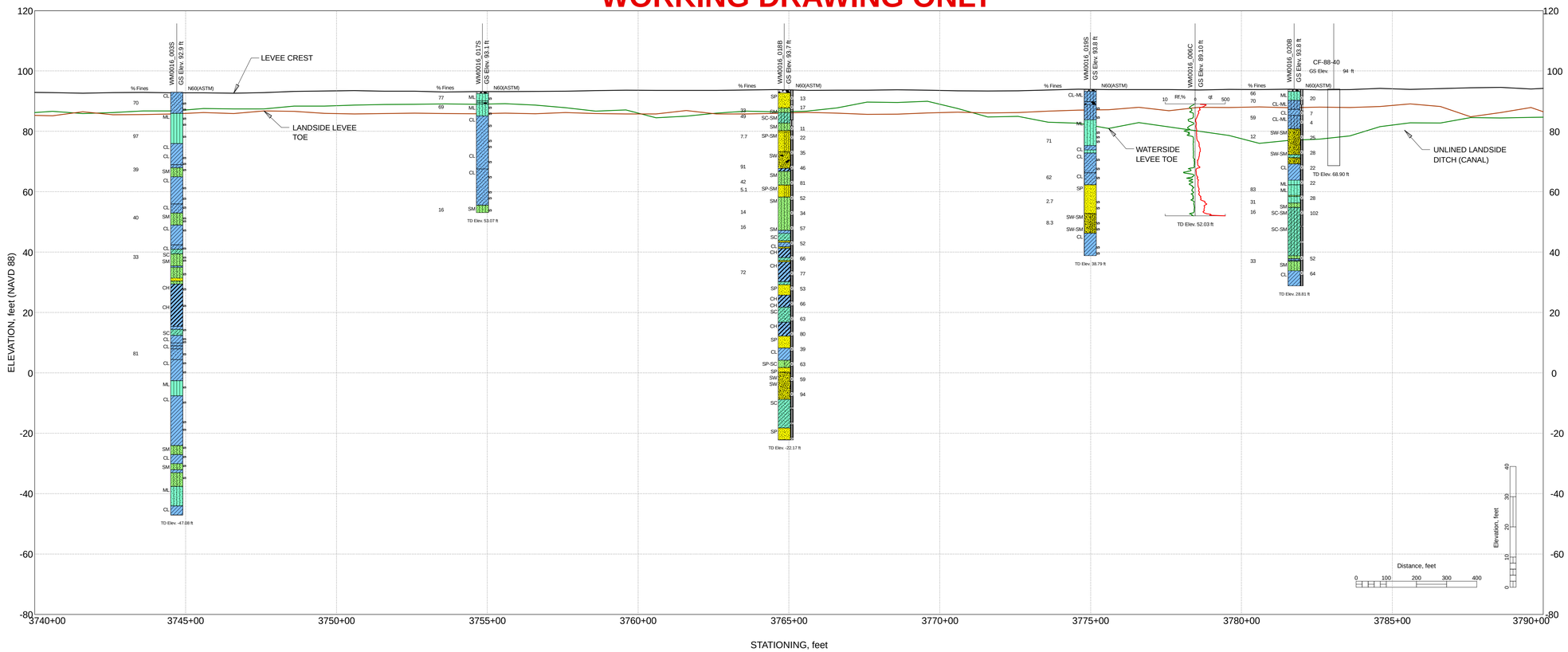
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A34

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WORKING DRAWING ONLY



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Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



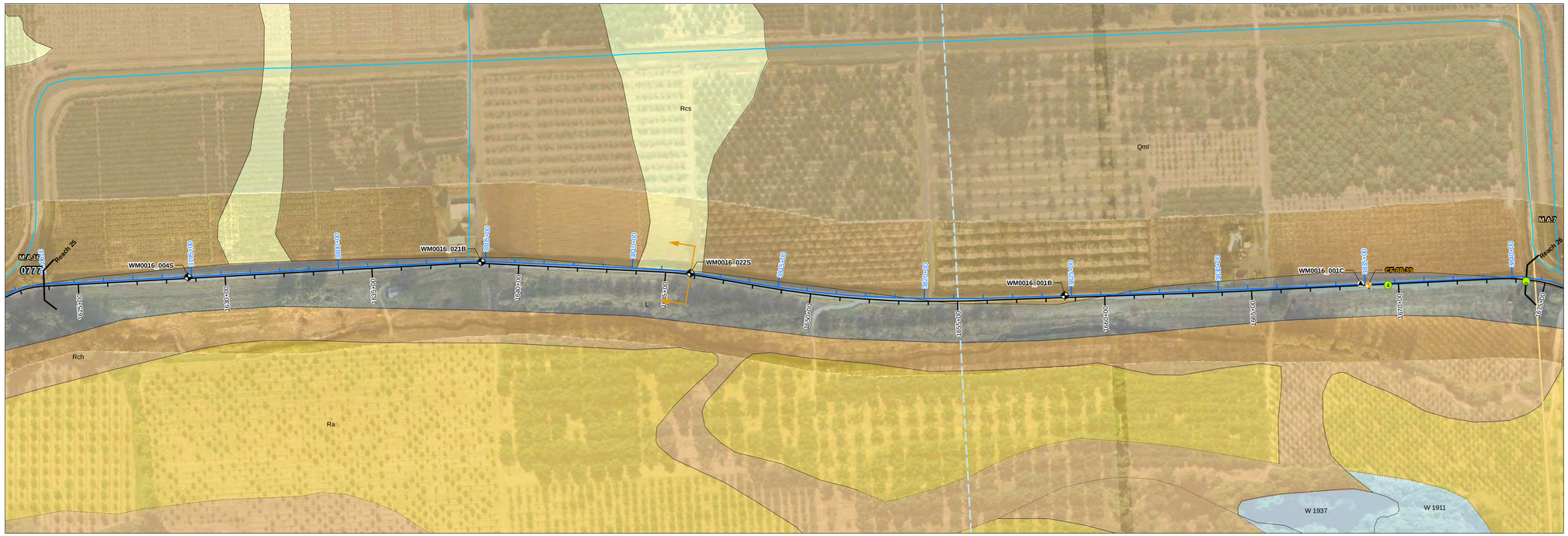
FRWL Project Plan Views and Stick Figures
DWR: Station 3740+00 to Station 3790+00
FRWL Project: Station 1573+91 to Station 1623+89

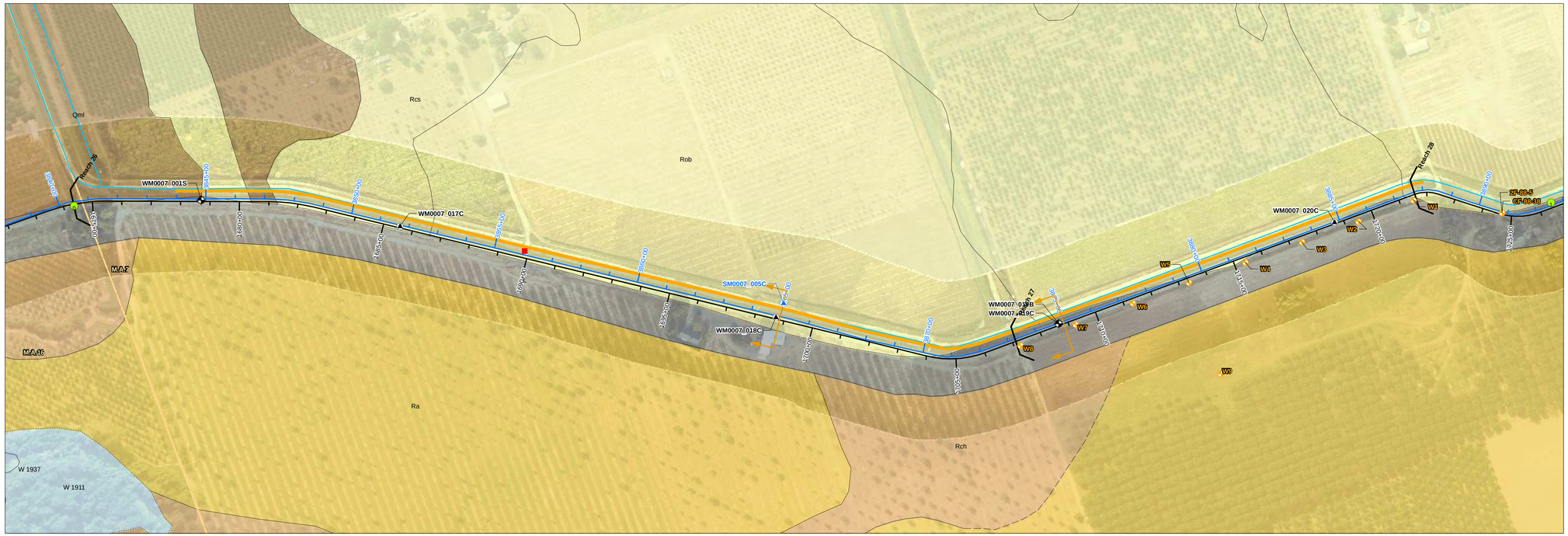
URS
Report of Geotechnical Analyses for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

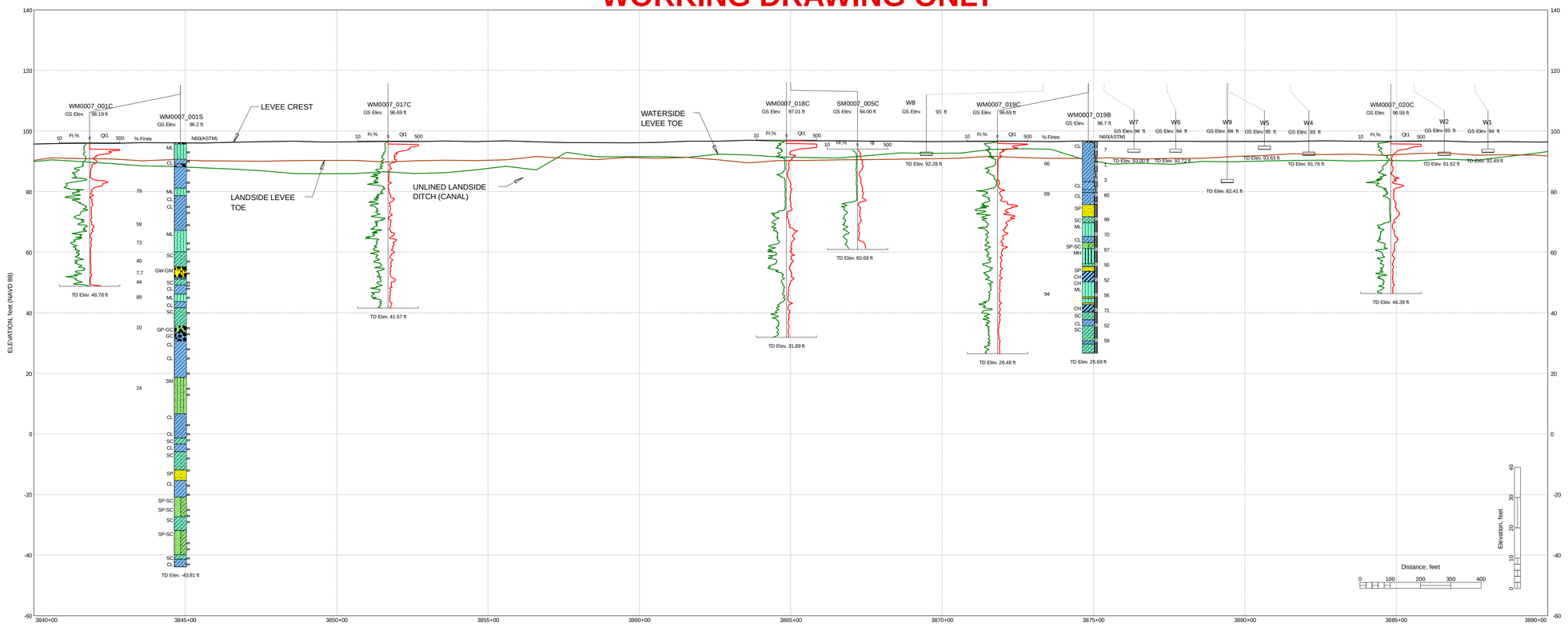
Appendix A35

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Rcs
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Rch
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W 1937
W 1911
MA6
MA7
0777
Reach 2S
WM0016_004S
WM0016_021B
WM0016_022S
WM0016_001B
WM0016_001C
CF-88-39
1625+00
1630+00
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1645+00
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WORKING DRAWING ONLY



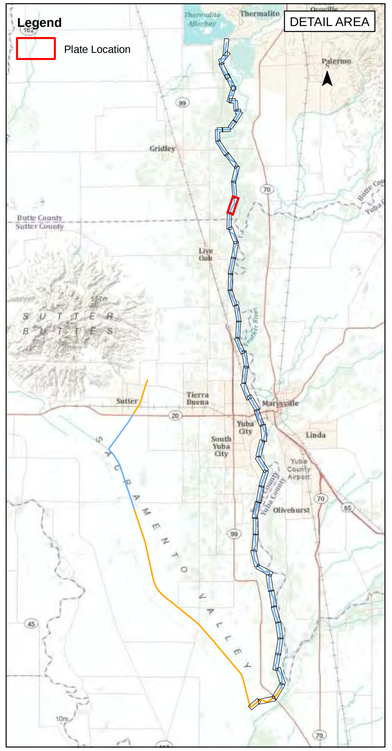
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Feet

DRAFT

NOTES:

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6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



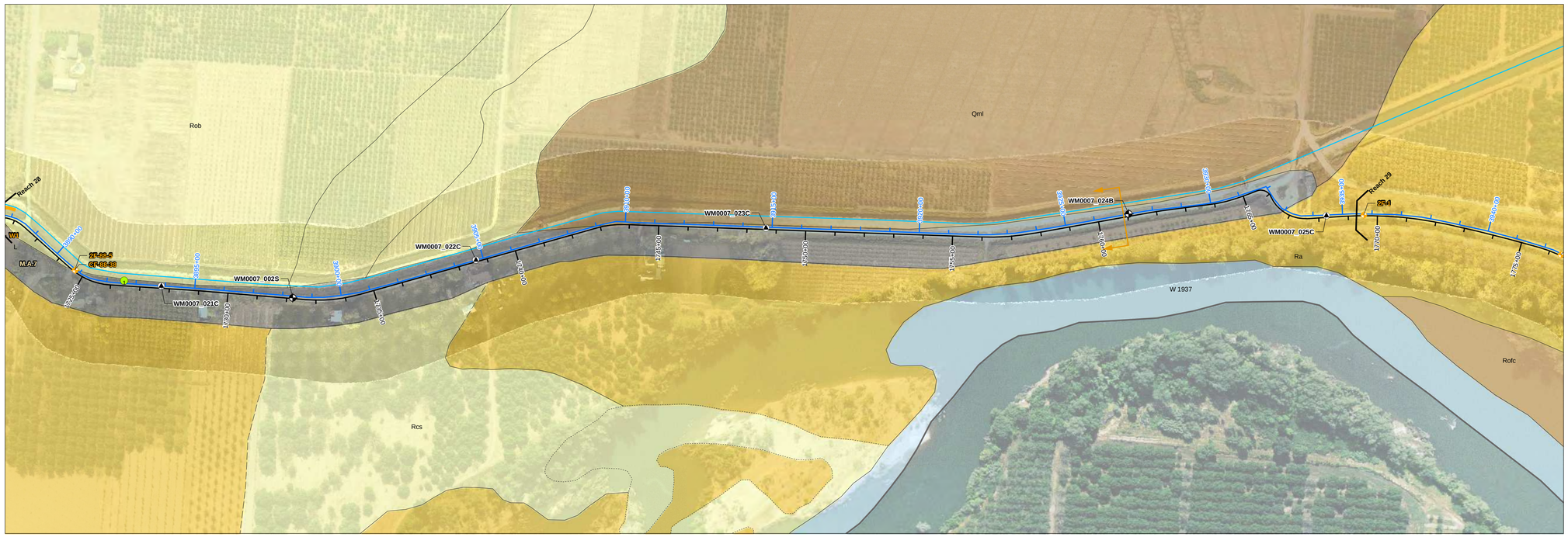
FRWL Project Plan Views and Stick Figures
DWR: Station 3840+00 to Station 3890+00
FRWL Project: Station 1673+90 to Station 1723+85

URS — Report of Geotechnical Analyses for Pre-Design Formulation

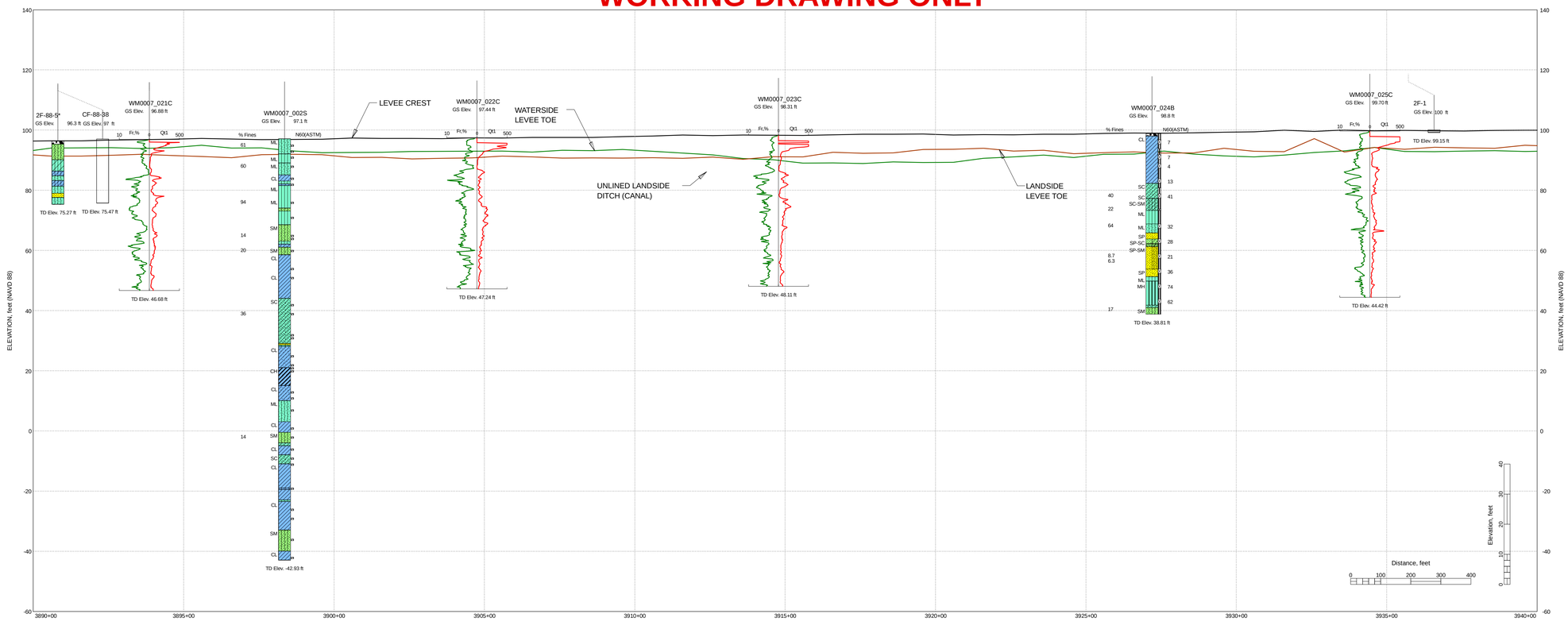
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A37

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WORKING DRAWING ONLY



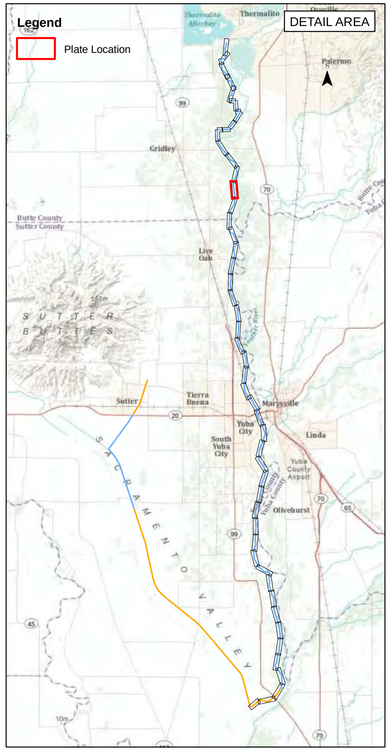
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0 100 200
Feet

DRAFT

NOTES:

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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3890+00 to Station 3940+00
FRWL Project: Station 1723+85 to Station 1773+82

URS — Report of Geotechnical Analyses for Pre-Design Formulation

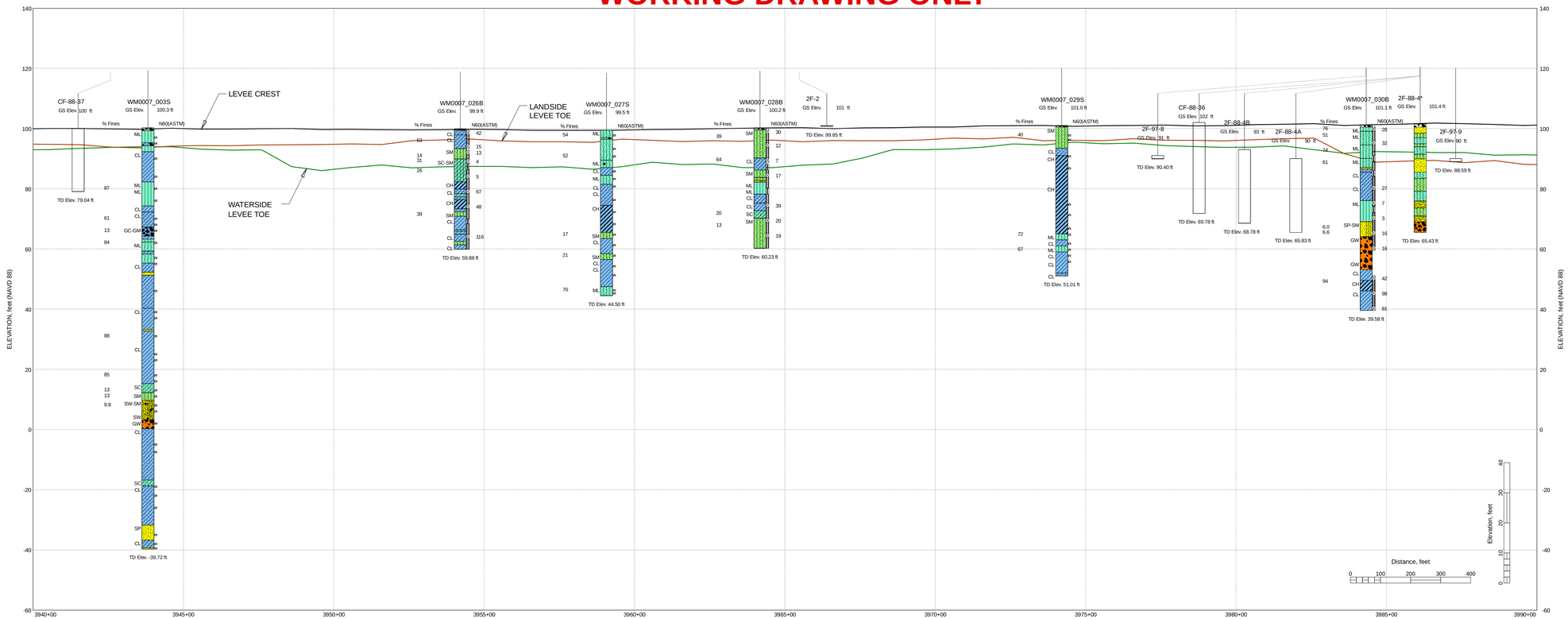
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A38

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WORKING DRAWING ONLY



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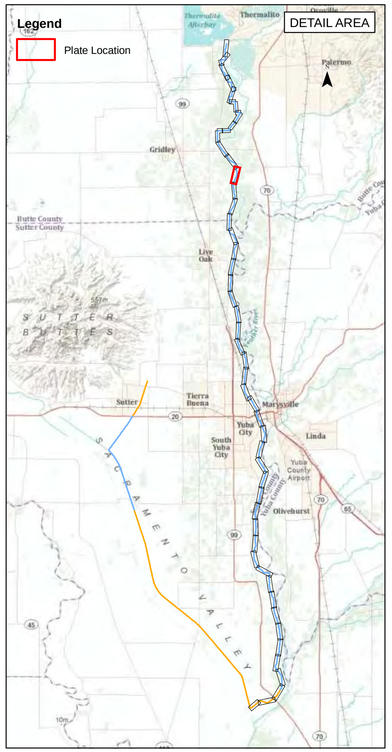
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Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3940+00 to Station 3990+00
FRWL Project: Station 1773+82 to Station 1823+90

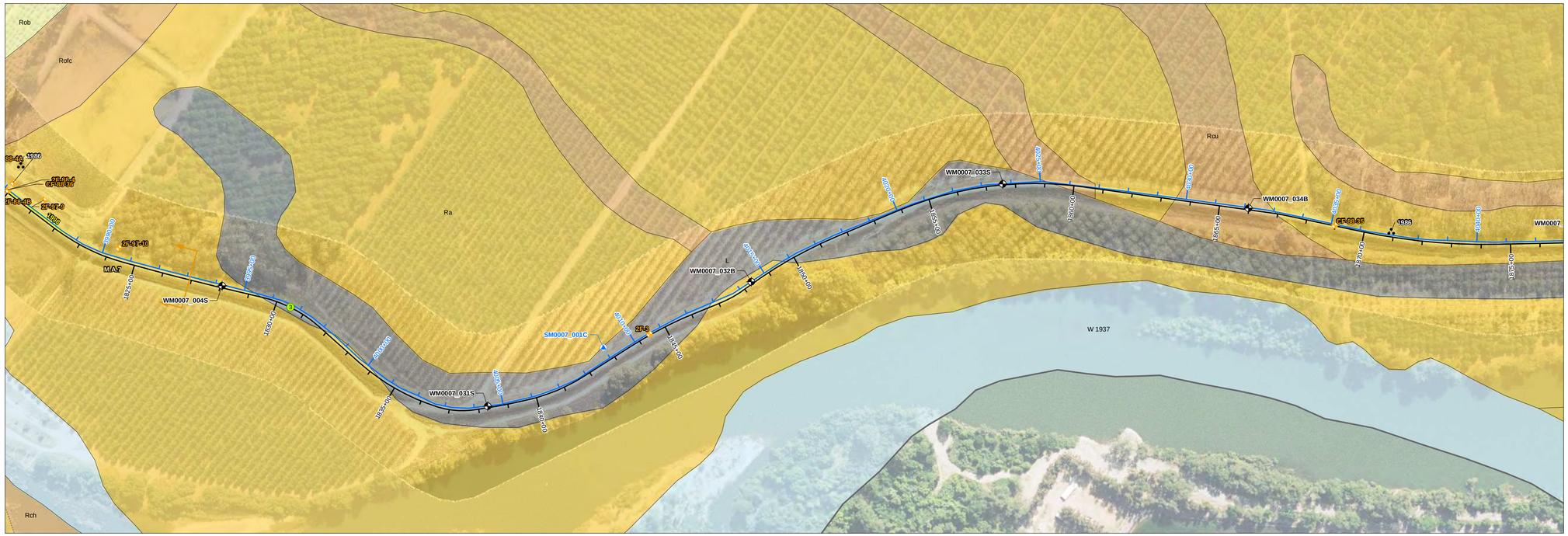
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Report of Geotechnical Analyses for Pre-Design Formulation

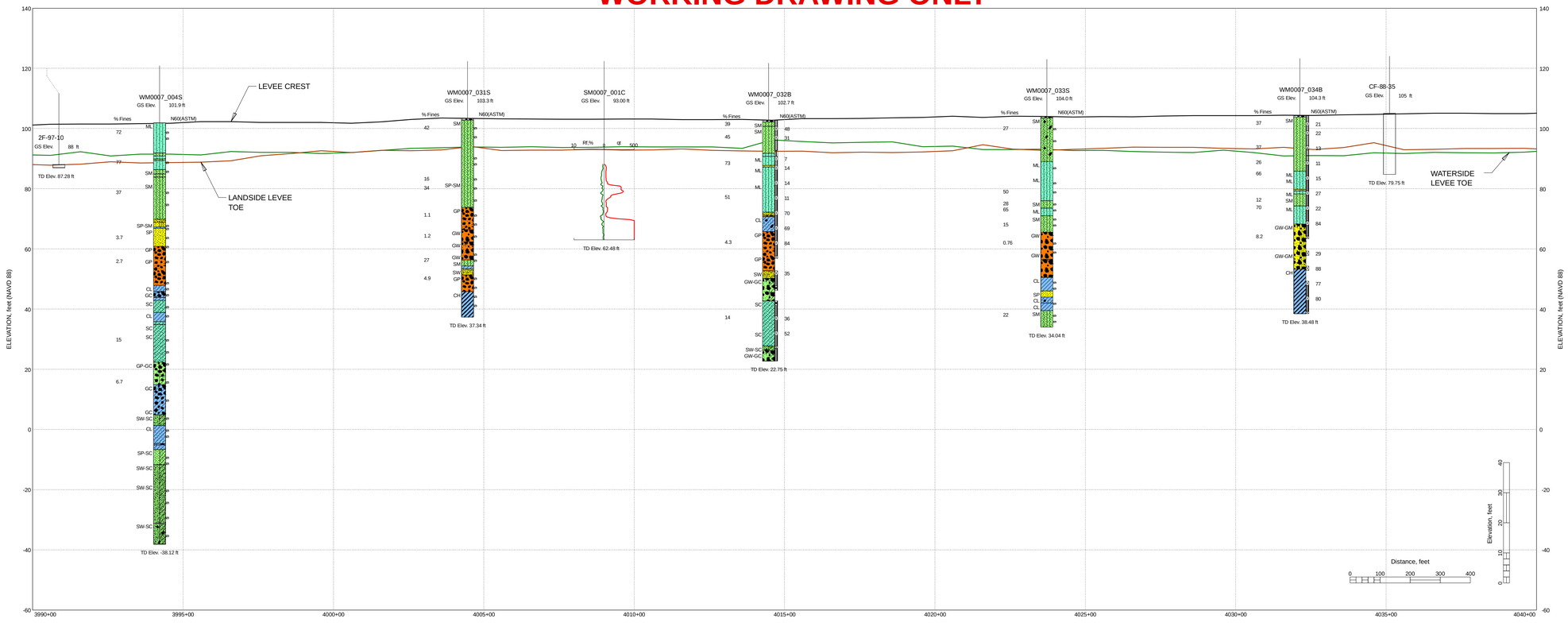
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A39

J:\Projects\SBFCA\ArcMap\SBFCA_GEI_EIP_Mapbook.mxd Fig 2.1 10 SAC



WORKING DRAWING ONLY



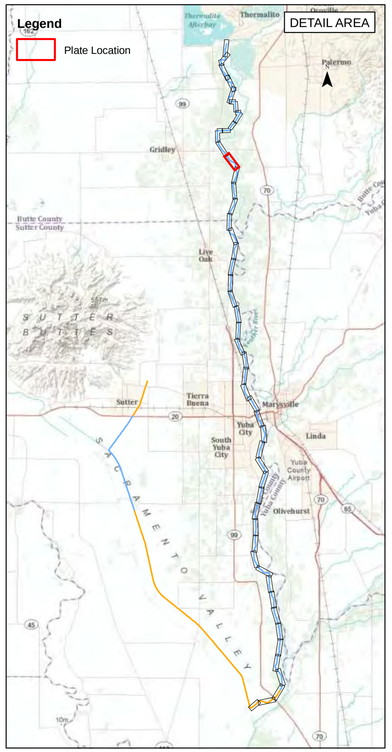
N

0 100 200
Feet

DRAFT

NOTES:

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5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 3990+00 to Station 4040+00
FRWL Project: Station 1823+90 to Station 1873+90

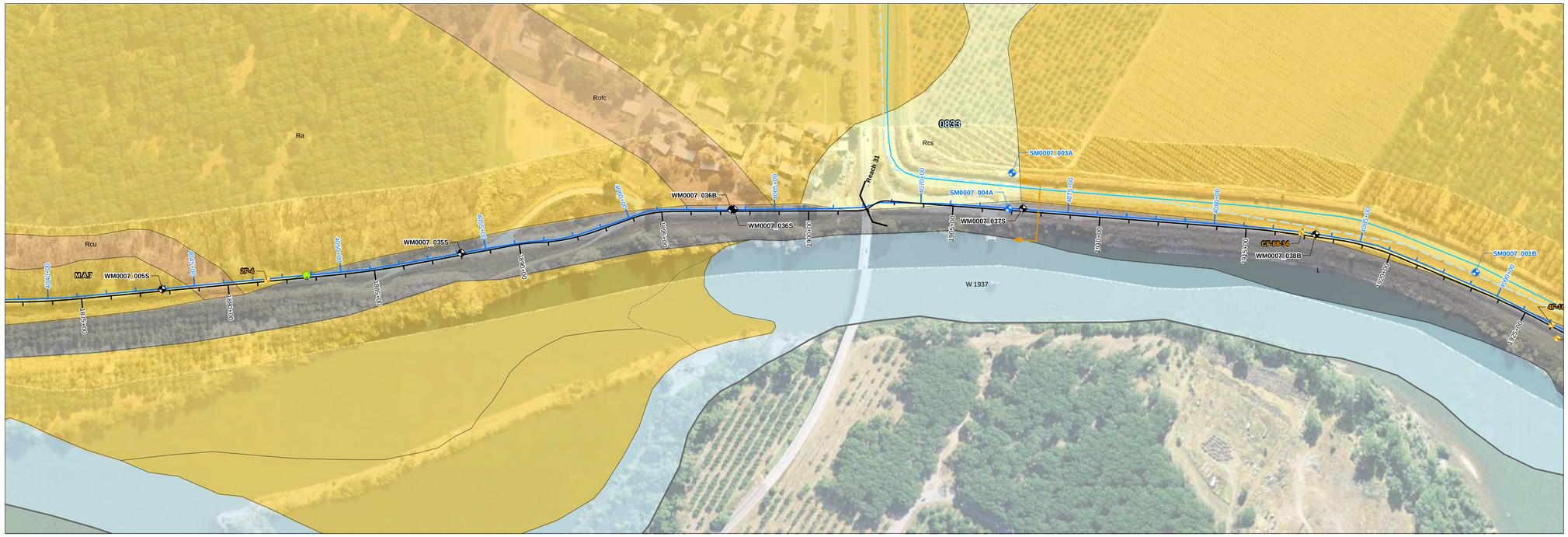
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Report of Geotechnical Analyses for Pre-Design Formulation

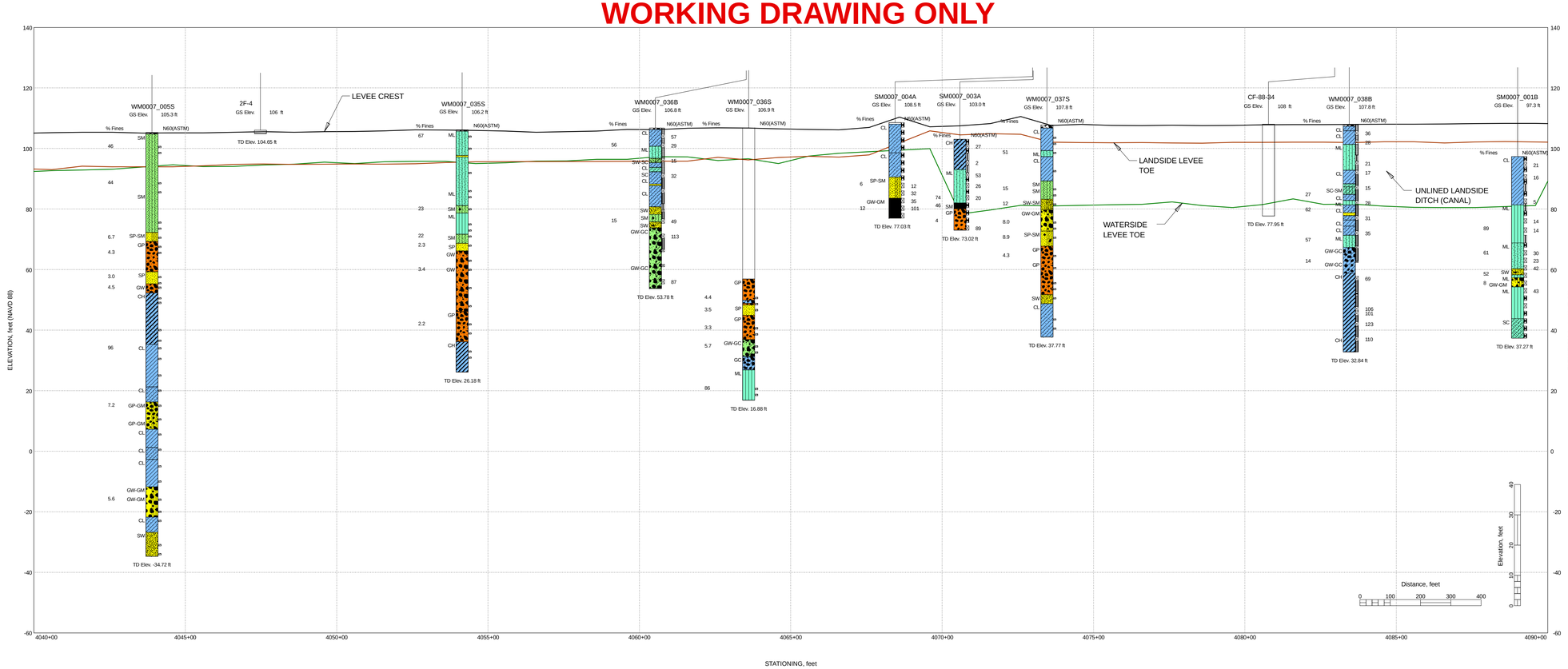
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

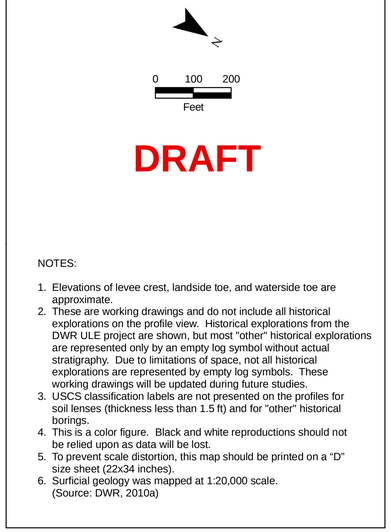
Appendix A40

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WORKING DRAWING ONLY

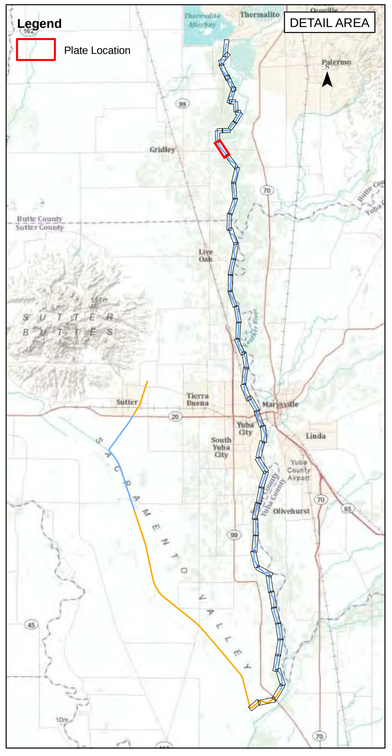




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NOTES:

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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 4040+00 to Station 4090+00
FRWL Project: Station 1873+90 to Station 1923+92

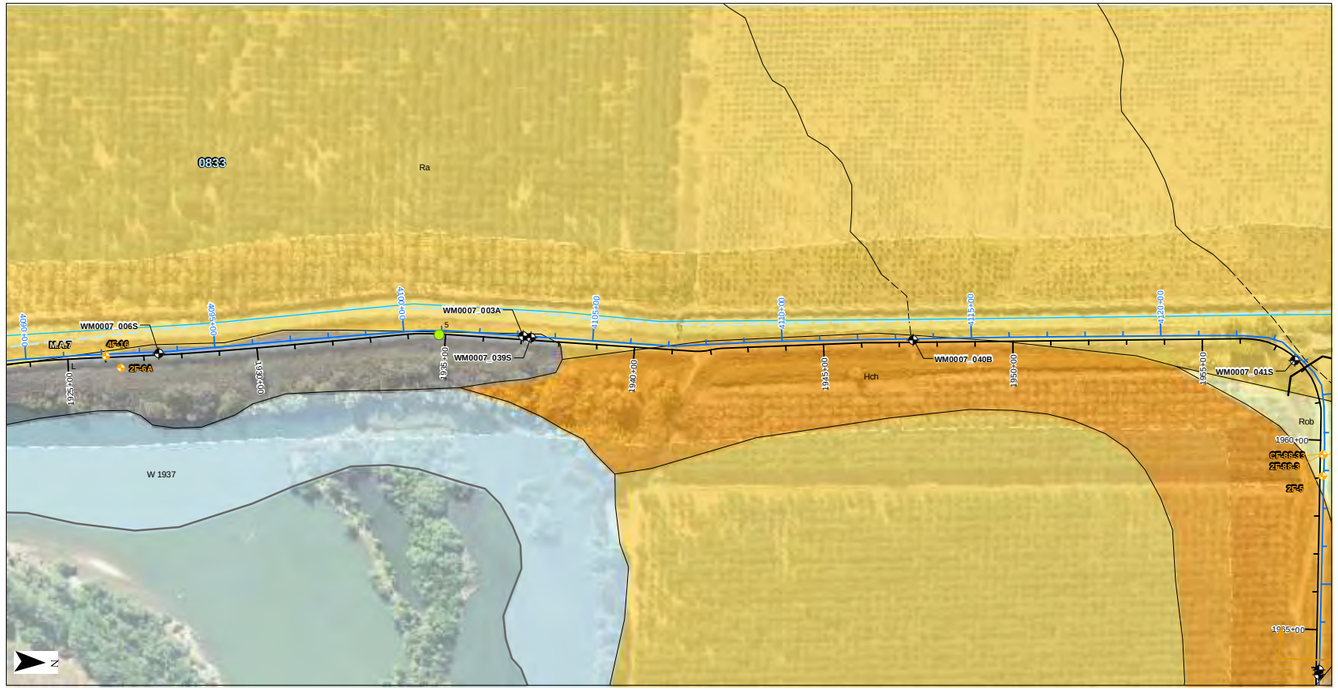
URS

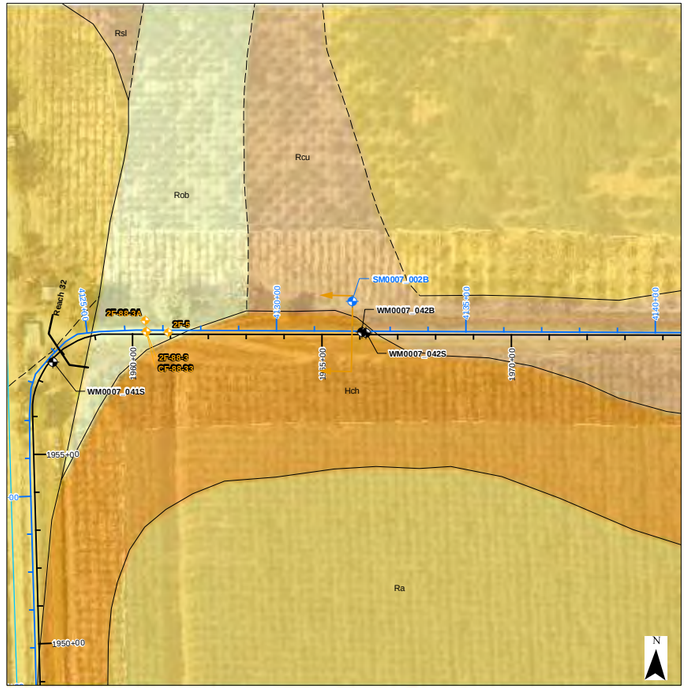
Report of Geotechnical Analyses
for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

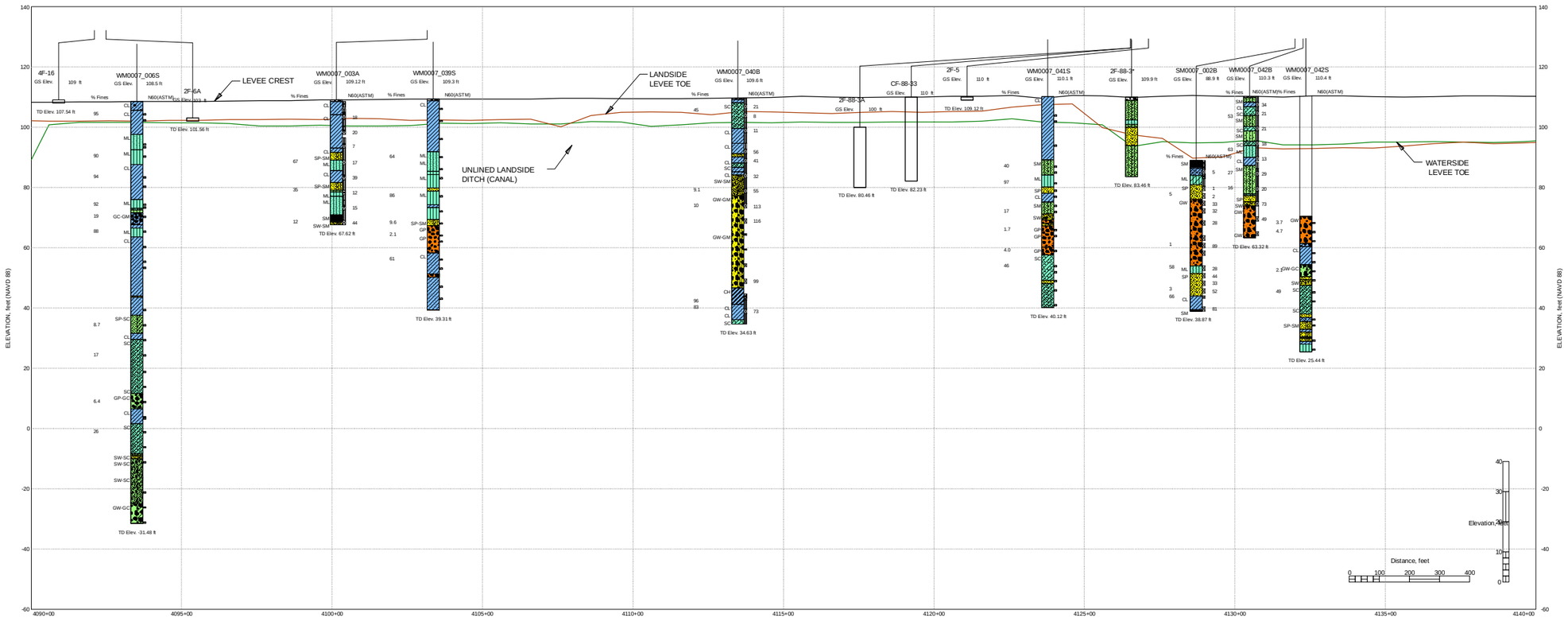
Appendix A41

I:\Projects\SBFCA\Maps\SBFCA_GEI_EIP_Mapbook.mxd 8/4/2010 SAC





WORKING DRAWING ONLY



0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 4090+00 to Station 4140+00
FRWL Project: Station 1923+92 to Station 1973+78

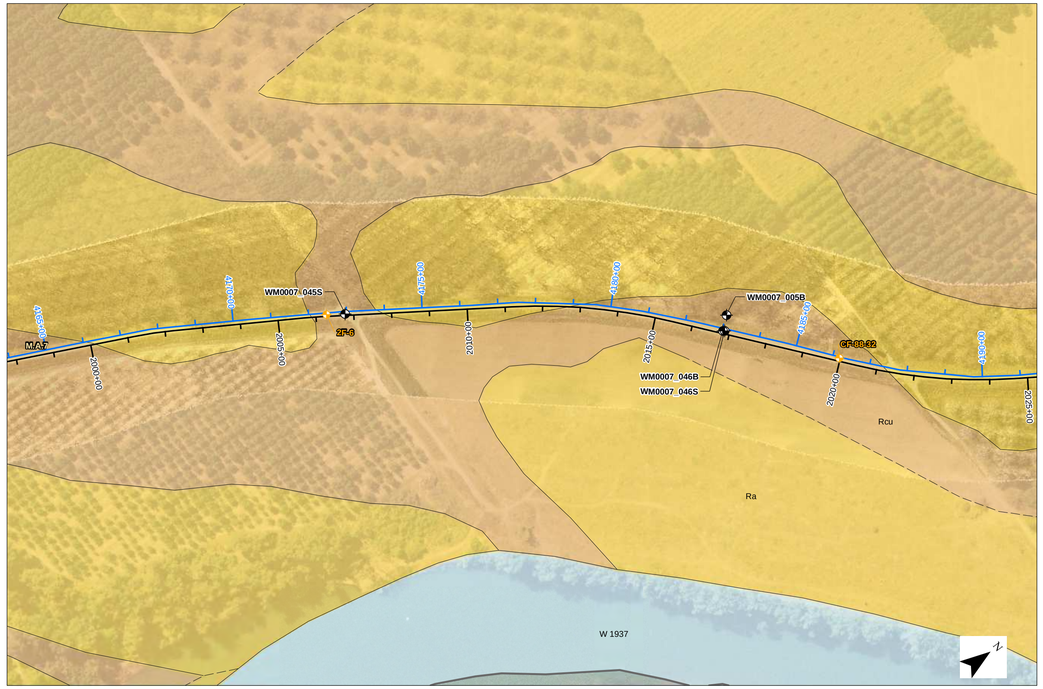
URS
Report of Geotechnical Analyses for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A42

G:\Projects\SBFCA\Work\SBFCA_GEI Eval - Marysville Plates\3 mxd 8X 12 11 10.SOC



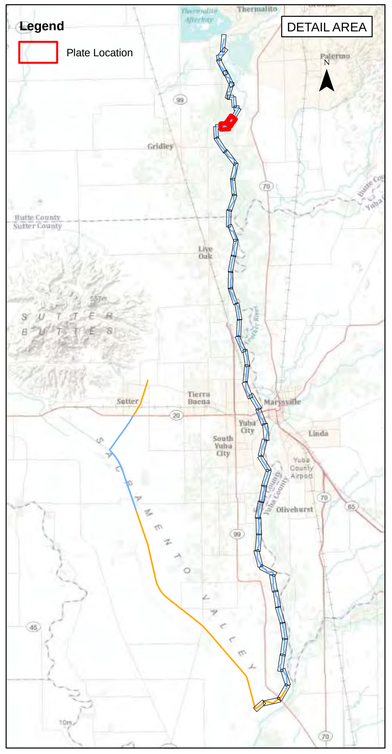


NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

0 100 200
Feet

DRAFT



FRWL Project Plan Views and Stick Figures
DWR: Station 4140+00 to Station 4190+00
FRWL Project: Station 1973+78 to Station 2023+79

URS

FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

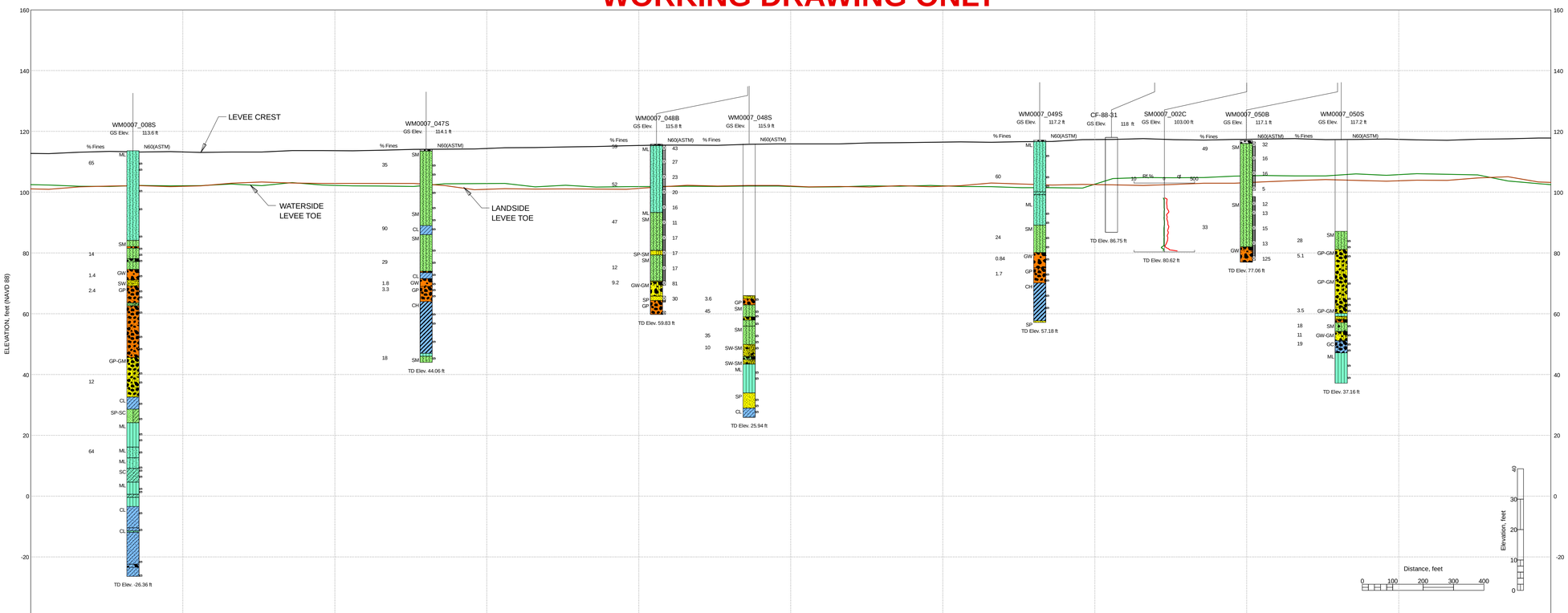
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE
REHABILITATION EIP PROJECT

Appendix A43

Plotted:08/04/2011 10:54:47 AM By:Jeffrey Mayer
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WORKING DRAWING ONLY

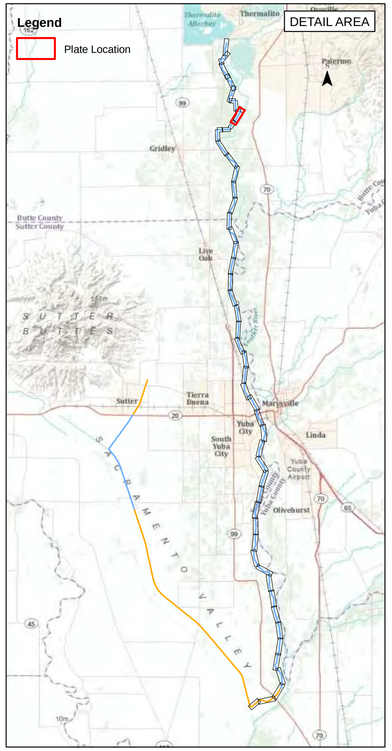


NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

0 100 200
Feet

DRAFT



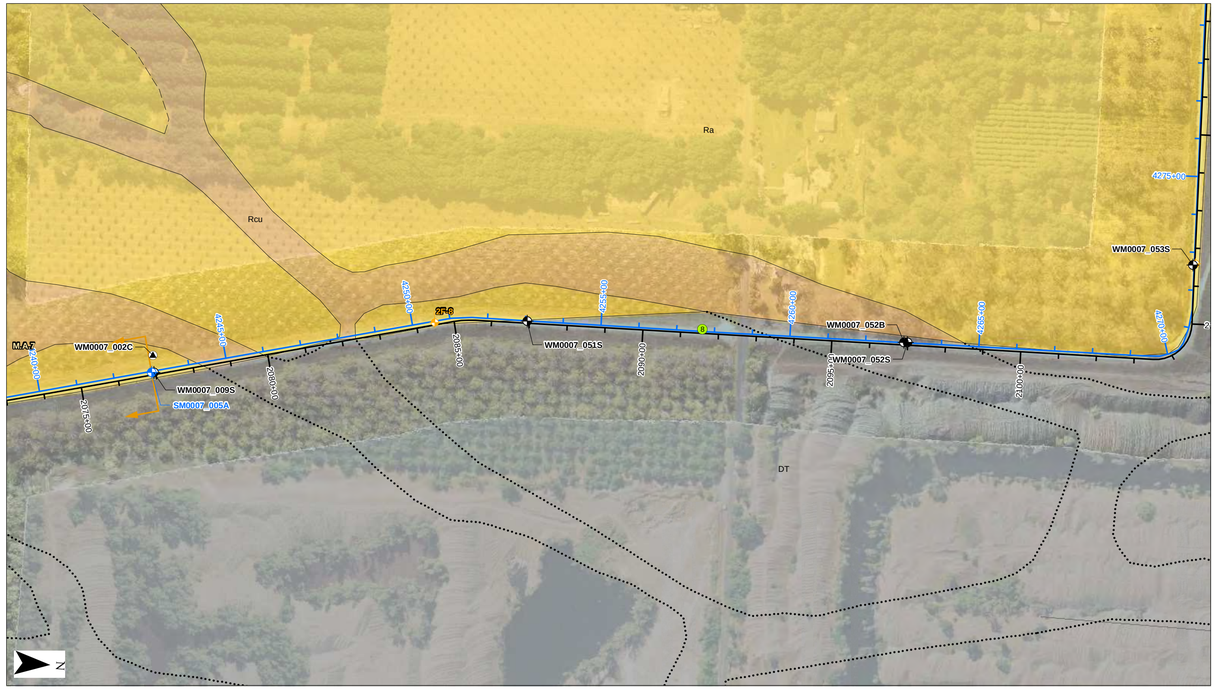
FRWL Project Plan Views and Stick Figures
DWR: Station 4190+00 to Station 4240+00
FRWL Project: Station 2023+79 to Station 2073+93

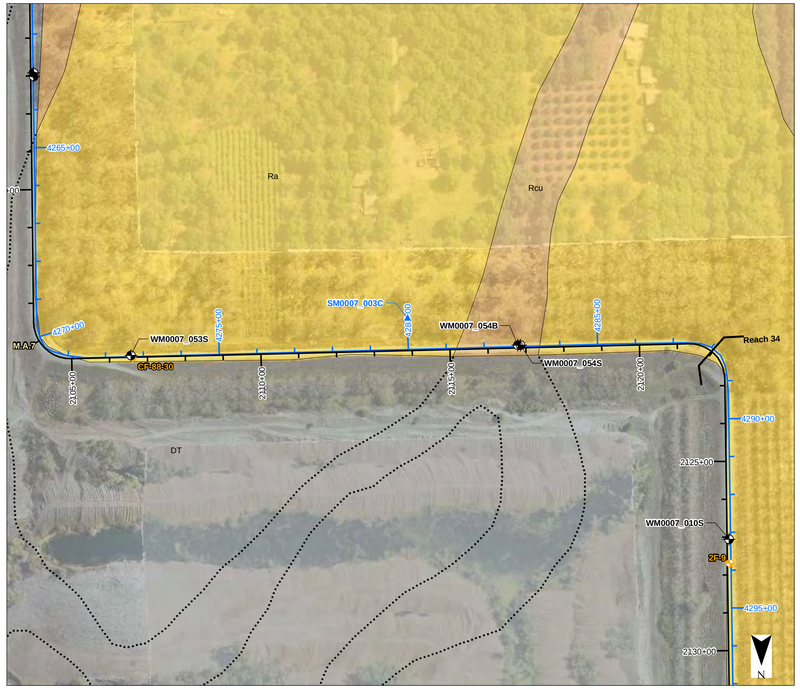
URS
Report of Geotechnical Analyses for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

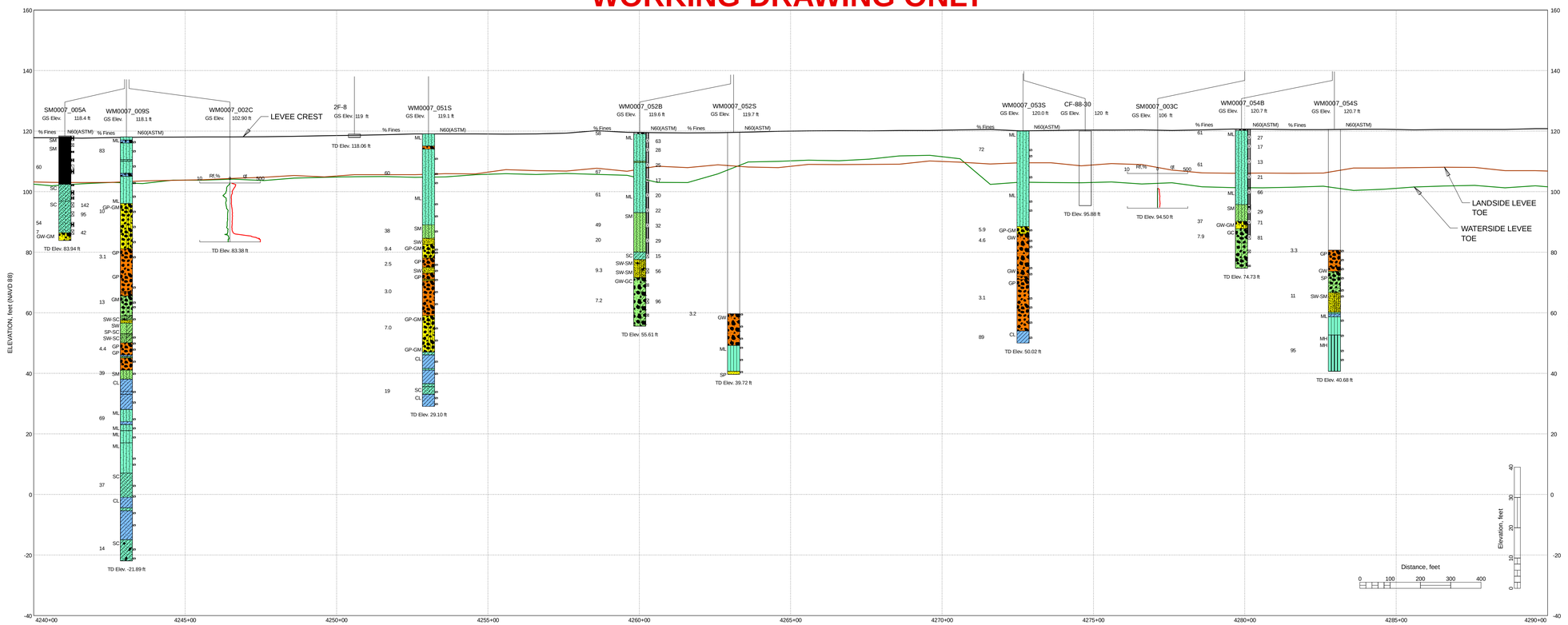
Appendix A44

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WORKING DRAWING ONLY



0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
2. These are working drawings and do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown, but most "other" historical explorations are represented only by an empty log symbol without actual stratigraphy. Due to limitations of space, not all historical explorations are represented by empty log symbols. These working drawings will be updated during future studies.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



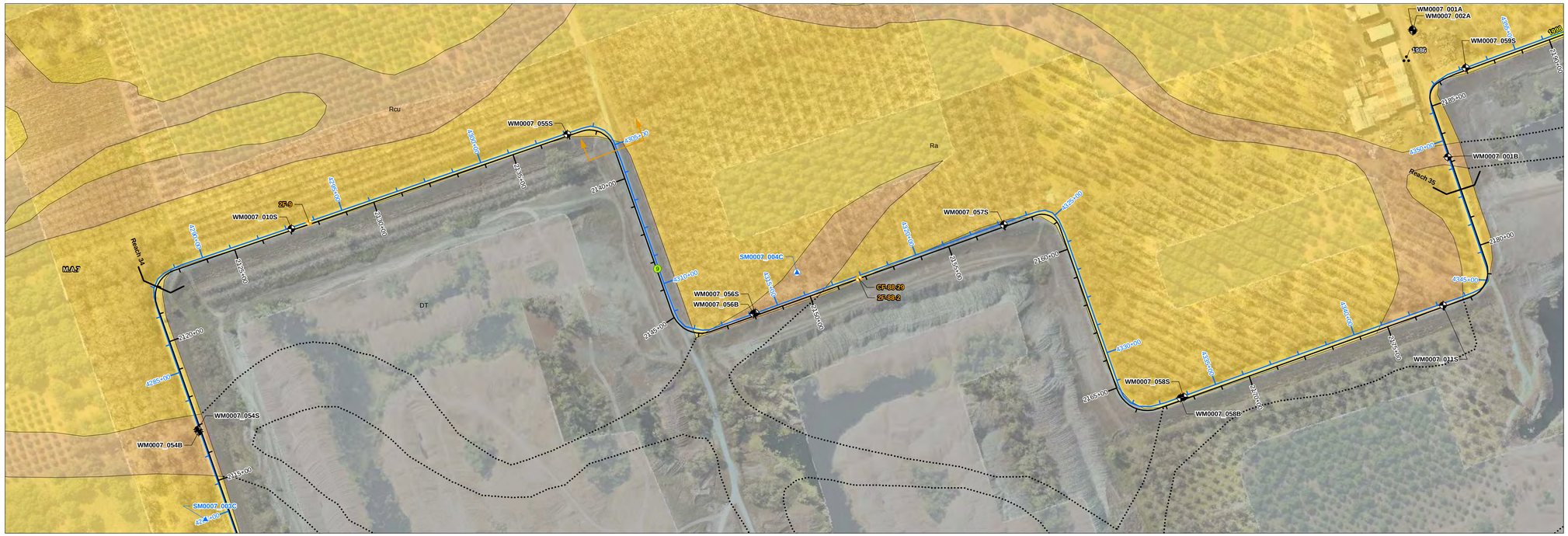
FRWL Project Plan Views and Stick Figures
DWR: Station 4240+00 to Station 4290+00
FRWL Project: Station 2073+93 to Station 2123+89

URS
Report of Geotechnical Analyses for Pre-Design Formulation

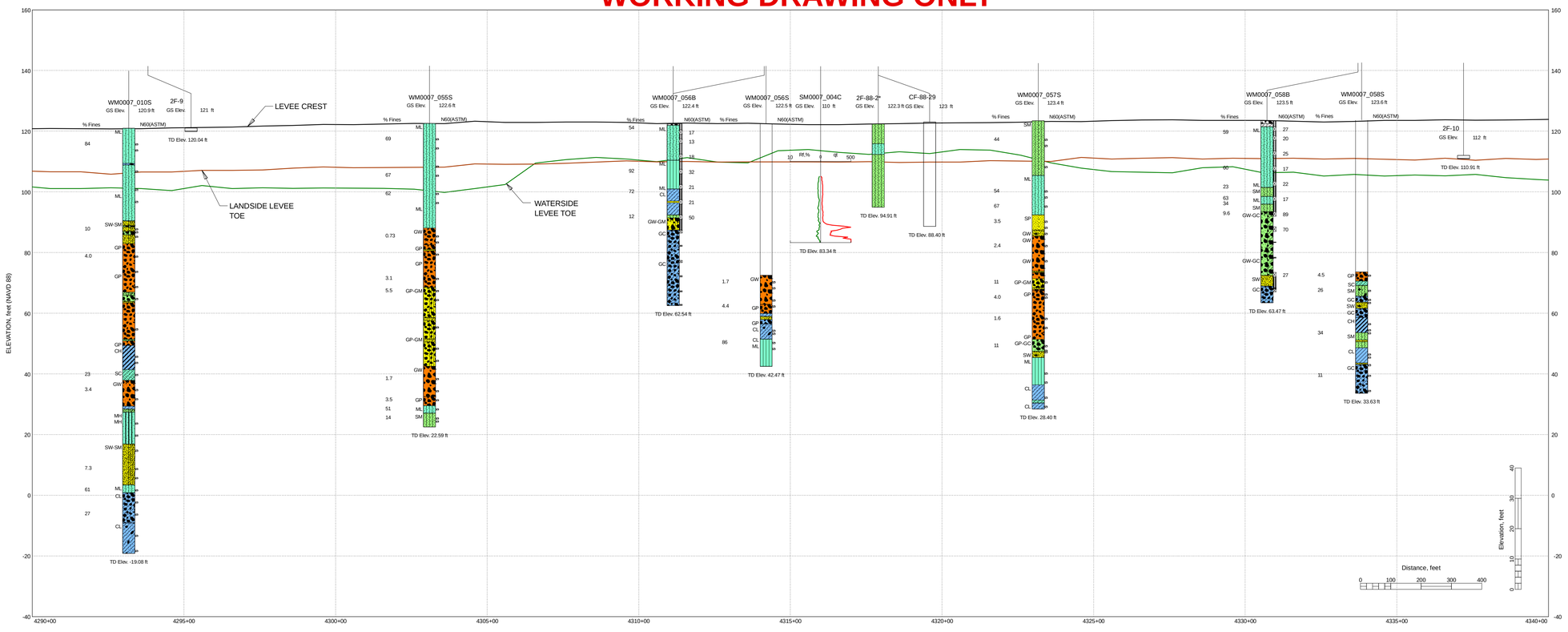
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A45

I:\Projects\SBFCA_Levee\SBFCA_GEI_EIP_Markup_Plates\5 mxd\Fig 4 2123 10 SSC



WORKING DRAWING ONLY



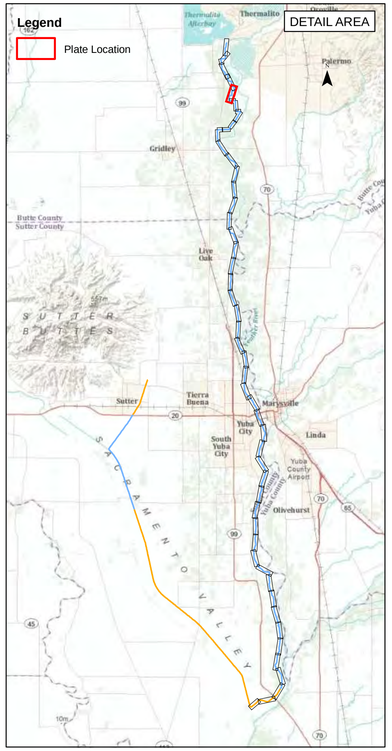
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0 100 200
Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 4290+00 to Station 4340+00
FRWL Project: Station 2123+89 to Station 2173+85

URS — Report of Geotechnical Analyses for Pre-Design Formulation

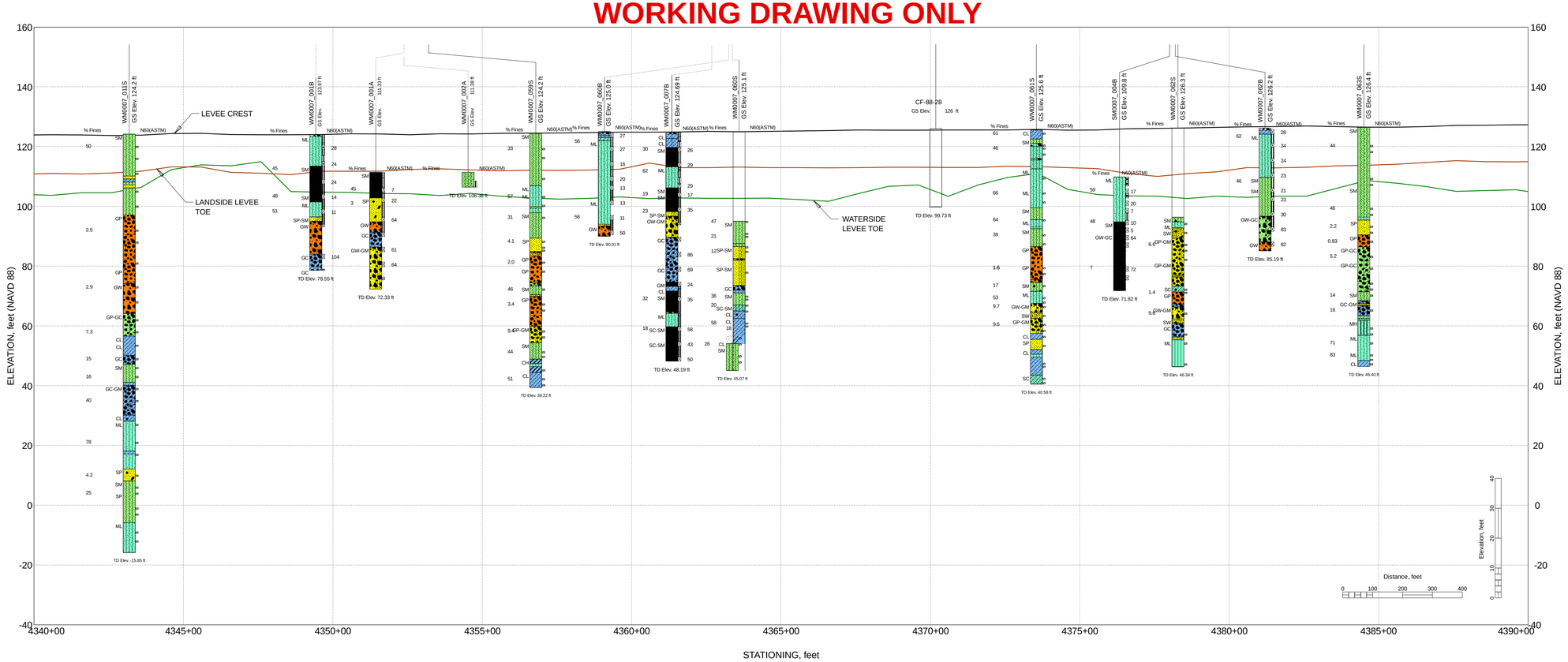
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A46

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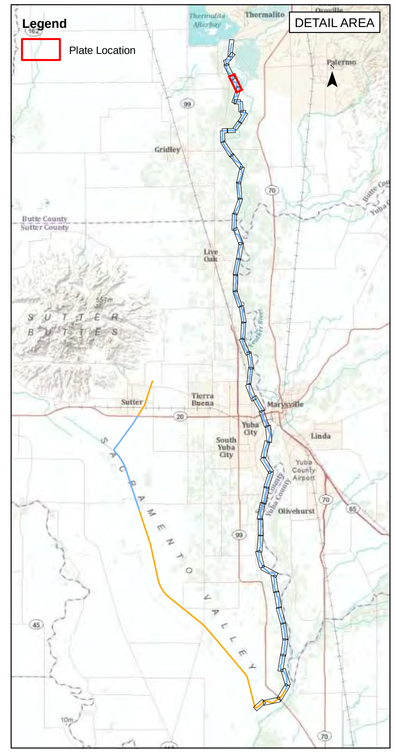
WORKING DRAWING ONLY



DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



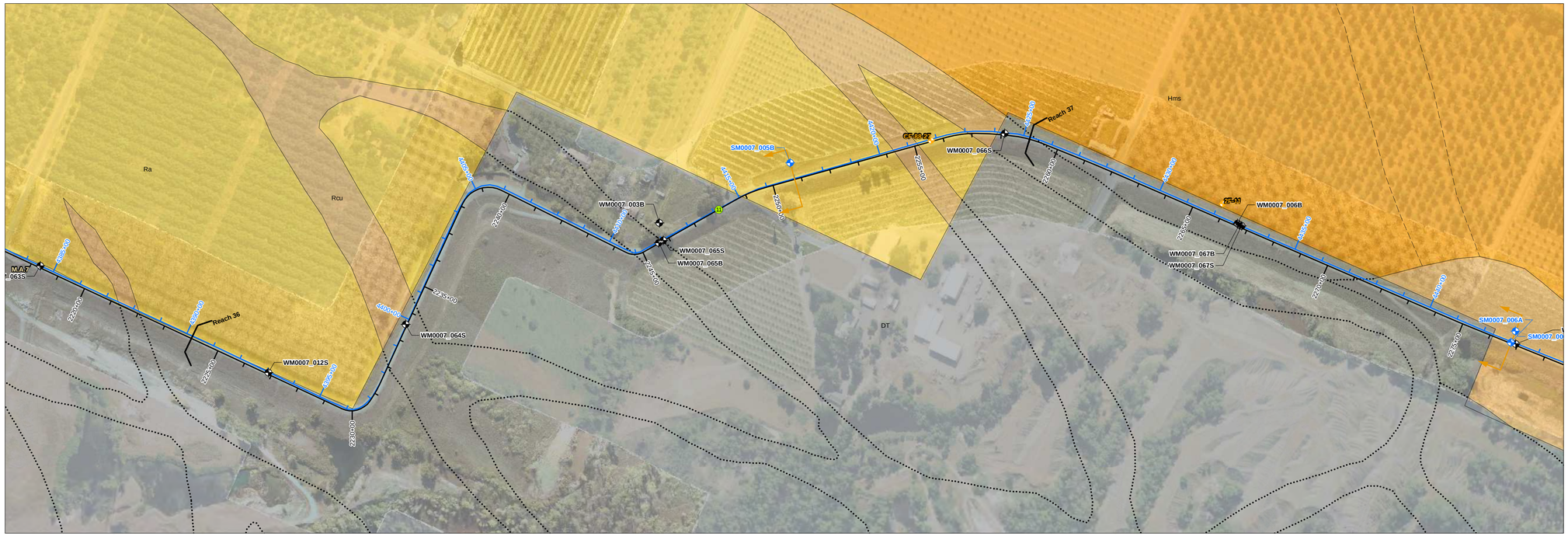
FRWL Project Plan Views and Stick Figures
DWR: Station 4340+00 to Station 4390+00
FRWL Project: Station 2173+85 to Station 2223+84

URS
Report of Geotechnical Analyses for Pre-Design Formulation

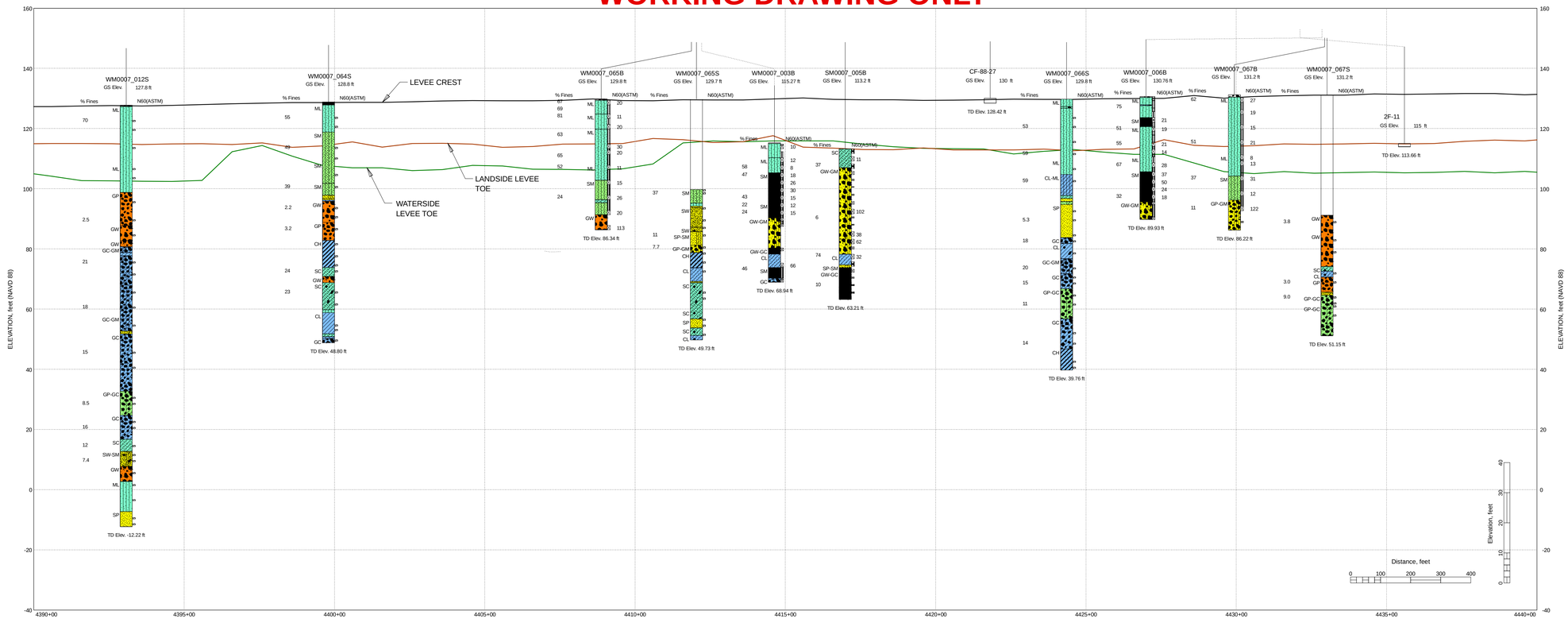
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A47

J:\Projects\SBFCA\Maps\SBFCA_GEI_EIP_Mapbook.mxd 8/4/2010 SAC



WORKING DRAWING ONLY



NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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4. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

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Feet

DRAFT

FRWL Project Plan Views and Stick Figures
DWR: Station 4390+00 to Station 4440+00
FRWL Project: Station 2223+84 to Station 2273+75

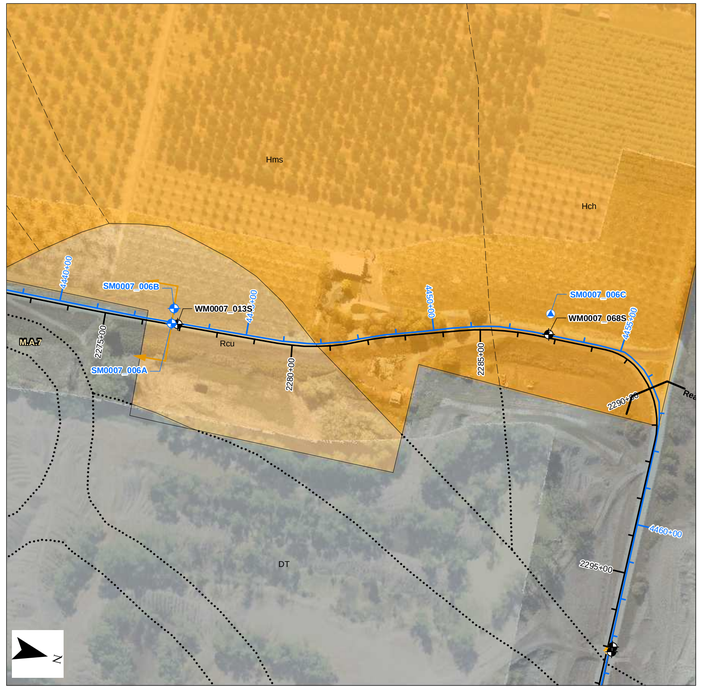
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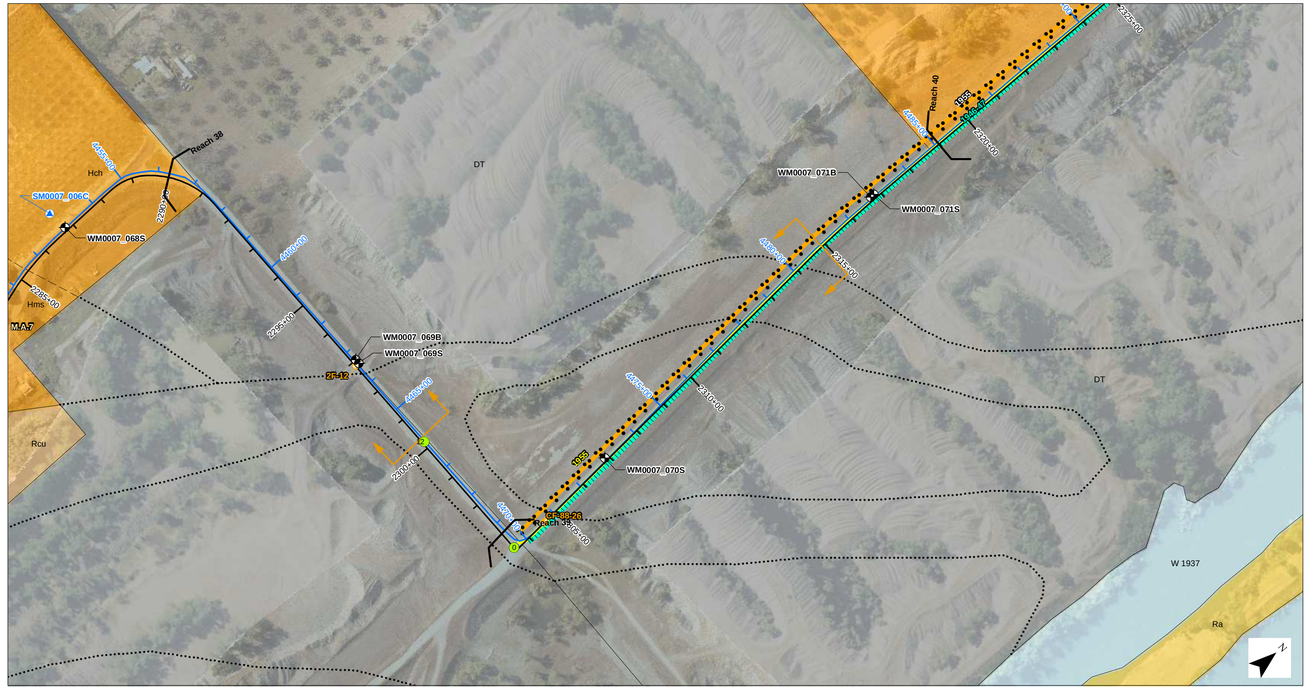
Report of Geotechnical Analyses for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

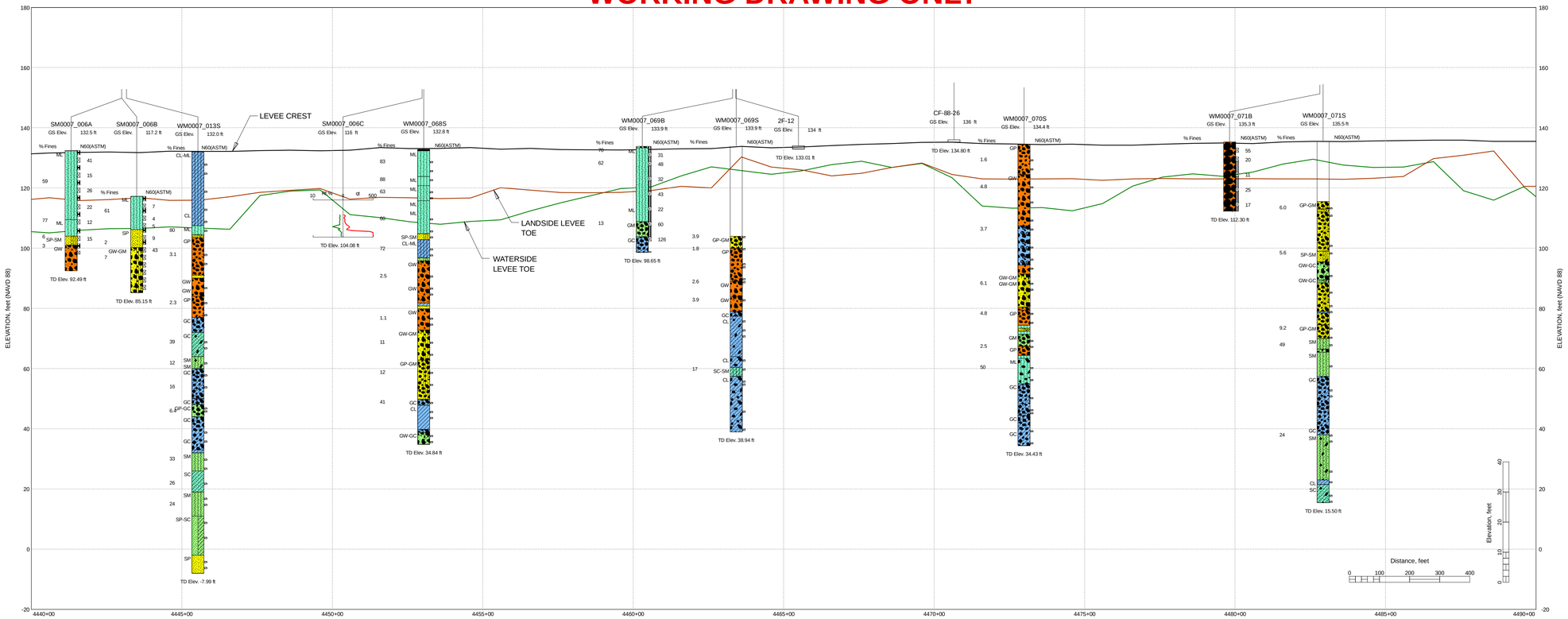
Appendix A48

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WORKING DRAWING ONLY

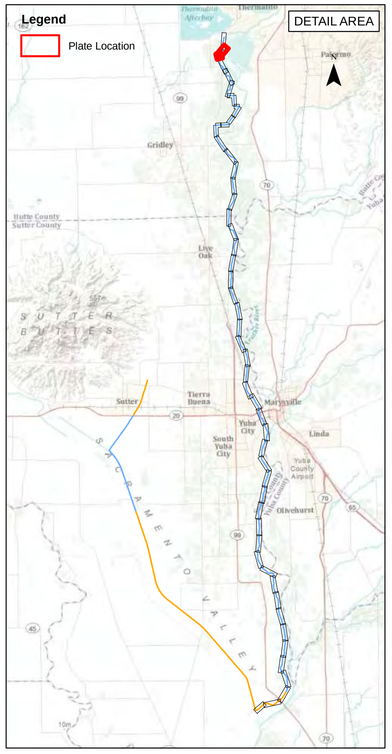


0 100 200
Feet

DRAFT

NOTES:

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6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)



FRWL Project Plan Views and Stick Figures
DWR: Station 4440+00 to Station 4490+00
FRWL Project: Station 2273+75 to Station 2323+91

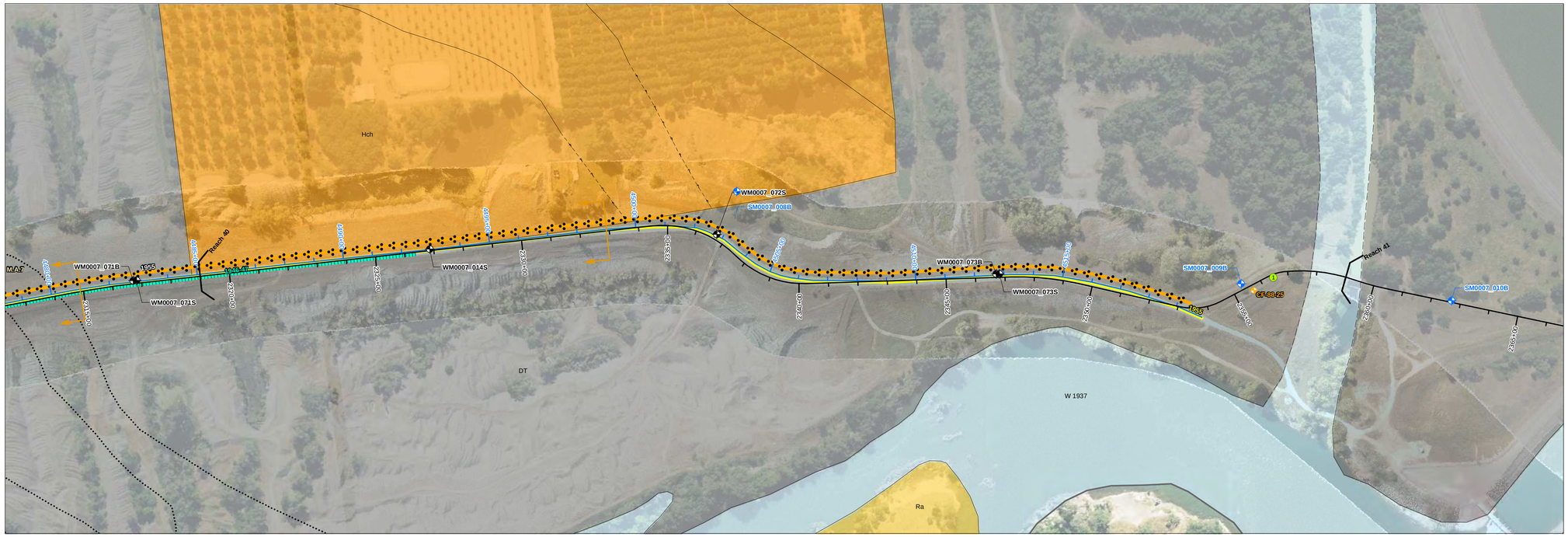
URS

Report of Geotechnical Analyses for Pre-Design Formulation

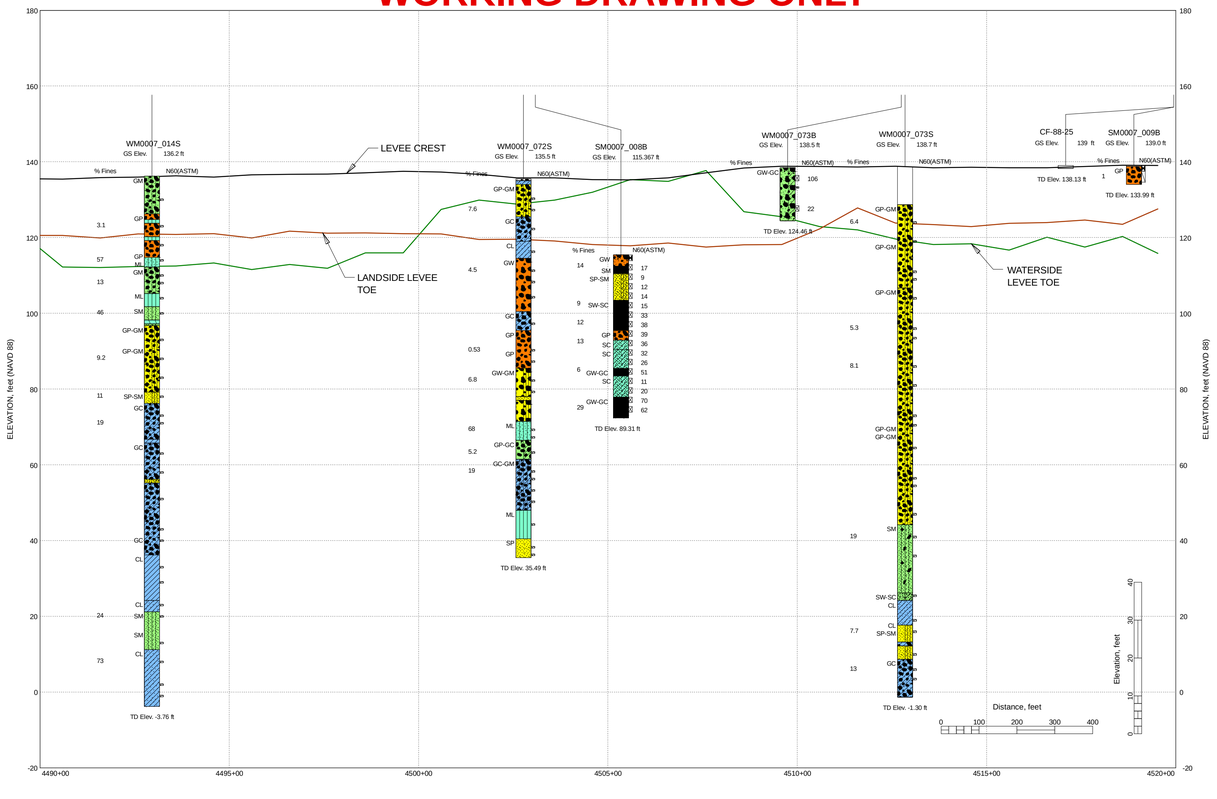
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

Appendix A49

I:\Projects\SBFCA_FRWL\Maps\SBFCA_GEI_EIP_Working_Data\9.mxd Rx 12.21.13 KSF



WORKING DRAWING ONLY



Z

0 100 200

Feet

DRAFT

NOTES:

1. Elevations of levee crest, landside toe, and waterside toe are approximate.
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5. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
6. Surficial geology was mapped at 1:20,000 scale. (Source: DWR, 2010a)

FRWL Project Plan Views and Stick Figures
DWR: Station 4490+00 to Station 4520+00
FRWL Project: Station 2323+91 to Station 2354+00

URS

Report of Geotechnical Analyses for Pre-Design Formulation

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE REHABILITATION EIP PROJECT

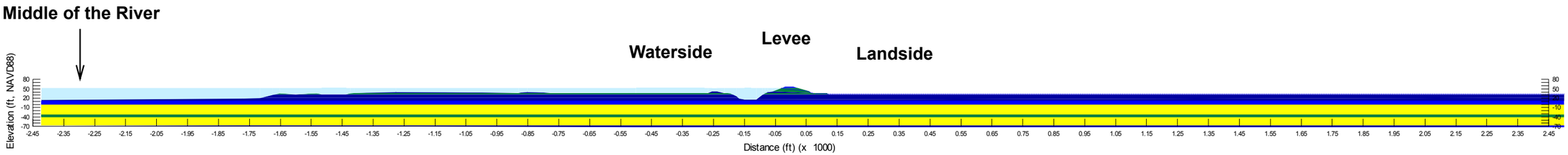
Appendix A50

Plotted:06/02/2011 12:21:10 PM By:Jason.Gilbert
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APPENDIX B

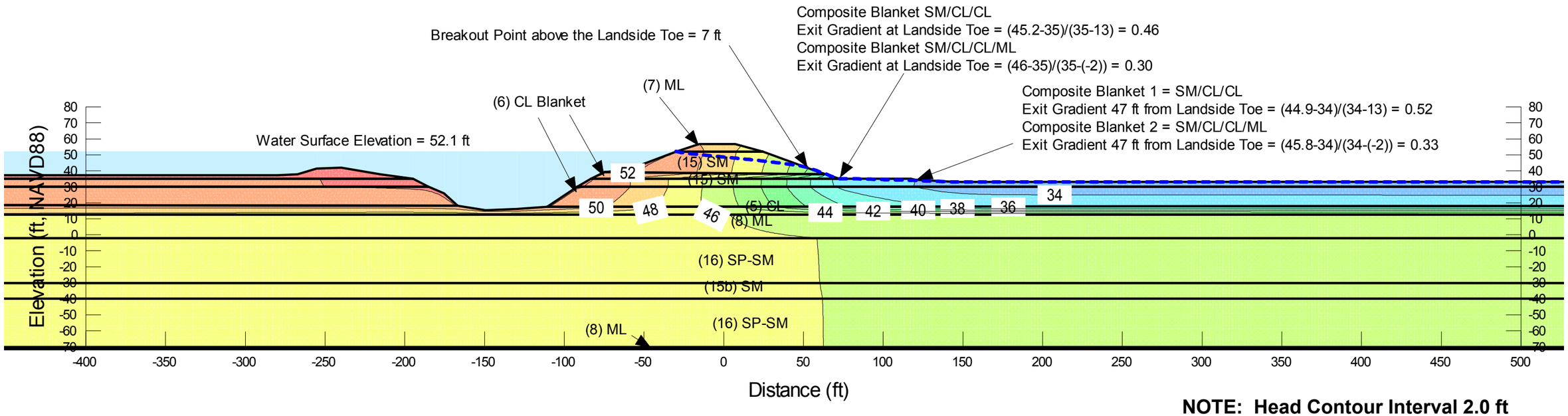
Analysis Results Figures

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



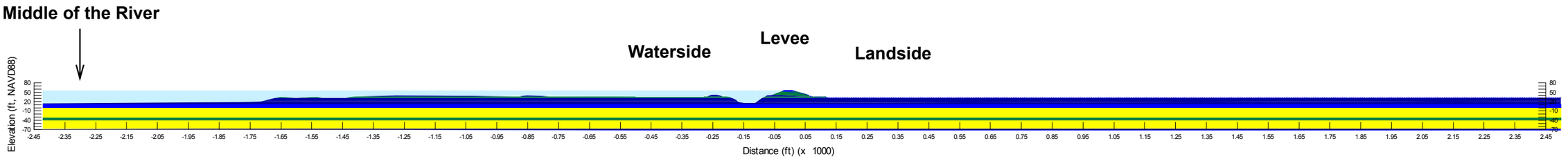
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(15b) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25

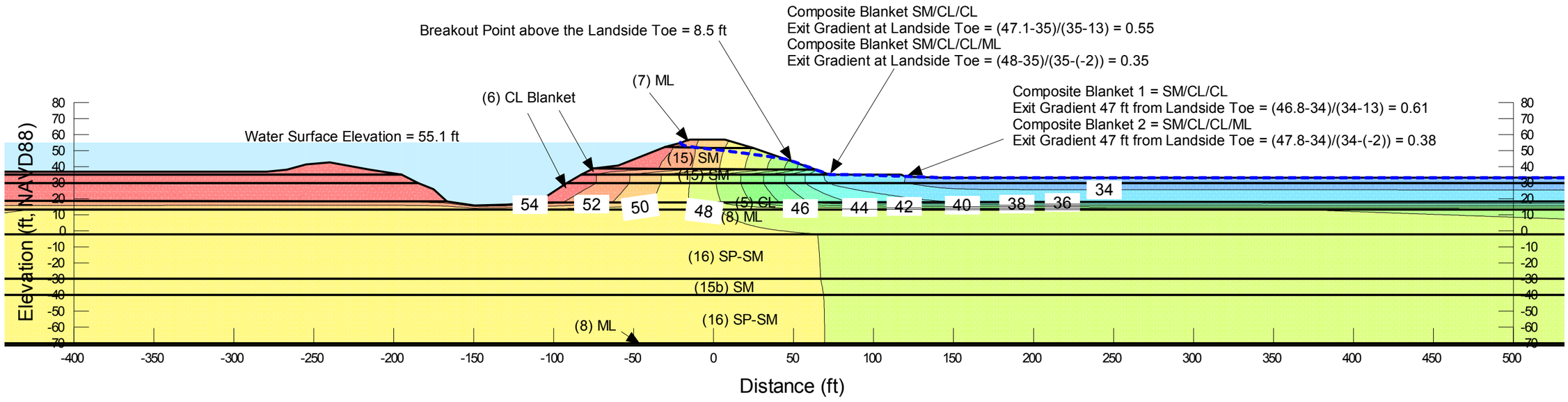
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 1, Section at Sta. 106+11 Existing Conditions WSE at 100yr
			TASK ORDER 1	ANALYZED BDC/NCH	FIGURE B01-E1
			DATE 2/4/2011	CHECKED BDC	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



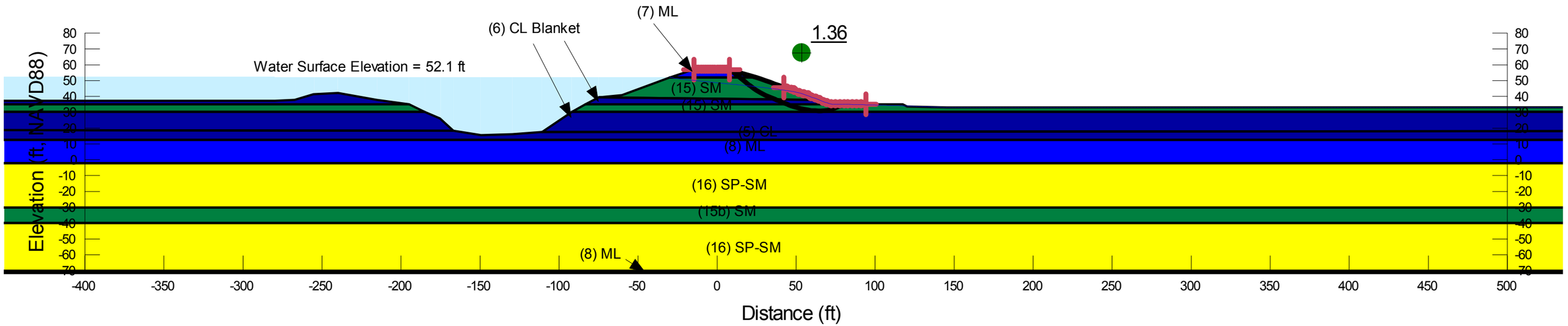
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(15b) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 1, Section at Sta. 106+11 Existing Conditions WSE at 100yr + 3ft
			TASK ORDER 1	ANALYZED BDC/NCH	FIGURE B01-E2
			DATE 2/4/2011	CHECKED BDC	

Slope Stability Analysis Results, Critical Slip Surface

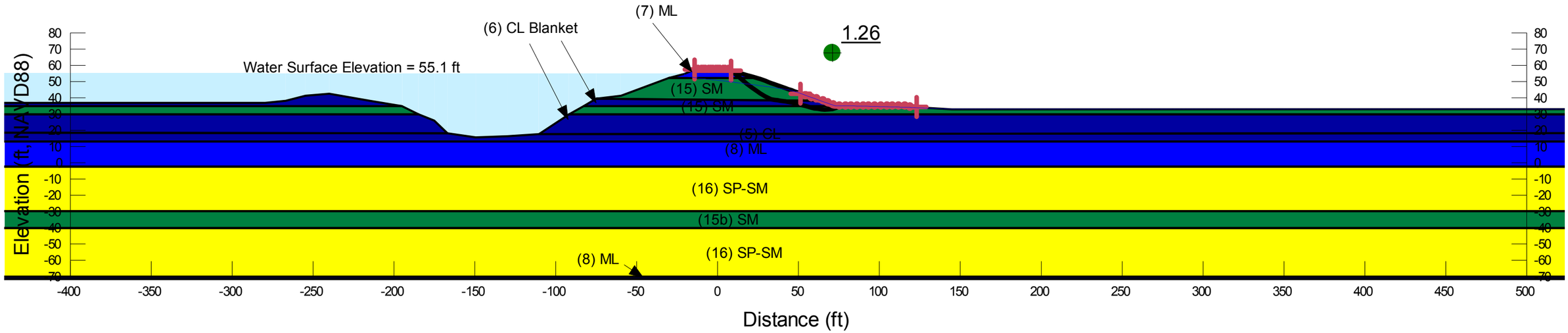


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	120 pcf	C'=0, Phi'=32
(14) Silty Sand	120 pcf	C'=0, Phi'=30
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(16) Silty Sand	130 pcf	C'=0, Phi'=36
(15b) Silty Sand	125 pcf	C'=0, Phi'=36

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/4/2011	DRAWN NCH ANALYZED NCH CHECKED BDC	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 1, Section at Sta. 106+11 Existing Conditions WSE at 100yr	FIGURE B01-E3

Slope Stability Analysis Results,
Critical Slip Surface



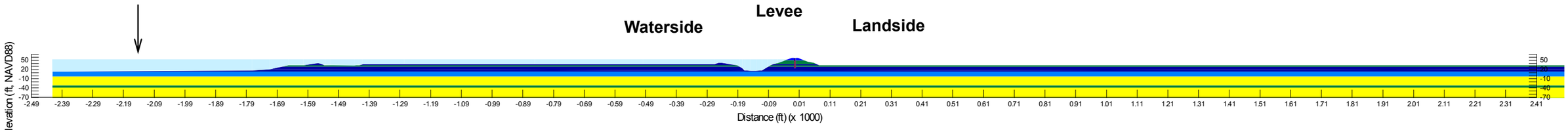
Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	120 pcf	C'=0, Phi'=32
(14) Silty Sand	120 pcf	C'=0, Phi'=30
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(16) Silty Sand	130 pcf	C'=0, Phi'=36
(15b) Silty Sand	125 pcf	C'=0, Phi'=36

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 1, Section at Sta. 106+11 Existing Conditions WSE at 100yr+ 3ft
			TASK ORDER 1	ANALYZED NCH	FIGURE B01-E4
			DATE 2/4/2011	CHECKED BDC	

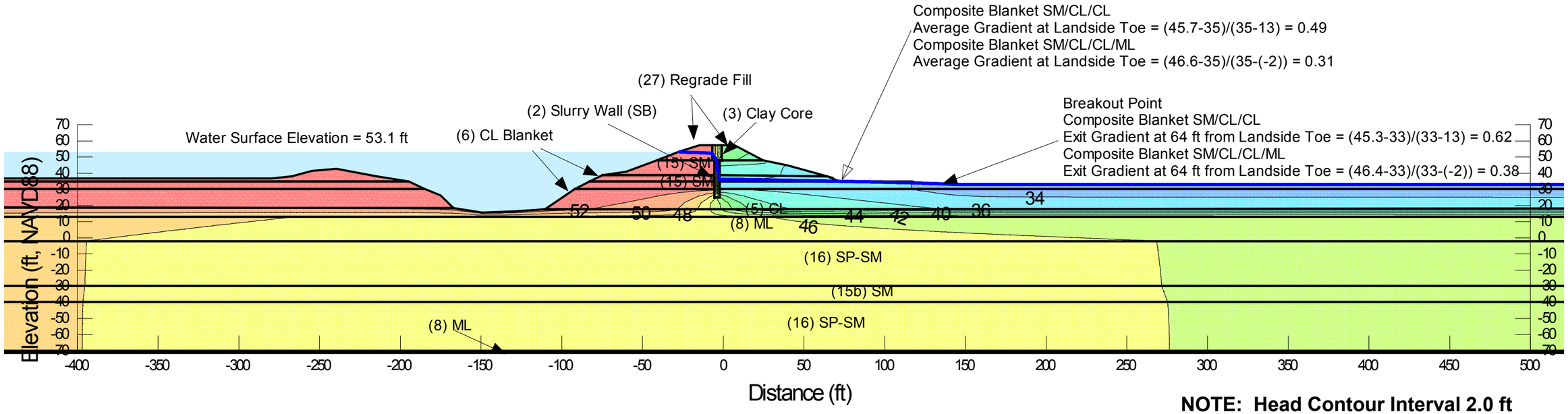
Model Geometry

Middle of the River



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

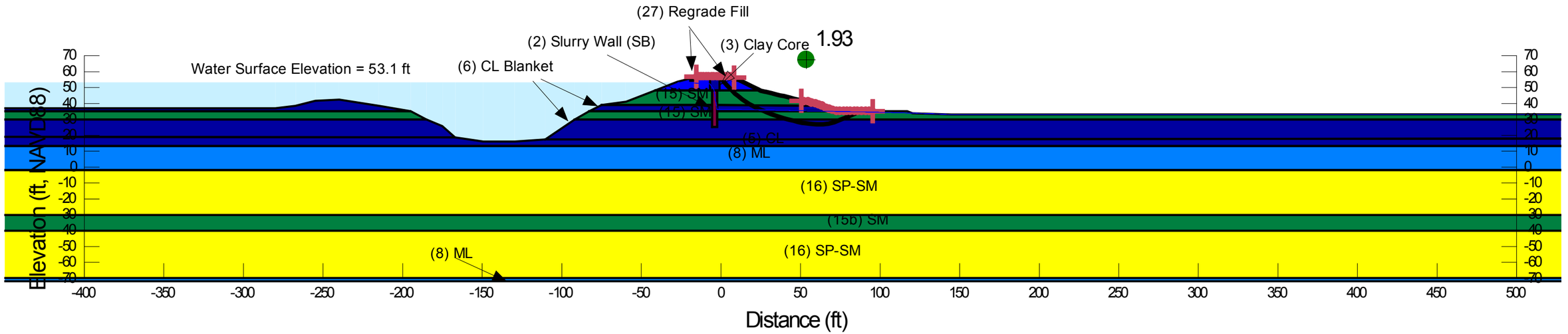
(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade Fill		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15b) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/4/2011	DRAWN NCH ANALYZED BDC/NCH CHECKED BDC

STEADY-STATE SEEPAGE ANALYSIS
Reach 1, Section at Sta. 106+11
Alternative 1: Cutoff Wall
WSE at 100yr + 1ft

FIGURE B01-A1

Slope Stability Analysis Results,
Critical Slip Surface



Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

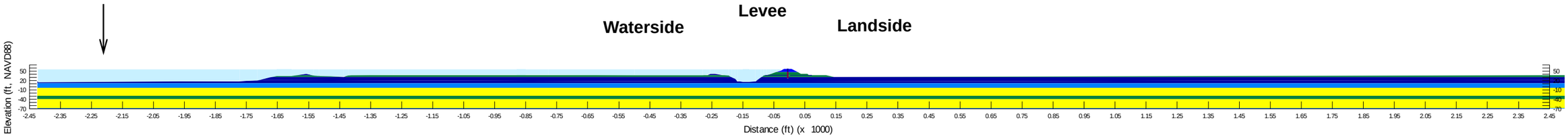
(2) Slurry Wall	100 pcf	C'=50, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100, Phi'=30
(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	120 pcf	C'=0, Phi'=32
(14) Silty Sand	120 pcf	C'=0, Phi'=30
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(15b) Silty Sand	125 pcf	C'=0, Phi'=36
(16) Silty Sand	130 pcf	C'=0, Phi'=36
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 1, Section at Sta. 106+11 Alternative 1: Cutoff Wall WSE at 100yr + 1ft
			TASK ORDER 1	ANALYZED NCH	
			DATE 2/4/2011	CHECKED BDC	

FIGURE B01-A2

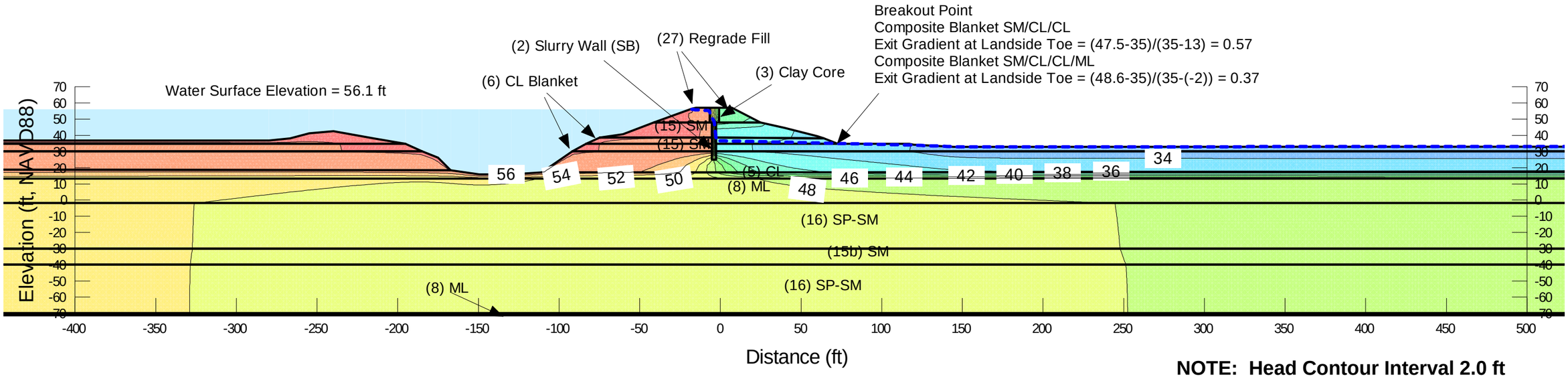
Model Geometry

Middle of the River



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



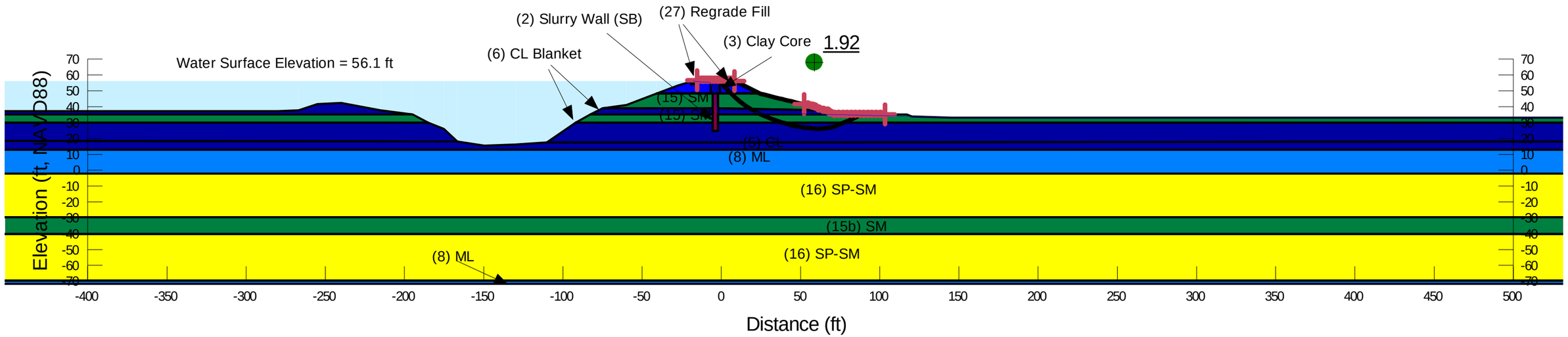
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(15b) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(27) Regrade Fill		Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 1, Section at Sta. 106+11 Alternative 1: Cutoff Wall WSE at 100yr + 4ft
			TASK ORDER 1	ANALYZED BDC/NCH	
			DATE 2/4/2011	CHECKED BDC	FIGURE B01-A3

Slope Stability Analysis Results, Critical Slip Surface

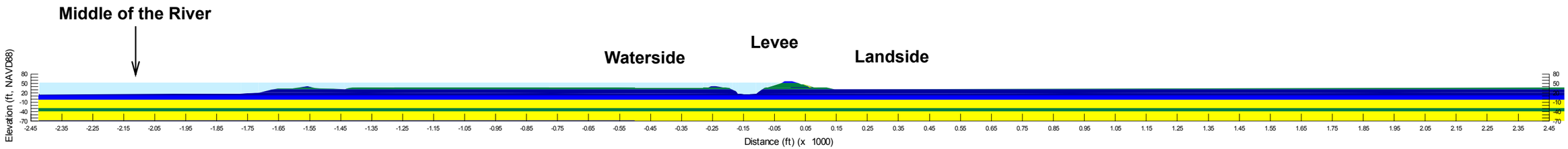


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(2) Slurry Wall	100 pcf	C'=50, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100, Phi'=30
(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	120 pcf	C'=0, Phi'=32
(14) Silty Sand	120 pcf	C'=0, Phi'=30
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(15b) Silty Sand	125 pcf	C'=0, Phi'=36
(16) Silty Sand	130 pcf	C'=0, Phi'=36
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

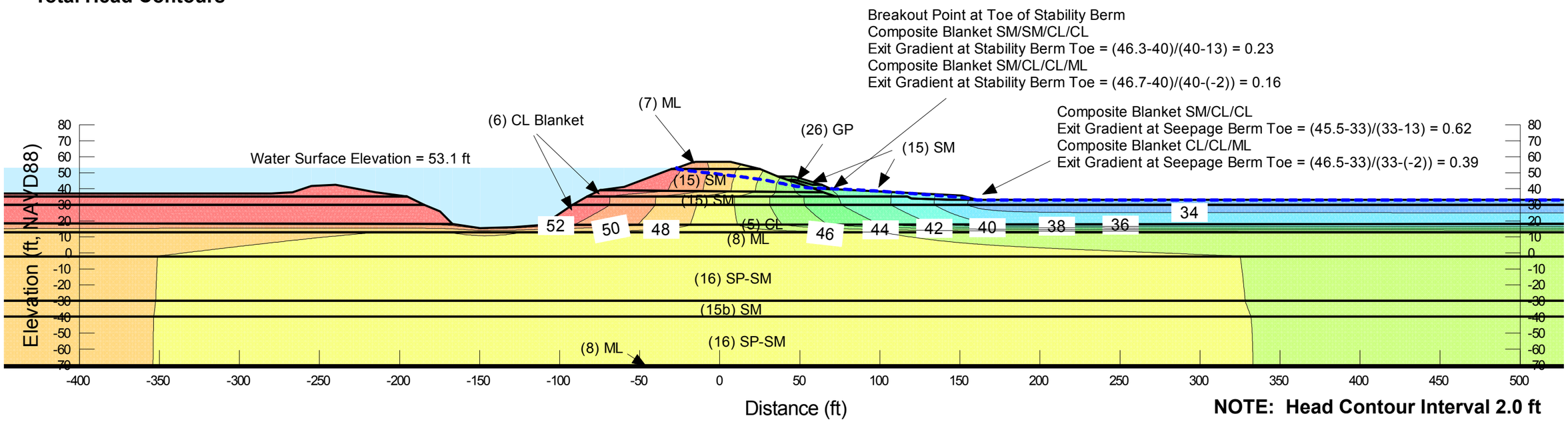
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/4/2011	DRAWN NCH ANALYZED NCH CHECKED BDC	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 1, Section at Sta. 106+11 Alternative 1: Cutoff Wall WSE at 100yr + 4ft	FIGURE B01-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

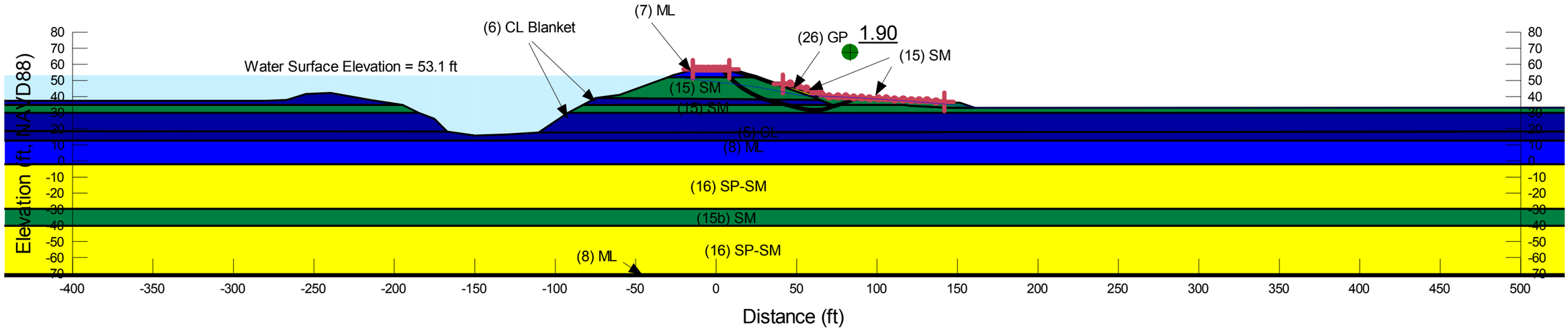
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(15b) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 1, Section at Sta. 106+11 Alternative 2: Seepage Berm with Stability Berm WSE at 100yr + 1ft
			TASK ORDER 1	ANALYZED BDC/NCH	
			DATE 2/4/2011	CHECKED BDC	

FIGURE B01-A5

Slope Stability Analysis Results, Critical Slip Surface

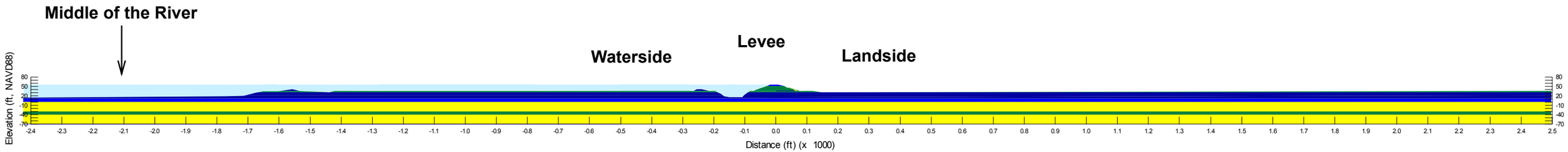


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	120 pcf	C'=0, Phi'=32
(14) Silty Sand	120 pcf	C'=0, Phi'=30
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(15b) Silty Sand	125 pcf	C'=0, Phi'=36
(16) Silty Sand	130 pcf	C'=0, Phi'=36
(26) Silty Gravel to Sandy Gravel	130 pcf	C'=0, Phi'=36

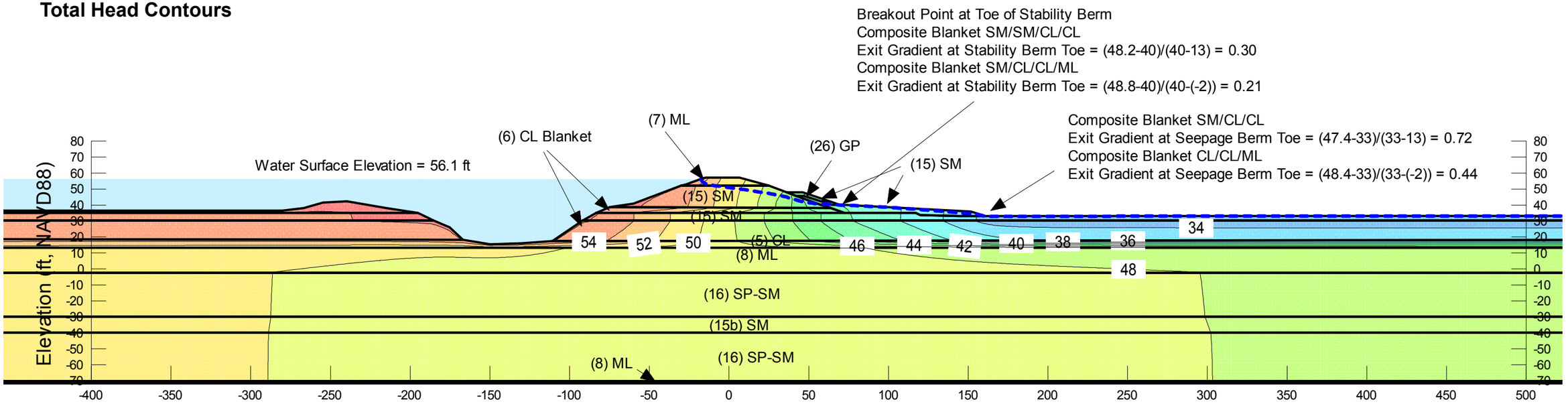
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 1, Section at Sta. 106+11 Alternative 2: Seepage Berm with Stability Berm WSE at 100yr + 1ft
			TASK ORDER 1	ANALYZED NCH	FIGURE B01-A6
			DATE 2/4/2011	CHECKED BDC	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

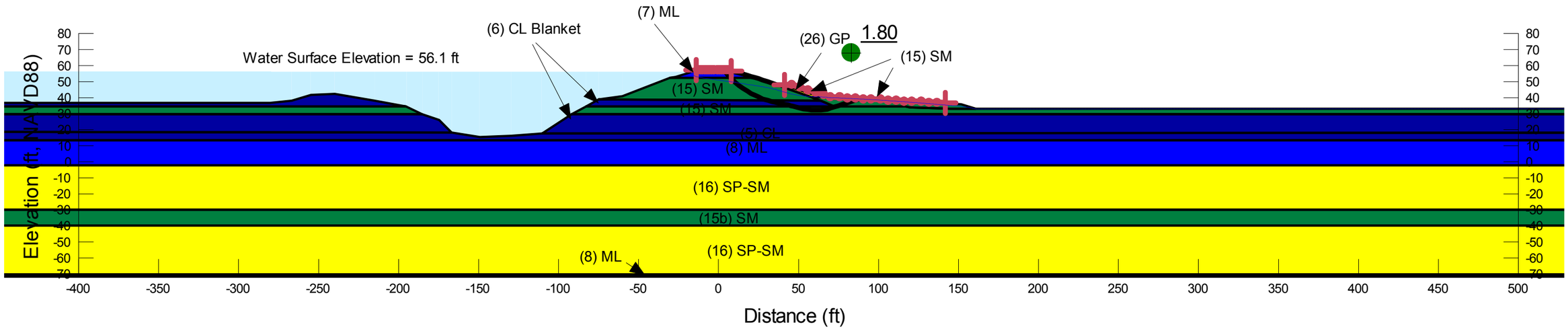
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(15b) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 1, Section at Sta. 106+11 Alternative 2: Seepage Berm with Stability Berm WSE at 100yr + 4ft
			TASK ORDER 1	ANALYZED BDC/NCH	
			DATE 2/4/2011	CHECKED BDC	

FIGURE B01-A7

Slope Stability Analysis Results, Critical Slip Surface

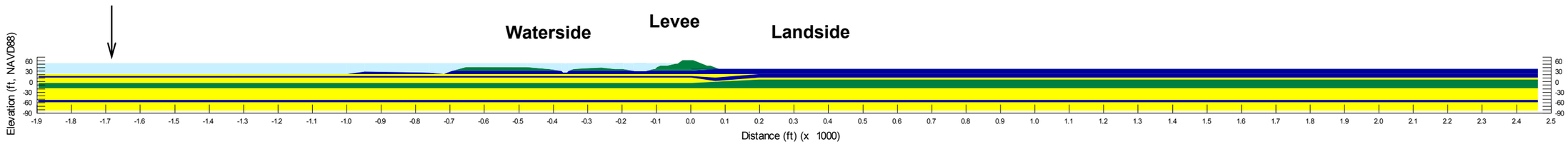


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	120 pcf	C'=0, Phi'=32
(14) Silty Sand	120 pcf	C'=0, Phi'=30
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(15b) Silty Sand	125 pcf	C'=0, Phi'=36
(16) Silty Sand	130 pcf	C'=0, Phi'=36
(26) Silty Gravel to Sandy Gravel	130 pcf	C'=0, Phi'=36

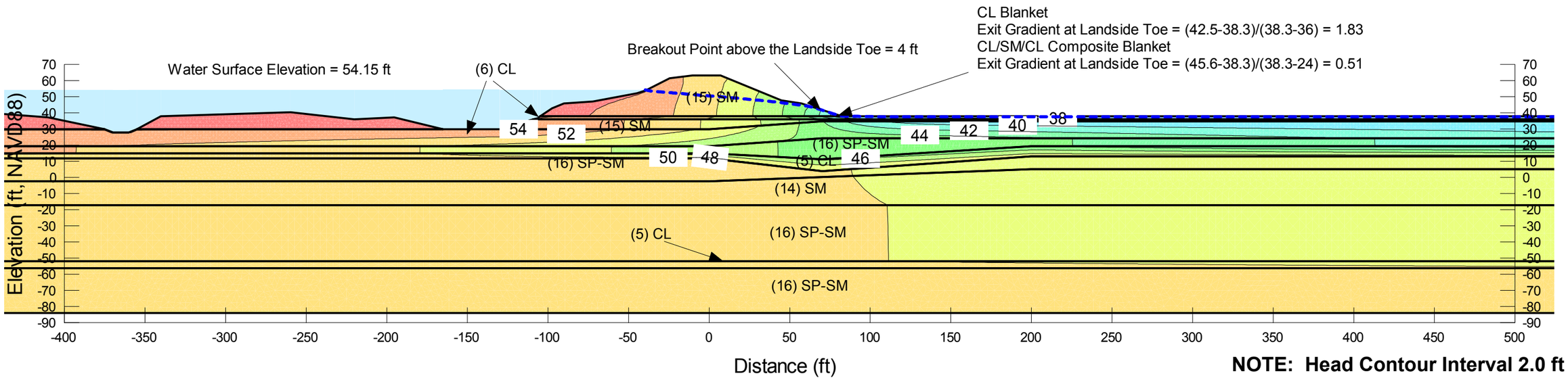
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 1, Section at Sta. 106+11 Alternative 2: Seepage Berm with Stability Berm WSE at 100yr + 4ft	FIGURE B01-A8
			TASK ORDER 1	ANALYZED NCH		
			DATE 2/4/2011	CHECKED BDC		

Model Geometry



Seepage Analysis Results,
Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

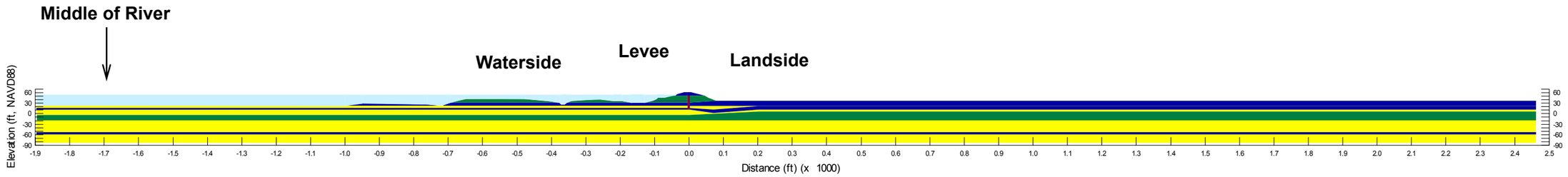
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH
			TASK ORDER 1	ANALYZED BDC/NCH
			DATE 2/4/2011	CHECKED BDC

STEADY-STATE SEEPAGE ANALYSIS
Reach 2, Section at Sta. 181+13
Existing Conditions
WSE at 100yr

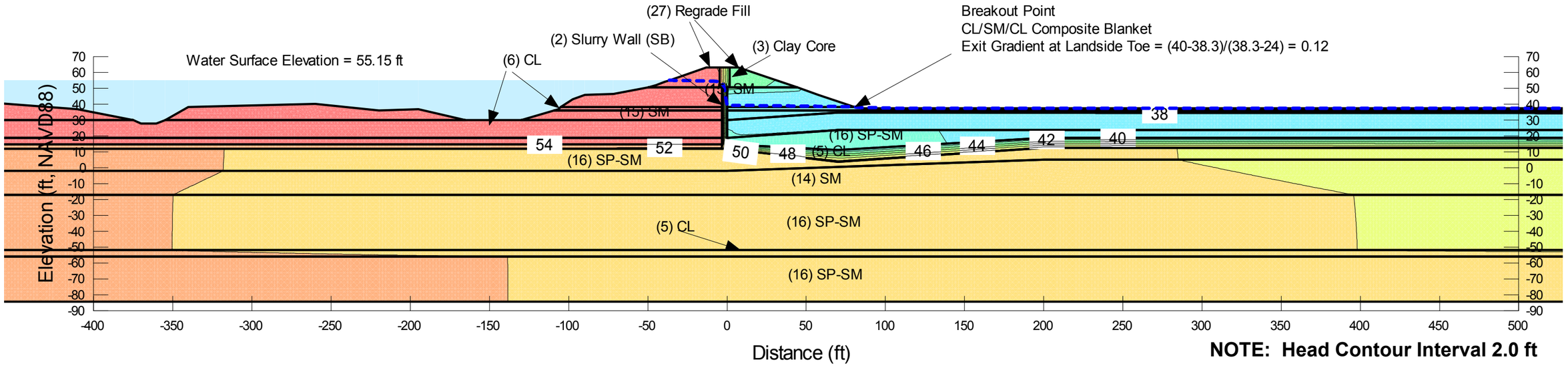
FIGURE B02-E1

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



NOTE: Head Contour Interval 2.0 ft

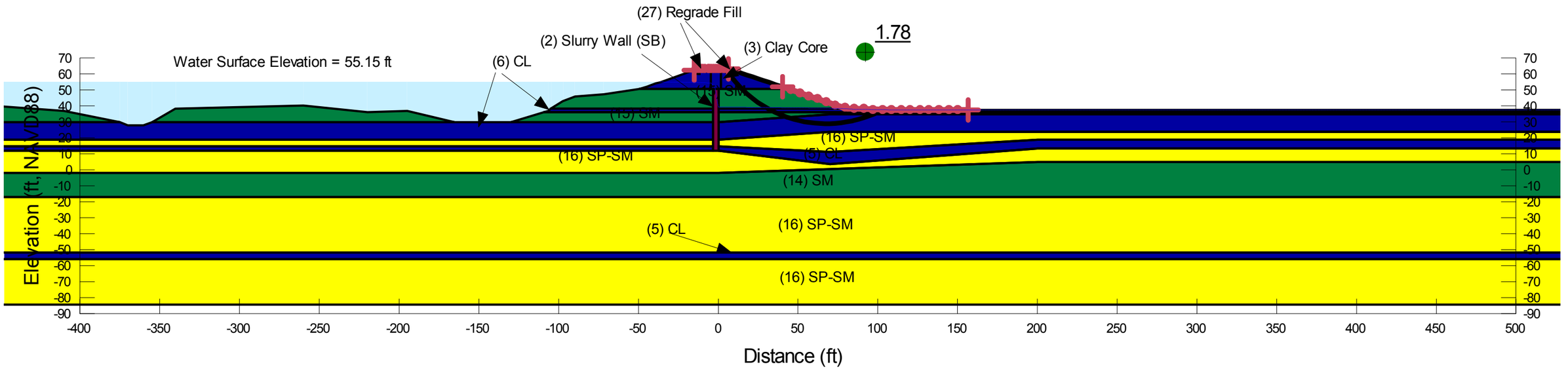
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(27) Regrade Fill,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 2, Section at Sta. 181+13 Alternative 1: Cutoff Wall WSE at 100yr + 1ft
			TASK ORDER 1	ANALYZED BDC/NCH	
			DATE 2/4/2011	CHECKED BDC	

FIGURE B02-A1

Slope Stability Analysis Results,
Critical Slip Surface

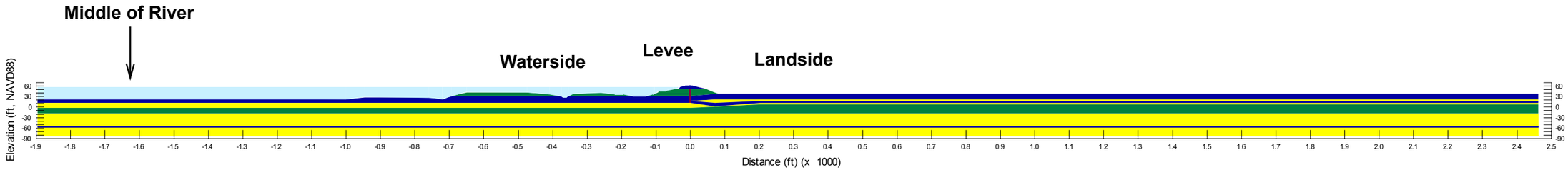


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(2) Slurry Wall	100 pcf	C'=300, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100, Phi'=32
(5) Clay Layer	125 pcf	C'=100, Phi'=31
(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(14) Silty Sand	125 pcf	C'=0, Phi'=36
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(16) Silty Sand	120 pcf	C'=0, Phi'=34
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

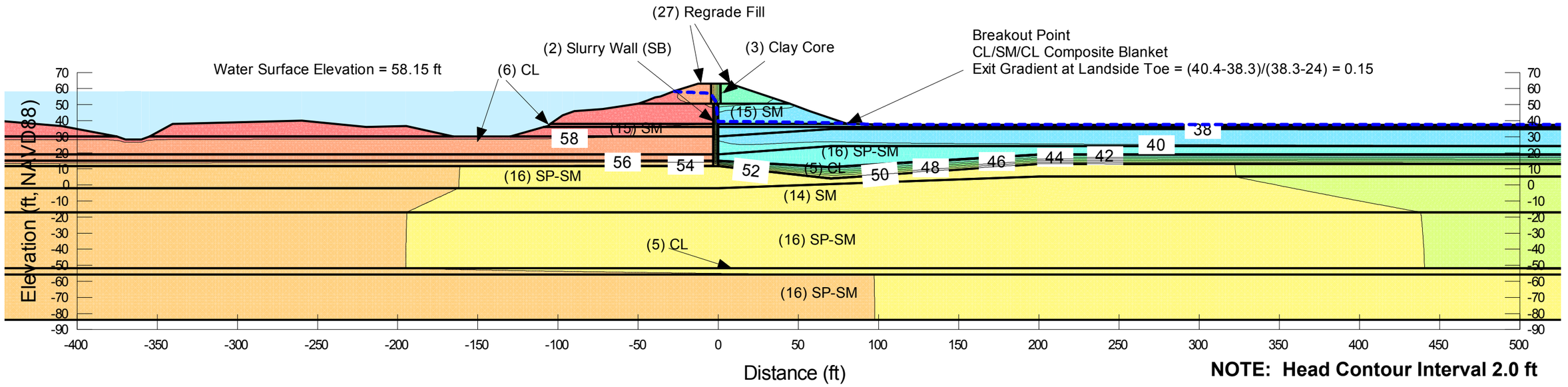
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/4/2011	DRAWN NCH ANALYZED NCH CHECKED BDC	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 2, Section at Sta. 181+13 Alternative 1: Cutoff Wall WSE at 100yr + 1ft	FIGURE B02-A2

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



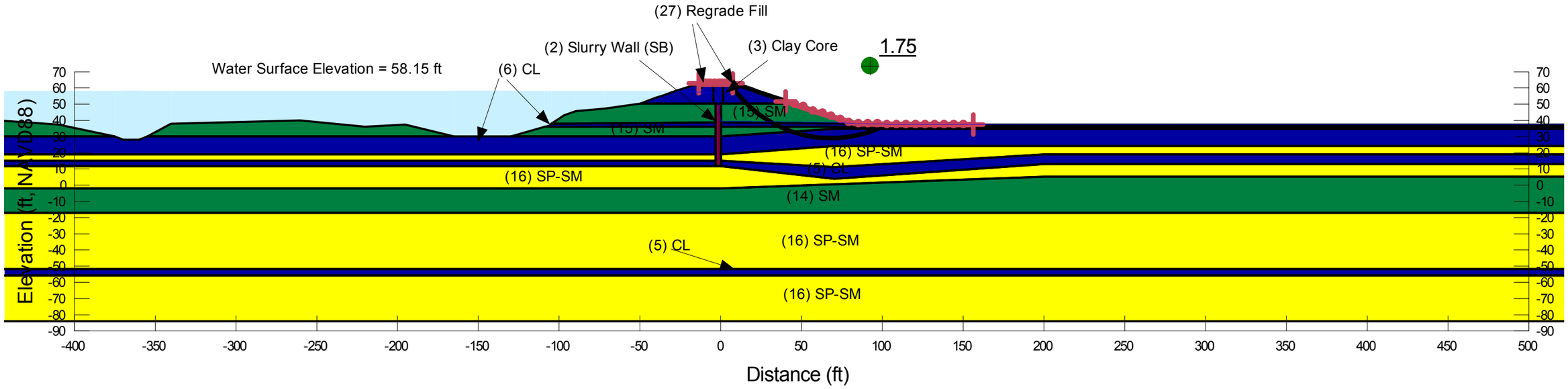
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade Fill,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 2, Section at Sta. 181+13 Alternative 1: Cutoff Wall WSE at 100yr + 4ft
			TASK ORDER 1	ANALYZED BDC/NCH	FIGURE B02-A3
			DATE 2/4/2011	CHECKED BDC	

Slope Stability Analysis Results, Critical Slip Surface

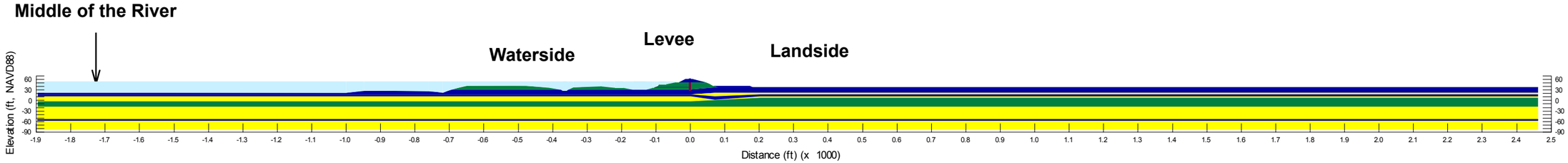


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(2) Slurry Wall	100 pcf	C'=300, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100, Phi'=32
(5) Clay Layer	125 pcf	C'=100, Phi'=31
(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(14) Silty Sand	125 pcf	C'=0, Phi'=36
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(16) Silty Sand	120 pcf	C'=0, Phi'=34
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

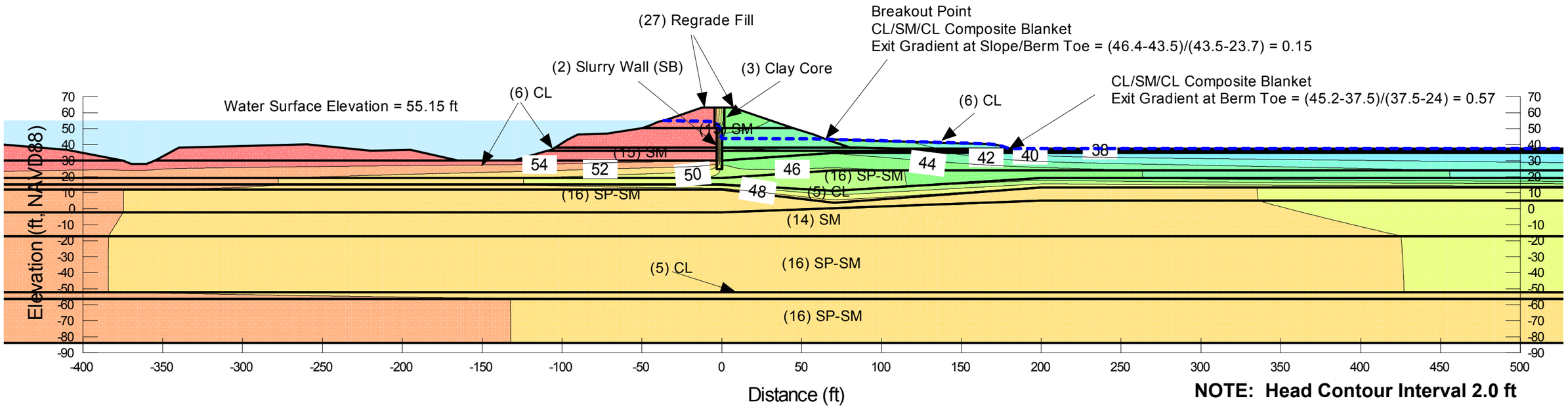
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 2, Section at Sta. 181+13 Alternative 1: Cutoff Wall WSE at 100yr + 4ft
			TASK ORDER 1	ANALYZED NCH	FIGURE B02-A4
			DATE 2/4/2011	CHECKED BDC	

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



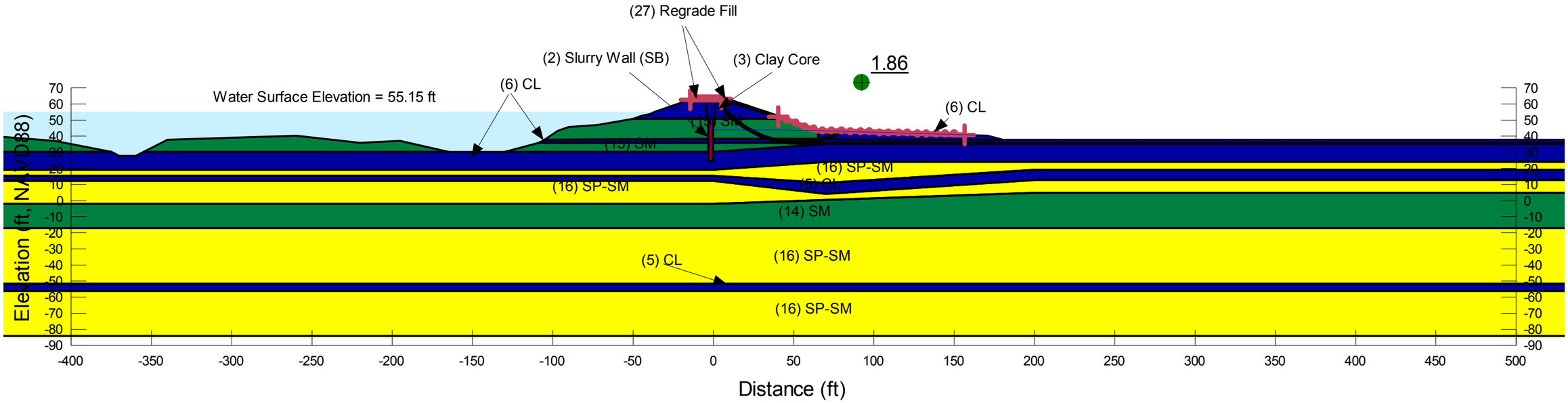
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade Fill,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NCH TASK ORDER 1 / ANALYZED BDC/NCH DATE 2/4/2011 / CHECKED BDC	STEADY-STATE SEEPAGE ANALYSIS Reach 2, Section at Sta. 181+13 Alternative 2: Seepage Berm and Cutoff Wall WSE at 100yr + 1ft	FIGURE B02-A5

Slope Stability Analysis Results, Critical Slip Surface

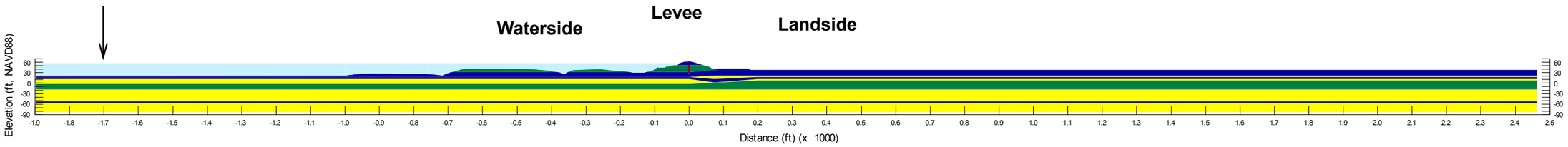


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(2) Slurry Wall	100 pcf	C'=300, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100, Phi'=32
(5) Clay Layer	125 pcf	C'=100, Phi'=31
(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(14) Silty Sand	125 pcf	C'=0, Phi'=36
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(16) Silty Sand	120 pcf	C'=0, Phi'=34
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

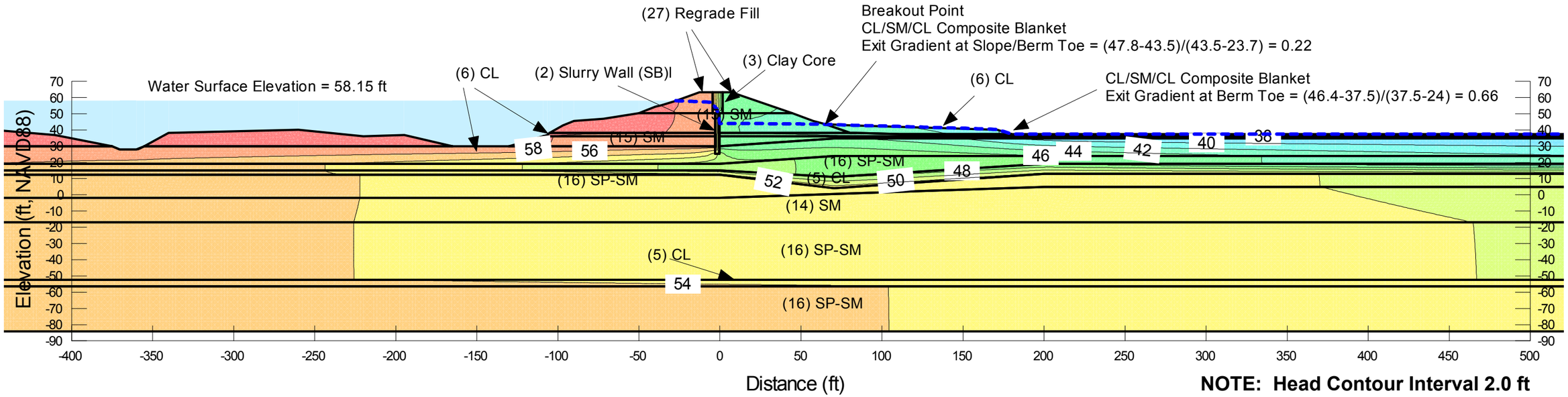
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 2, Section at Sta. 181+13 Alternative 2: Seepage Berm and Cutoff Wall WSE at 100yr + 1ft	FIGURE B02-A6
			TASK ORDER 1	ANALYZED NCH		
			DATE 2/4/2011	CHECKED BDC		

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



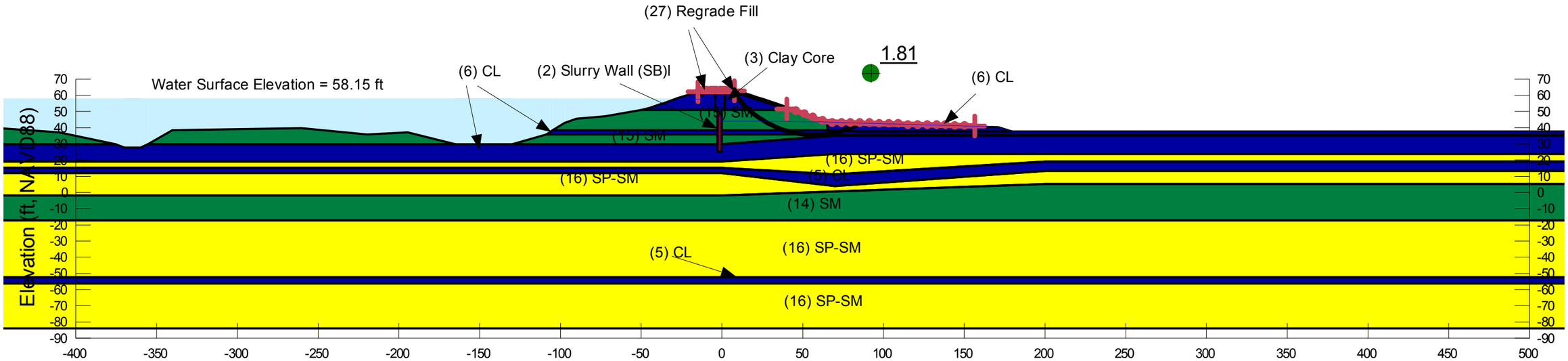
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade Fill,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NCH TASK ORDER 1 / ANALYZED BDC/NCH DATE 2/4/2011 / CHECKED BDC	STEADY-STATE SEEPAGE ANALYSIS Reach 2, Section at Sta. 181+13 Alternative 2: Seepage Berm and Cutoff Wall WSE at 100yr + 4ft	FIGURE B02-A7

Slope Stability Analysis Results, Critical Slip Surface

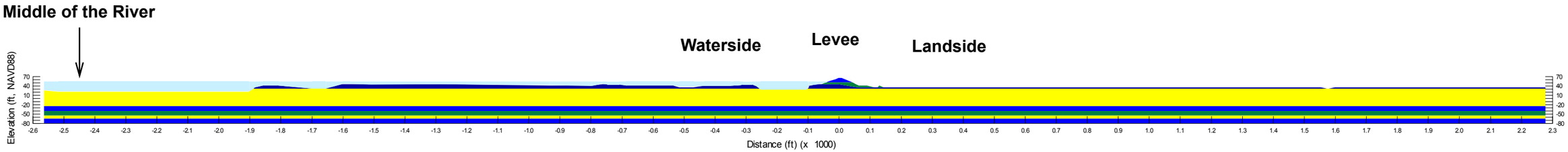


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(2) Slurry Wall	100 pcf	C'=300, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100, Phi'=32
(5) Clay Layer	125 pcf	C'=100, Phi'=31
(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(14) Silty Sand	125 pcf	C'=0, Phi'=36
(15) Silty Sand	120 pcf	C'=0, Phi'=30
(16) Silty Sand	120 pcf	C'=0, Phi'=34
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

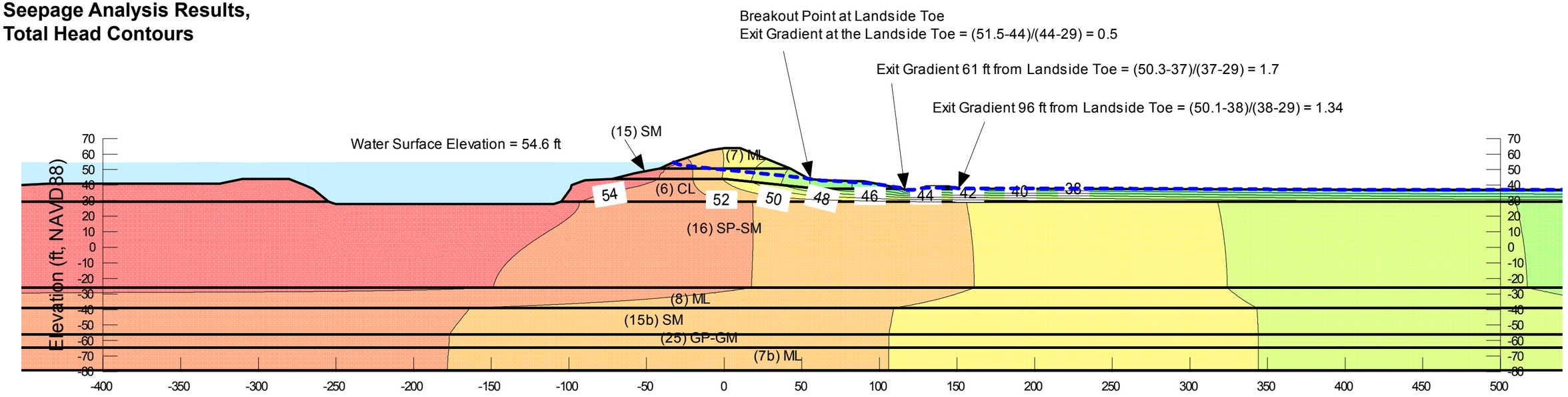
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 2, Section at Sta. 181+13 Alternative 2: Seepage Berm and Cutoff Wall WSE at 100yr + 4ft
			TASK ORDER 1	ANALYZED NCH	FIGURE B02-A8
			DATE 2/4/2011	CHECKED BDC	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

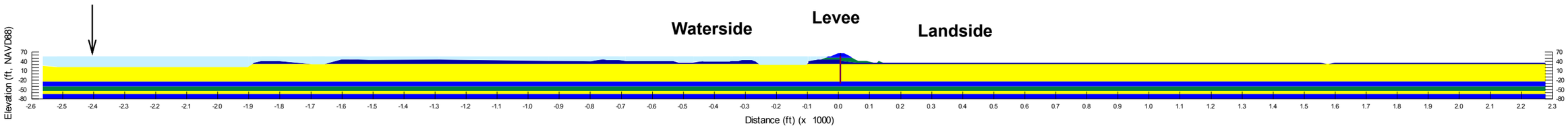
Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(25) Silty Gravel to Sandy Gravel, 8- 12% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(15b) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(7b) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 3, Section at Sta. 239+78 Existing Conditions WSE at 100yr
			TASK ORDER 1	ANALYZED BDC/NCH	
			DATE 2/4/2011	CHECKED BDC	FIGURE B03-E1

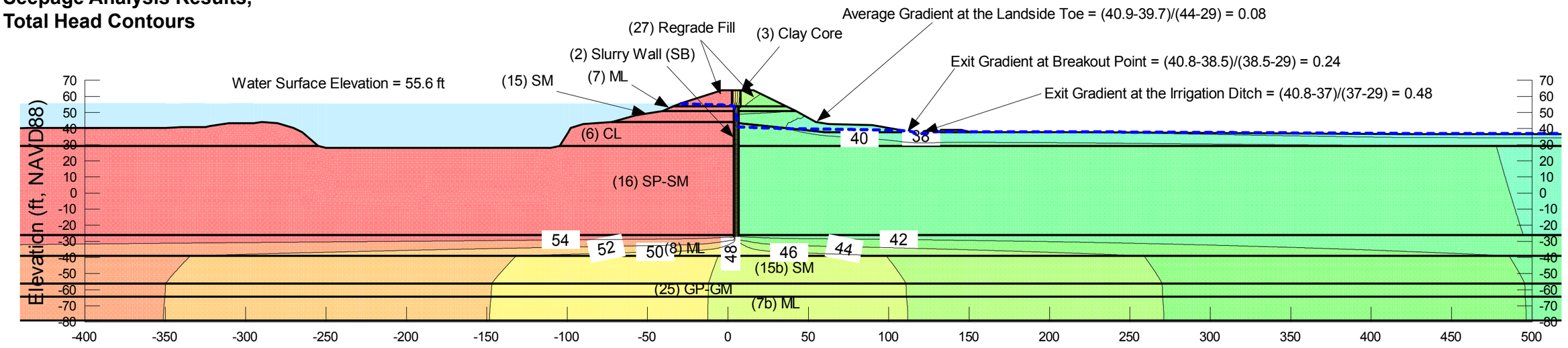
Model Geometry

Middle of the River



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



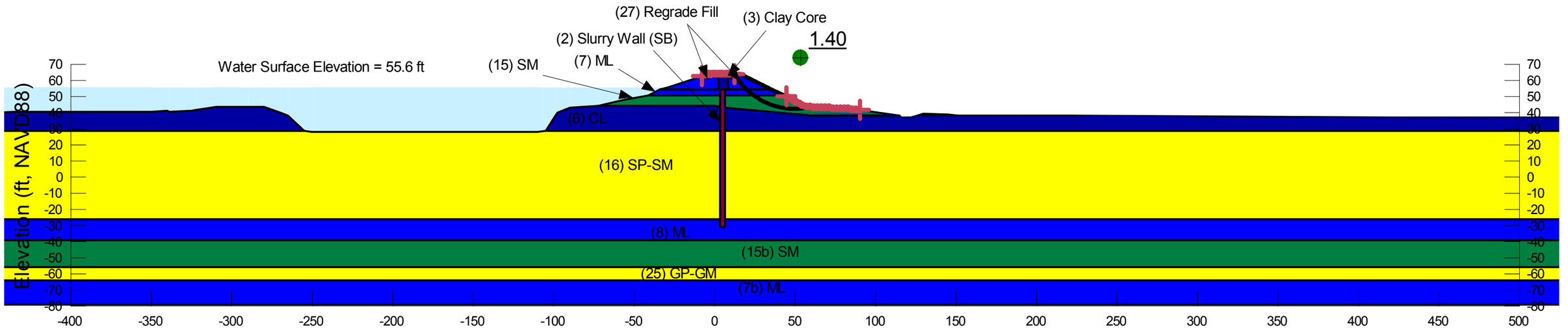
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(15b) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(7b) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(27) Regrade Fill		Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 3, Section at Sta. 239+78 Alternative 1: Cutoff Wall WSE at 100yr + 1ft
			TASK ORDER 1	ANALYZED BDC/NCH	FIGURE B03-A1
			DATE 2/4/2011	CHECKED BDC	

Slope Stability Analysis Results,
Critical Slip Surface



Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

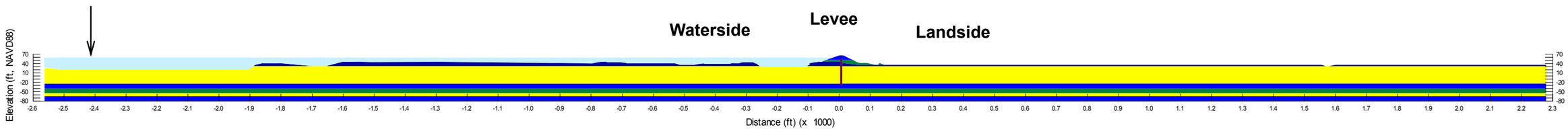
(2) Slurry Wall (SB)	100 pcf	C'=300, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100, Phi'=30
(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	125 pcf	C'=50, Phi'=32
(15) Silty Sand	120 pcf	C'=0, Phi'=28
(16) Silty Sand	125 pcf	C'=0, Phi'=36
(25) Silty Gravel	130 pcf	C'=0, Phi'=36
(15b) Silty Sand	130 pcf	C'=0, Phi'=36
(7b) Silt	130 pcf	C'=50, Phi'=32
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 3, Section at Sta. 239+78 Alternative 1: Cutoff Wall WSE at 100yr + 1ft
			TASK ORDER 1	ANALYZED NCH	
			DATE 2/4/2011	CHECKED BDC	

FIGURE B03-A2

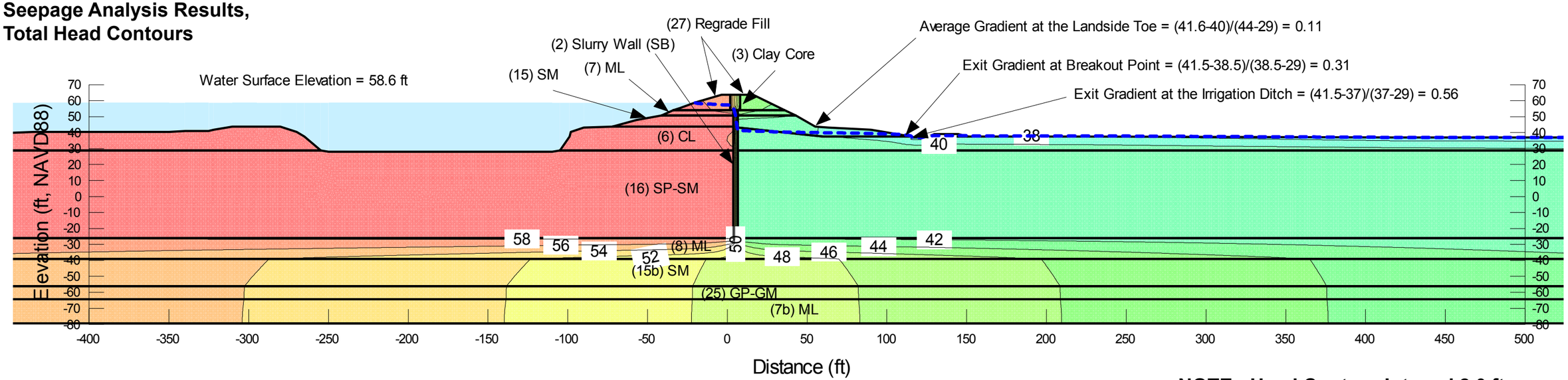
Model Geometry

Middle of the River



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



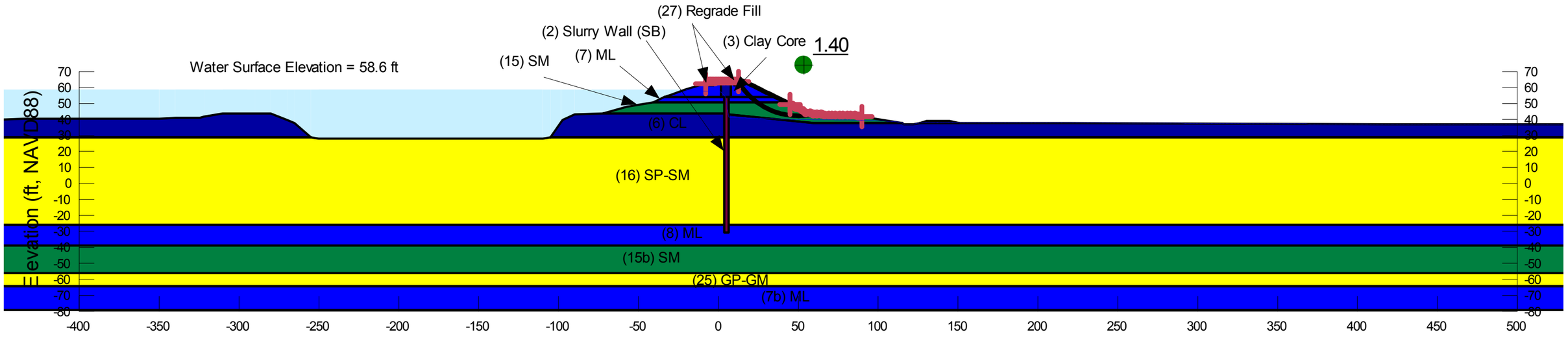
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(15b) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(7b) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(27) Regrade Fill		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NCH TASK ORDER 1 / ANALYZED BDC/NCH DATE 2/4/2011 / CHECKED BDC	STEADY-STATE SEEPAGE ANALYSIS Reach 3, Section at Sta. 239+78 Alternative 1: Cutoff Wall WSE at 100yr + 4ft	FIGURE B03-A3

Slope Stability Analysis Results, Critical Slip Surface

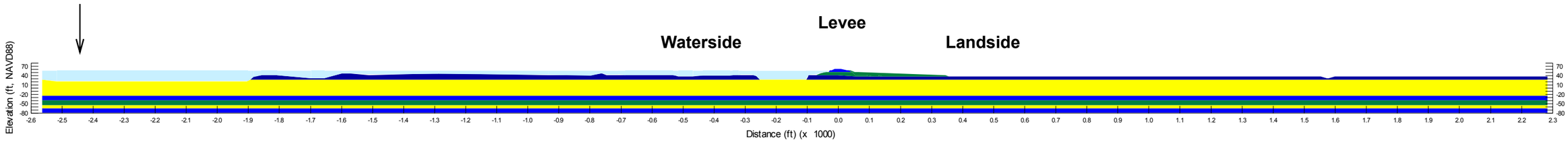


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(2) Slurry Wall (SB)	100 pcf	C'=300, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100, Phi'=30
(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	125 pcf	C'=50, Phi'=32
(15) Silty Sand	120 pcf	C'=0, Phi'=28
(16) Silty Sand	125 pcf	C'=0, Phi'=36
(25) Silty Gravel	130 pcf	C'=0, Phi'=36
(15b) Silty Sand	130 pcf	C'=0, Phi'=36
(7b) Silt	130 pcf	C'=50, Phi'=32
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

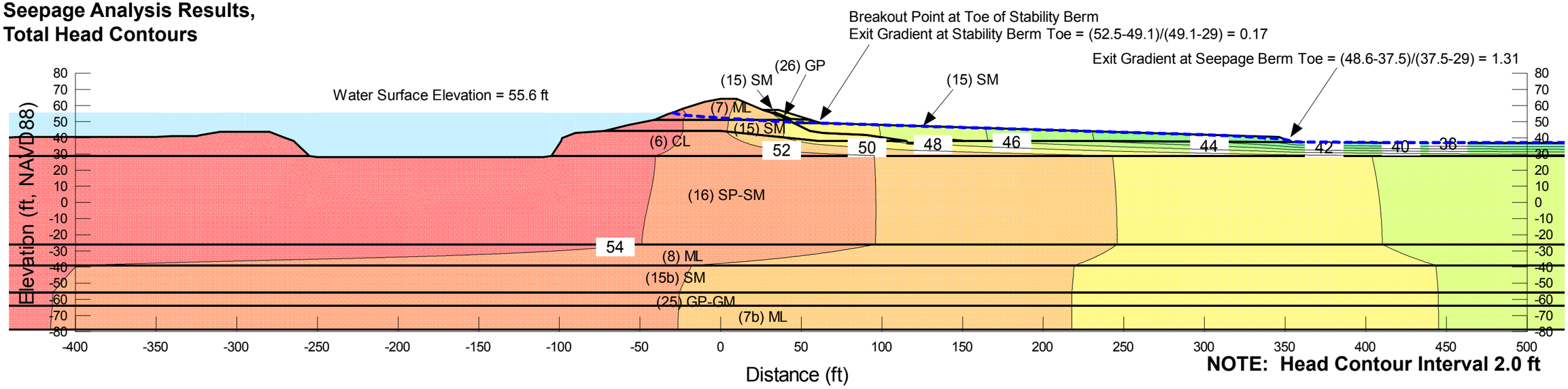
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/4/2011	DRAWN NCH ANALYZED NCH CHECKED BDC	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 3, Section at Sta. 239+78 Alternative 1: Cutoff Wall WSE at 100yr + 4ft	FIGURE B03-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



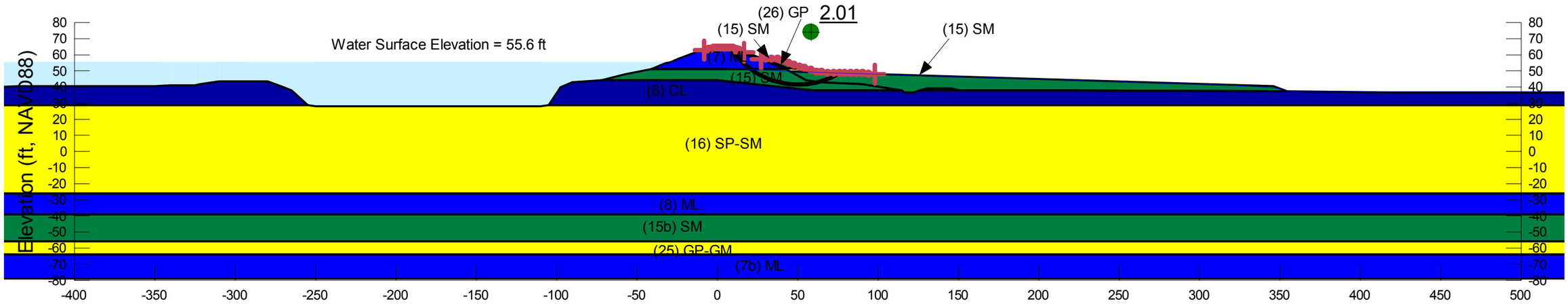
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(25) Silty Gravel to Sandy Gravel, 8- 12% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(15b) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(7b) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 3, Section at Sta. 239+78 Alternative 2: Seepage Berm with Stability Berm WSE at 100yr + 1ft
			TASK ORDER 1	ANALYZED BDC/NCH	FIGURE B03-A5
			DATE 2/4/2011	CHECKED BDC	

Slope Stability Analysis Results,
Critical Slip Surface

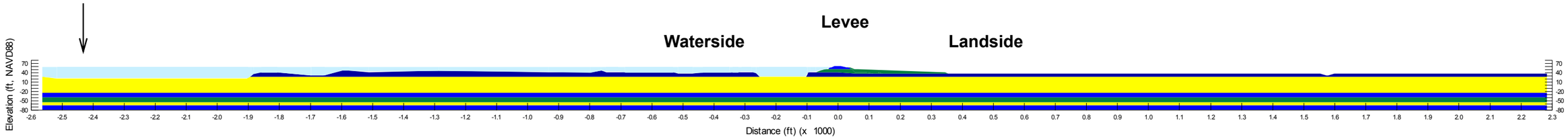


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	125 pcf	C'=50, Phi'=32
(15) Silty Sand	120 pcf	C'=0, Phi'=28
(16) Silty Sand	125 pcf	C'=0, Phi'=36
(25) Silty Gravel	130 pcf	C'=0, Phi'=36
(15b) Silty Sand	130 pcf	C'=0, Phi'=36
(7b) Silt	130 pcf	C'=50, Phi'=32
(26) Silty Gravel to Sandy Gravel	130 pcf	C'=0, Phi = 36

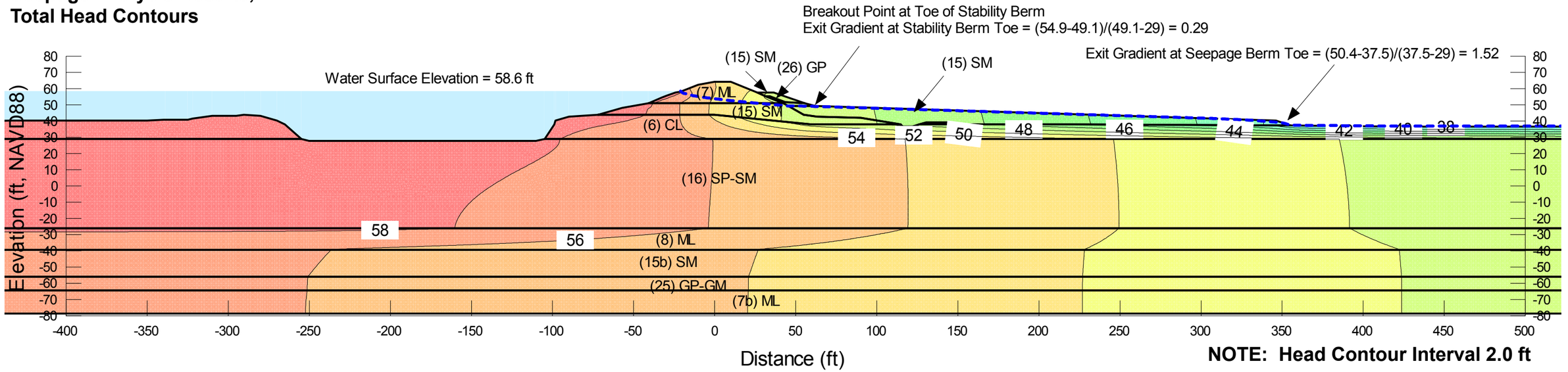
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/4/2011	DRAWN NCH ANALYZED NCH CHECKED BDC	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 3, Section at Sta. 239+78 Alternative 2: Seepage Berm with Stability Berm WSE at 100yr + 1ft	FIGURE B03-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

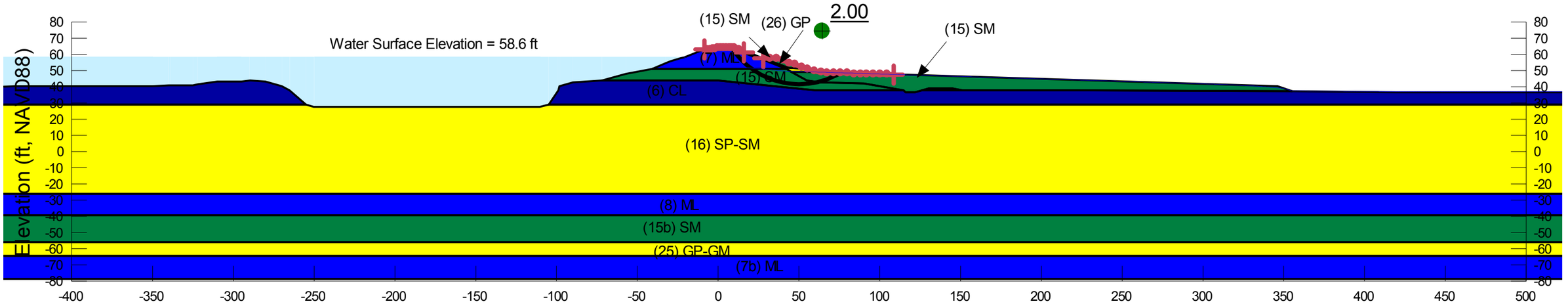
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(15b) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(7b) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/4/2011	DRAWN NCH ANALYZED BDC/NCH CHECKED BDC

STEADY-STATE SEEPAGE ANALYSIS
Reach 3, Section at Sta. 239+78
Alternative 2: Seepage Berm with Stability Berm
WSE at 100yr + 4ft

FIGURE B03-A7

Slope Stability Analysis Results,
Critical Slip Surface



Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

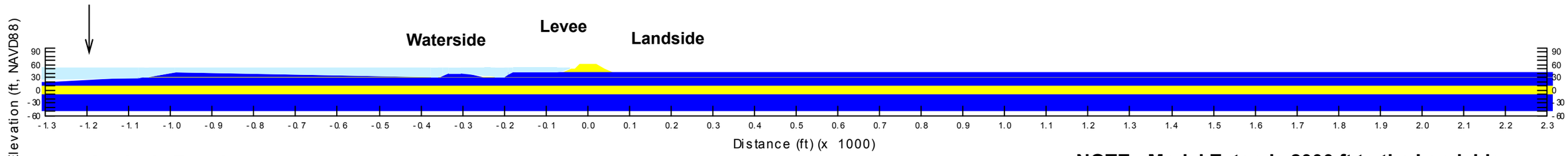
(6) Clay Blanket	120 pcf	C'=0, Phi'=30
(7) Silt	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	125 pcf	C'=50, Phi'=32
(15) Silty Sand	120 pcf	C'=0, Phi'=28
(16) Silty Sand	125 pcf	C'=0, Phi'=36
(25) Silty Gravel	130 pcf	C'=0, Phi'=36
(15b) Silty Sand	130 pcf	C'=0, Phi'=36
(7b) Silt	130 pcf	C'=50, Phi'=32
(26) Silty Gravel to Sandy Gravel	130 pcf	C'=0, Phi'=36

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/4/2011	DRAWN NCH ANALYZED NCH CHECKED BDC

STEADY-STATE SLOPE STABILITY ANALYSIS
Reach 3, Section at Sta. 239+78
Alternative 2: Seepage Berm with Stability Berm
WSE at 100yr + 4ft

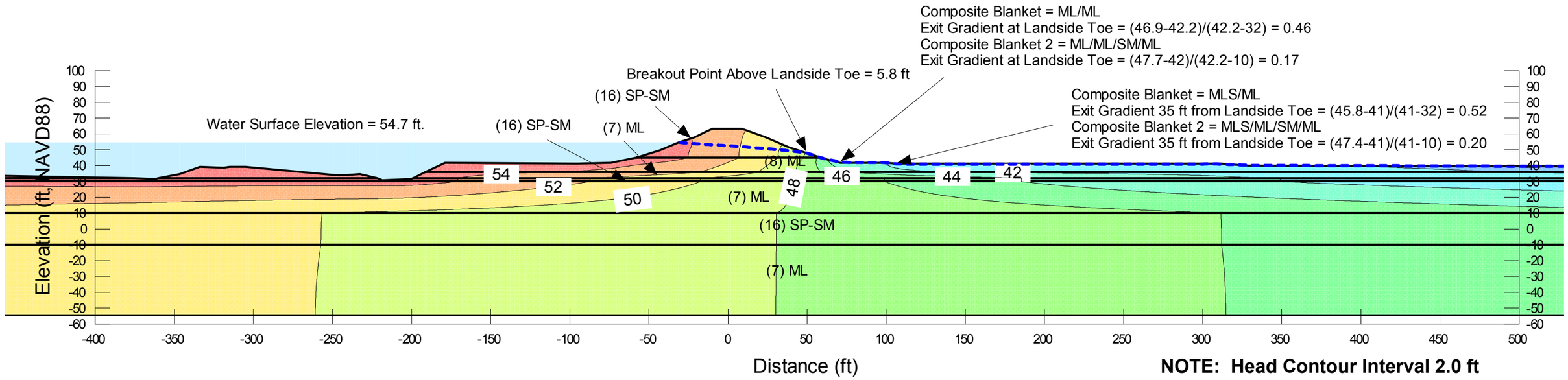
FIGURE B03-A8

Model Geometry



Seepage Analysis Results,
Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



NOTE: Head Contour Interval 2.0 ft

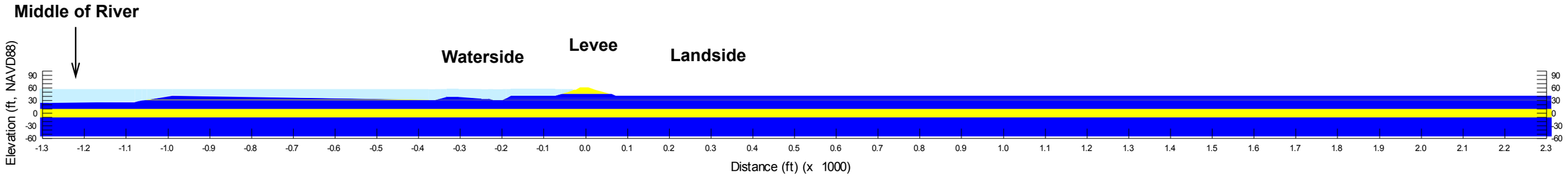
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 4, Section at Sta. 306+33 Existing Conditions WSE at 100yr
			TASK ORDER 1	ANALYZED BDC/NCH	
			DATE 2/4/2011	CHECKED BDC	

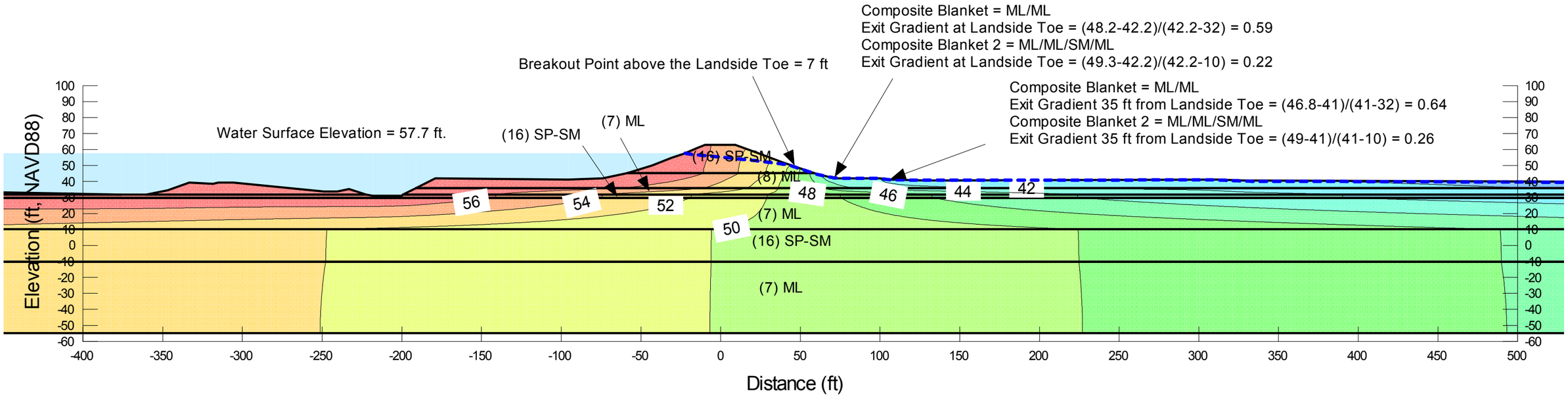
FIGURE B04-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



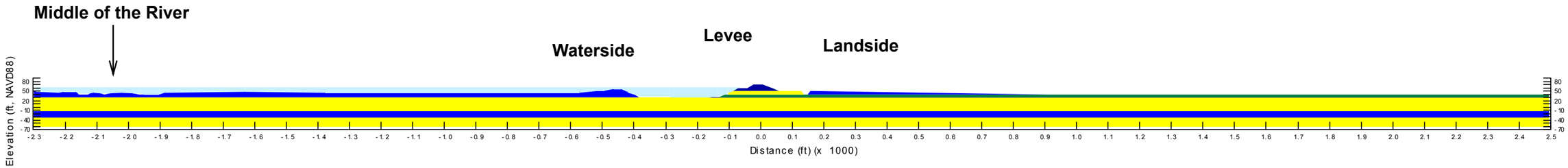
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25

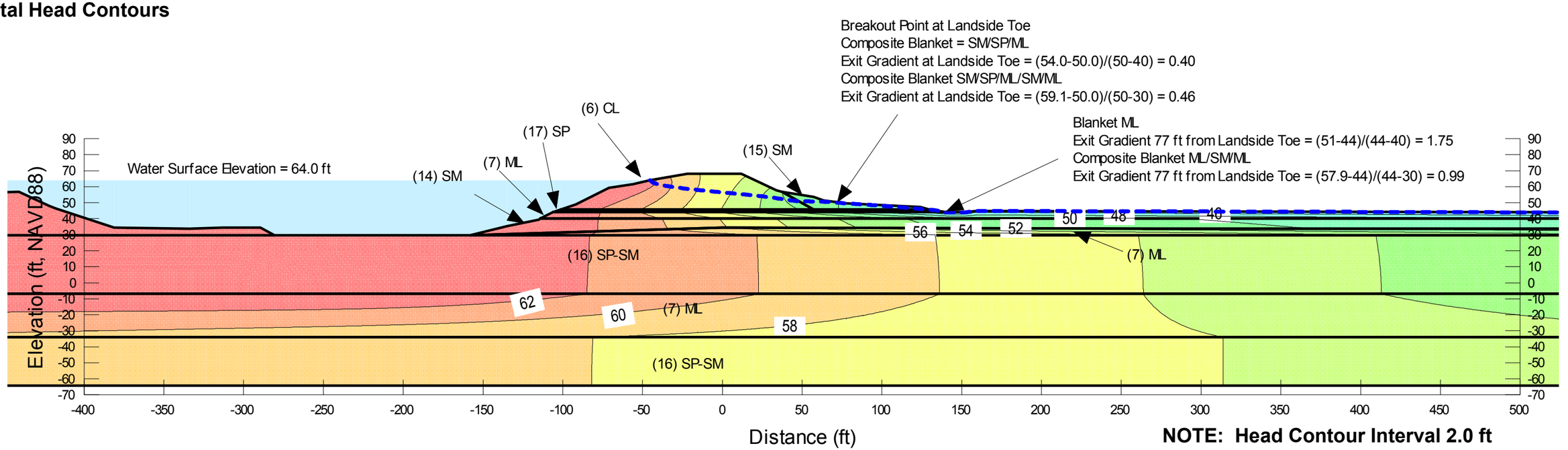
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 4, Section at Sta. 306+33 Existing Conditions WSE at 100yr + 3ft
			TASK ORDER 1	ANALYZED BDC/NCH	FIGURE B04-E2
			DATE 2/4/2011	CHECKED BDC	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

Material Type and ID, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

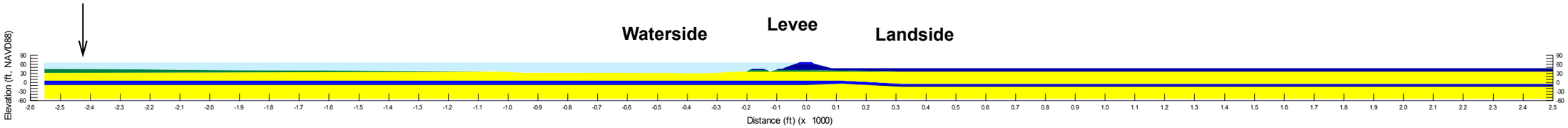
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt, 80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 5, Section at Sta. 477+01 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED BDC/NCH	
			DATE 2/4/2011	CHECKED BDC	

FIGURE B05-E1

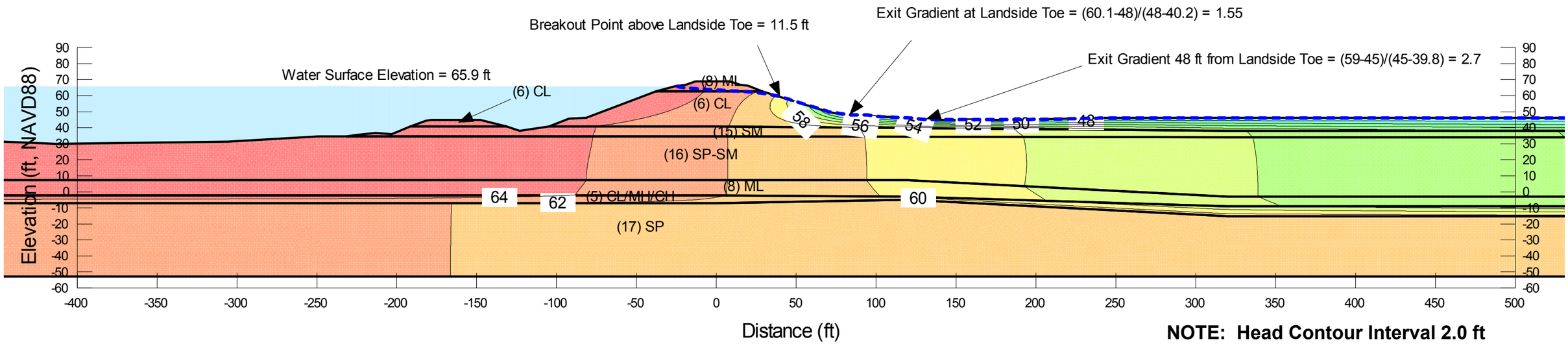
Model Geometry

Middle of the River



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



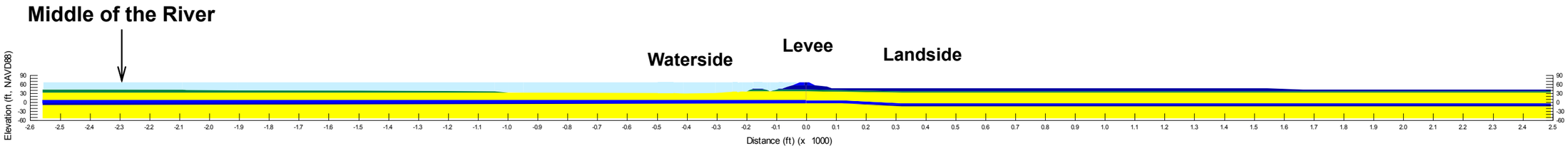
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25

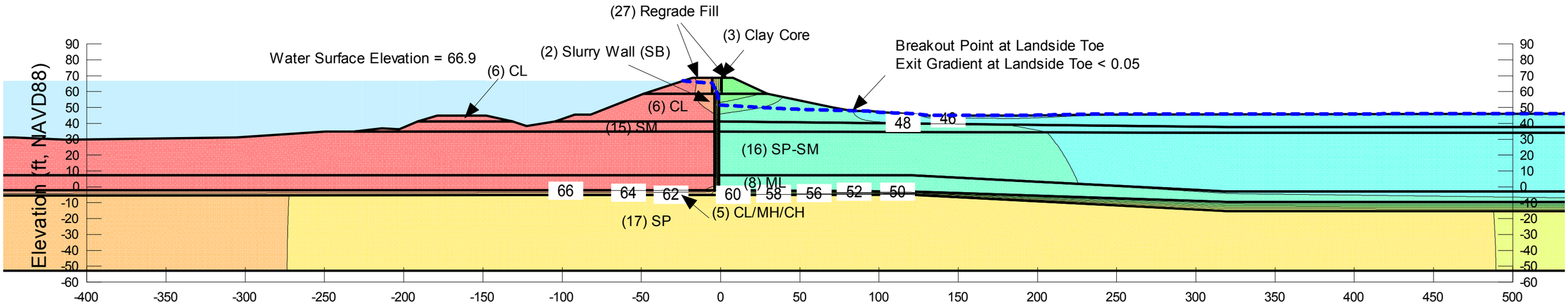
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NCH TASK ORDER 1 / ANALYZED BDC/NCH DATE 2/4/2011 / CHECKED BDC	STEADY-STATE SEEPAGE ANALYSIS Reach 7, Section at Sta. 539+30 Existing Conditions WSE at 200yr	FIGURE B07-E1

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



NOTE: Head Contour Interval 2.0 ft

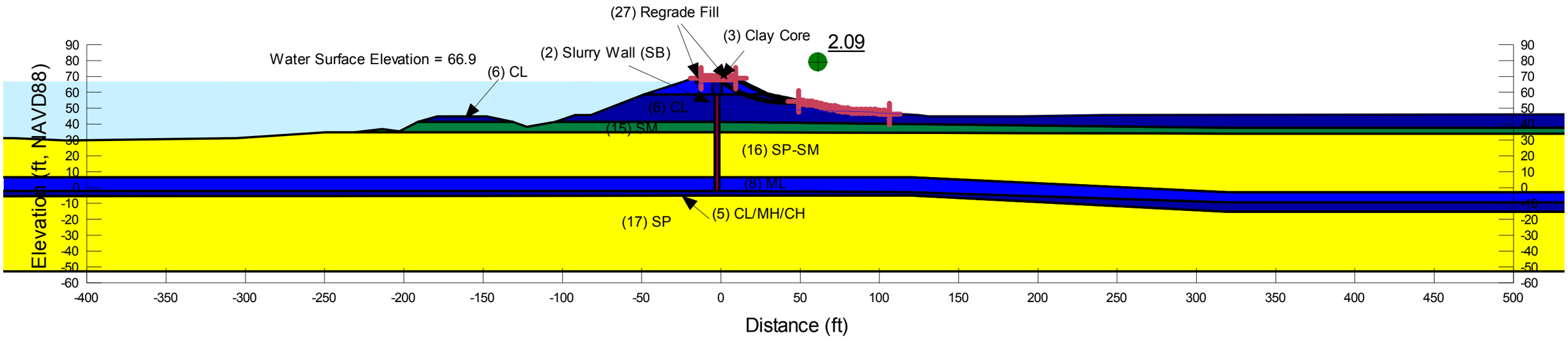
Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(27) Regrade Fill		Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 7, Section at Sta. 539+30 Alternative 1: Cutoff Wall WSE at 200yr +1ft
			TASK ORDER 1	ANALYZED BDC/NCH	
			DATE 2/4/2011	CHECKED BDC	

FIGURE B07-A1

Slope Stability Analysis Results,
Critical Slip Surface

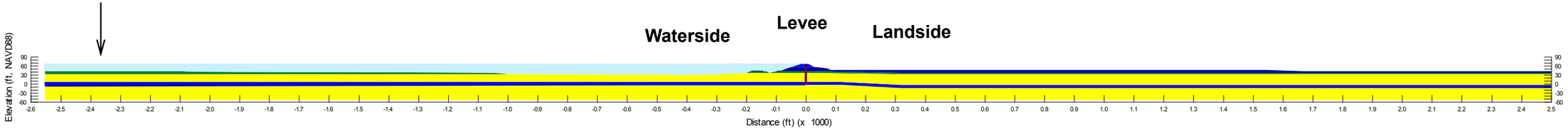


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(2) Slurry Wall	100 pcf	C'=300, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100 , Phi'=32
(5) Clay Layer	125 pcf	C'=50 , Phi'= 32
(6) Clay Blanket	120 pcf	C'=0 , Phi'=32
(8) Sandy Silt	125 pcf	C'=50 , Phi'=32
(15) Silty Sand	120 pcf	C'=0 , Phi'=28
(16) Silty Sand	120 pcf	C'=0 , Phi'=34
(17) Silty Sand	130 pcf	C'=0 , Phi'=36
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

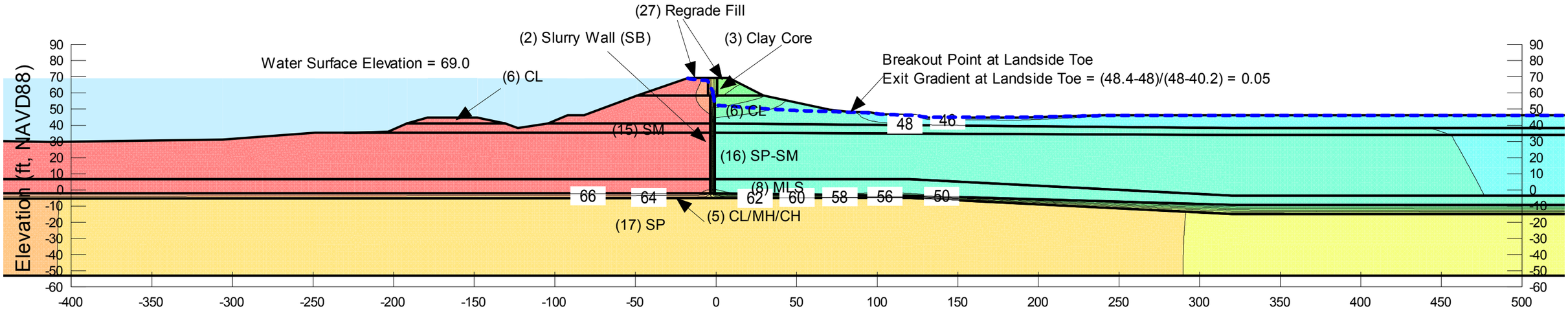
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 7, Section at Sta. 539+30 Alternative 1: Cutoff Wall WSE at 200yr +1ft
			TASK ORDER 1	ANALYZED NCH	FIGURE B07-A2
			DATE 2/4/2011	CHECKED BDC	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

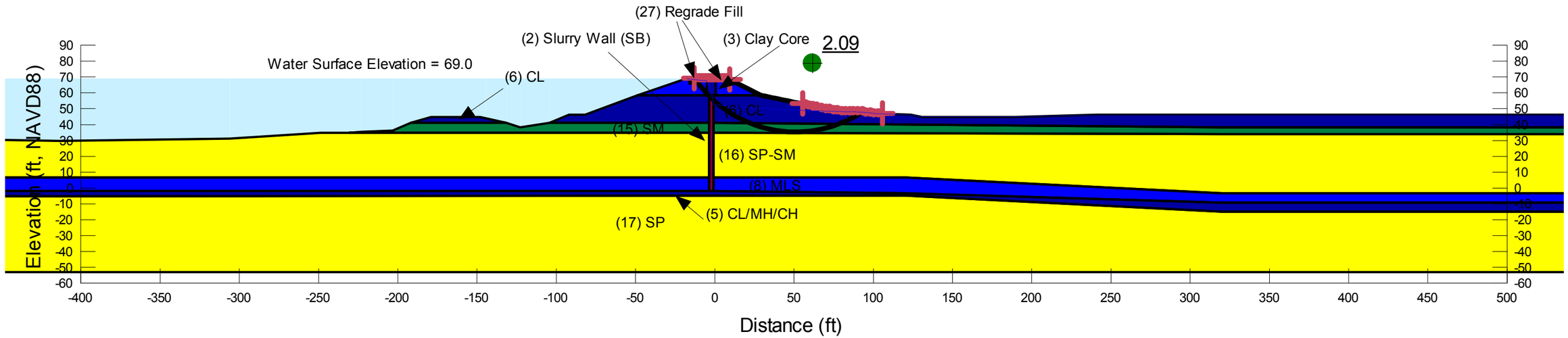
Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(27) Regrade Fill		Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SEEPAGE ANALYSIS Reach 7, Section at Sta. 539+30 Alternative 1: Cutoff Wall WSE at HTOL
			TASK ORDER 1	ANALYZED BDC/NCH	
			DATE 2/4/2011	CHECKED BDC	

FIGURE B07-A3

Slope Stability Analysis Results,
Critical Slip Surface



Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

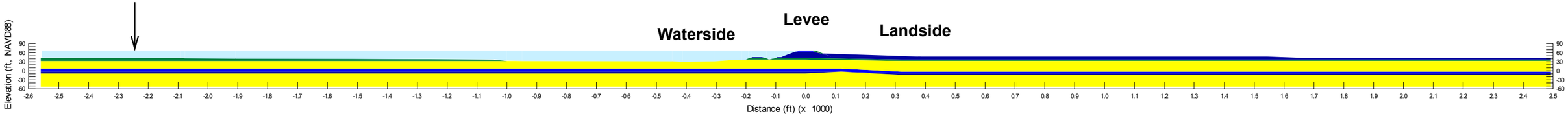
(2) Slurry Wall	100 pcf	C'=300, Phi'=0
(3) New Compacted Clay Levee	120 pcf	C'=100, Phi'=32
(5) Clay Layer	125 pcf	C'=50 , Phi'= 32
(6) Clay Blanket	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	125 pcf	C'=50, Phi'=32
(15) Silty Sand	120 pcf	C'=0, Phi'=28
(16) Silty Sand	120 pcf	C'=0, Phi'=34
(17) Silty Sand	130 pcf	C'=0, Phi'=36
(27) Regrade Fill	120 pcf	C'=50, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 7, Section at Sta. 539+30 Alternative 1: Cutoff Wall WSE at HTOL
			TASK ORDER 1	ANALYZED NCH	
			DATE 2/4/2011	CHECKED BDC	

FIGURE B07-A4

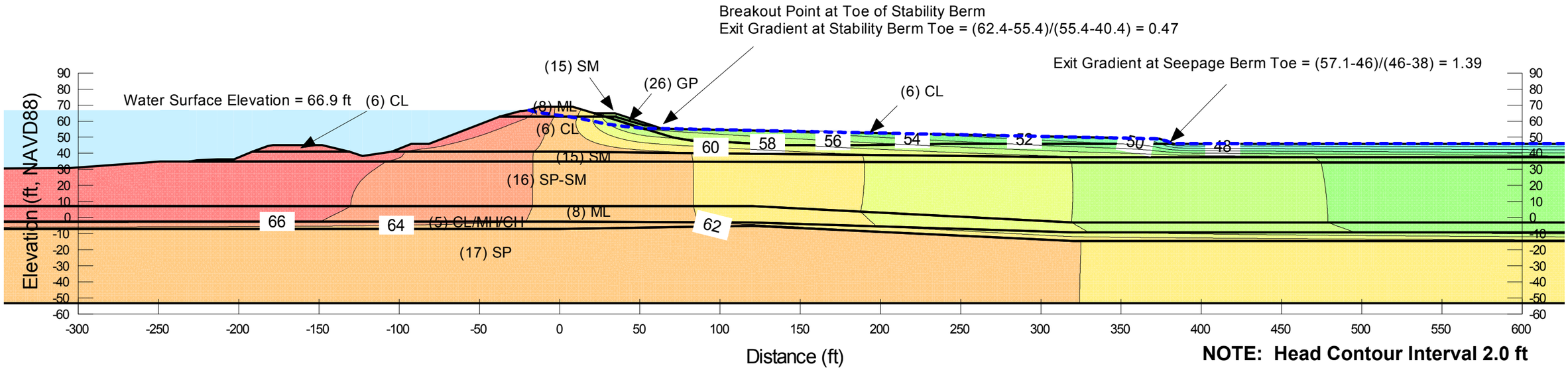
Model Geometry

Middle of the River



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



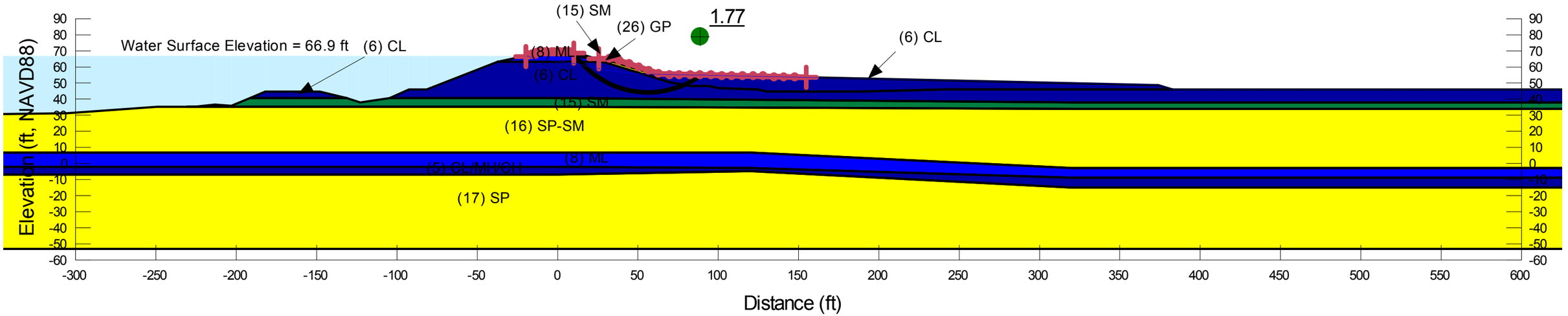
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NCH TASK ORDER 1 / ANALYZED BDC/NCH DATE 2/4/2011 / CHECKED BDC	STEADY-STATE SEEPAGE ANALYSIS Reach 7, Section at Sta. 539+30 Alternative 2: Seepage Berm with Stability Berm WSE at 200yr +1ft	FIGURE B07-A5

Slope Stability Analysis Results,
Critical Slip Surface



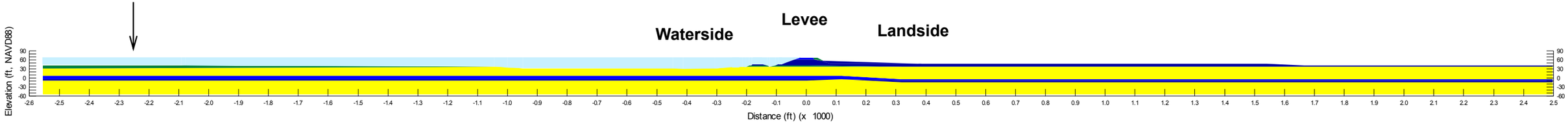
Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(5) Clay Layer	125 pcf	C'=50, Phi'= 32
(6) Clay Blanket	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	125 pcf	C'=50, Phi'=3 2
(15) Silty Sand	120 pcf	C'=0, Phi'=28
(16) Silty Sand	120 pcf	C'=0, Phi'=34
(17) Silty Sand	130 pcf	C'=0, Phi'=36
(26) Silty Gravel to Sandy Gravel	130 pcf	C'=0, Phi'=36

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NCH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 7, Section at Sta. 539+30 Alternative 2: Seepage Berm with Stability Berm WSE at 200yr +1ft
			TASK ORDER 1	ANALYZED NCH	FIGURE B07-A6
			DATE 2/4/2011	CHECKED BDC	

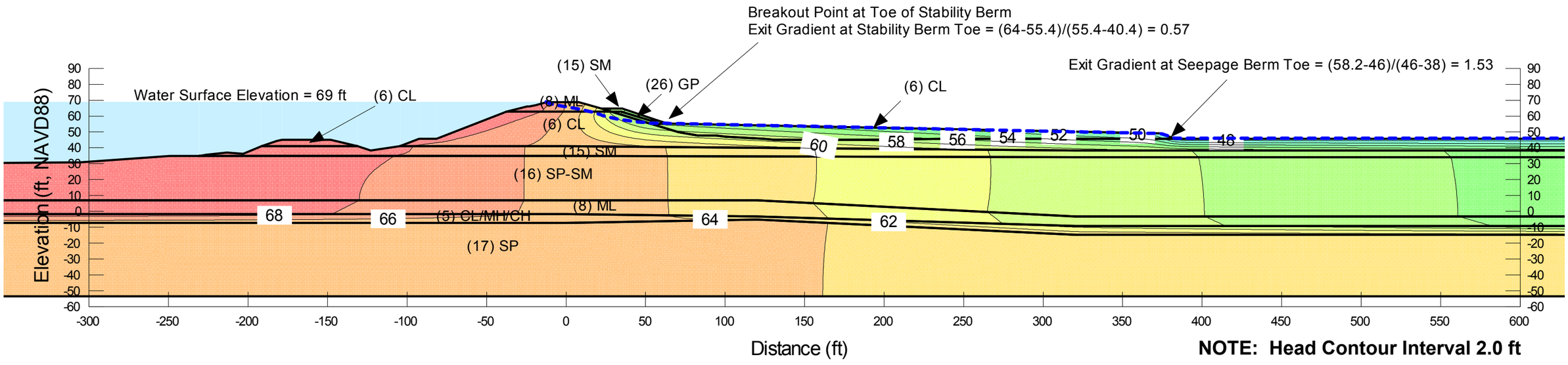
Model Geometry

Middle of the River



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



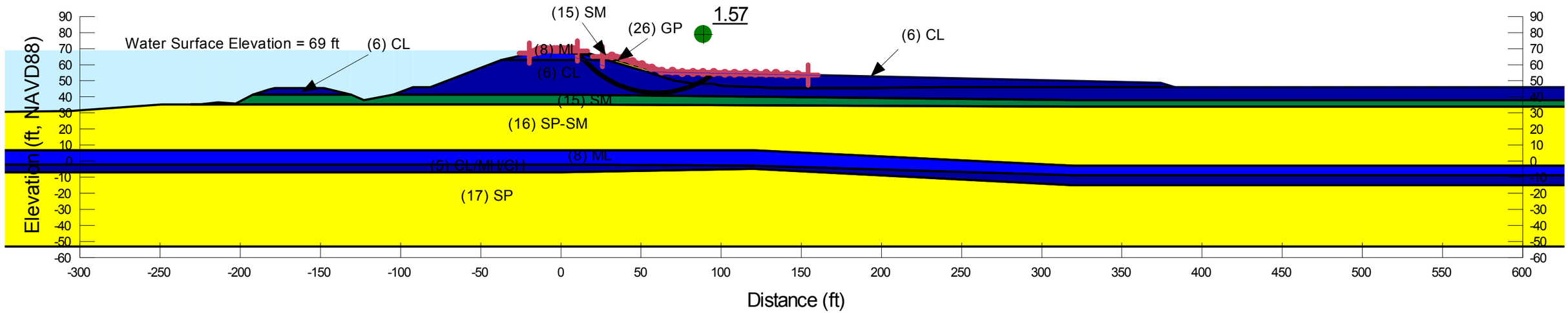
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NCH TASK ORDER 1 / ANALYZED BDC/NCH DATE 2/4/2011 / CHECKED BDC	STEADY-STATE SEEPAGE ANALYSIS Reach 7, Section at Sta. 539+30 Alternative 2: Stability and Seepage Berms WSE at HTOL	FIGURE B07-A7

Slope Stability Analysis Results,
Critical Slip Surface

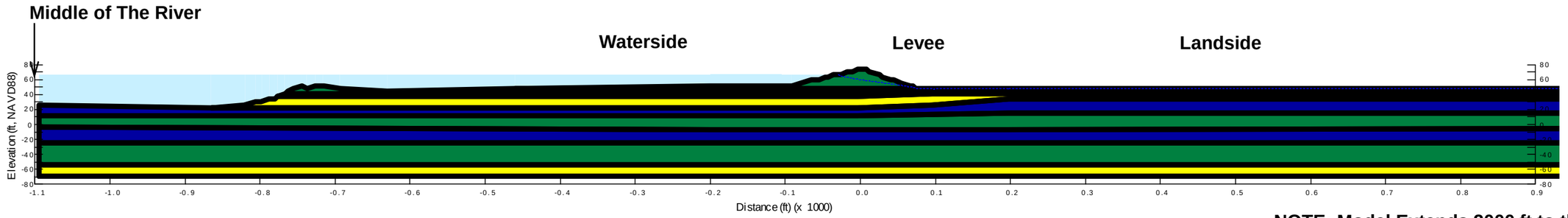


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

(5) Clay Layer	125 pcf	C'=50, Phi'= 32
(6) Clay Blanket	120 pcf	C'=0, Phi'=32
(8) Sandy Silt	125 pcf	C'=50, Phi'=3 2
(15) Silty Sand	120 pcf	C'=0, Phi'=28
(16) Silty Sand	120 pcf	C'=0, Phi'=34
(17) Silty Sand	130 pcf	C'=0, Phi'=36
(26) Silty Gravel to Sandy Gravel	130 pcf	C'=0, Phi'=36

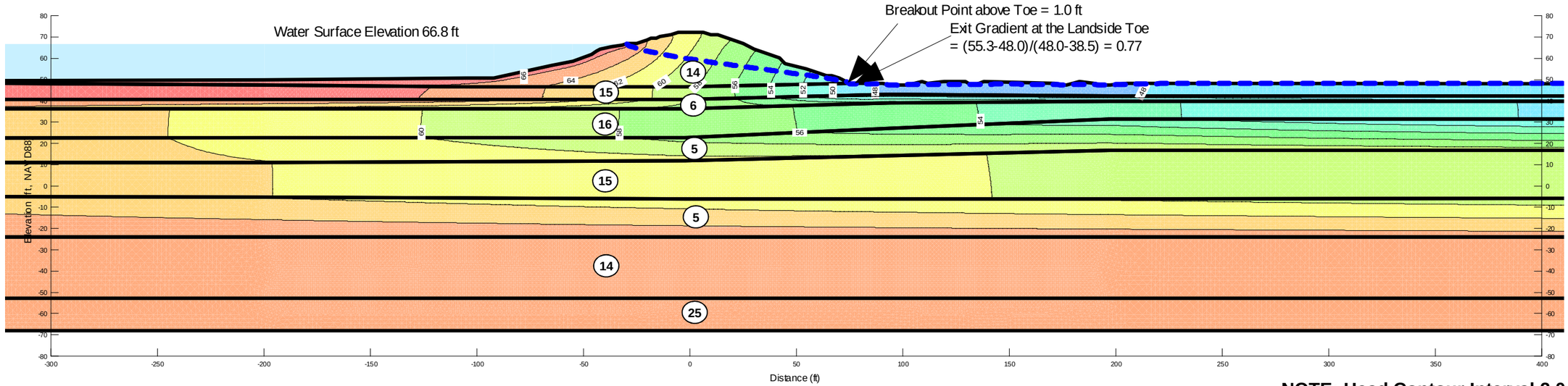
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/4/2011	DRAWN NCH ANALYZED NCH CHECKED BDC	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 7, Section at Sta. 539+30 Alternative 2: Stability and Seepage Berms WSE at HTOL	FIGURE B07-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



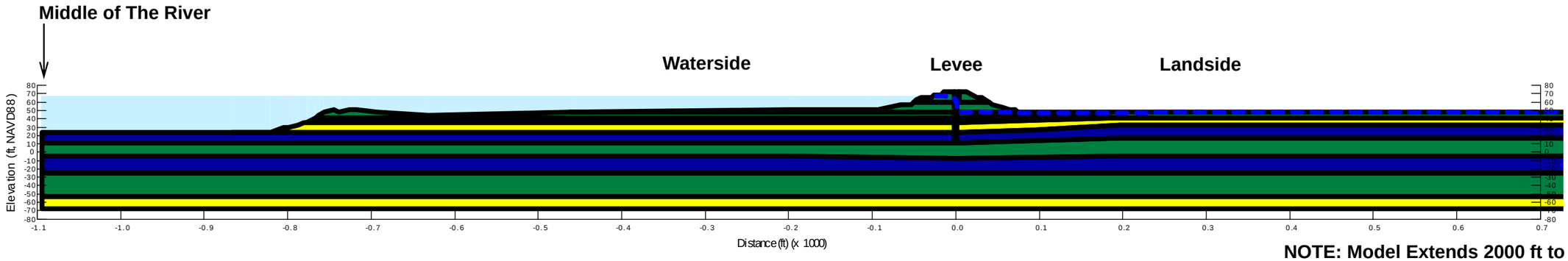
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25

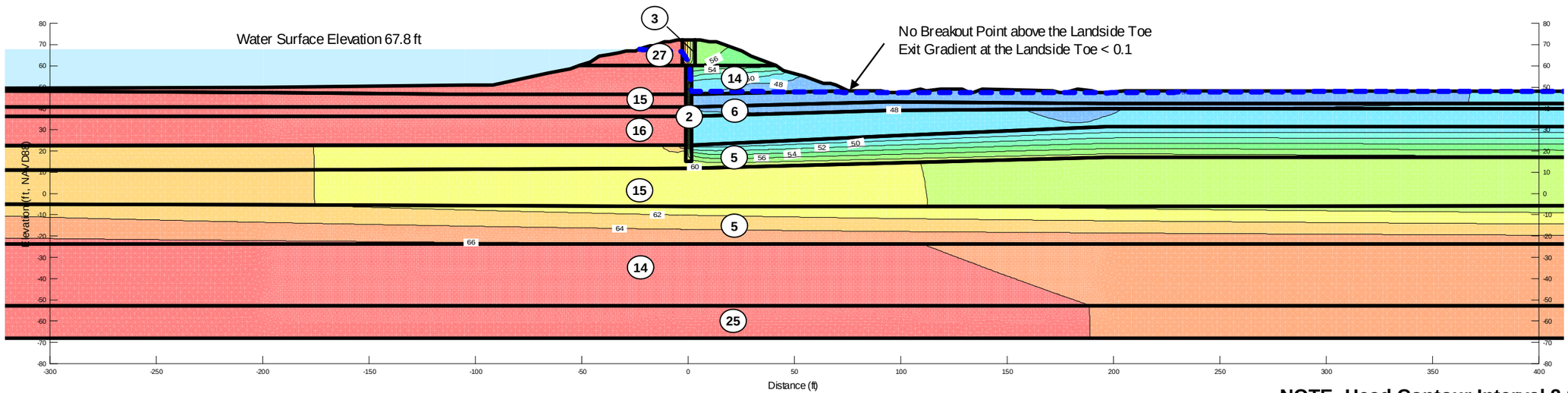
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 08, Section at Sta. 623+86 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED NT	FIGURE B08-E1
			DATE 02/07/2011	CHECKED GTH	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

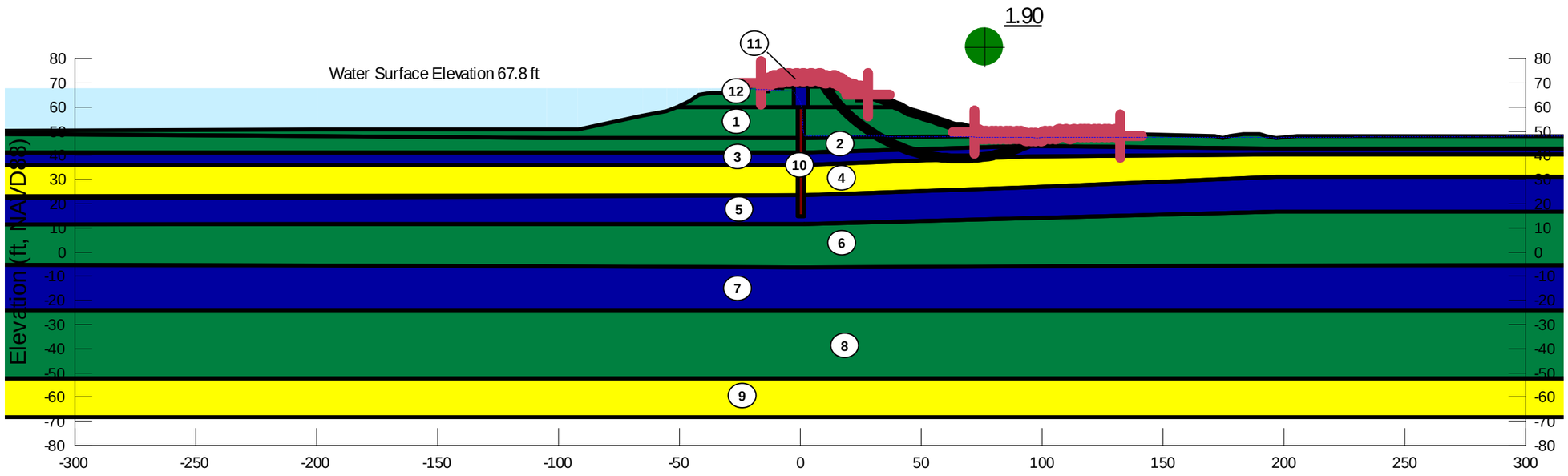
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(27) Regrade SM,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 08, Section at Sta. 623+86 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	
			DATE 02/07/2011	CHECKED GTH	

FIGURE B08-A1

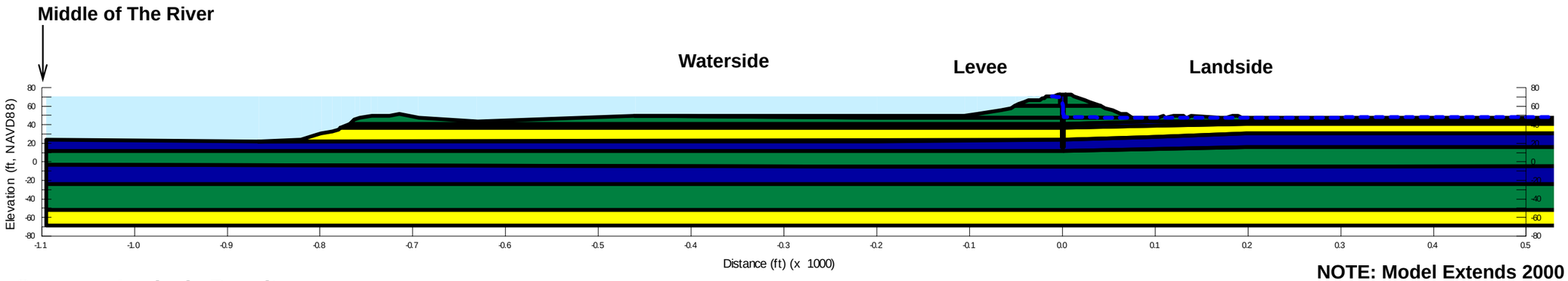
Slope Stability Analysis Results,
Critical Slip Surface



Material ID and Type, Unit Weightm Effective Strength Parameters (Cohesion Intercept and Friction Angle)
1 SM 120 pcf C'=0, Phi'=34
2 SP 120 pcf C'=0, Phi'=33
3 CL 110 pcf C'=0, Phi'=30
4 SP 120 pcf C'=0, Phi'=35
5 CL 115 pcf C'=0, Phi'=30
6 SP 115 pcf C'=0, Phi'=30
7 CL 115 pcf C'=0, Phi'=30
8 SM-SC 120 pcf C'=0, Phi'=36
9 GP 130 pcf C'=0, Phi'=36
10 SB Wall 100 pcf C'=300 psf, Phi'=0
11 Clay Cap 120 pcf C'=100 psf, Phi'=32
12 Regrade SM 120 pcf C'=50 psf, Phi'=32

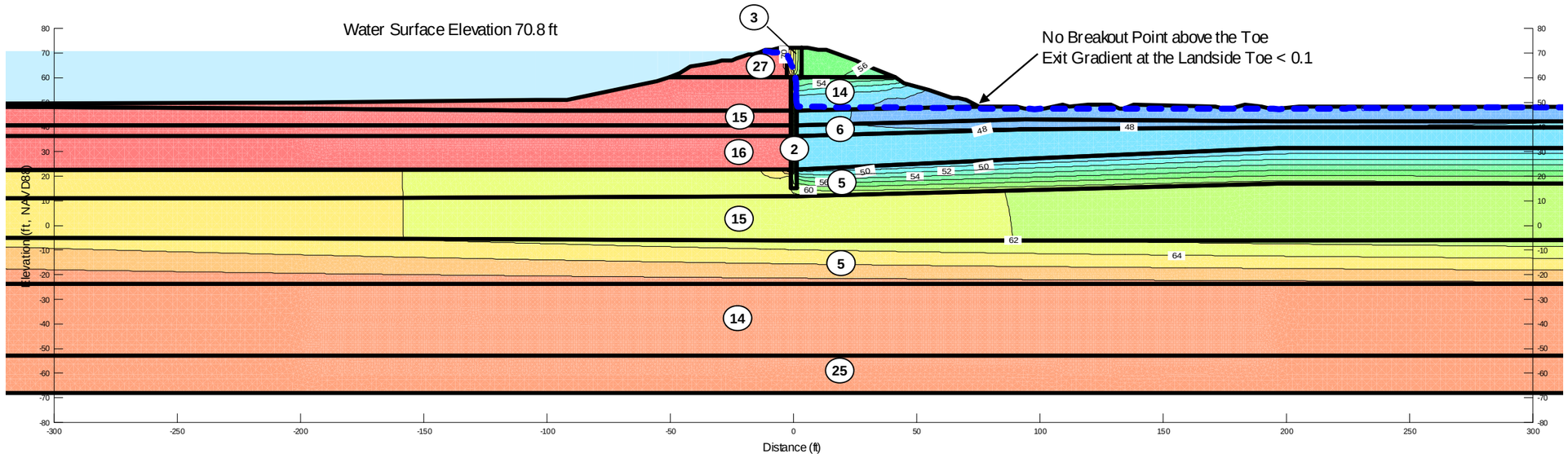
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 08, Section at Sta. 623+86 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B08-A2
			TASK ORDER 1	ANALYZED NT		
			DATE 02/07/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



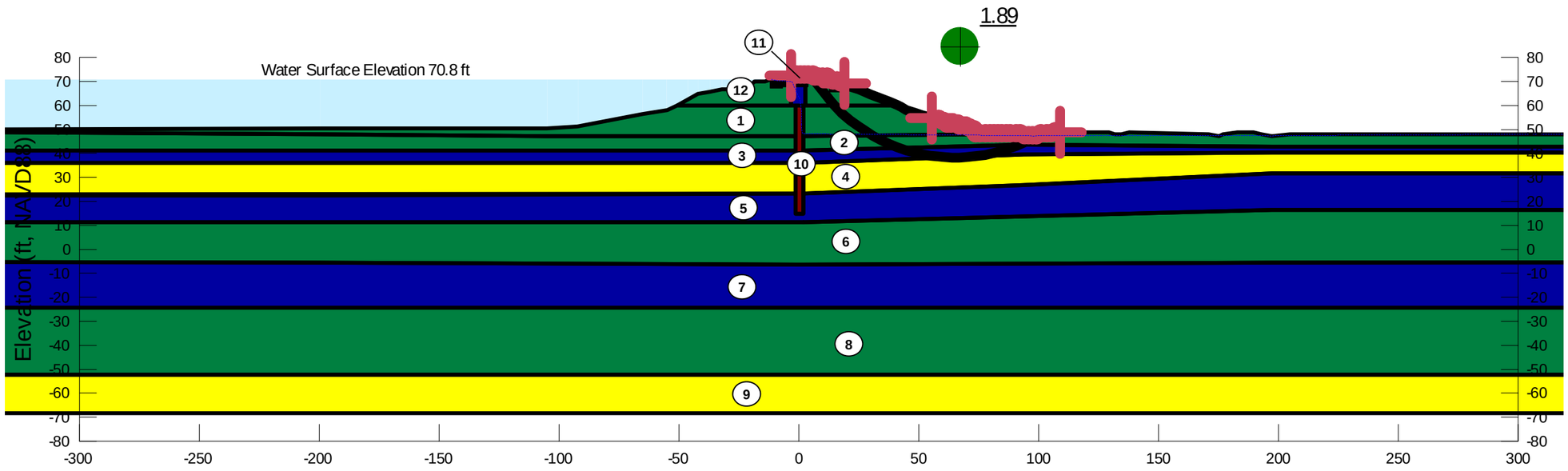
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(27) Regrade SM,		Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 08, Section at Sta. 623+86 Alternative 1: Cutoff Wall WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B08-A3
			DATE 02/07/2011	CHECKED GTH	

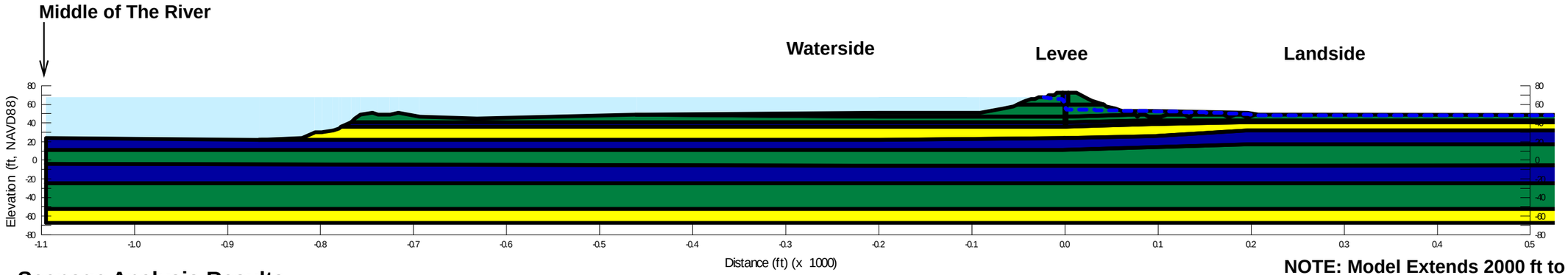
Slope Stability Analysis Results,
Critical Slip Surface



Material ID and Type, Unit Weightm Effective Strength Parameters (Cohesion Intercept and Friction Angle)
1 SM 120 pcf C'=0, Phi'=34
2 SP 120 pcf C'=0, Phi'=33
3 CL 110 pcf C'=0, Phi'=30
4 SP 120 pcf C'=0, Phi'=35
5 CL 115 pcf C'=0, Phi'=30
6 SP 115 pcf C'=0, Phi'=30
7 CL 115 pcf C'=0, Phi'=30
8 SM-SC 120 pcf C'=0, Phi'=36
9 GP 130 pcf C'=0, Phi'=36
10 SB Wall 100 pcf C'=300 psf, Phi'=0
11 Clay Cap 120 pcf C'=100 psf, Phi'=32
12 Regrade SM 120 pcf C'=50 psf, Phi'=32

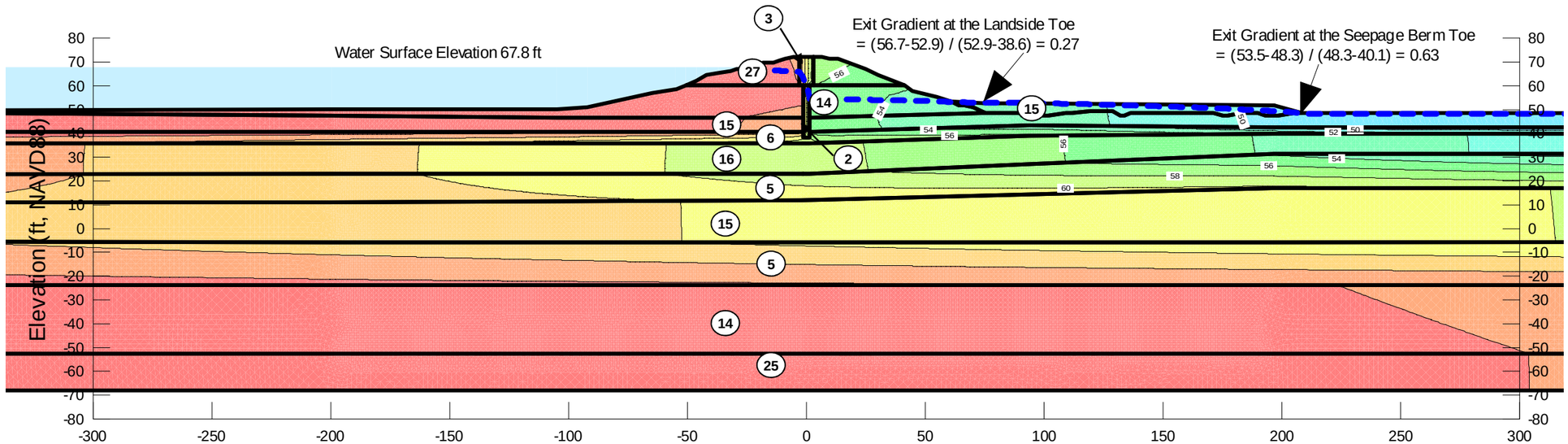
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 08, Section at Sta. 623+86 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B08-A4
			TASK ORDER 1	ANALYZED NT		
			DATE 02/07/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



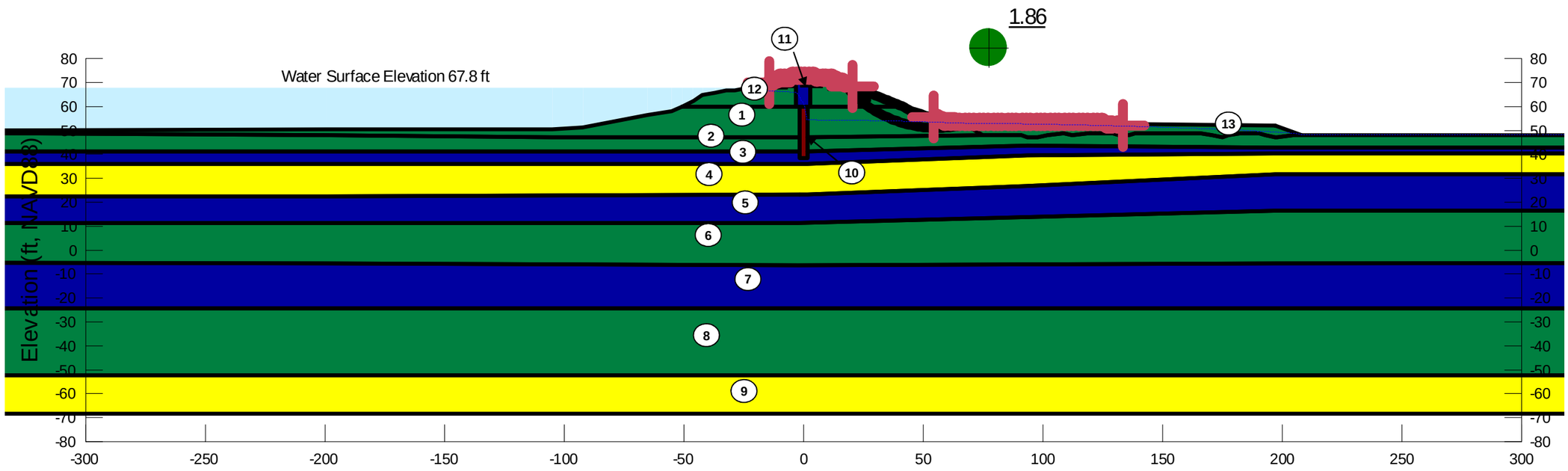
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(27) Regrade Fill,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 08, Section at Sta. 623+86 Alternative 2: Seepage Berm and Shallow Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B08-A5
			DATE 02/07/2011	CHECKED GTH	

Slope Stability Analysis Results,
Critical Slip Surface

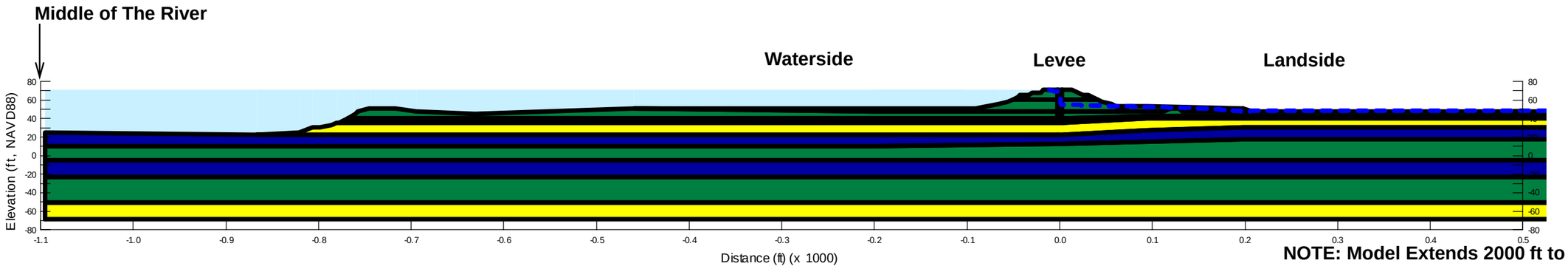


Material ID and Type, Unit Weight, Effective strength Parameters (Cohesion Intercept and Friction Angle)

1 SM Shear/Normal Fn. 120 pcf C'=0, Phi'=34
2 SP Shear/Normal Fn. 120 pcf C'=0, Phi'=33
3 CL Shear/Normal Fn. 110 pcf C'=0, Phi'=30
4 SP Shear/Normal Fn. 120 pcf C'=0, Phi'=35
5 CL Shear/Normal Fn. 115 pcf C'=0, Phi'=30
6 SP Shear/Normal Fn. 115 pcf C'=0, Phi'=35
7 CL Shear/Normal Fn. 115 pcf C'=0, Phi'=30
8 SM-SC Shear/Normal Fn. 120 pcf C'=0, Phi'=36
9 GP Shear/Normal Fn. 130 pcf C'=0, Phi'=36
10 SB Wall Shear/Normal Fn. 100 pcf C'=300 psf, Phi'=0
11 Clay Cap Shear/Normal Fn. 120 pcf C'=100 psf, Phi'=32
12 Regrade SM Shear/Normal Fn. 120 pcf C'=0, Phi'=35
13 Compacted Berm, SM Shear/Normal Fn. 120 pcf C'=0, Phi'=35

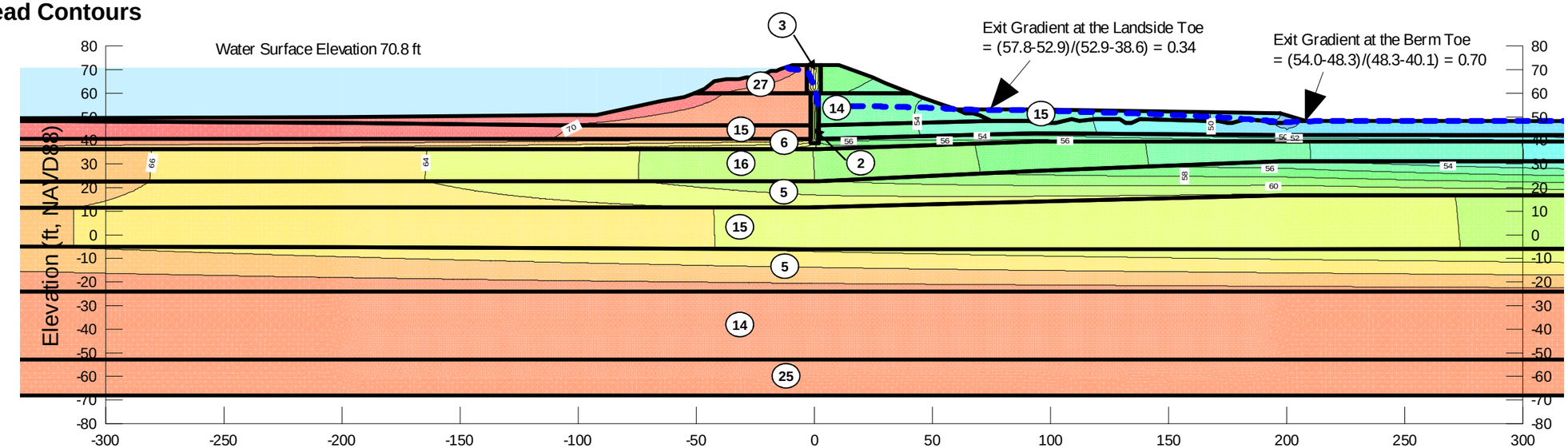
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 08, Section at Sta. 623+86 Alternative 2: Seepage Berm and Shallow Cutoff Wall WSE at 200yr+1 ft	FIGURE B08-A6
			TASK ORDER 1	ANALYZED NT		
			DATE 02/07/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



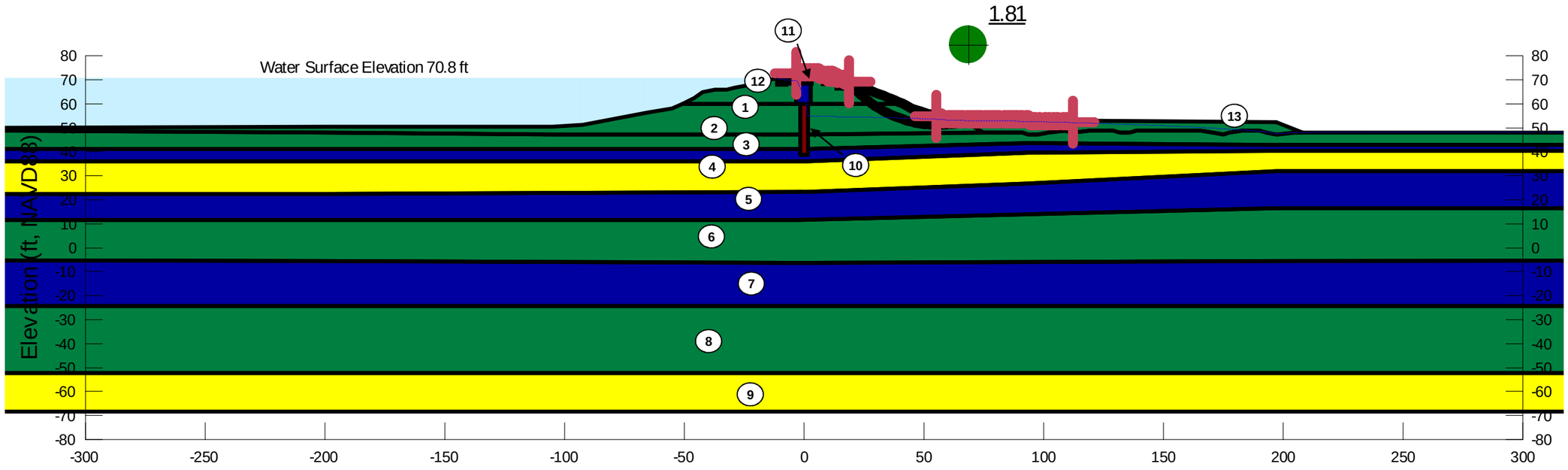
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(27) Regrade Fill,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 08, Section at Sta. 623+86 Alternative 2: Seepage Berm and Shallow Cutoff Wall WSE at 200yr+4 ft	FIGURE B08-A7
			TASK ORDER 1	ANALYZED NT		
			DATE 02/07/2011	CHECKED GTH		

Slope Stability Analysis Results, Critical Slip Surface

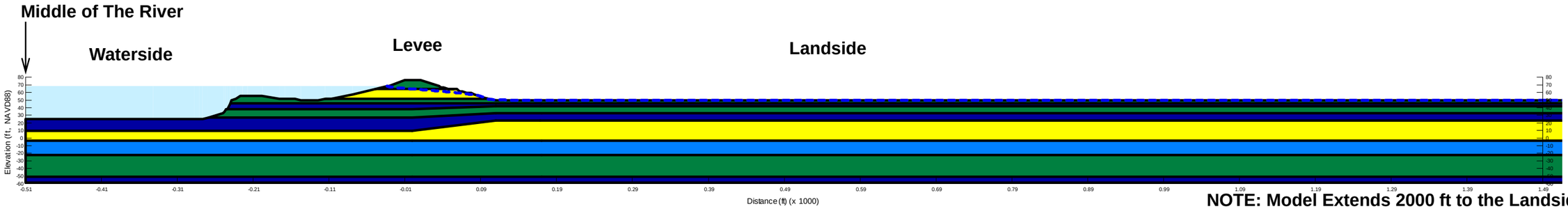


Material ID and Type, Unit Weight, Effective strength Parameters (Cohesion Intercept and Friction Angle)

1 SM Shear/Normal Fn. 120 pcf C'=0, Phi'=34
2 SP Shear/Normal Fn. 120 pcf C'=0, Phi'=33
3 CL Shear/Normal Fn. 110 pcf C'=0, Phi'=30
4 SP Shear/Normal Fn. 120 pcf C'=0, Phi'=35
5 CL Shear/Normal Fn. 115 pcf C'=0, Phi'=30
6 SP Shear/Normal Fn. 115 pcf C'=0, Phi'=35
7 CL Shear/Normal Fn. 115 pcf C'=0, Phi'=30
8 SM-SC Shear/Normal Fn. 120 pcf C'=0, Phi'=36
9 GP Shear/Normal Fn. 130 pcf C'=0, Phi'=36
10 SB Wall Shear/Normal Fn. 100 pcf C'=300 psf, Phi'=0
11 Clay Cap Shear/Normal Fn. 120 pcf C'=100 psf, Phi'=32
12 Regrade SM Shear/Normal Fn. 120 pcf C'=0, Phi'=35
13 Compacted Berm, SM Shear/Normal Fn. 120 pcf C'=0, Phi'=35

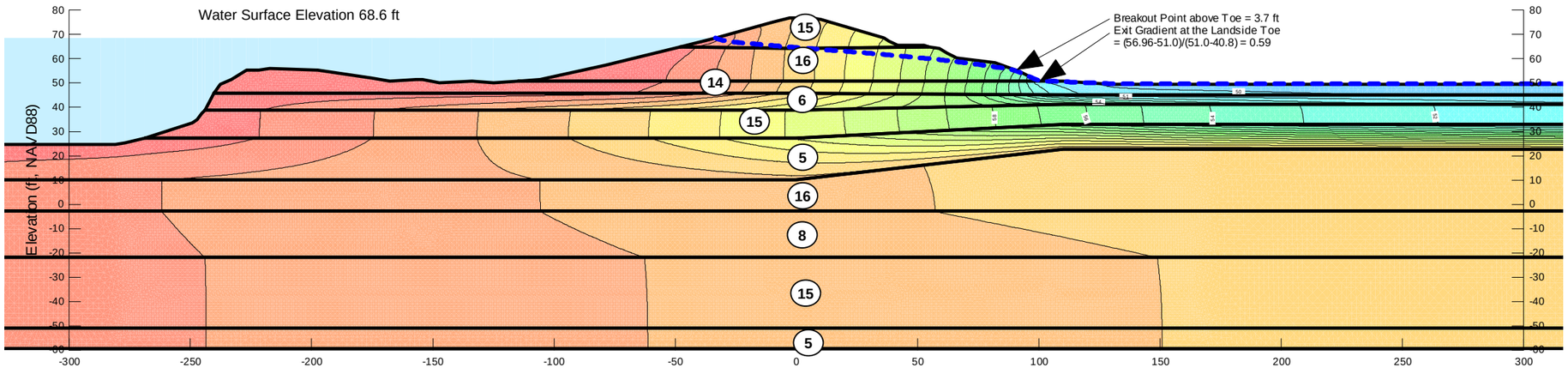
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/07/2011	DRAWN NT ANALYZED NT CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 08, Section at Sta. 623+86 Alternative 2: Seepage Berm and Shallow Cutoff Wall WSE at 200yr+4 ft	FIGURE B08-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



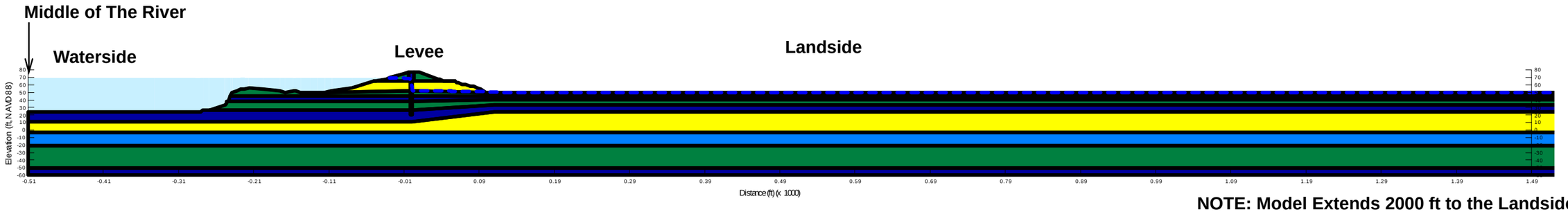
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

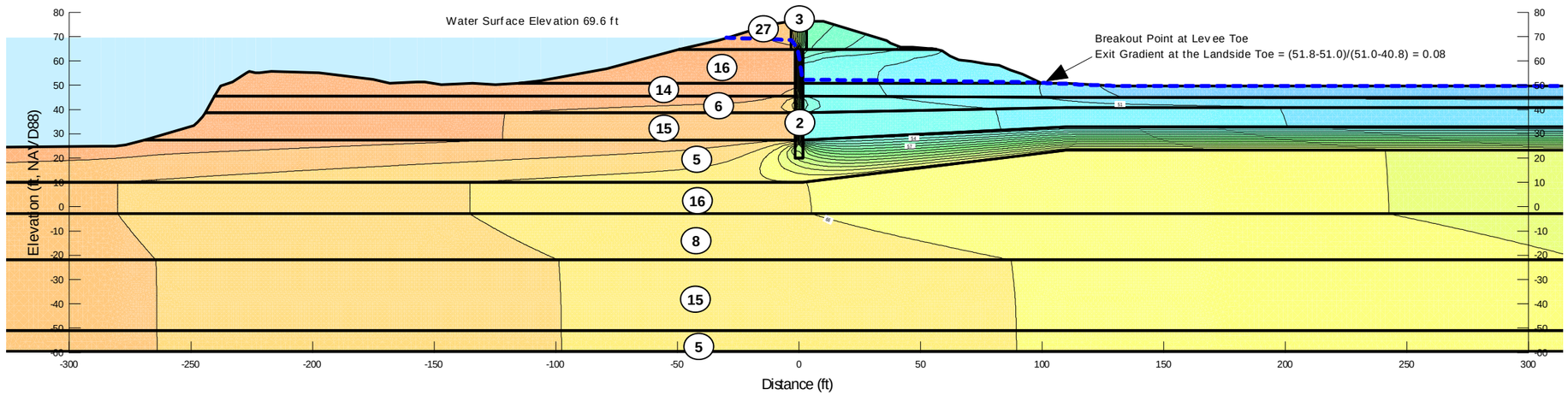
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NT TASK ORDER 1 / ANALYZED NT DATE 2/8/2011 / CHECKED MHW	STEADY-STATE SEEPAGE ANALYSIS Reach 09, Section at Sta. 705+84 Existing Conditions WSE at 200yr	FIGURE B09-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



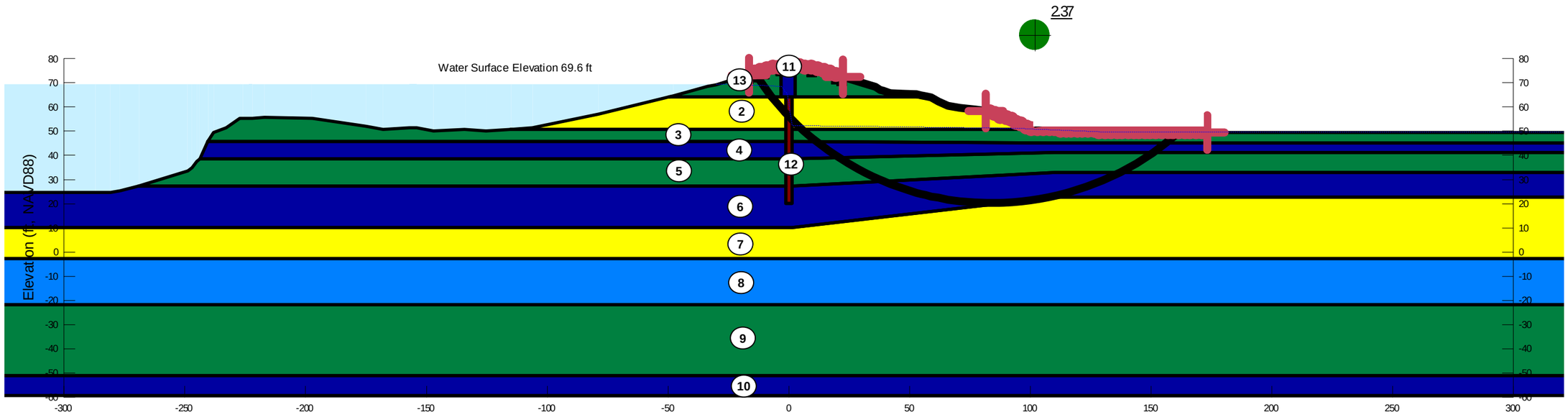
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(1) Slurry Wall (SCB or CB),		Kh=0.0028 ft/day	(=1x10-6 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade SM,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NT TASK ORDER 1 / ANALYZED NT DATE 2/8/2011 / CHECKED MHW	STEADY-STATE SEEPAGE ANALYSIS Reach 09, Section at Sta. 705+84 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B09-A1

Slope Stability Analysis Results, Critical Slip Surface

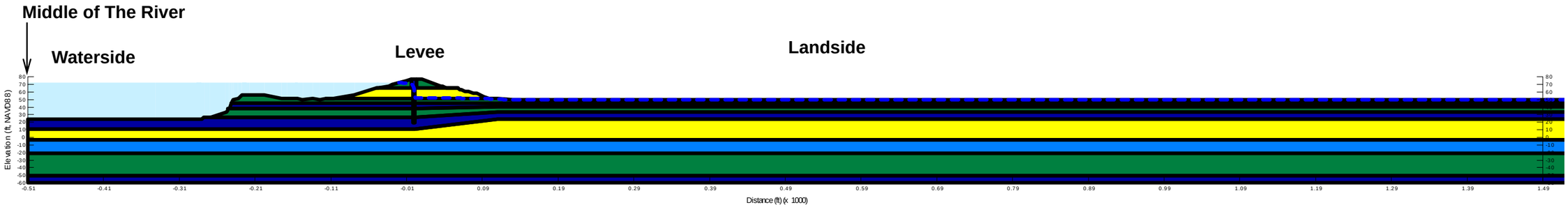


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

2 SP-SM 120 pcf C'=0, Phi'=32
3 SM 120 pcf C'=0, Phi'=35
4 CL 115 pcf C'=100, Phi'=31
5 SP-SM 120 pcf C'=0, Phi'=35
6 CL-ML 120 pcf C'=100, Phi'=31
7 SP-SM 120 pcf C'=0, Phi'=36
8 ML 115 pcf C'=50, Phi'=32
9 SM 120 pcf C'=0, Phi'=36
10 CL 115 pcf C'=0, Phi'=30
11 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
12 SB Wall 100 pcf C'=300, Phi'=0
13 Regrade SM 120 pcf C'=0, Phi'=35

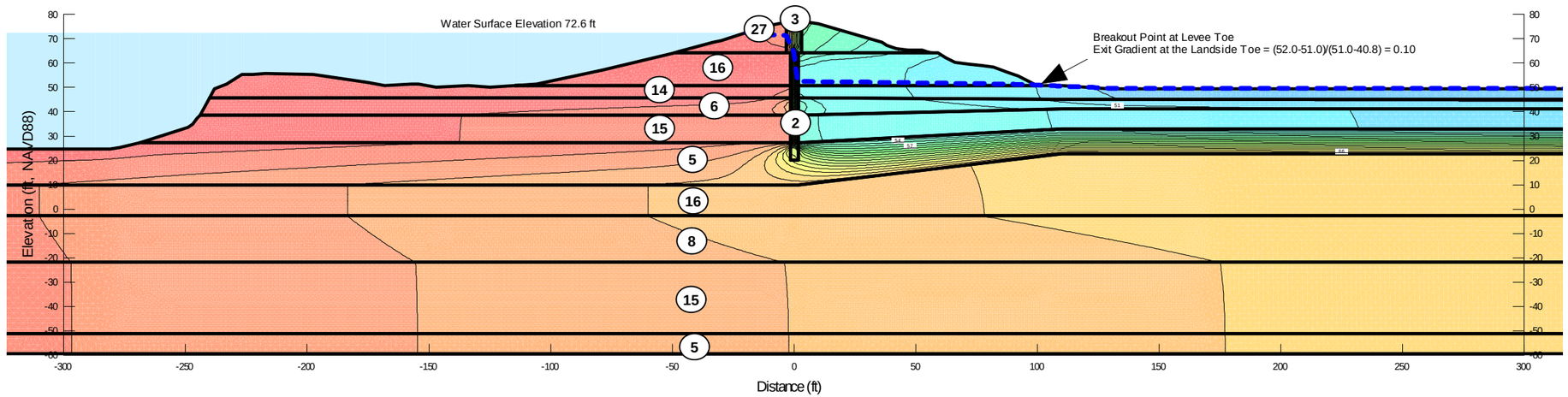
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 09, Section at Sta. 705+84 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B09-A2
			DATE 2/8/2011	CHECKED MHW	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



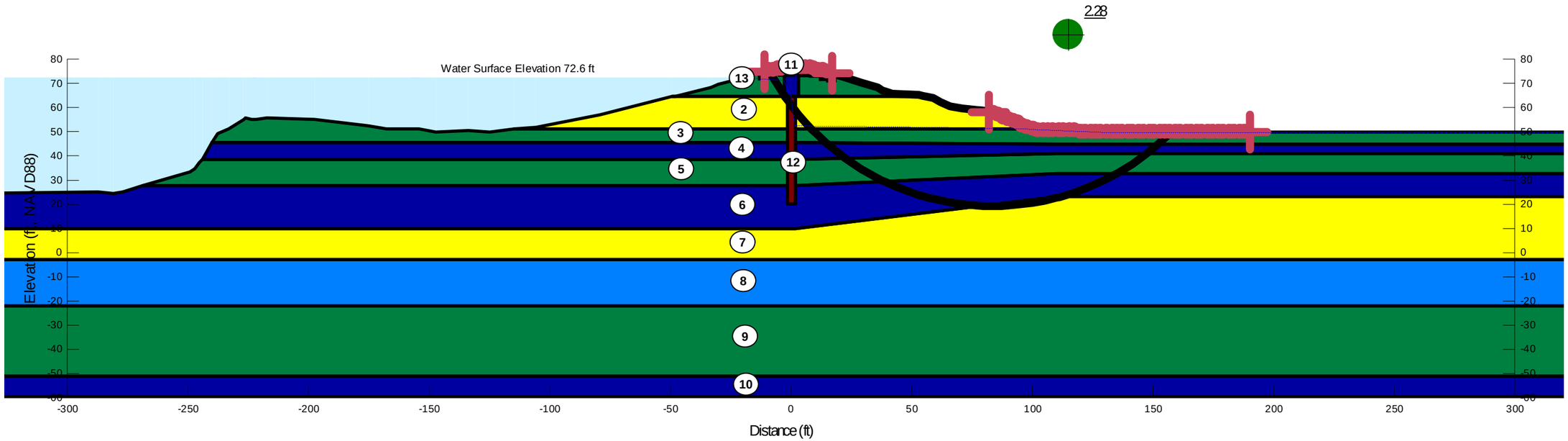
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(1) Slurry Wall (SCB or CB),		Kh=0.0028 ft/day	(=1x10-6 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade SM,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NT TASK ORDER 1 / ANALYZED NT DATE 2/8/2011 / CHECKED MHW	STEADY-STATE SEEPAGE ANALYSIS Reach 09, Section at Sta. 705+84 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B09-A3

Slope Stability Analysis Results, Critical Slip Surface



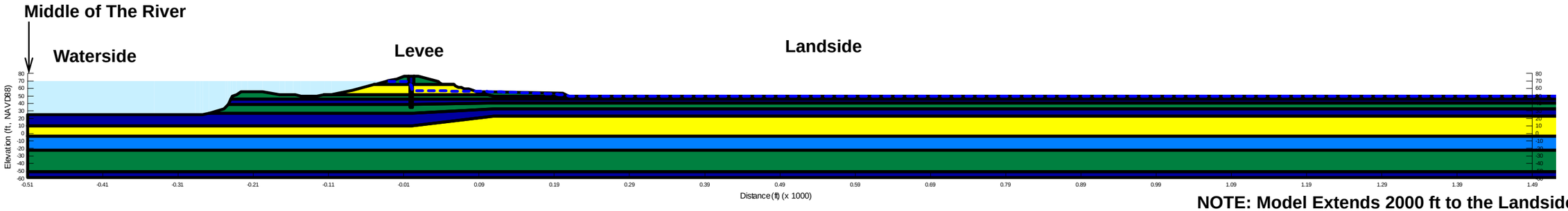
Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

2	SP-SM	120 pcf	C'=0, Phi'=32
3	SM	120 pcf	C'=0, Phi'=35
4	CL	115 pcf	C'=100, Phi'=31
5	SP-SM	120 pcf	C'=0, Phi'=35
6	CL-ML	120 pcf	C'=100, Phi'=31
7	SP-SM	120 pcf	C'=0, Phi'=36
8	ML	115 pcf	C'=50, Phi'=32
9	SM	120 pcf	C'=0, Phi'=36
10	CL	115 pcf	C'=0, Phi'=30
11	New Compacted Clay Levee, Clay Cap	120 pcf	C'=100, Phi'=32
12	SB Wall	100 pcf	C'=300, Phi'=0
13	Regrade SM	120 pcf	C'=0, Phi'=35

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 09, Section at Sta. 705+84 Alternative 1: Cutoff Wall WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	
			DATE 2/8/2011	CHECKED MHW	

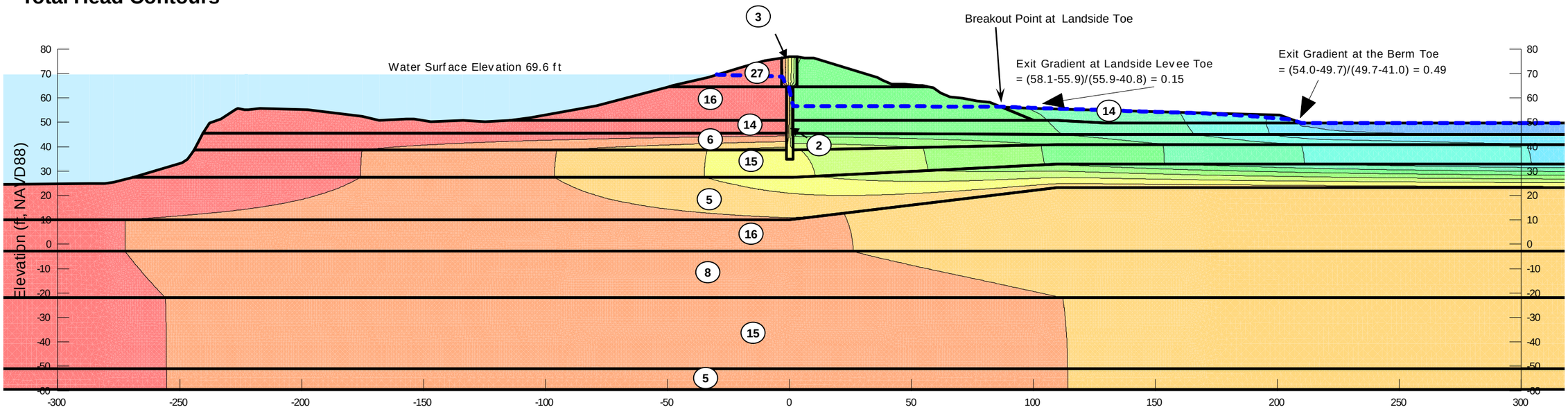
FIGURE B09-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



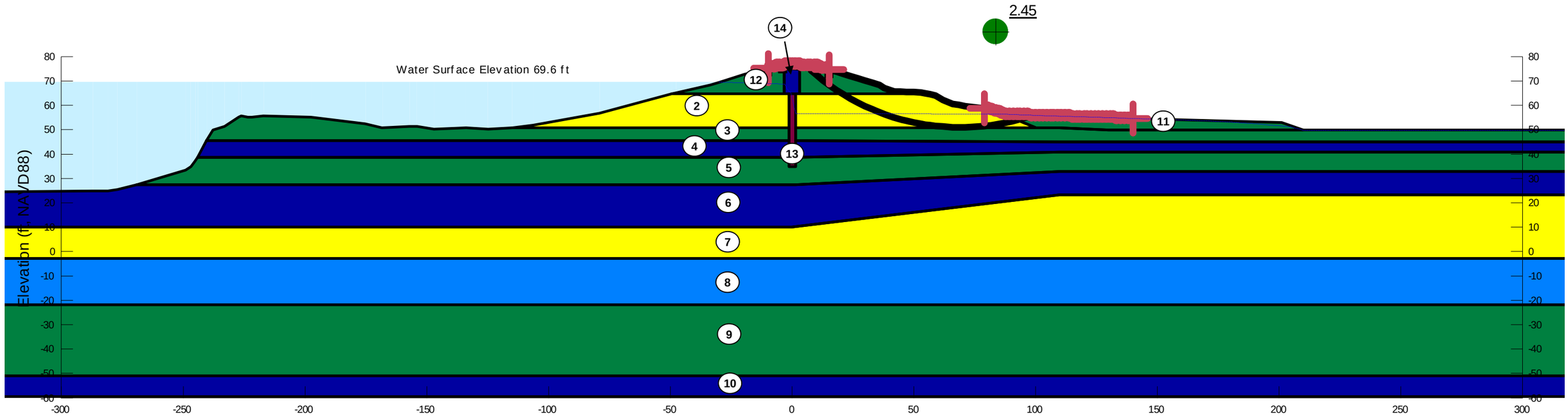
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade Fill,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NT TASK ORDER 1 / ANALYZED NT DATE 02/09/2011 / CHECKED MHW	STEADY-STATE SEEPAGE ANALYSIS Reach 09, Section at Sta. 705+84 Alternative 2: Cutoff Wall and Seepage Berm WSE at 200yr+1 ft	FIGURE B09-A5

Slope Stability Analysis Results,
Critical Slip Surface

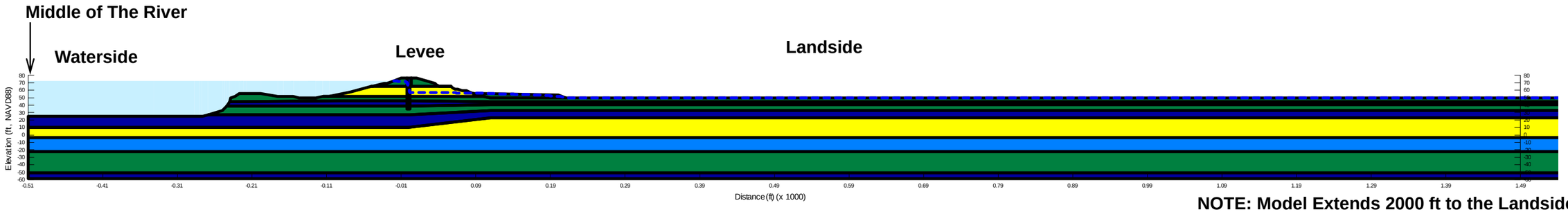


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 SM 120 pcf C'=0, Phi'=32
2 SP-SM 120 pcf C'=0, Phi'=32
3 SM 120 pcf C'=0, Phi'=35
4 CL 115 pcf C'=100, Phi'=31
5 SP-SM 120 pcf C'=0, Phi'=35
6 CL-ML 120 pcf C'=100, Phi'=31
7 SP-SM 120 pcf C'=0, Phi'=36
8 ML 115 pcf C'=50, Phi'=32
9 SM 120 pcf C'=0, Phi'=36
10 CL 115 pcf C'=0, Phi'=30
11 Compacted Berm 120 pcf C'=0, Phi'=35
13 SB Wall 100 pcf C'=0, Phi'=35
14 Compacted Levee, Clay Cap 120 pcf C'=100, Phi'=32

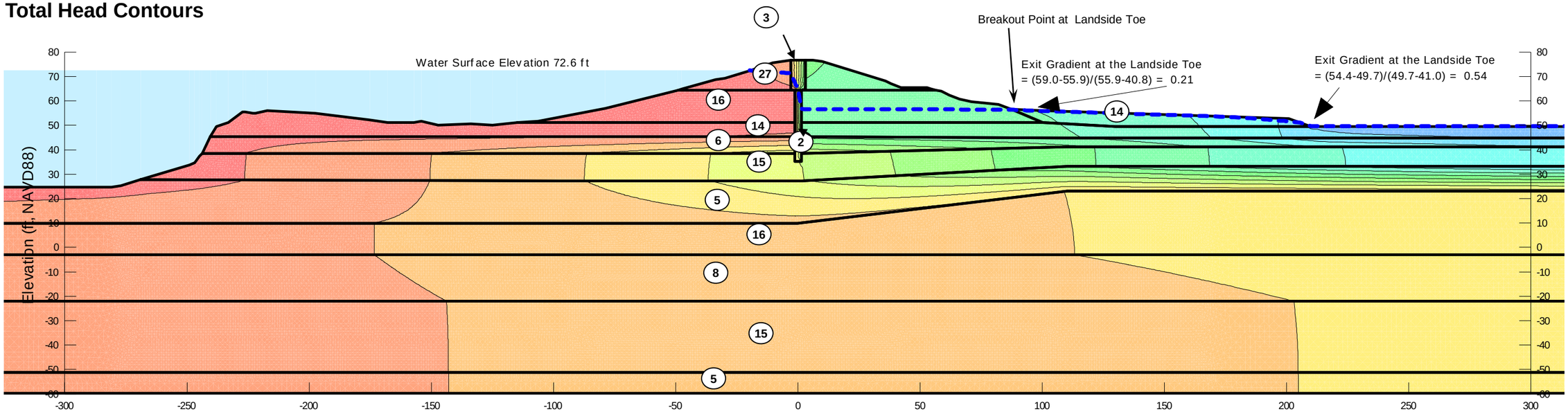
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 09, Section at Sta. 705+84 Alternative 2: Cutoff Wall and Seepage Berm WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B09-A6
			DATE 02/09/2011	CHECKED MHW	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



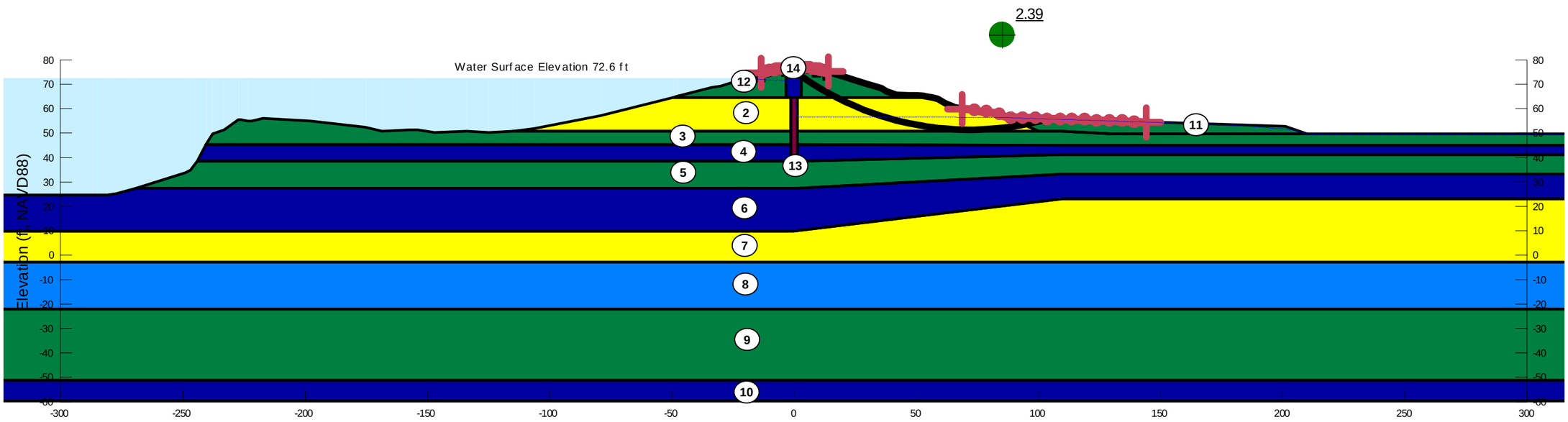
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade Fill,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NT TASK ORDER 1 / ANALYZED NT DATE 02/09/2011 / CHECKED MHW	STEADY-STATE SEEPAGE ANALYSIS Reach 09, Section at Sta. 705+84 Alternative 2: Cutoff Wall and Seepage Berm WSE at 200yr+4 ft	FIGURE B09-A7

Slope Stability Analysis Results,
Critical Slip Surface

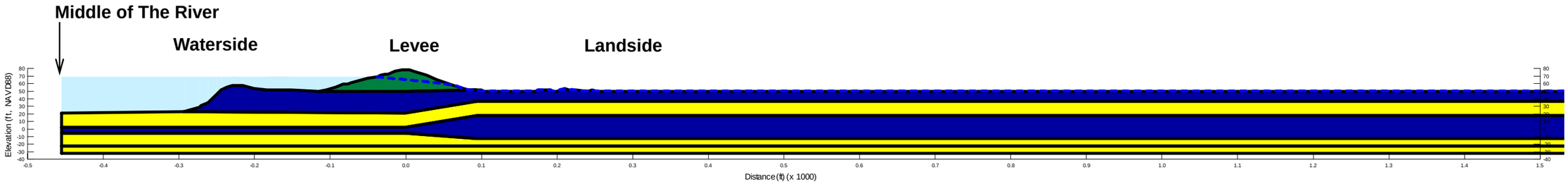


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

2 SP-SM 120 pcf C'=0, Phi'=32
3 SM 120 pcf C'=0, Phi'=35
4 CL 115 pcf C'=100, Phi'=31
5 SP-SM 120 pcf C'=0, Phi'=35
6 CL-ML 120 pcf C'=100, Phi'=31
7 SP-SM 120 pcf C'=0, Phi'=36
8 ML 115 pcf C'=50, Phi'=32
9 SM 120 pcf C'=0, Phi'=36
10 CL 115 pcf C'=0, Phi'=30
11 Compacted Berm 120 pcf C'=0, Phi'=35
12 Regrade SM 120 pcf C'=300, Phi'=0
13 SB Wall 100 pcf C'=0, Phi'=35
14 Compacted Levee, Clay Cap 120 pcf C'=100, Phi'=32

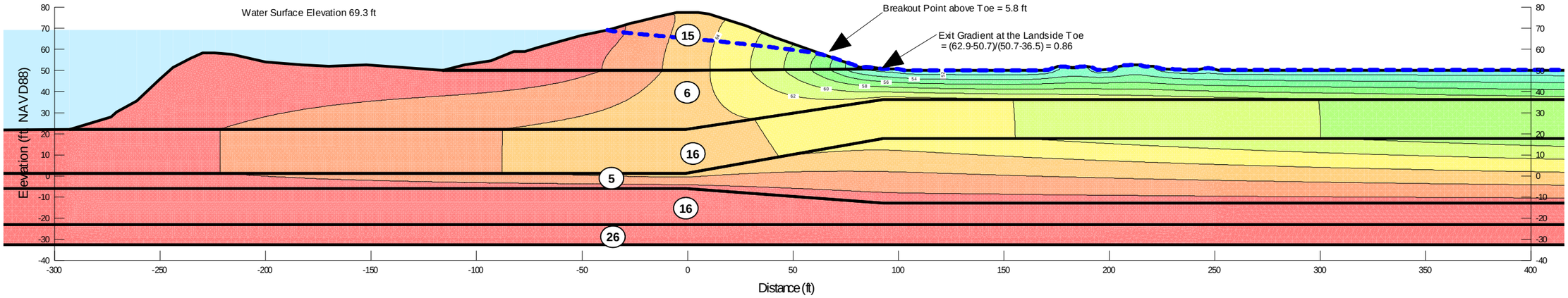
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 09, Section at Sta. 705+84 Alternative 2: Cutoff Wall and Seepage Berm WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B09-A8
			DATE 02/09/2011	CHECKED MHW	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



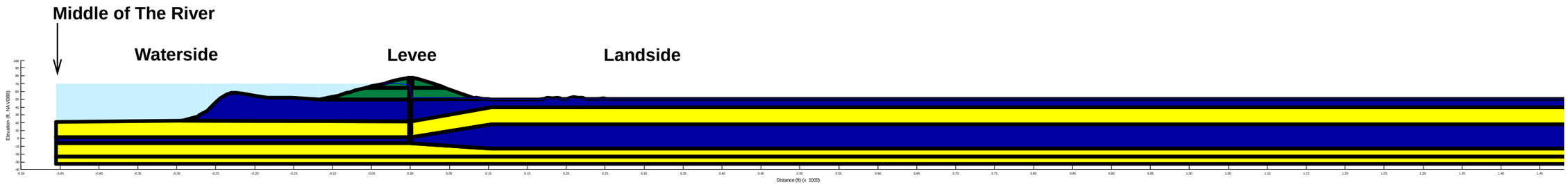
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

NOTE: Head Contour Interval 2.0 ft

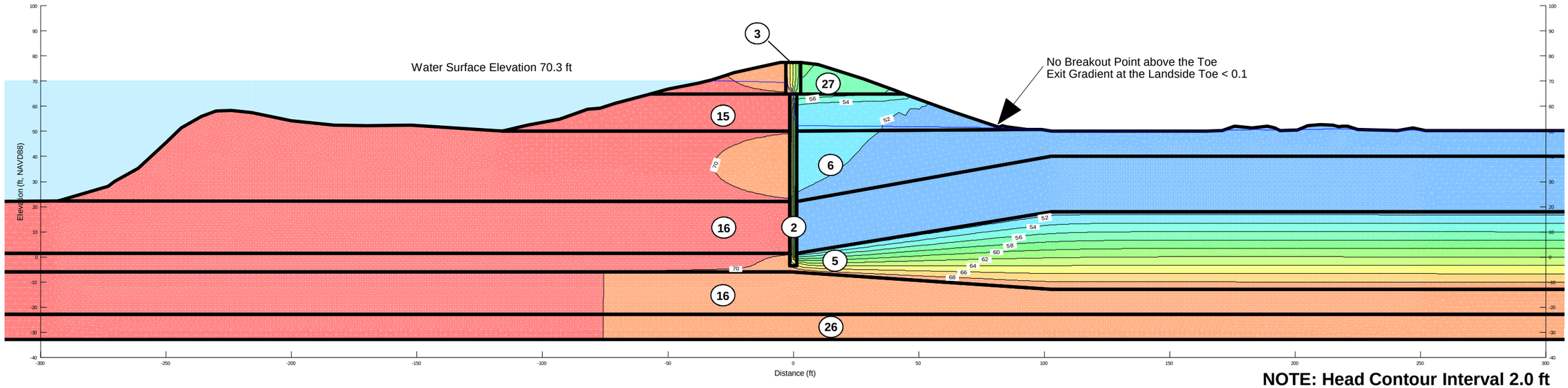
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 10, Section at Sta. 733+84 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED NT	FIGURE B10-E1
			DATE 2/8/2011	CHECKED GTH	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



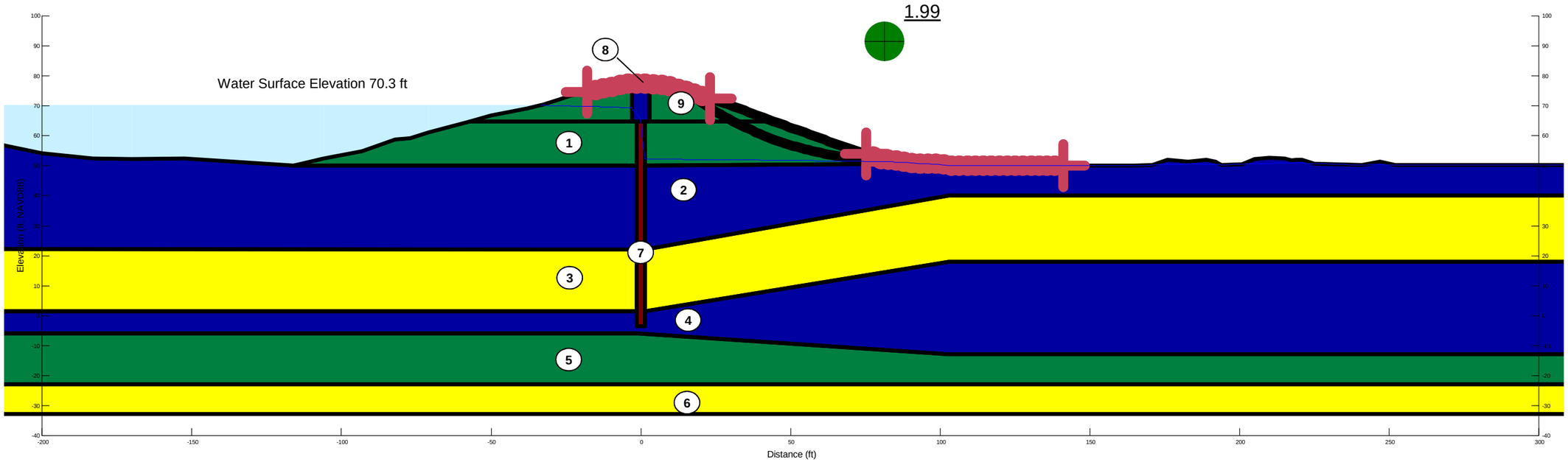
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day (=3x10-2 cm/s)	0.25
(27) Regrade SM		Kh=0.085 ft/day (=3x10-5cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 10, Section at Sta. 733+84 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B10-A1
			DATE 2/8/2011	CHECKED GTH	

Slope Stability Analysis Results, Critical Slip Surface

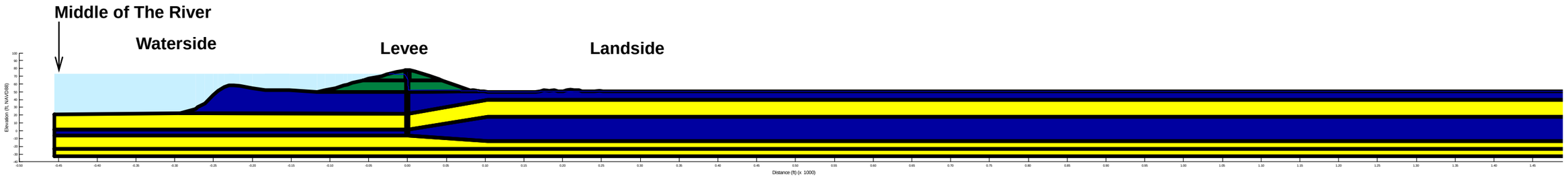


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 SM C'=0, Phi'=34
2 CL C'=100 psf, Phi'=31
3 SM/SP C'=0, Phi'=33
4 CL C'=100 psf, Phi'=31
5 SP-SM C'=0, Phi'=36
6 GW C'=0, Phi'=36
7 SB Wall C'=300 psf, Phi'=0
8 Clay Cap C'=100 psf, Phi'=32
9 Regraded SM C'=0, Phi'=35

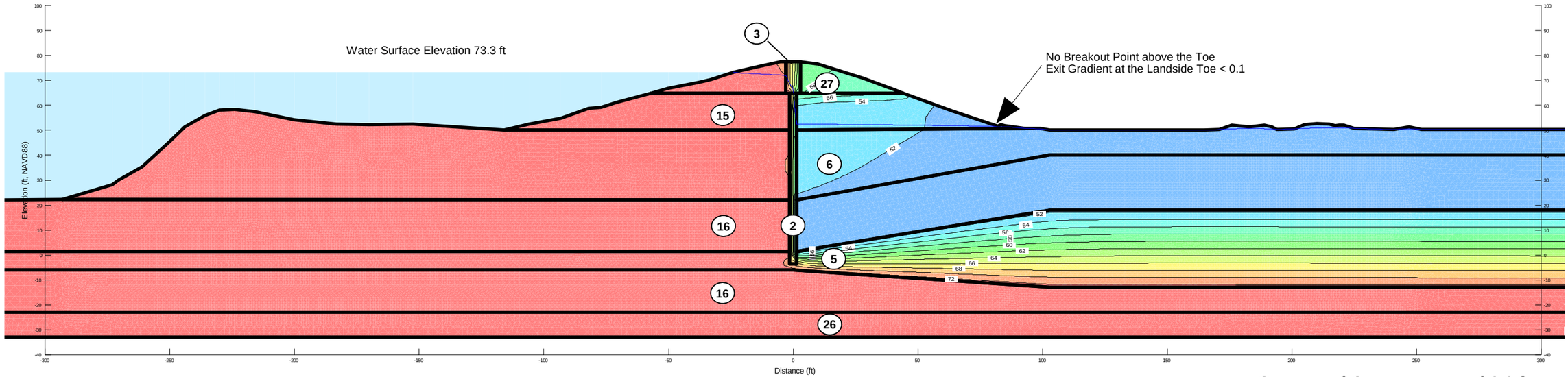
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 10, Section at Sta. 733+84 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B10-A2
			TASK ORDER 1	ANALYZED NT		
			DATE 2/8/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



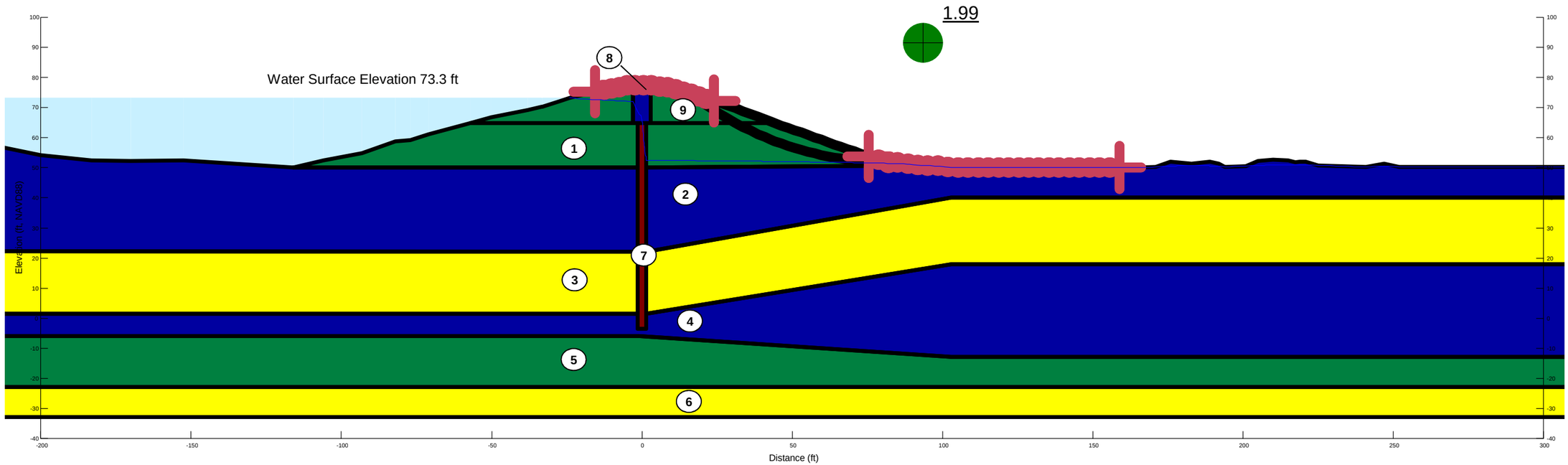
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day (=3x10-2 cm/s)	0.25
(27) Regrade SM		Kh=0.085 ft/day (=3x10-5cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 10, Section at Sta. 733+84 Alternative 1: Cutoff Wall WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B10-A3
			DATE 2/8/2011	CHECKED GTH	

Slope Stability Analysis Results, Critical Slip Surface

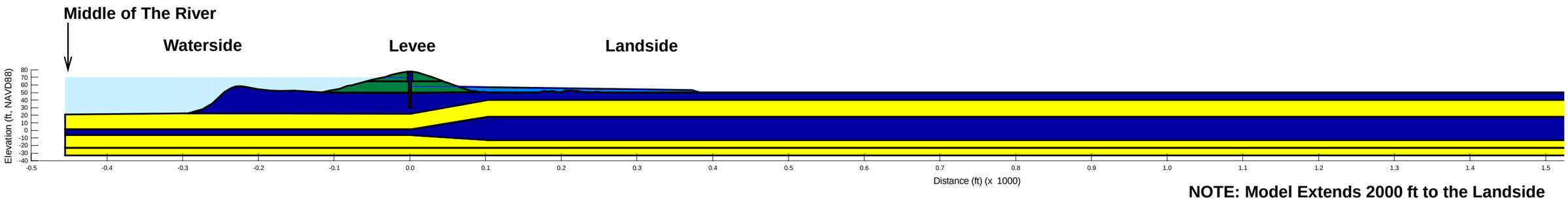


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 SM C'=0, Phi'=34
2 CL C'=100 psf, Phi'=31
3 SM/SP C'=0, Phi'=33
4 CL C'=100 psf, Phi'=31
5 SP-SM C'=0, Phi'=36
6 GW C'=0, Phi'=36
7 SB Wall C'=300 psf, Phi'=0
8 Clay Cap C'=100 psf, Phi'=32
9 Regraded SM C'=0, Phi'=35

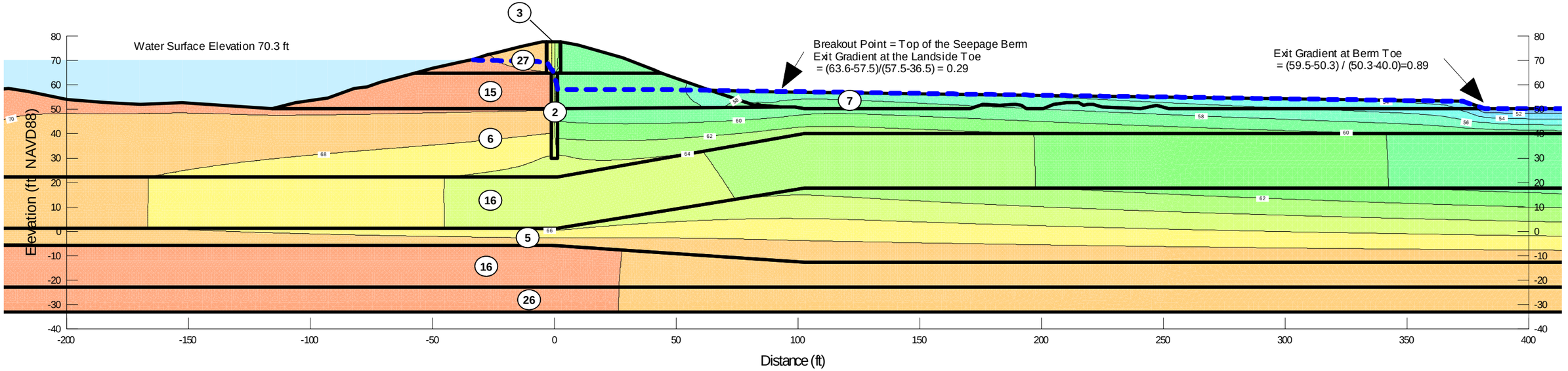
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/8/2011	DRAWN NT ANALYZED NT CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 10, Section at Sta. 733+84 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B10-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



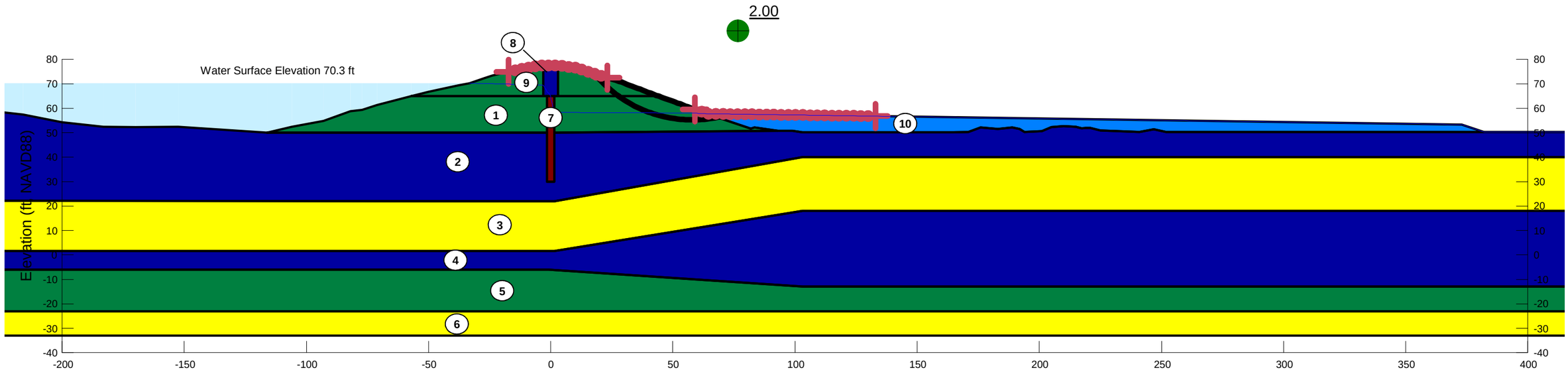
Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(2) Slurry Wall (SB),	Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(15) Silty Sand to Sand, 13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand, 8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade SM	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 10, Section at Sta. 733+84 Alternative 2: Seepage Berm with Shallow Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B10-A5
			DATE 2/8/2011	CHECKED GTH	

Slope Stability Analysis Results, Critical Slip Surface

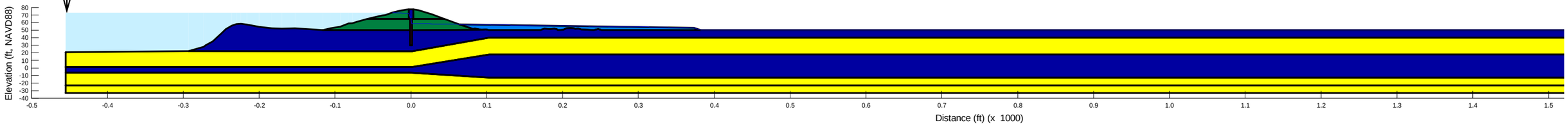


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 SM C'=0, Phi'=34
2 CL C'=100 psf, Phi'=31
3 SM/SP C'=0, Phi'=33
4 CL C'=100 psf, Phi'=31
5 SP-SM C'=0, Phi'=36
6 GW C'=0, Phi'=36
7 SB Wall C'=300 psf, Phi'=0
8 Clay Cap C'=100 psf, Phi'=32
10 Compacted Berm, ML C'=50 psf, Phi'=32
9 Regrade SM C'=0, Phi'=35

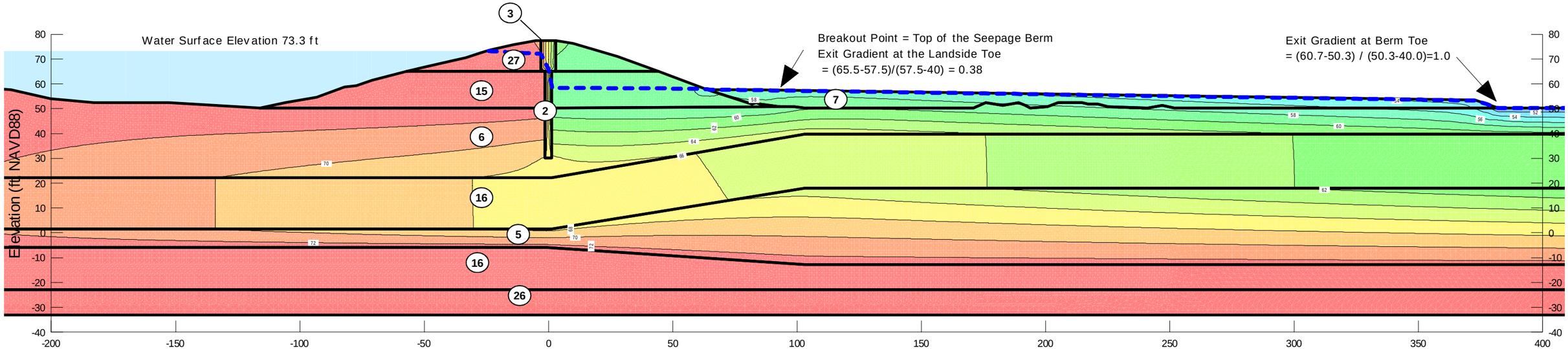
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 10, Section at Sta. 733+84 Alternative 2: Seepage Berm with Shallow Cutoff Wall WSE at 200yr+1 ft	FIGURE B10-A6
			TASK ORDER 1	ANALYZED NT		
			DATE 02/08/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



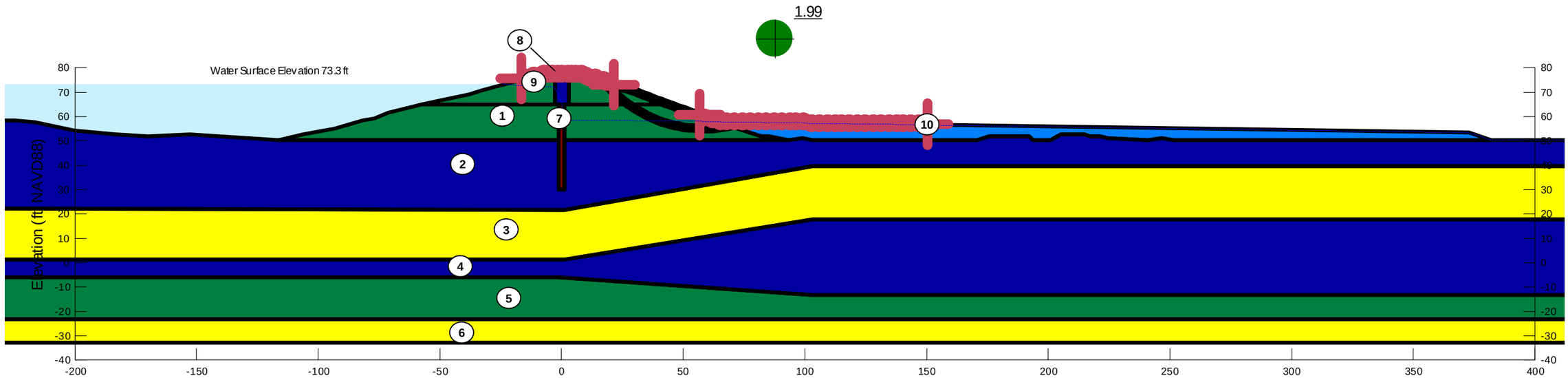
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),	Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(15) Silty Sand to Sand, 13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand, 8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade SM	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 10, Section at Sta. 733+84 Alternative 2: Seepage Berm with Shallow Cutoff Wall WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	
			DATE 02/08/2011	CHECKED GTH	FIGURE B10-A7

Slope Stability Analysis Results, Critical Slip Surface

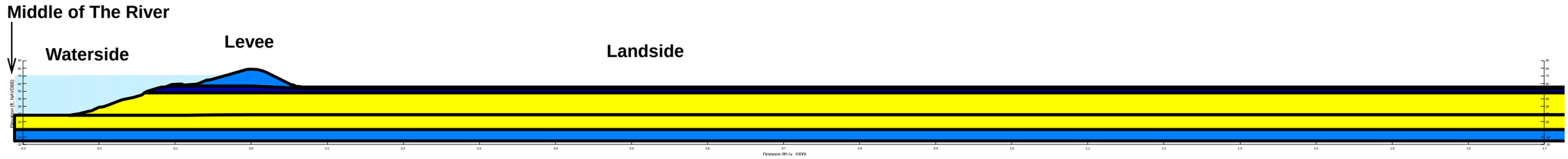


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 SM C'=0, Phi'=34
2 CL C'=100 psf, Phi'=31
3 SM/SP C'=0, Phi'=33
4 CL C'=100 psf, Phi'=31
5 SP-SM C'=0, Phi'=36
6 GW C'=0, Phi'=36
7 SB Wall C'=300 psf, Phi'=0
8 Clay Cap C'=100 psf, Phi'=32
10 Compacted Berm, ML C'=50 psf, Phi'=32
9 Regrade SM C'=0, Phi'=35

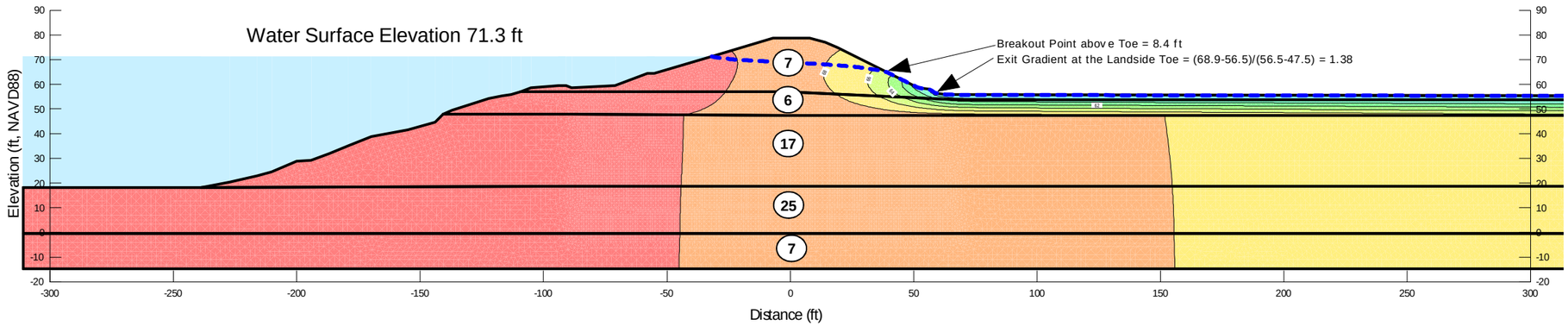
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 10, Section at Sta. 733+84 Alternative 2: Seepage Berm with Shallow Cutoff Wall WSE at 200yr+4 ft	FIGURE B10-A8
			TASK ORDER 1	ANALYZED NT		
			DATE 02/08/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



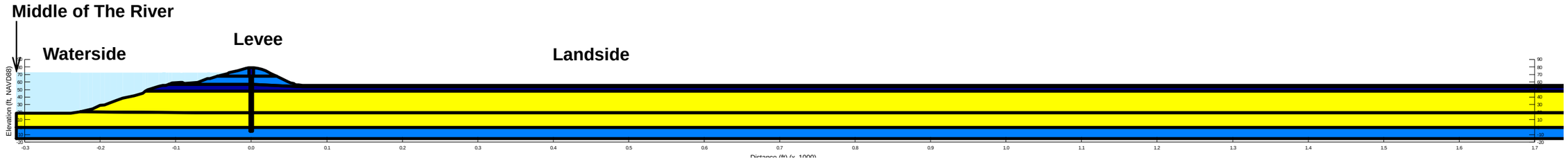
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(25) Silty Gravel to Sandy Gravel, 8- 12% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25

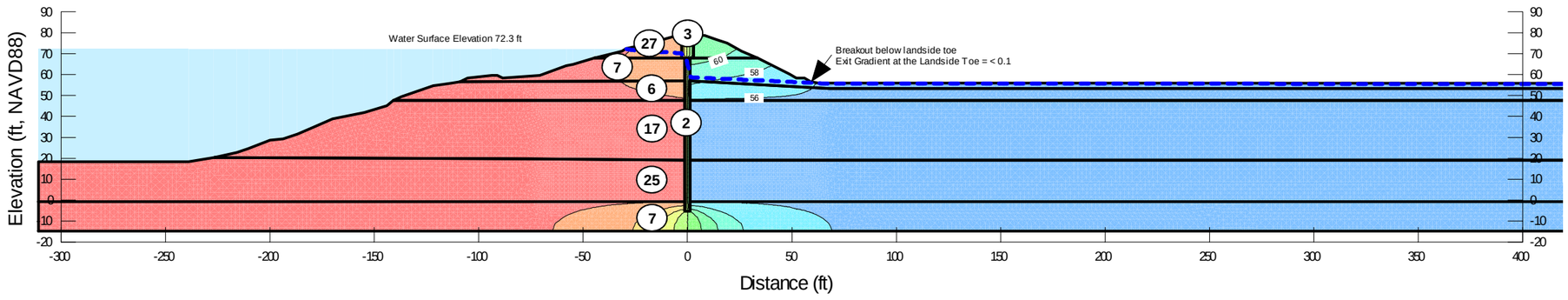
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 11, Section at Sta. 808+85 Existing Conditions WSE at 200yr	FIGURE B11-E1
			TASK ORDER 1	ANALYZED NT		
			DATE 2/9/2011	CHECKED MHW		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



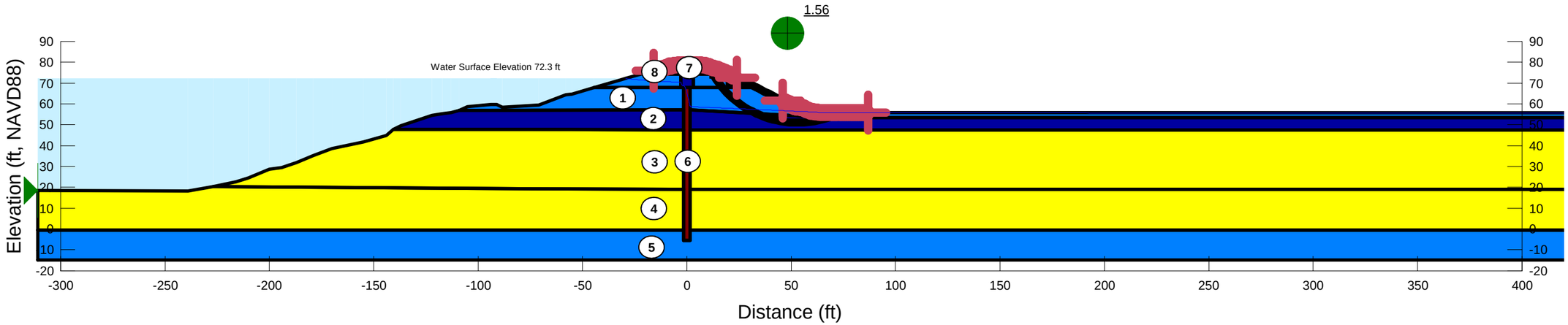
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB), Kh=0.00028 ft/day (=1x10-7 cm/s) 1
(3) New Compacted Clay Levee, Clay Cap Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(25) Silty Gravel to Sandy Gravel, 8- 12% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(27) Regrade SM, Kh=0.085 ft/day (=3x10-5 cm/s) (2) 0.25

NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 11, Section at Sta. 808+85 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B11-A1
			DATE 2/9/2011	CHECKED MHW	

Slope Stability Analysis Results,
Critical Slip Surface

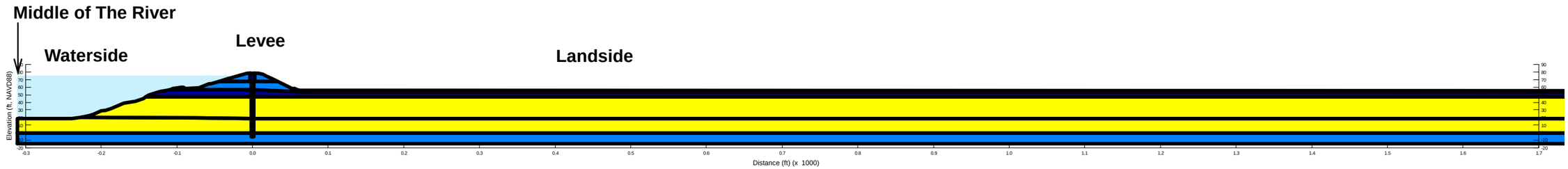


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi'=32
2 CL 115 pcf C'=0, Phi'=30
3 SP 120 pcf C'=0, Phi'=34
4 GM 130 pcf C'=0, Phi'=36
5 ML 115 pcf C'=0, Phi'=32
6 SB Wall 100 pcf C'=300, Phi'=0
7 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
8 Regrade ML 120 pcf C'=50, Phi'=32

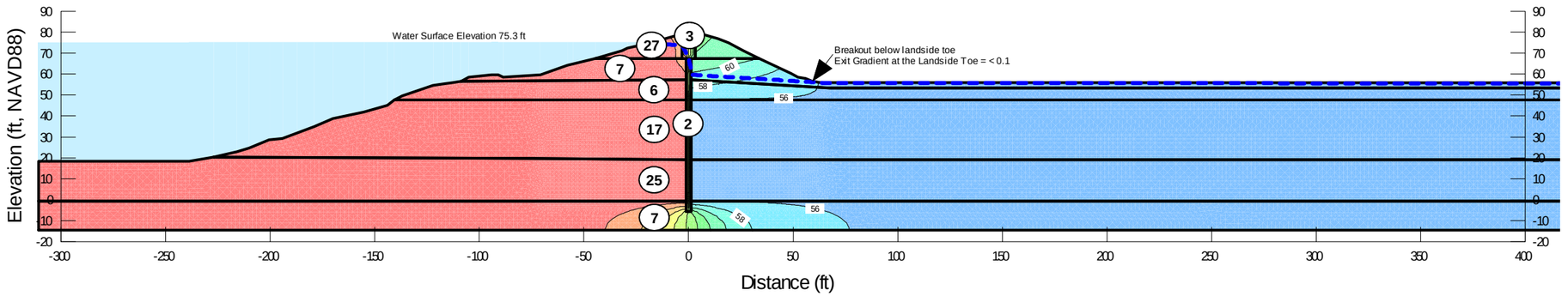
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 11, Section at Sta. 808+85 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B11-A2
			TASK ORDER 1	ANALYZED NT		
			DATE 2/9/2011	CHECKED MHW		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



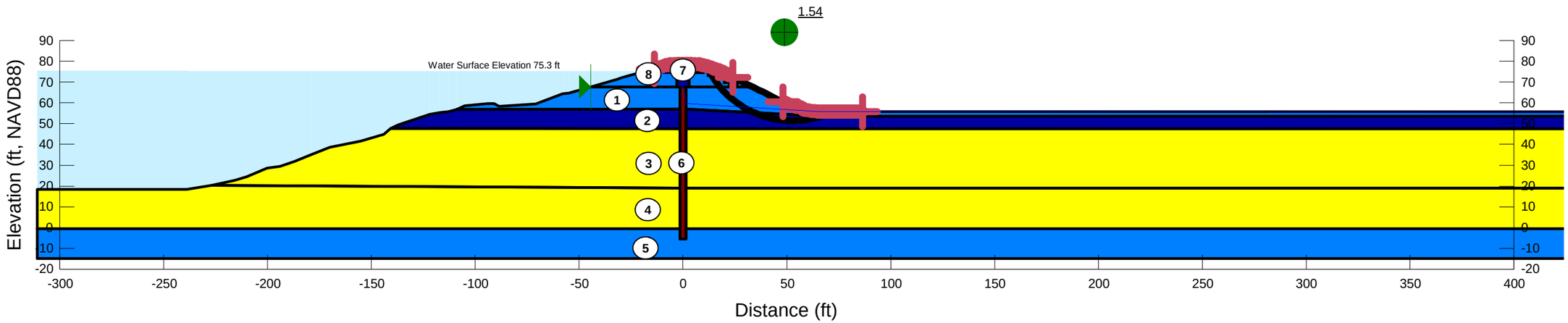
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),	Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee, Clay Cap	Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,	Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,	Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(17) Silty Sand to Sand, 3- 7% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel, 8- 12% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(27) Regrade SM,	Kh=0.085 ft/day (=3x10-5 cm/s) (2)	0.25

NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 11, Section at Sta. 808+85 Alternative 1: Cutoff Wall WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B11-A3
			DATE 2/9/2011	CHECKED MHW	

Slope Stability Analysis Results,
Critical Slip Surface

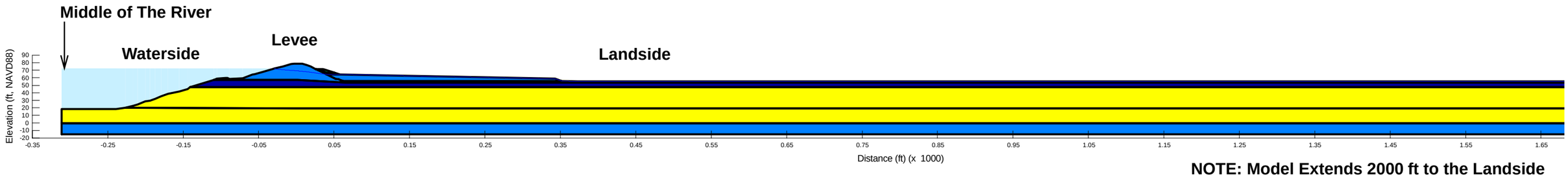


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi'=32
2 CL 115 pcf C'=0, Phi'=30
3 SP 120 pcf C'=0, Phi'=34
4 GM 130 pcf C'=0, Phi'=36
5 ML 115 pcf C'=0, Phi'=32
6 SB Wall 100 pcf C'=300, Phi'=0
7 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
8 Regrade ML 120 pcf C'=50, Phi'=32

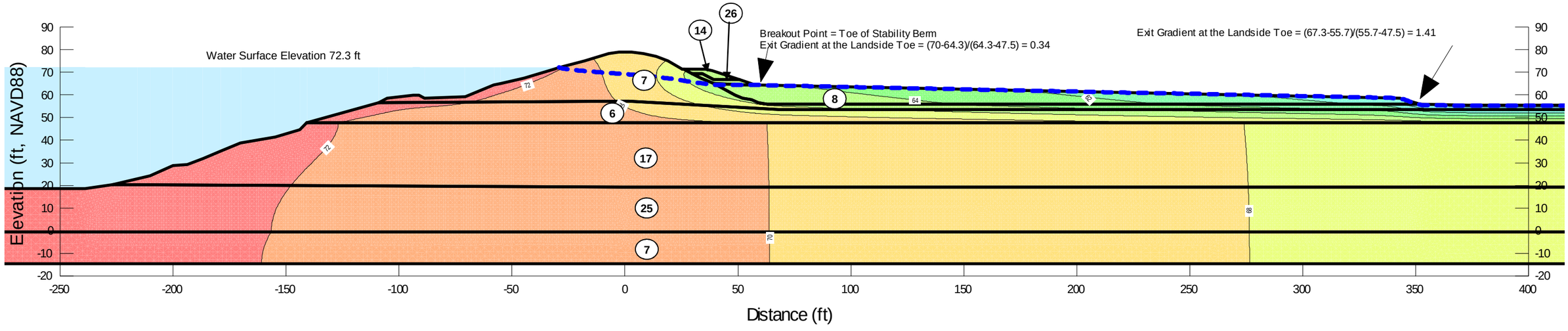
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 11, Section at Sta. 808+85 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B11-A4
			TASK ORDER 1	ANALYZED NT		
			DATE 2/9/2011	CHECKED MHW		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



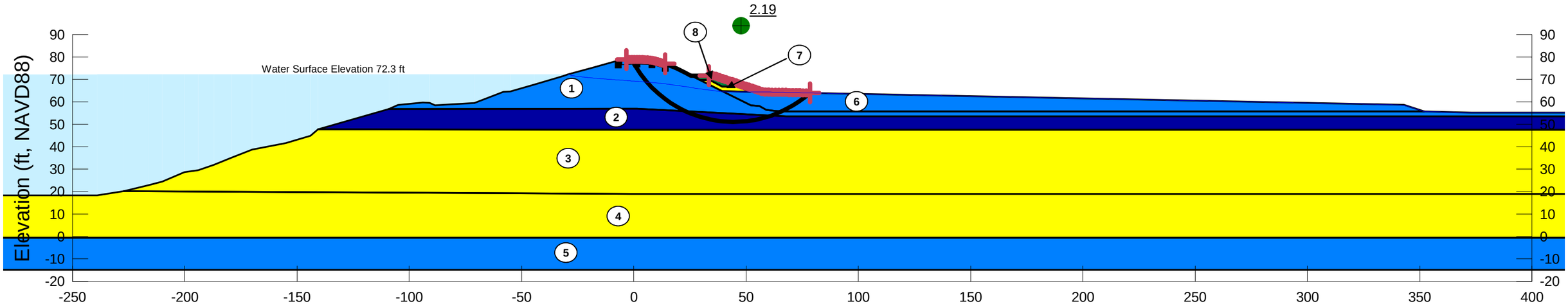
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8-12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NT TASK ORDER 1 / ANALYZED NT DATE 2/9/2011 / CHECKED MHW	STEADY-STATE SEEPAGE ANALYSIS Reach 11, Section at Sta. 808+85 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft	FIGURE B11-A5

Slope Stability Analysis Results, Critical Slip Surface

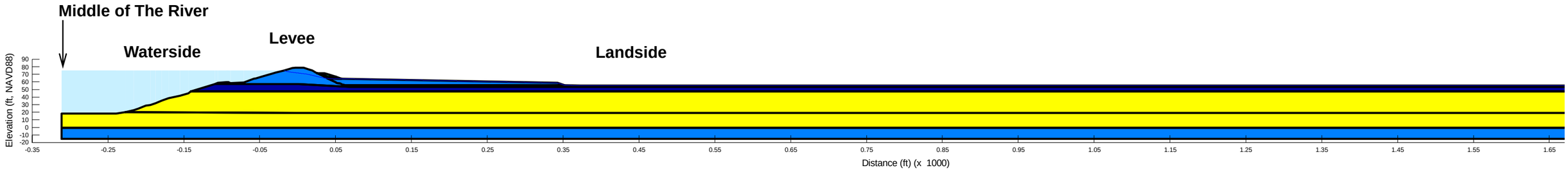


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi'=32
2 CL 115 pcf C'=0, Phi'=30
3 SP 120 pcf C'=0, Phi'=34
4 GM 130 pcf C'=0, Phi'=36
5 ML 115 pcf C'=0, Phi'=32
7 Drainage Material, GP 130 pcf C'=0, Phi'=36
8 SM 120 pcf C'=0, Phi'=35
6 Sandy Silt Berm 120 pcf C'=50, Phi'=32

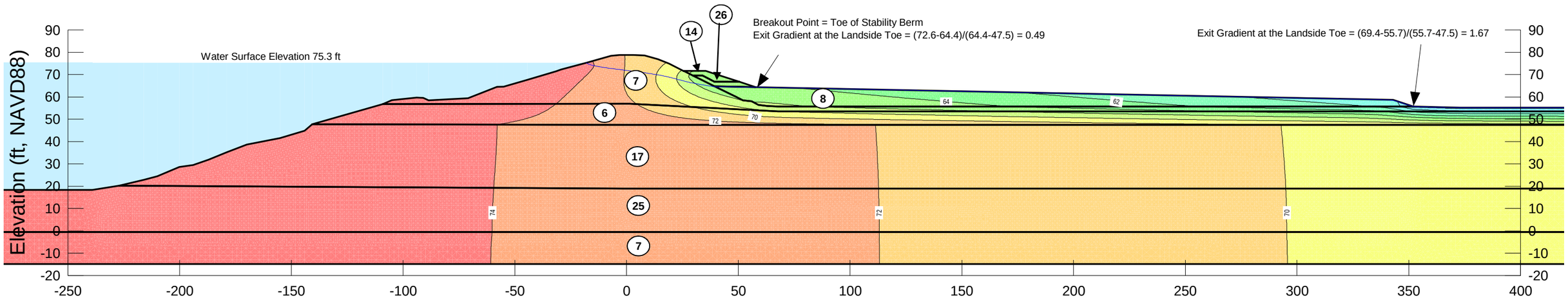
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 11, Section at Sta. 808+85 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B11-A6
			DATE 2/9/2011	CHECKED MHW	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



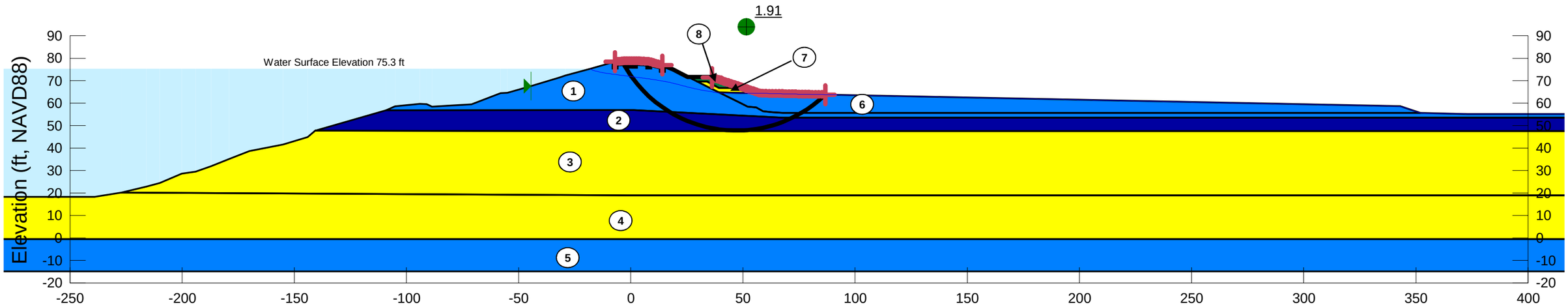
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NT TASK ORDER 1 / ANALYZED NT DATE 2/9/2011 / CHECKED MHW	STEADY-STATE SEEPAGE ANALYSIS Reach 11, Section at Sta. 808+85 Alternative 2: Seepage and Stability Berm WSE at 200yr+4 ft	FIGURE B11-A7

Slope Stability Analysis Results,
Critical Slip Surface

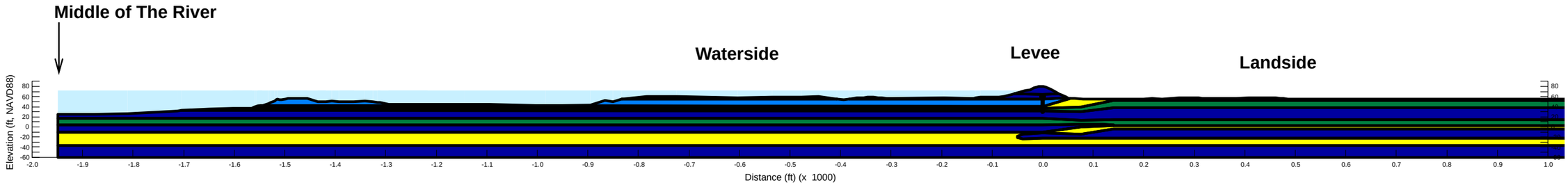


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi'=32
2 CL 115 pcf C'=0, Phi'=30
3 SP 120 pcf C'=0, Phi'=34
4 GM 130 pcf C'=0, Phi'=36
5 ML 115 pcf C'=0, Phi'=32
7 Drainage Material, GP 130 pcf C'=0, Phi'=36
8 SM 120 pcf C'=0, Phi'=35
6 Sandy Silt Berm 120 pcf C'=50, Phi'=32

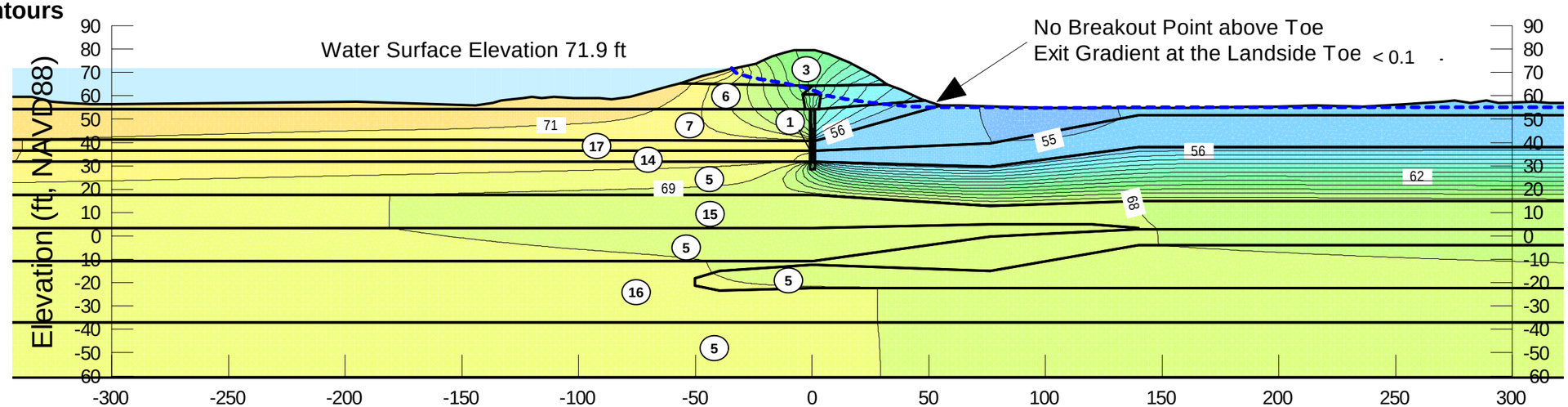
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 11, Section at Sta. 808+85 Alternative 2: Seepage and Stability Berm WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B11-A8
			DATE 2/9/2011	CHECKED MHW	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



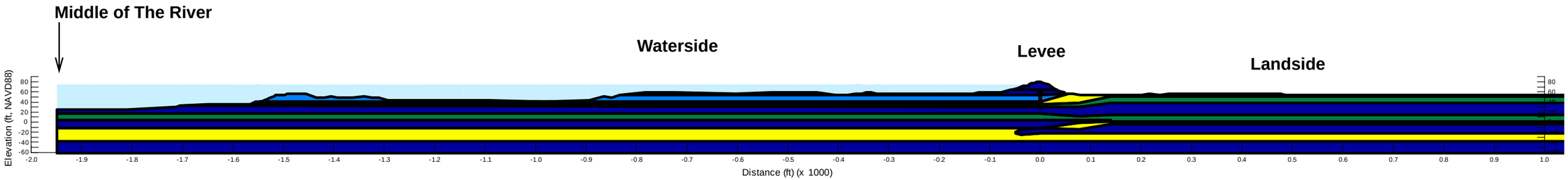
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(1) Slurry Wall (SCB or CB), Kh=0.0028 ft/day (=1x10-6 cm/s) 1
(3) New Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(5) Silty Sand to Sand, 30-49% fines, 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(9) Silty Sand to Sand, 8- 12% fines, 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25

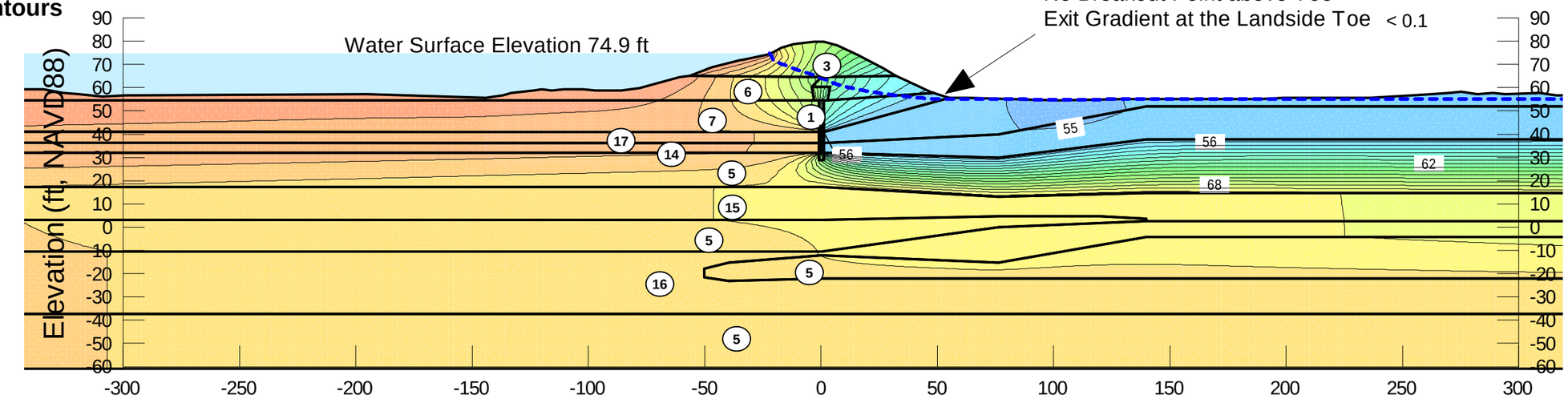
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 12, Section at Sta. 830+59 Existing Conditions WSE at 200yr	FIGURE B12-E1
			TASK ORDER 1	ANALYZED MW and MC		
			DATE 02/08/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



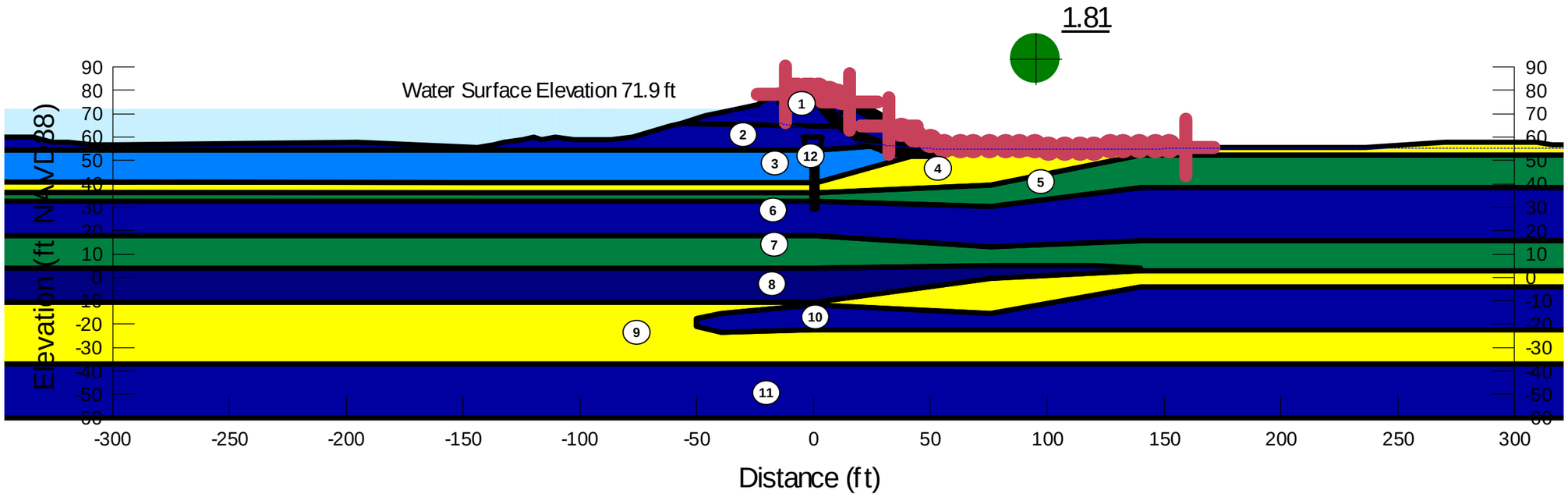
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anistropic Ratio (Kv/Kh)

(1) Slurry Wall (SCB or CB), Kh=0.0028 ft/day (=1x10-6 cm/s) 1
(3) New Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(5) Silty Sand to Sand, 30-49% fines, 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(9) Silty Sand to Sand, 8- 12% fines, 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/08/2011	DRAWN MW ANALYZED MW and MC CHECKED GTH	STEADY-STATE SEEPAGE ANALYSIS Reach 12, Section at Sta. 830+59 Existing Conditions WSE at 200yr+3 ft	FIGURE B12-E2

Slope Stability Analysis Results,
Critical Slip Surface

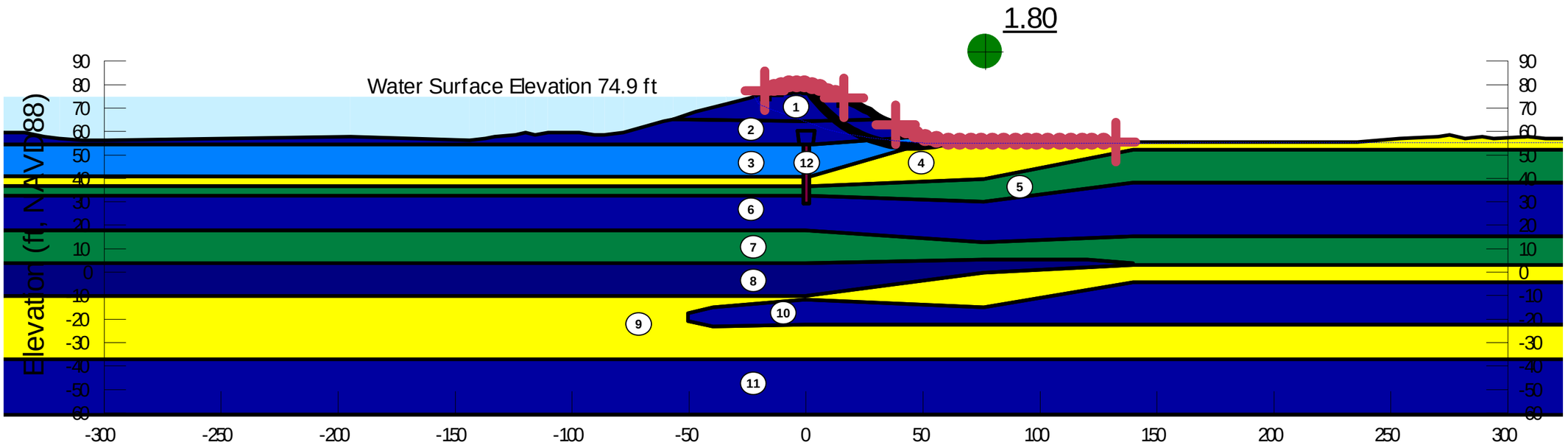


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 120 pcf C'=100, Phi'=32
2 CL 115 pcf C'=100, Phi'=31
3 ML 115 pcf C'=50, Phi'=32
4 SP 120 pcf C'=0, Phi'=36
5 SM 120 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100, Phi'=31
7 SM 125 pcf C'=0, Phi'=36
8 CL 120 pcf C'=100, Phi'=31
9 SW-SM 125 pcf C'=0, Phi'=36
10 CL 120 pcf C'=100, Phi'=31
11 CL 120 pcf C'=100, Phi'=31
12 SCB Wall 100 pcf C'=300, Phi'=0

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 12, Section at Sta. 830+59 Existing Conditions WSE at 200yr	FIGURE B12-E3
			TASK ORDER 1	ANALYZED MW and MC		
			DATE 02/08/2011	CHECKED GTH		

Slope Stability Analysis Results,
Critical Slip Surface

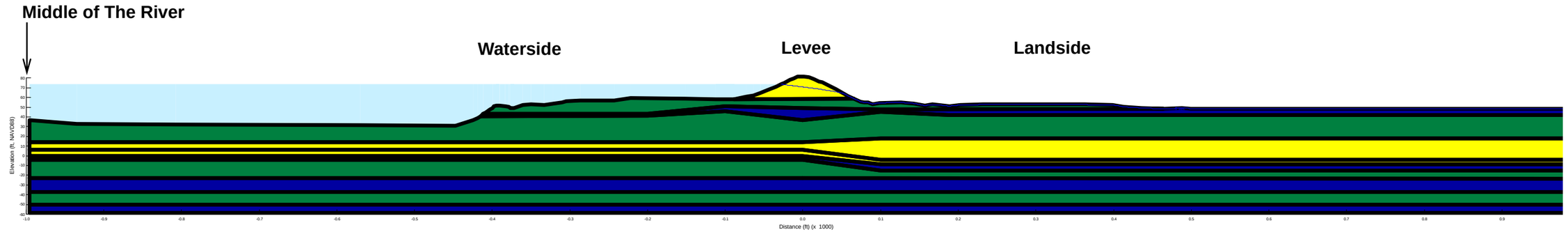


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 120 pcf C'=100, Phi'=32
2 CL 115 pcf C'=100, Phi'=31
3 ML 115 pcf C'=50, Phi'=32
4 SP 120 pcf C'=0, Phi'=36
5 SM 120 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100, Phi'=31
7 SM 125 pcf C'=0, Phi'=36
8 CL 120 pcf C'=100, Phi'=31
9 SW-SM 125 pcf C'=0, Phi'=36
10 CL 120 pcf C'=100, Phi'=31
11 CL 120 pcf C'=100, Phi'=31
12 SCB Wall 100 pcf C'=300, Phi'=0

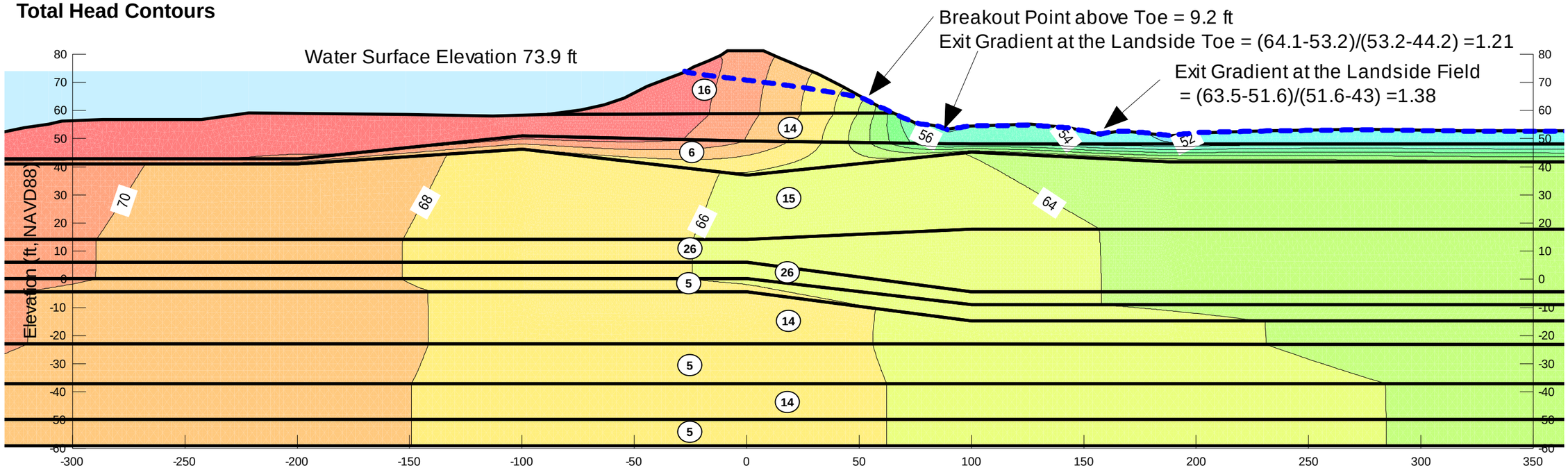
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 12, Section at Sta. 830+59 Existing Conditions WSE at 200yr+3 ft
			TASK ORDER 1	ANALYZED MW and MC	
			DATE 02/08/2011	CHECKED GTH	FIGURE B12-E4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



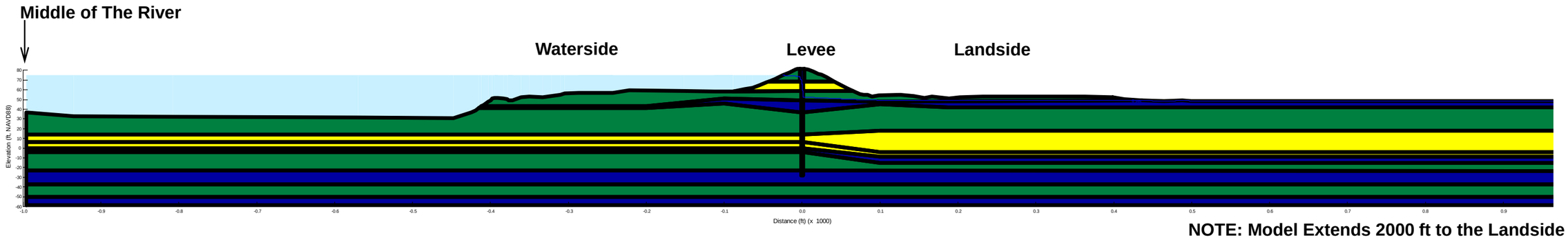
Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

NOTE: Head Contour Interval 2.0 ft

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(14) Silty Sand to Sand, 30-49% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

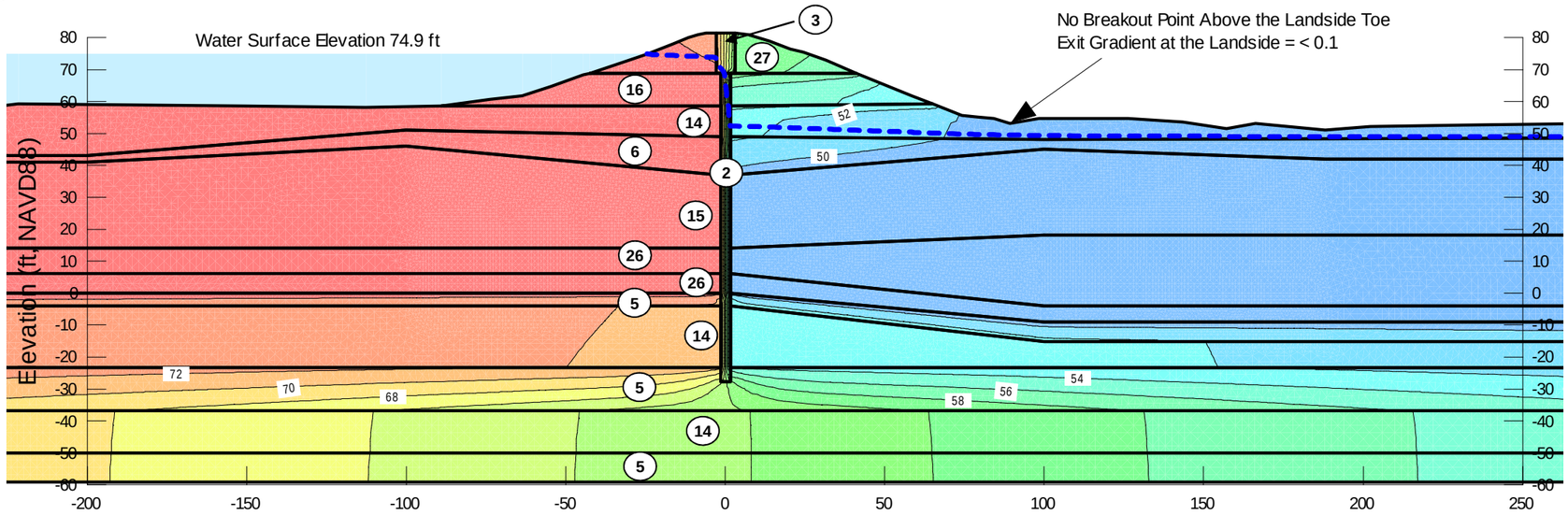
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / TASK ORDER 1 / DATE 02/09/2011	DRAWN NT / ANALYZED NT / CHECKED GTH	STEADY-STATE SEEPAGE ANALYSIS Reach 13, Section at Sta. 861+33 Existing Conditions WSE at 200yr	FIGURE B13-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



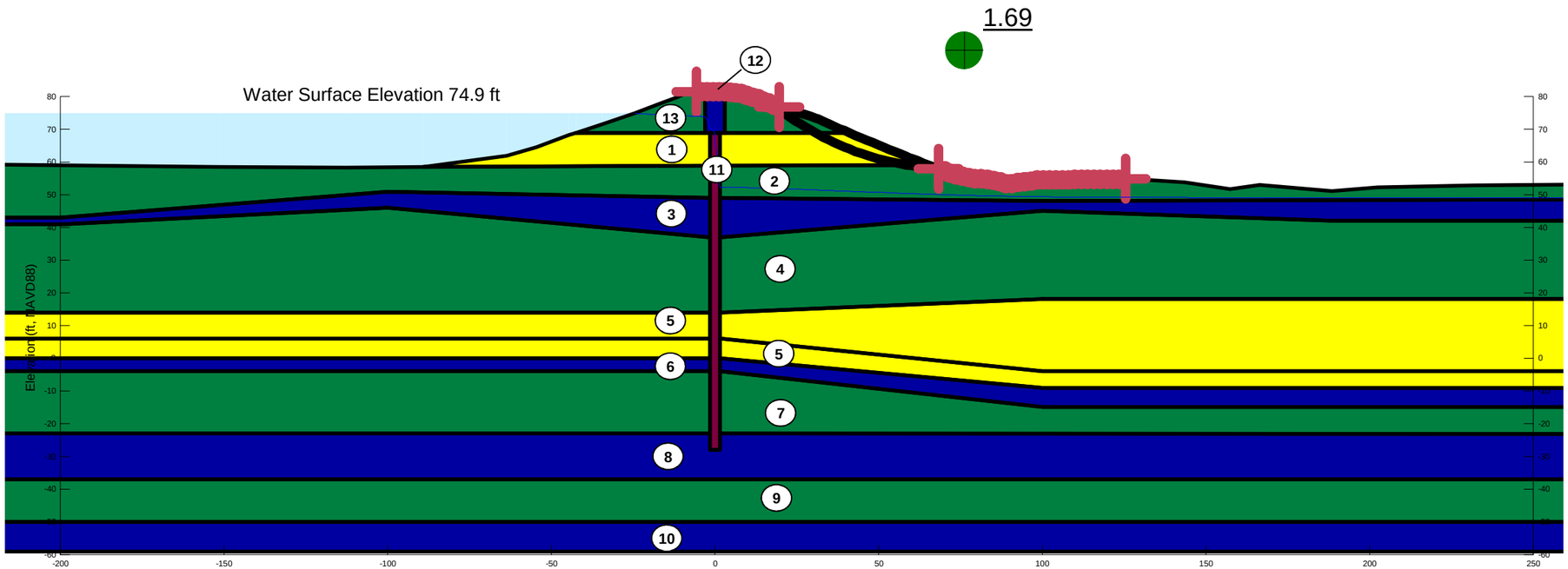
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),	Kh=0.00028 ft/day	(=1x10-7 cm/s)	(2) Clay	1
(3) New Compacted Clay Levee,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	(3) Clay	0.25
(5) Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	(5) Clay	0.25
(6) Clay Blanket,	Kh=0.028 ft/day	(=1x10-5 cm/s)	(6) Clay	0.25
(14) Silty Sand to Sand, 30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	(14) Sand	0.25
(15) Silty Sand to Sand, 13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	(15) Sand	0.25
(16) Silty Sand to Sand, 8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	(16) Sand	0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	(26) Gravel	0.25
(27) Regrade SM,	Kh=0.085 ft/day	(=3x10-5 cm/s)	Regrade Fill SM	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 13, Section at Sta. 861+33 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B13-A1
			TASK ORDER 1	ANALYZED NT		
			DATE 02/09/2011	CHECKED GTH		

Slope Stability Analysis Results,
Critical Slip Surface

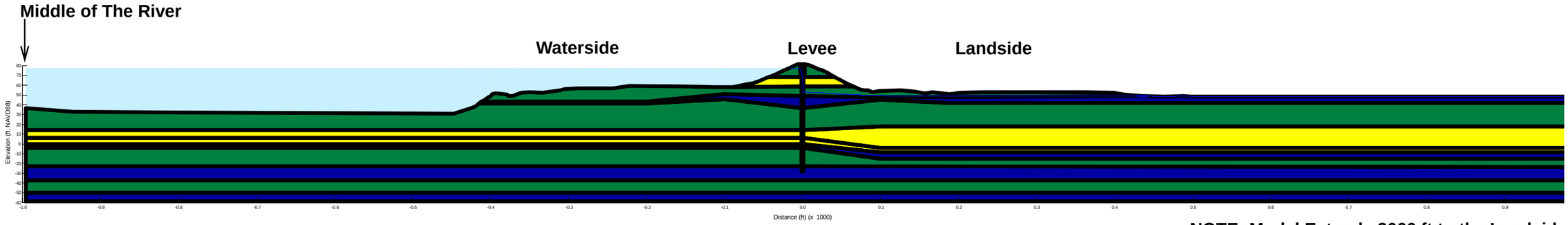


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 SP 120 pcf C'=0, Phi'=32
2 SM 120 pcf C'=0, Phi'=35
3 CL 120 pcf C'=100 psf, Phi'=31
4 SM-SP 125 pcf C'=0, Phi'=34
5 GW-GP 125 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100 psf, Phi'=31
7 SM-SP 120 pcf C'=0, Phi'=36
8 CL 120 pcf C'=100 psf, Phi'=31
9 SM 125 pcf C'=0, Phi'=34
10 CL 125 pcf C'=100 psf, Phi'=31
13 Regrade SM 120 pcf C'=0, Phi'=35
11 SB Wall 100 pcf C'=300 psf, Phi'=0
12 Clay Cap 120 pcf C'=100 psf, Phi'=32

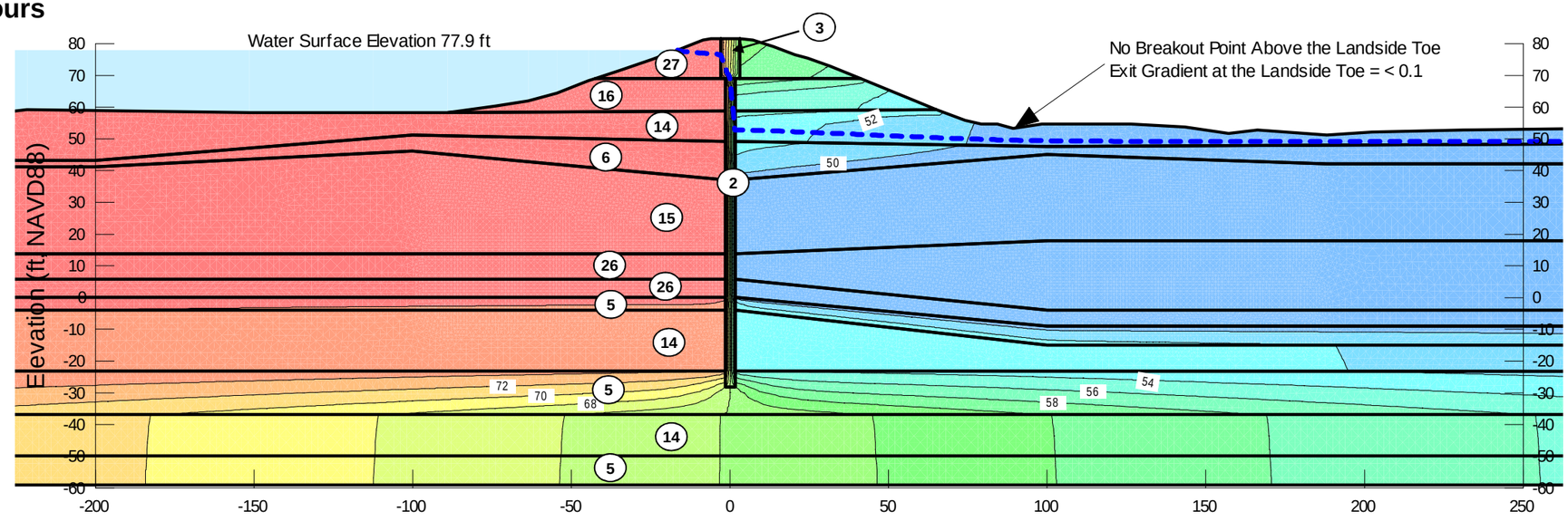
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 13, Section at Sta. 861+33 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B13-A2
			TASK ORDER 1	ANALYZED NT		
			DATE 02/09/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



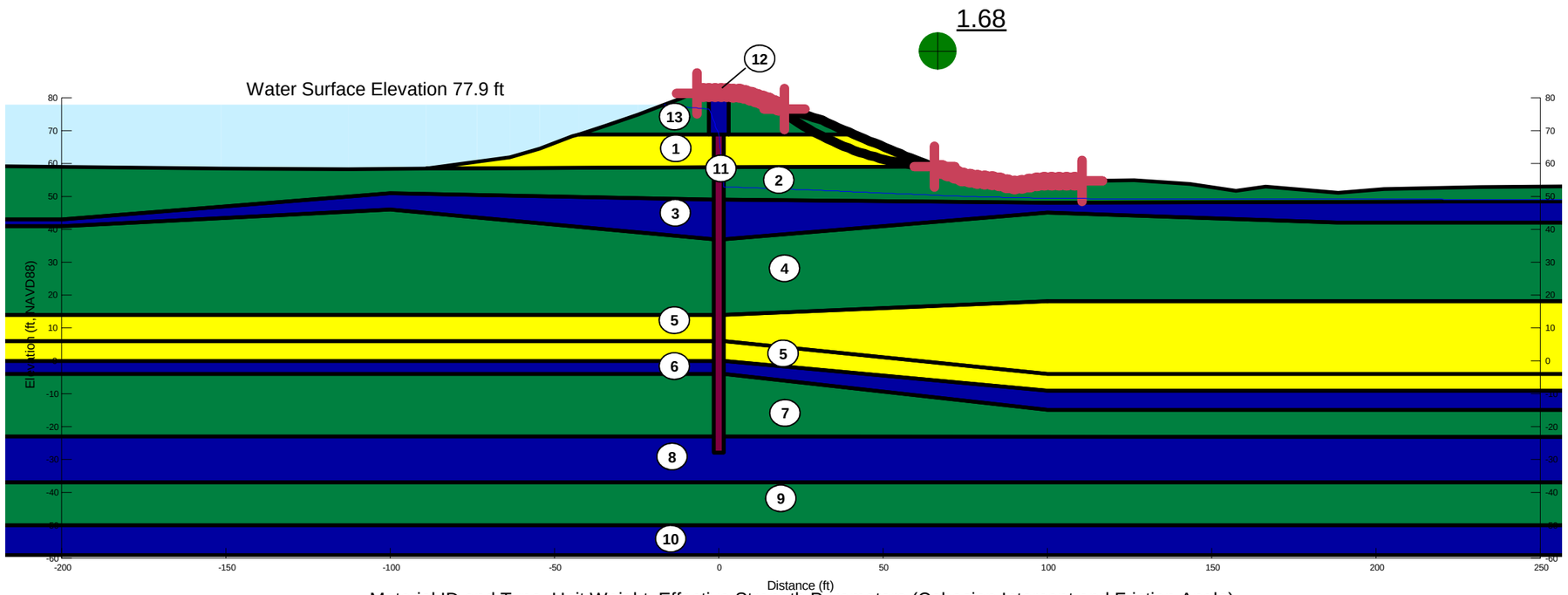
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand, 30-49% fines,		Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day (=3x10-2 cm/s)	0.25
(27) Regrade SM,		Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 13, Section at Sta. 861+33 Alternative 1: Cutoff Wall WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B13-A3
			DATE 02/09/2011	CHECKED GTH	

Slope Stability Analysis Results, Critical Slip Surface

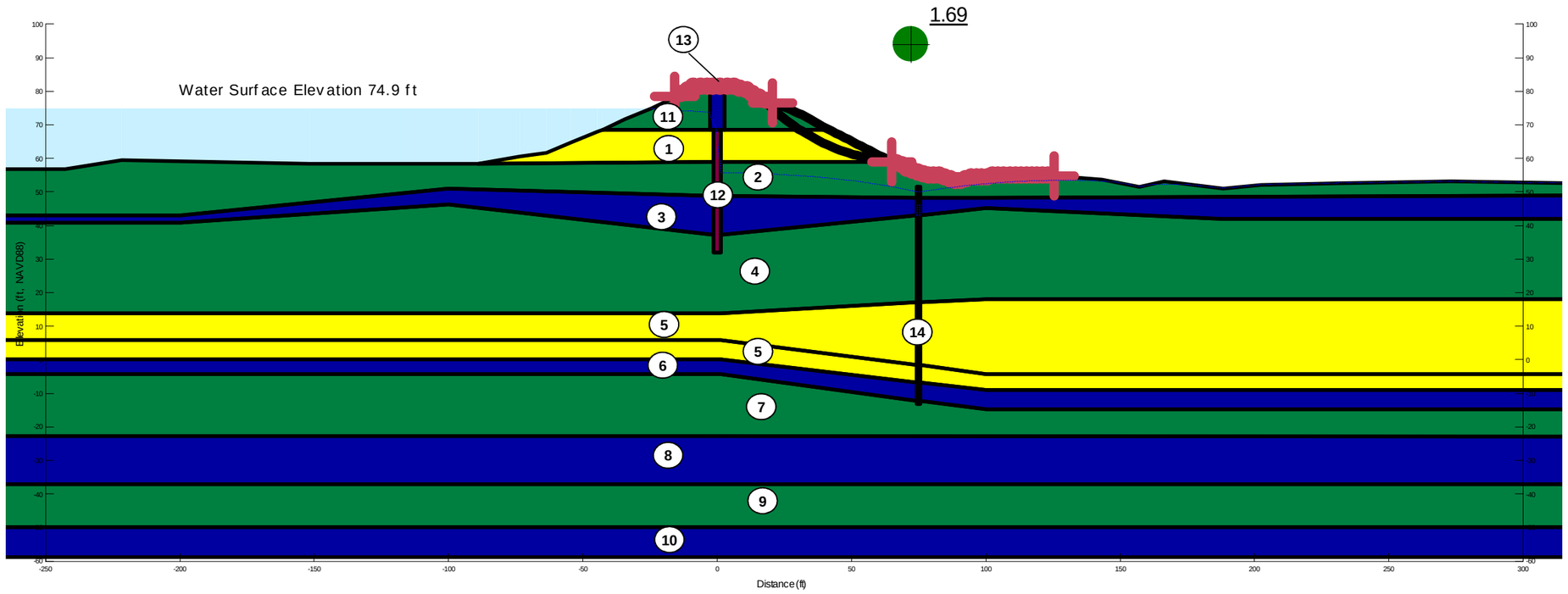


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 SP 120 pcf C'=0, Phi'=32
2 SM 120 pcf C'=0, Phi'=35
3 CL 120 pcf C'=100 psf, Phi'=31
4 SM-SP 125 pcf C'=0, Phi'=34
5 GW-GP 125 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100 psf, Phi'=31
7 SM-SP 120 pcf C'=0, Phi'=36
8 CL 120 pcf C'=100 psf, Phi'=31
9 SM 125 pcf C'=0, Phi'=34
10 CL 125 pcf C'=100 psf, Phi'=31
13 Regrade SM 120 pcf C'=0, Phi'=35
11 SB Wall 100 pcf C'=300 psf, Phi'=0
12 Clay Cap 120 pcf C'=100 psf, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN NT ANALYZED NT CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 13, Section at Sta. 861+33 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B13-A4

Slope Stability Analysis Results, Critical Slip Surface

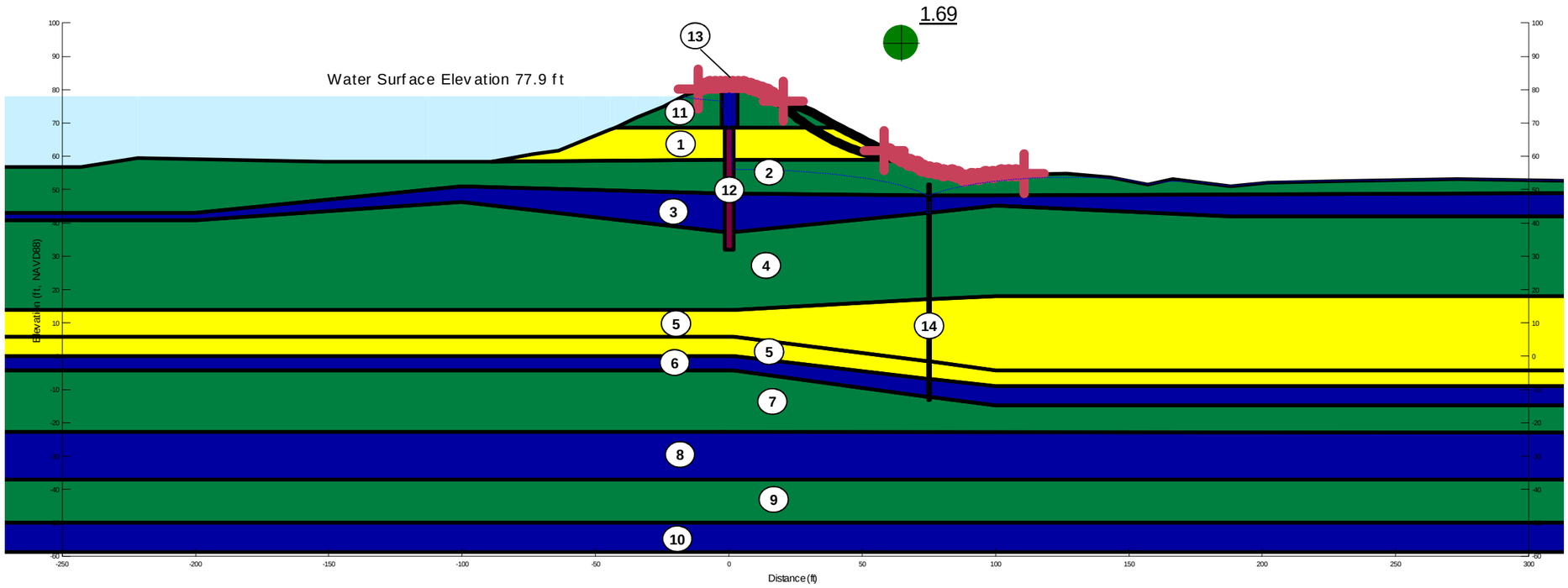


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 SP 120 pcf C'=0, Phi'=32
2 SM 120 pcf C'=0, Phi'=35
3 CL 120 pcf C'=100 psf, Phi'=31
4 SM 125 pcf C'=0, Phi'=34
5 GW-GM 125 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100 psf, Phi'=31
7 SM 120 pcf C'=0, Phi'=36
8 CL 120 pcf C'=100 psf, Phi'=31
9 SM 125 pcf C'=0, Phi'=34
10 CL 125 pcf C'=0, Phi'=35
11 Regrade SM 120 pcf C'=0, Phi'=35
12 SB Wall 100 pcf C'=300 psf, Phi'=0
13 Clay Cap 120 pcf C'=100 psf, Phi'=32
14 Relief Well 120 pcf C'=0, Phi'=33

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 13, Section at Sta. 861+33 Alternative 2: Shallow Cutoff Wall and Relief Well WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B13-A5
			DATE 02/09/2011	CHECKED GTH	

Slope Stability Analysis Results, Critical Slip Surface

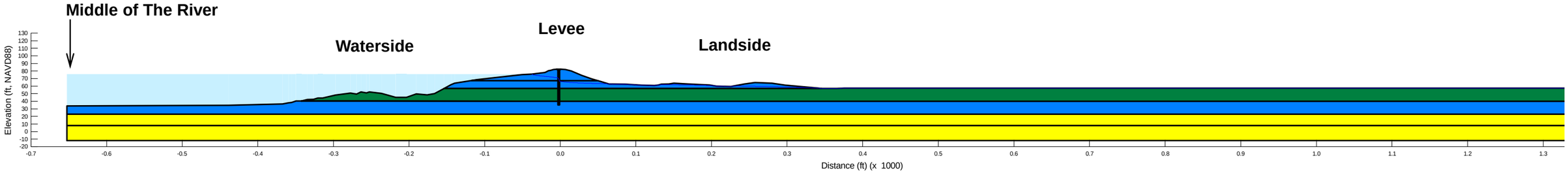


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 SP 120 pcf C'=0, Phi'=32
2 SM 120 pcf C'=0, Phi'=35
3 CL 120 pcf C'=100 psf, Phi'=31
4 SM 125 pcf C'=0, Phi'=34
5 GW-GM 125 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100 psf, Phi'=31
7 SM 120 pcf C'=0, Phi'=36
8 CL 120 pcf C'=100 psf, Phi'=31
9 SM 125 pcf C'=0, Phi'=34
10 CL 125 pcf C'=0, Phi'=35
11 Regrade SM 120 pcf C'=0, Phi'=35
12 SB Wall 100 pcf C'=300 psf, Phi'=0
13 Clay Cap 120 pcf C'=100 psf, Phi'=32
14 Relief Well 120 pcf C'=0, Phi'=33

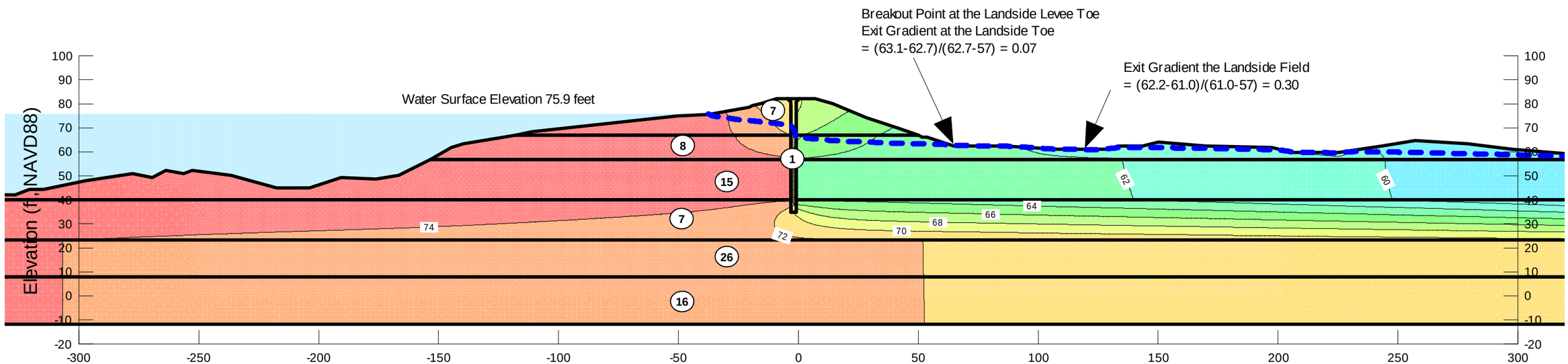
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 13, Section at Sta. 861+33 Alternative 2: Shallow Cutoff Wall and Relief Well WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B13-A6
			DATE 02/09/2011	CHECKED GTH	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



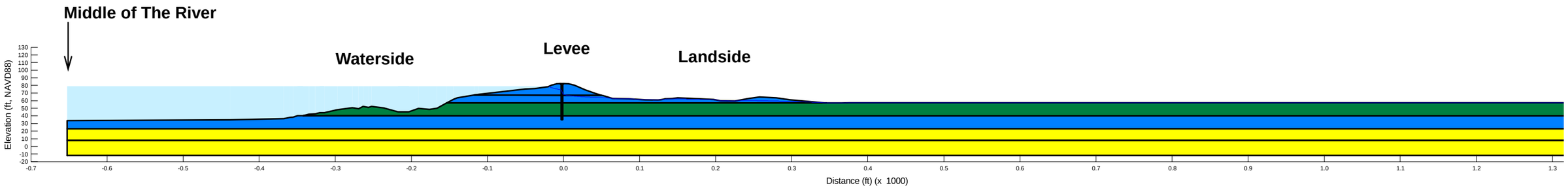
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(1) Slurry Wall (SCB or CB),		Kh=0.0028 ft/day	(=1x10-6 cm/s)	1
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

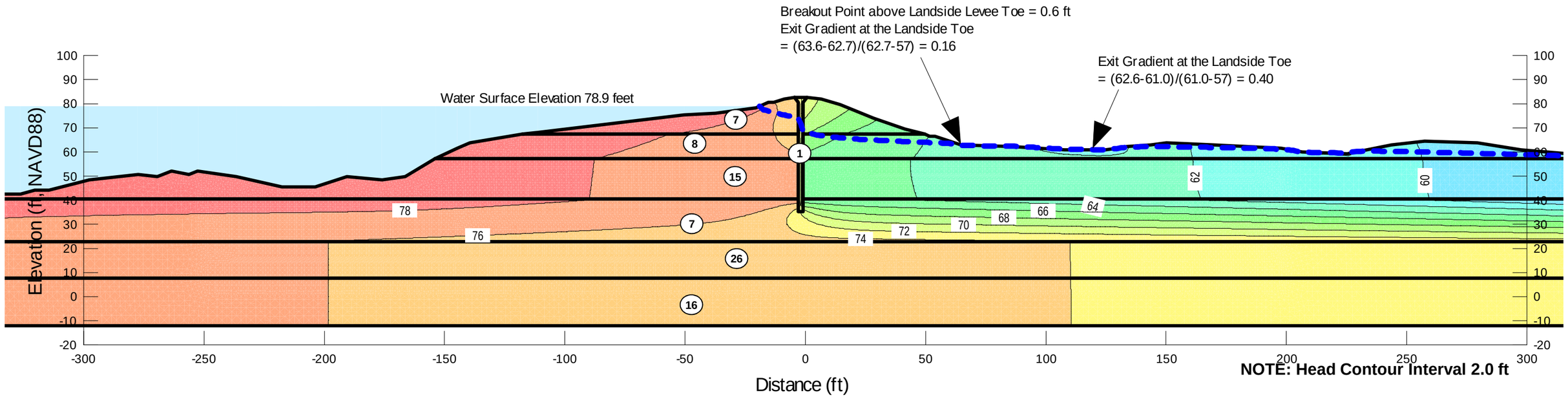
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 14, Section at Sta. 939+33 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED NT	FIGURE B14-E1
			DATE 02/09/2011	CHECKED MHW	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



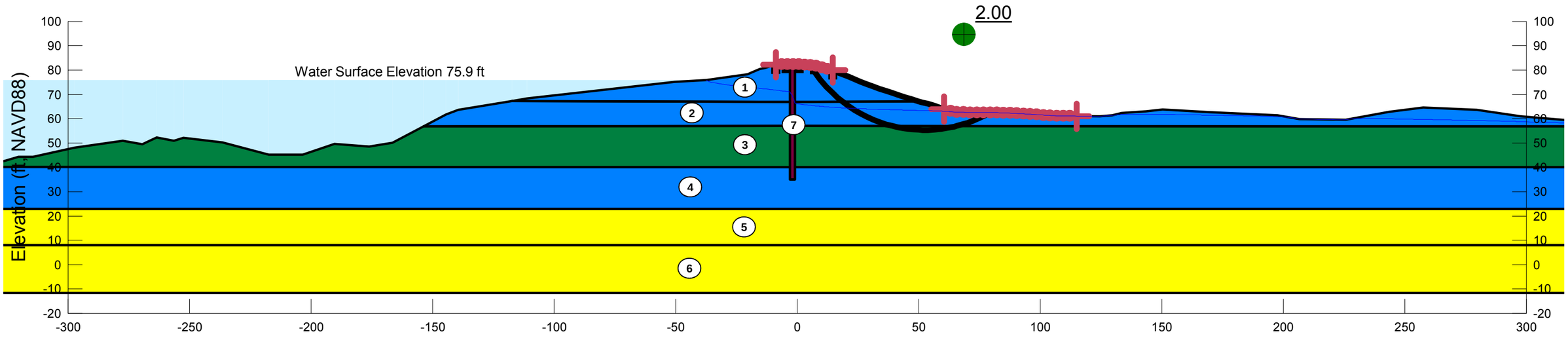
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(1) Slurry Wall (SCB or CB),		Kh=0.0028 ft/day	(=1x10-6 cm/s)	1
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 14, Section at Sta. 939+33 Existing Conditions WSE at 200yr+3 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B14-E2
			DATE 02/09/2011	CHECKED MHW	

Slope Stability Analysis Results, Critical Slip Surface

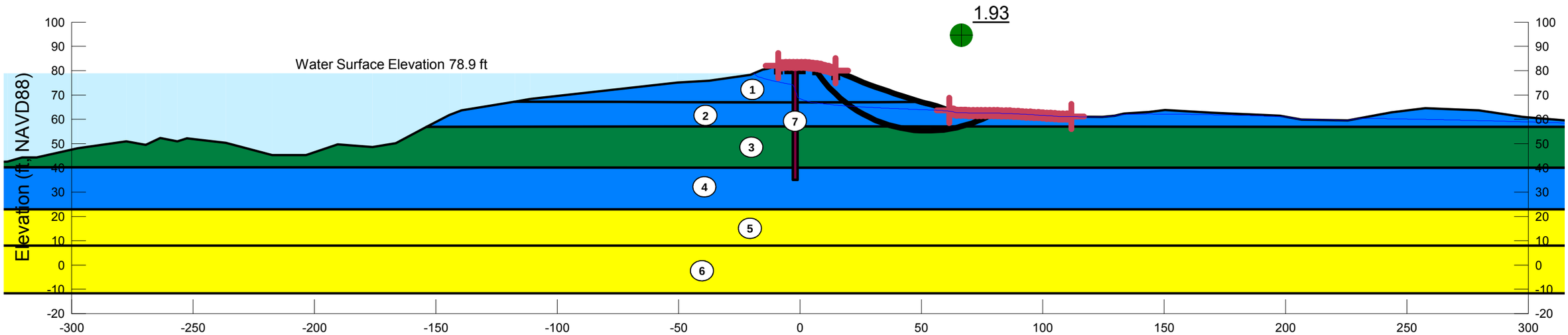


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi'=32
2 ML 115 pcf C'=50, Phi'=32
3 SM 115 pcf C'=0, Phi'=32
4 ML 115 pcf C'=0, Phi'=32
5 GP 130 pcf C'=0, Phi'=36
6 SM 120 pcf C'=0, Phi'=36
7 SCB Wall 130 pcf C'=0, Phi'=35

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 14, Section at Sta. 939+33 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED NT	FIGURE B14-E3
			DATE 02/09/2011	CHECKED MHW	

Slope Stability Analysis Results, Critical Slip Surface

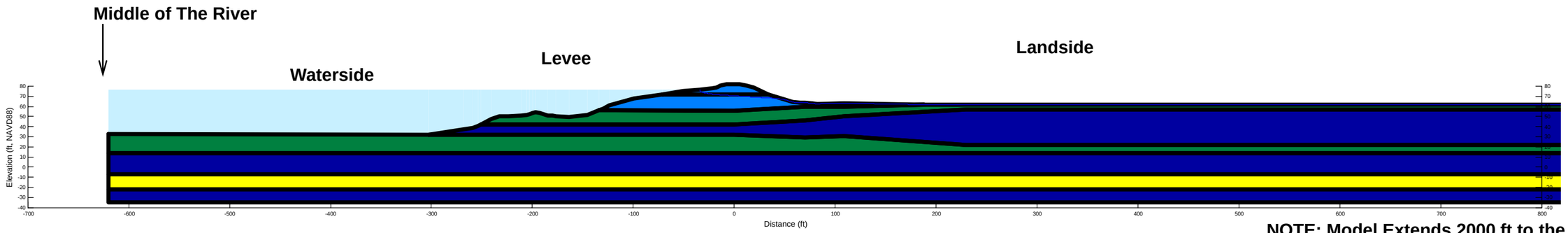


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi'=32
2 ML 115 pcf C'=50, Phi'=32
3 SM 115 pcf C'=0, Phi'=32
4 ML 115 pcf C'=0, Phi'=32
5 GP 130 pcf C'=0, Phi'=36
6 SM 120 pcf C'=0, Phi'=36
7 SCB Wall 130 pcf C'=0, Phi'=35

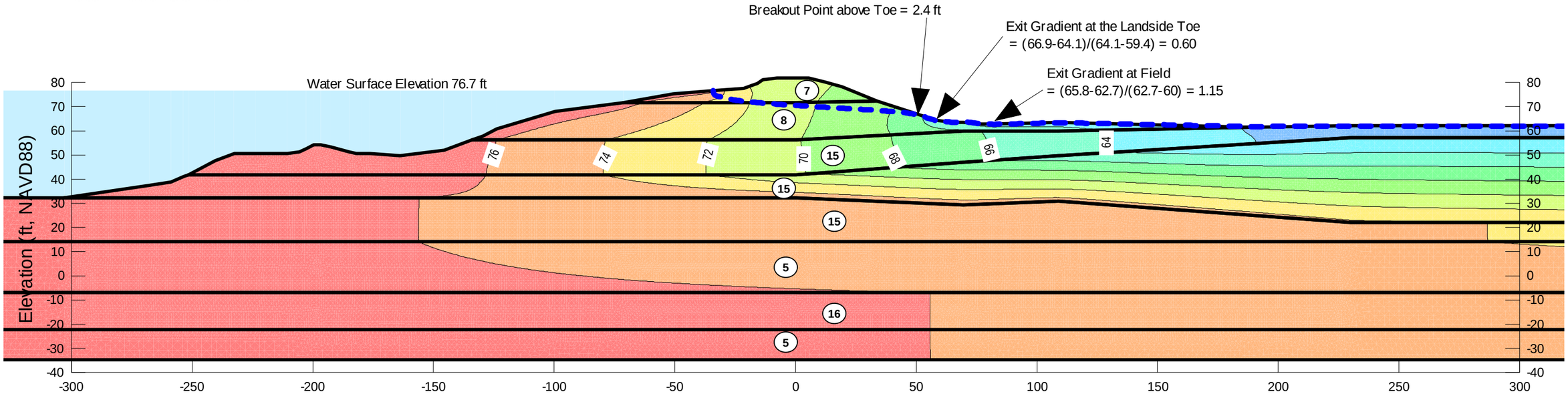
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 14, Section at Sta. 939+33 Existing Conditions WSE at 200y +3 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B14-E4
			DATE 02/09/2011	CHECKED MHW	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



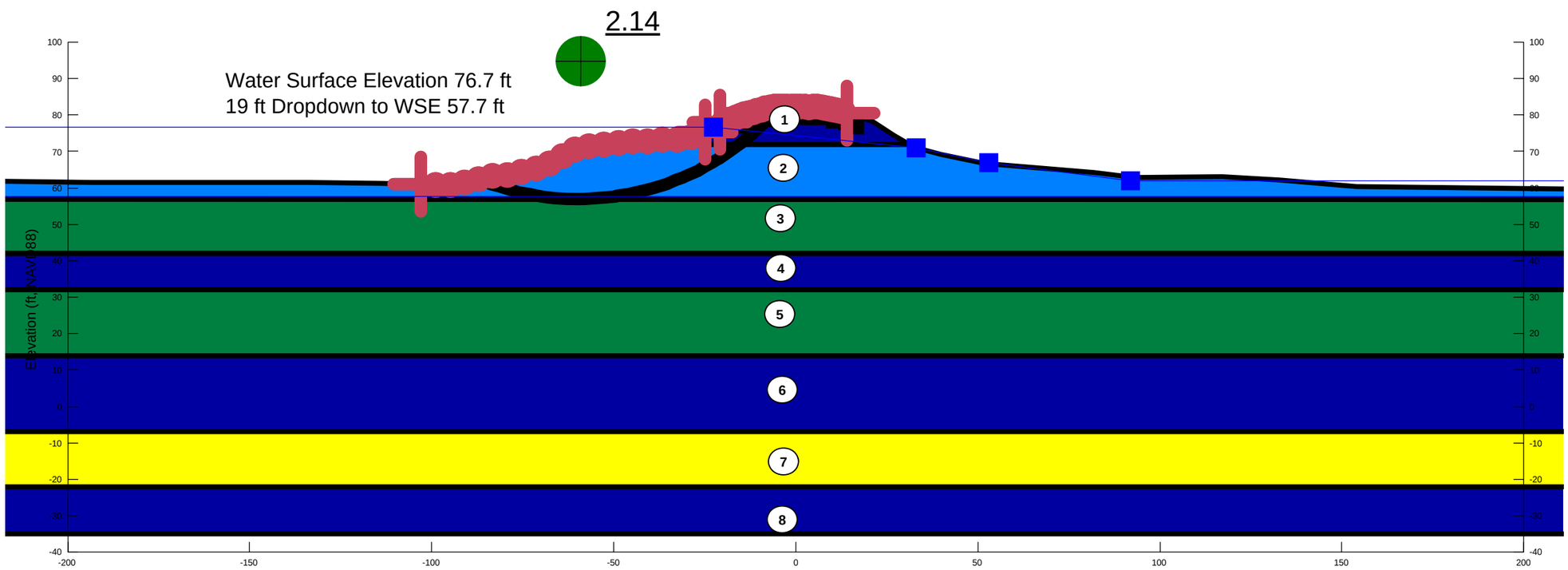
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(5) Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	(5) Clay	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,	Kh=0.028 ft/day	(=1x10-5 cm/s)	(7) Silt	0.25
(8) Sandy Silt,	50-79% fines, Kh=0.085 ft/day	(=3x10-5 cm/s)	(8) Silt	0.25
(15) Silty Sand to Sand,	13-29% fines, Kh=2.8 ft/day	(=1x10-3 cm/s)	(15) Sand	0.25
(16) Silty Sand to Sand,	8- 12% fines, Kh=14 ft/day	(=5x10-3 cm/s)	(16) Sand	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NT TASK ORDER 1 / ANALYZED NT DATE 02/09/2011 / CHECKED GTH	STEADY-STATE SEEPAGE ANALYSIS Reach 15, Section at Sta. 958+83 Existing Conditions WSE at 200yr	FIGURE B15-E1

Slope Stability Analysis Results,
Rapid Drawdown
Critical Slip Surface



Material ID and Type, Unit weight, Drained Strength Parameters (c' and phi'), Undrained Strength Parameters (c and phi)

1	CL	115 pcf	100 psf	31 °	200 psf	18 °
2	ML	115 pcf	50 psf	32 °	120 psf	24 °
3	SM	115 pcf	0 psf	30 °	0 psf	30 °
4	CL	115 pcf	0 psf	30 °	200 psf	18 °
5	SM	115 pcf	0 psf	32 °	0 psf	32 °
6	CL	115 pcf	0 psf	30 °	200 psf	18 °
7	SM	120 pcf	0 psf	36 °	0 psf	36 °
8	CL	115 pcf	0 psf	30 °	200 psf	18 °

Sutter Butte Flood Control Agency

FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT
Geotechnical Analyses for Pre-Design Formulation Report

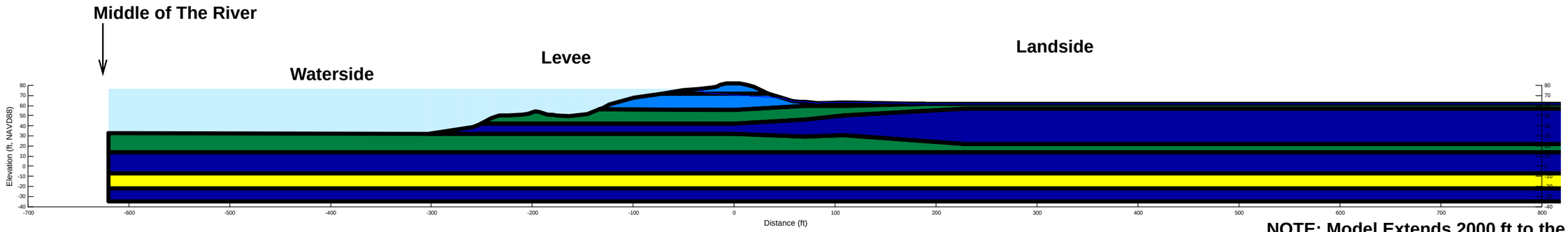
URS
In association with: blackburn consulting

URS PROJECT NO. 17326463	DRAWN GTH
TASK ORDER 1	ANALYZED GTH
DATE 02/09/2011	CHECKED MC

RAPID DRAWDOWN SLOPE STABILITY ANALYSIS
Reach 15, Section at Sta. 958+83
Existing Conditions
19 Feet Dropdown from WSE at 200yr ft

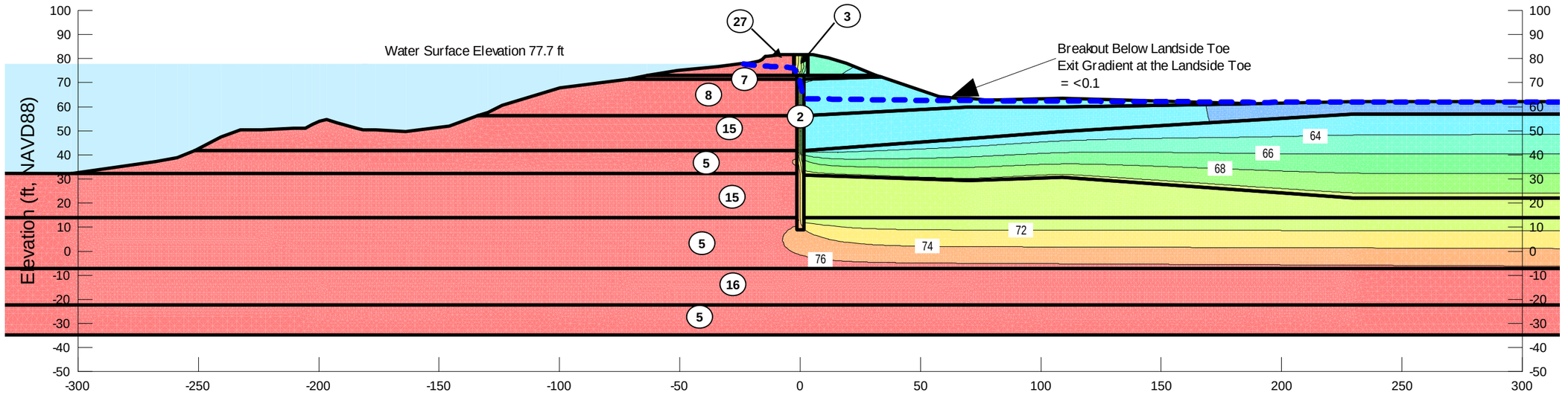
FIGURE B15-E2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



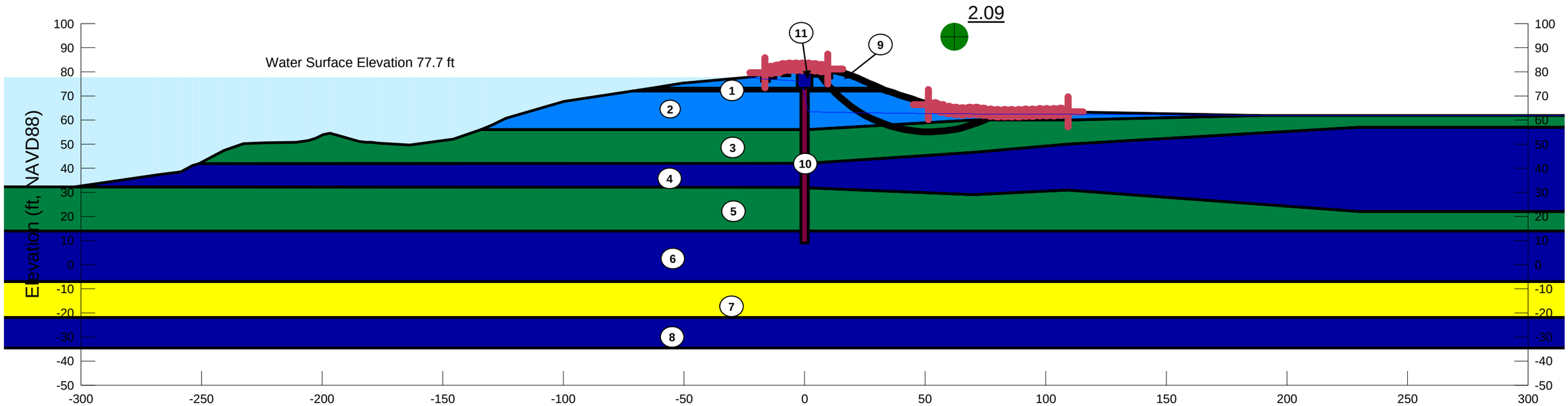
Material ID and Type, Horizontal Hydraulic Conductivity(kh), Anisotropic Ratio (kv/kh)

(2) Slurry Wall (SB), Kh=0.00028 ft/day (=1x10-7 cm/s) 1
(3) New Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(27) Regrade Fill 0.25

NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 15, Section at Sta. 958+83 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED NT	FIGURE B15-A1
			DATE 02/09/2011	CHECKED GTH	

Slope Stability Analysis Results, Critical Slip Surface

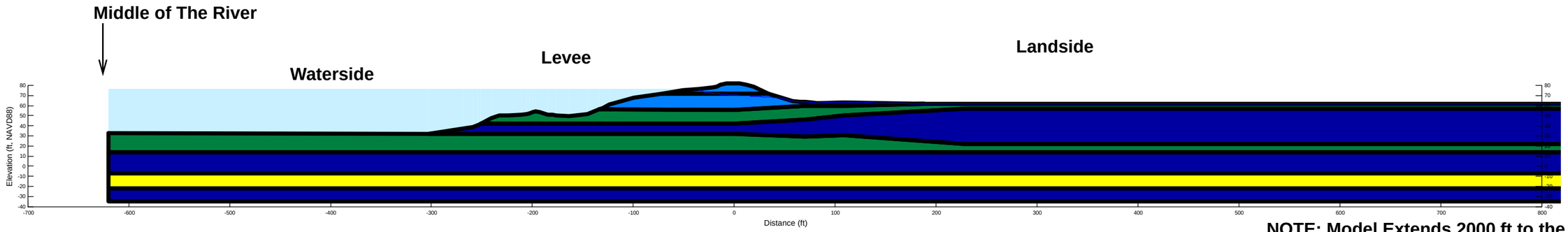


Material ID and Type, Unit Weight, Effective Strength Paramters (Cohesion Intercept and Friction Angle)

1 ML-CL 115 pcf C'=100, Phi'=31
2 ML 115 pcf Layer 2 ML
3 SM 115 pcf C'=0, Phi=30
4 CL 115 pcf C'=0, Phi=30
5 SM 115 pcf C'=0, Phi'=32
6 CL 115 pcf C'=0, Phi=30
7 SM 120 pcf C'=0, Phi'=36
8 CL 115 pcf C'=0, Phi=30
9 Regrade Fill 120 pcf C'=50, Phi=32
10 Cutoff Wall (SB) 100 pcf C'=300, Phi'=0
11 Cutoff Wall Cap 120 pcf C'=100, Phi=32

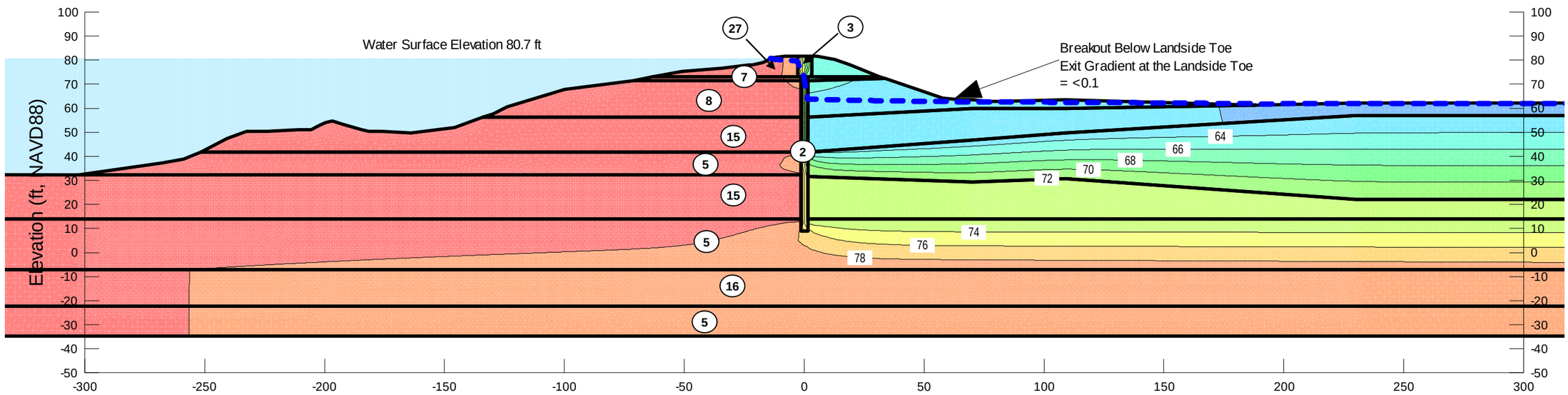
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / TASK ORDER 1 / DATE 02/09/2011	DRAWN NT / ANALYZED NT / CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 15, Section at Sta. 958+83 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B15-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

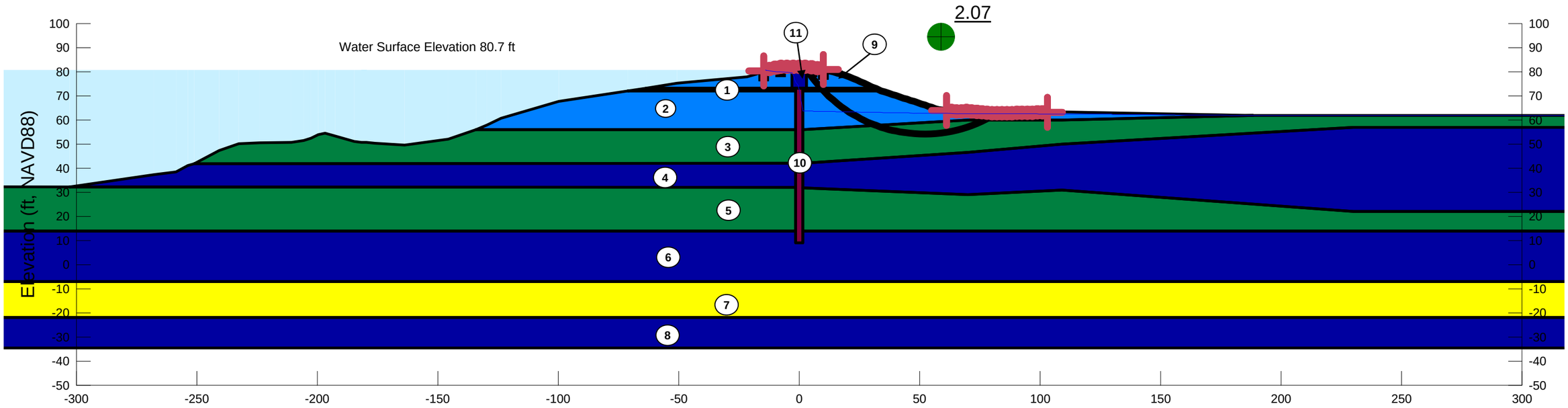
Material ID Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (kv/kh)

(2) Slurry Wall (SB),	Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt, 50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand, 13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand, 8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade Fill	0.25		

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 15, Section at Sta. 958+83 Alternative 1: Cutoff Wall WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED NT	
			DATE 02/09/2011	CHECKED GTH	

FIGURE B15-A3

Slope Stability Analysis Results, Critical Slip Surface

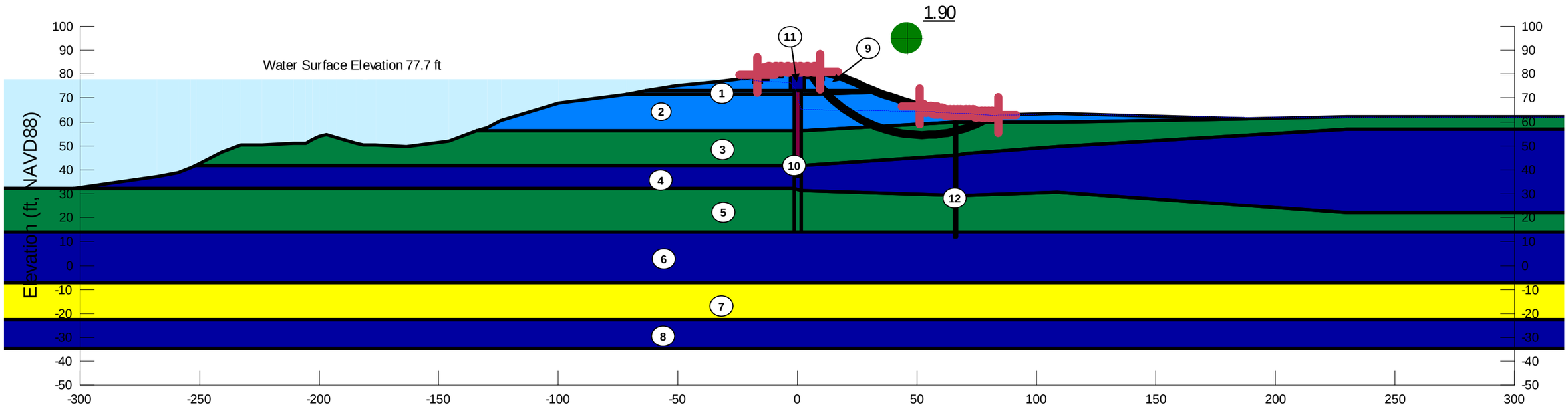


Material ID and Type, Unit Weight, Effective Strength Paramters (Cohesion Intercept and Friction Angle)

1 ML-CL 115 pcf C'=100, Phi'=31
2 ML 115 pcf Layer 2 ML
3 SM 115 pcf C'=0, Phi=30
4 CL 115 pcf C'=0, Phi=30
5 SM 115 pcf C'=0, Phi'=32
6 CL 115 pcf C'=0, Phi=30
7 SM 120 pcf C'=0, Phi'=36
8 CL 115 pcf C'=0, Phi=30
9 Regrade Fill 120 pcf C'=50, Phi=32
10 Cutoff Wall (SB) 100 pcf C'=300, Phi'=0
11 Cutoff Wall Cap 120 pcf C'=100, Phi=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 15, Section at Sta. 958+83 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B15-A4
			TASK ORDER 1	ANALYZED NT		
			DATE 02/09/2011	CHECKED GTH		

Slope Stability Analysis Results, Critical Slip Surface

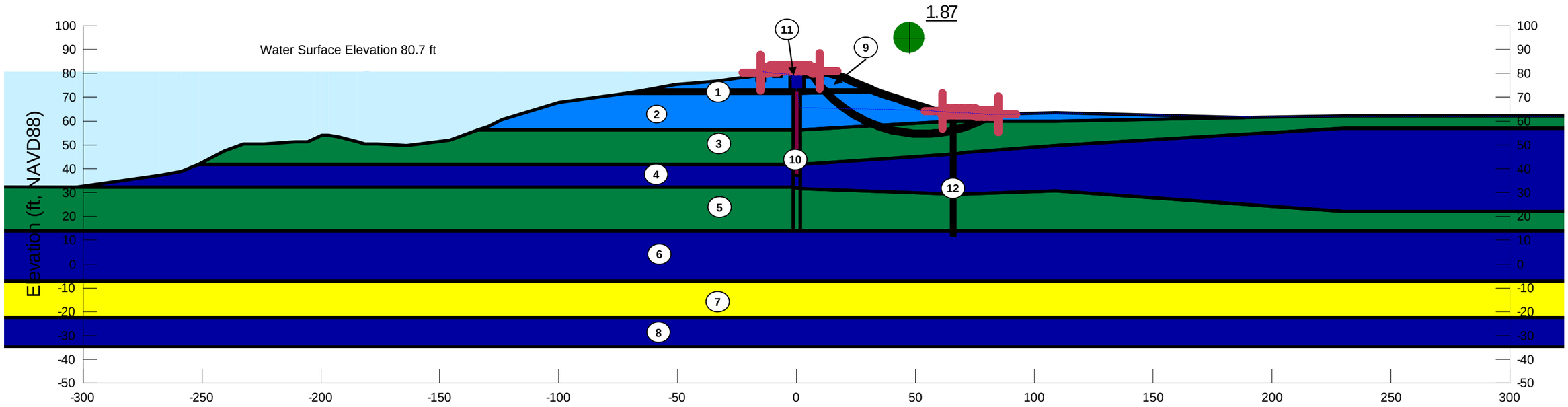


Material ID and Type, Unit Weight, Effective Strength Paramters (Cohesion Intercept and Friction Angle)

1 ML-CL 115 pcf C'=100, Phi'=31
2 ML 115 pcf Layer 2 ML
3 SM 115 pcf C'=0, Phi=30
4 CL 115 pcf C'=0, Phi=30
5 SM 115 pcf C'=0, Phi'=32
6 CL 115 pcf C'=0, Phi=30
7 SM 120 pcf C'=0, Phi'=36
8 CL 115 pcf C'=0, Phi=30
9 Regrade Fill 120 pcf C'=50, Phi=32
10 Cutoff Wall (SB) 100 pcf C'=300, Phi'=0
11 Cutoff Wall Cap 120 pcf C'=100, Phi=32
12 Relief Well 120 pcf C' =100 psf, Phi' =30 degree

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN NT ANALYZED NT CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 15, Section at Sta. 958+83 Alternative 2: Cutoff Wall and Relief Wells WSE at 200yr+1 ft	FIGURE B15-A5

Slope Stability Analysis Results, Critical Slip Surface

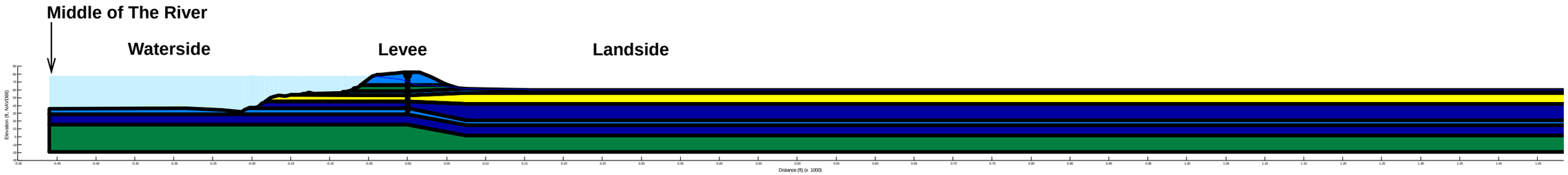


Material ID and Type, Unit Weight, Effective Strength Paramters (Cohesion Intercept and Friction Angle)

1 ML-CL 115 pcf C'=100, Phi'=31
2 ML 115 pcf Layer 2 ML
3 SM 115 pcf C'=0, Phi=30
4 CL 115 pcf C'=0, Phi=30
5 SM 115 pcf C'=0, Phi'=32
6 CL 115 pcf C'=0, Phi=30
7 SM 120 pcf C'=0, Phi'=36
8 CL 115 pcf C'=0, Phi=30
9 Regrade Fill 120 pcf C'=50, Phi=32
10 Cutoff Wall (SB) 100 pcf C'=300, Phi'=0
11 Cutoff Wall Cap 120 pcf C'=100, Phi=32
12 Relief Well 120 pcf C' =100 psf, Phi' =30 degree

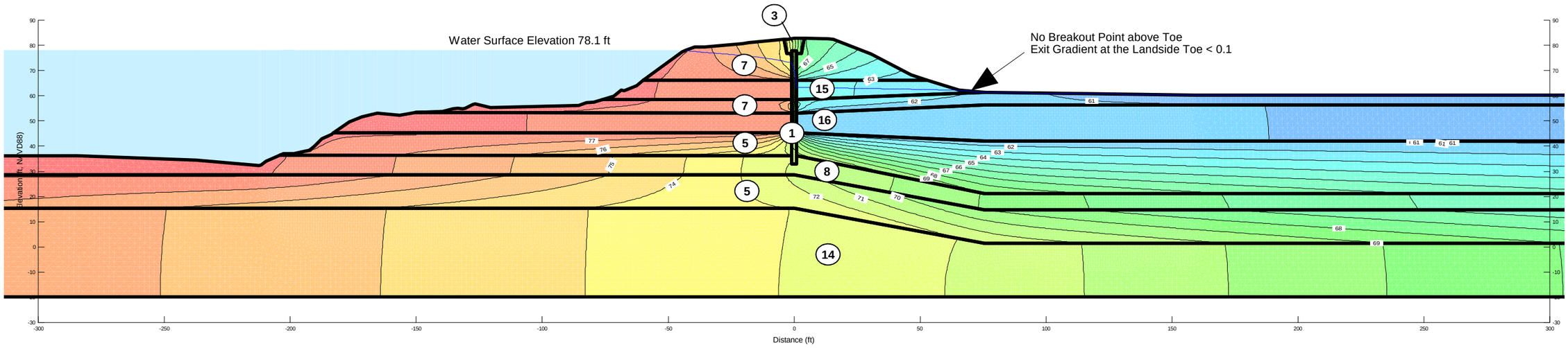
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN NT ANALYZED NT CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 15, Section at Sta. 958+83 Alternative 1: Cutoff Wall and Relief Wells WSE at 200yr+4 ft	FIGURE B15-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



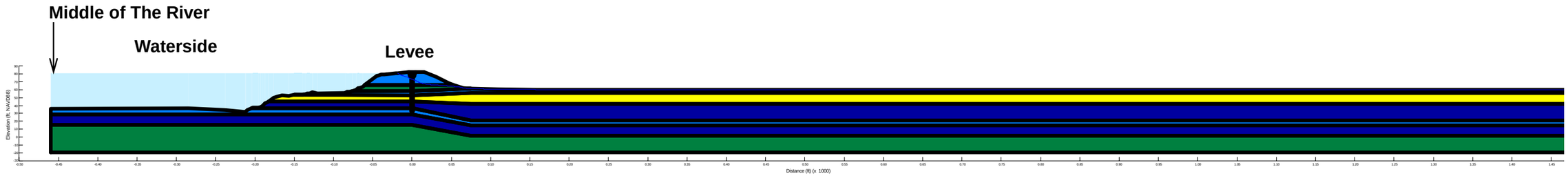
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(1) Slurry Wall (SCB or CB),	Kh=0.0028 ft/day	(=1x10-6 cm/s)	1
(3) New Compacted Clay Levee,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt, 50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand, 30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand, 13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand, 8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25

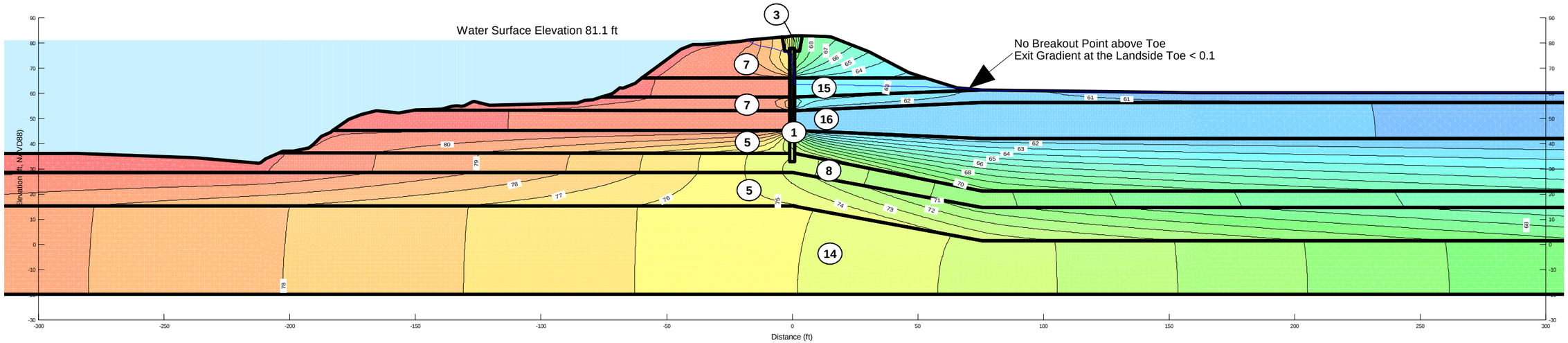
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / TASK ORDER 1 / DATE 02/07/2011	DRAWN NT / ANALYZED NT / CHECKED GTH	STEADY-STATE SEEPAGE ANALYSIS Reach 16, Section at Sta. 993+80 Existing Conditions WSE at 200yr	FIGURE B16a-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

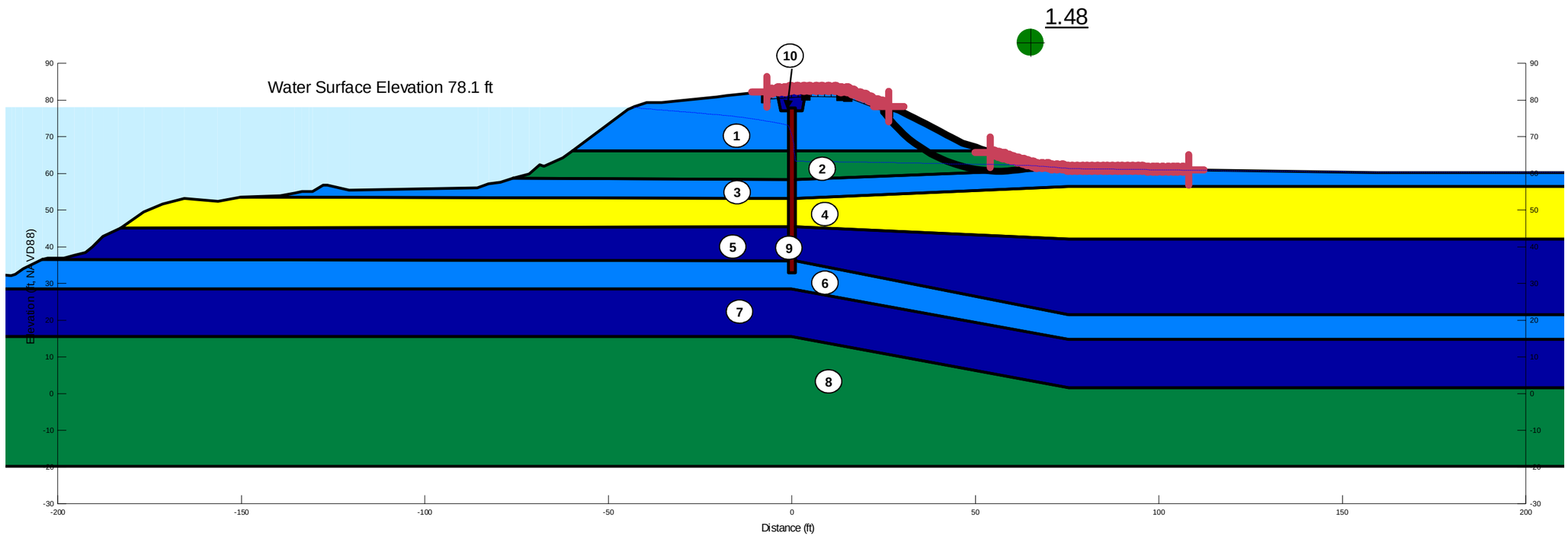
(1) Slurry Wall (SCB or CB),		Kh=0.0028 ft/day	(=1x10-6 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 16, Section at Sta. 993+80 Existing Conditions WSE at 200yr+3 ft
			TASK ORDER 1	ANALYZED NT	
			DATE 02/07/2011	CHECKED GTH	

FIGURE B16a-E2

Slope Stability Analysis Results, Critical Slip Surface

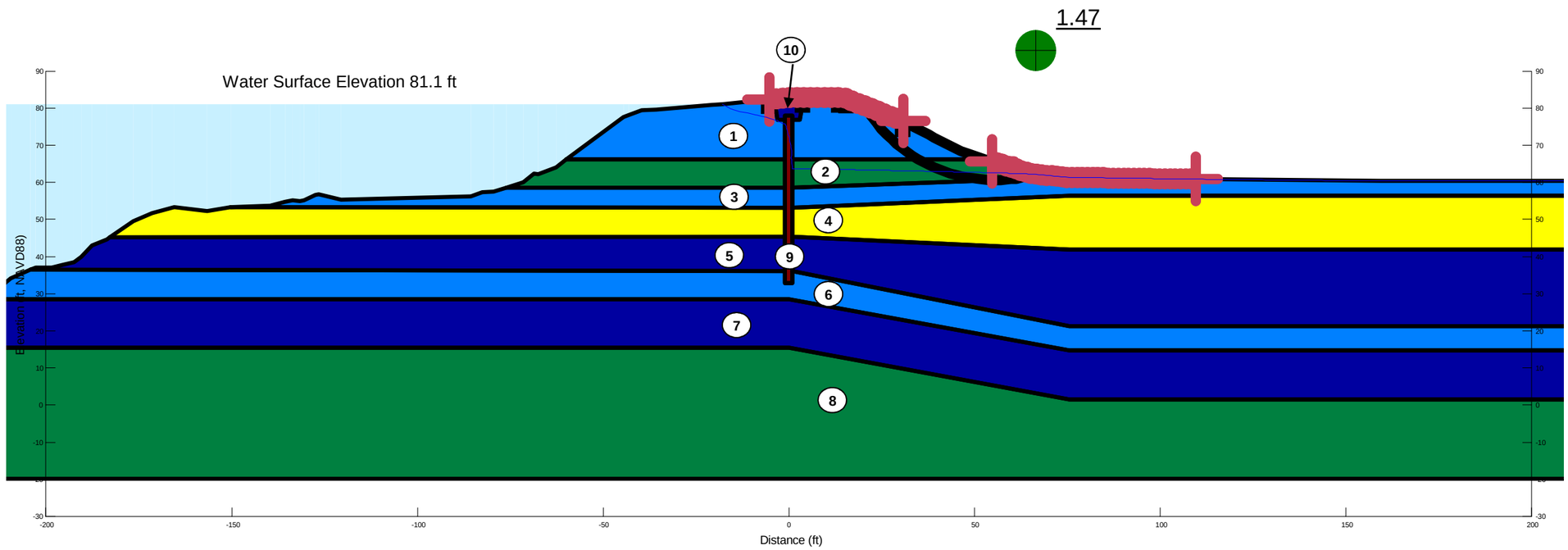


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50 psf, Phi'=32
2 SP-SM 110 pcf C'=0, Phi'=27
3 ML 115 pcf C'=0, Phi'=32
4 SP 120 pcf C'=0, Phi'=33
5 CL 115 pcf C'=100 psf, Phi'=31
6 ML/SM 115 pcf C'=0, Phi'=30
7 CL 110 pcf C'=0, Phi'=30
8 SM 120 pcf C'=0, Phi'=36
9 SCB Wall 130 pcf C'=0, Phi'=35
10 Clay Cap 120 pcf C'=100 psf, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 16, Section at Sta. 993+80 Existing Conditions WSE at 200yr	FIGURE B16a-E3
			TASK ORDER 1	ANALYZED NT		
			DATE 02/07/2011	CHECKED GTH		

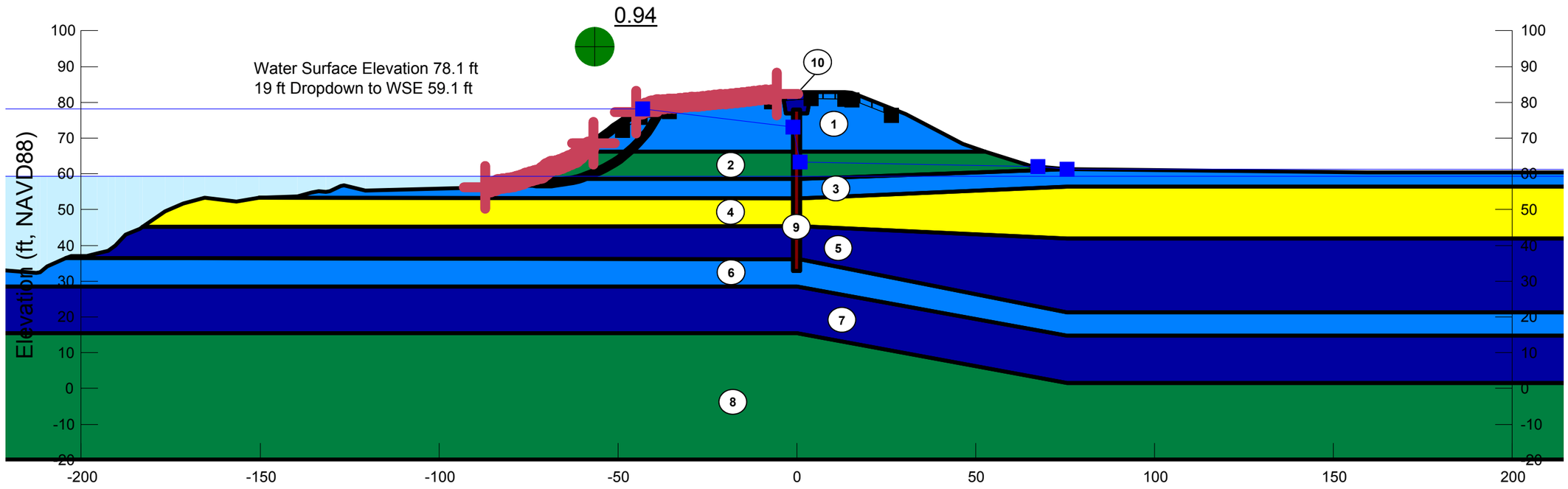
Slope Stability Analysis Results, Critical Slip Surface



Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)
1 ML 115 pcf C'=50 psf, Phi'=32
2 SP-SM 110 pcf C'=0, Phi'=27
3 ML 115 pcf C'=0, Phi'=32
4 SP 120 pcf C'=0, Phi'=33
5 CL 115 pcf C'=100 psf, Phi'=31
6 ML/SM 115 pcf C'=0, Phi'=30
7 CL 110 pcf C'=0, Phi'=30
8 SM 120 pcf C'=0, Phi'=36
9 SCB Wall 130 pcf C'=0, Phi'=35
10 Clay Cap 120 pcf C'=100 psf, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/07/2011	DRAWN NT ANALYZED NT CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 16, Section at Sta. 993+80 Existing Conditions WSE at 200yr+3 ft	FIGURE B16a-E4

Slope Stability Analysis Results,
Rapid Drawdown
Critical Slip Surface

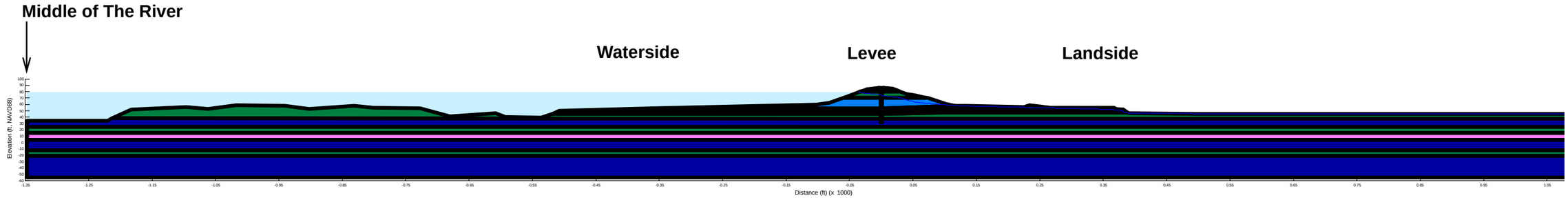


Material ID and Type, Unit weight, Drained Strength Parameters (c' and phi'), Undrained Strength Parameters (c and phi)

1 ML	115 pcf	50 psf	32 °	120 psf	24 °
2 SP-SM	110 pcf	0 psf	27 °	0 psf	27 °
3 ML	115 pcf	0 psf	32 °	120 psf	24 °
4 SP	120 pcf	0 psf	33 °	0 psf	33 °
5 CL	115 pcf	100 psf	31 °	200 psf	18 °
6 ML/SM	115 pcf	0 psf	30 °	120 psf	24 °
7 CL	110 pcf	0 psf	30 °	200 psf	18 °
8 SM	120 pcf	0 psf	36 °	0 psf	30 °
9 SCB Wall	130 pcf	0 psf	35 °	0 psf	35 °
10 Clay Cap	120 pcf	100 psf	31 °	200 psf	18 °

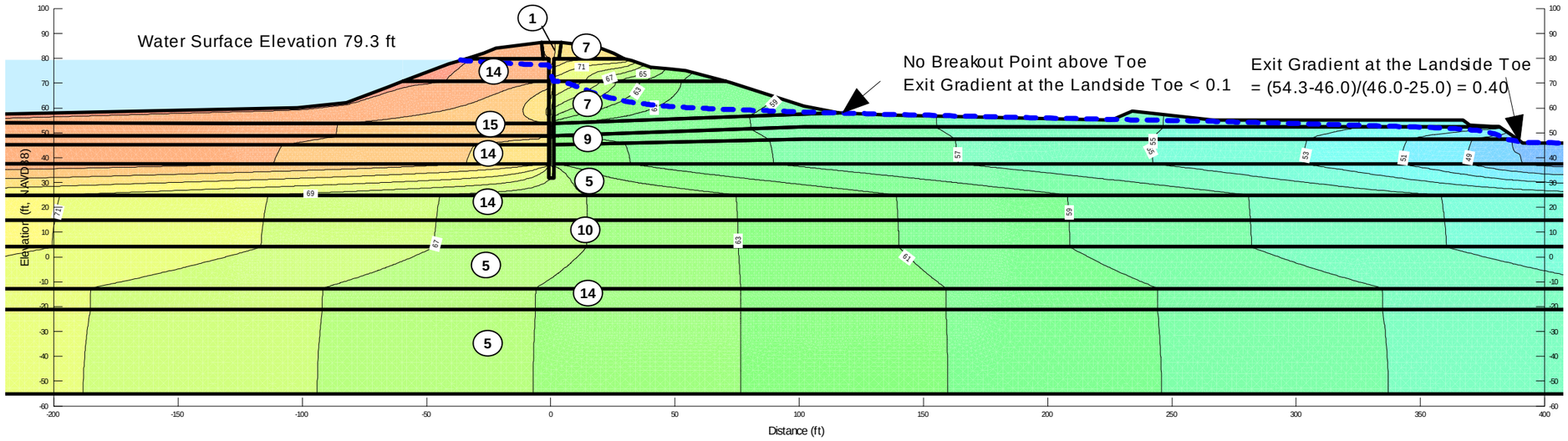
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 12/21/2010 / CHECKED MC	RAPID DRAWDOWN SLOPE STABILITY ANALYSIS Reach 16a, Section at Sta. 993+80 Existing Conditions 19 Feet Dropdown from WSE at 200yr ft	FIGURE B16a-E5

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



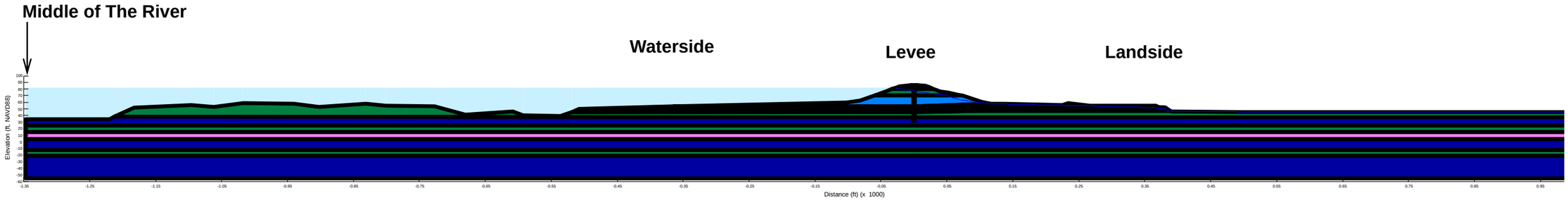
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(1) Slurry Wall (SCB or CB), Kh=0.0028 ft/day (=1x10-6 cm/s) 1
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(9*) Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(10*) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(14) Silty Sand to Sand, 30-49% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25

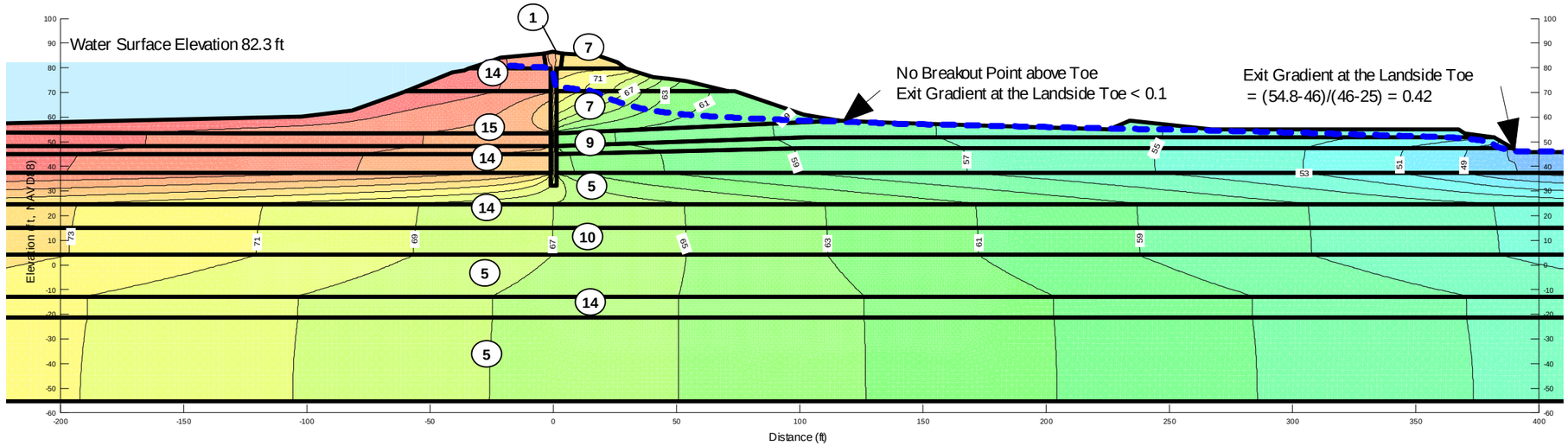
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 16, Section at Sta. 1043+88 Existing Conditions WSE at 200yr	FIGURE B16b-E1
			TASK ORDER 1	ANALYZED MW and MC		
			DATE 02/09/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(1) Slurry Wall (SCB or CB),	Kh=0.0028 ft/day	(=1x10-6 cm/s)	1
(5) Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(9*) Clayey Sand to Sand, 30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(10*) Clayey Sand to Sand, 13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(14) Silty Sand to Sand, 30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand, 13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25

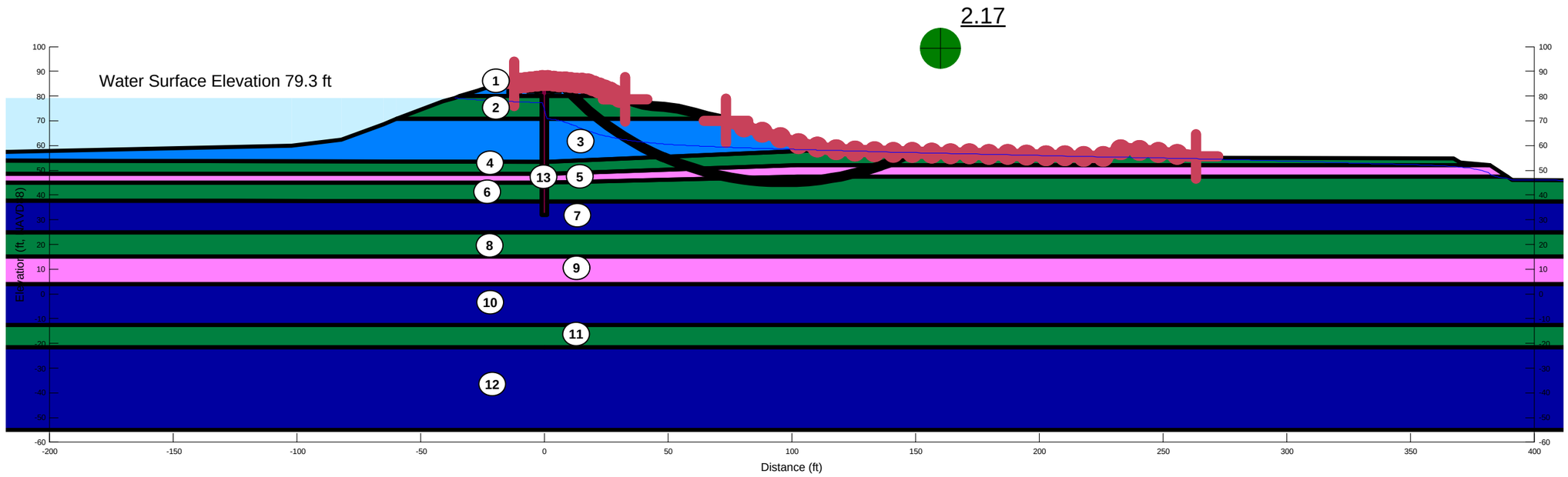
NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN MW ANALYZED MW and MC CHECKED GTH

STEADY-STATE SEEPAGE ANALYSIS
Reach 16, Section at Sta. 1043+88
Existing Conditions
WSE at 200yr+3 ft

FIGURE B16b-E2

Slope Stability Analysis Results, Critical Slip Surface

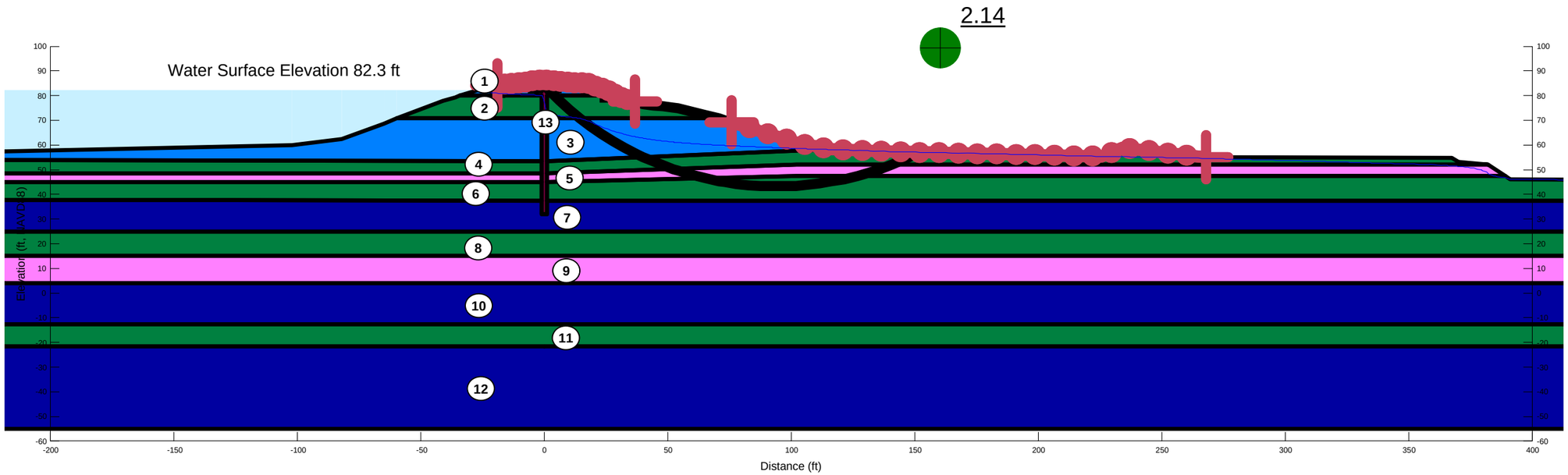


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 110 pcf C'=0, Phi'=32
2 SM 120 pcf C'=0, Phi'=34
3 ML 120 pcf C'=50 psf, Phi'=32
4 SM 110 pcf C'=0, Phi'=30
5 SC 110 pcf C'=0, Phi'=30
6 SM 110 pcf C'=0, Phi'=30
7 CL 115 pcf C'=0, Phi'=31
8 SM 120 pcf C'=0, Phi'=35
9 SC 120 pcf C'=0, Phi'=35
10 CL 120 pcf C'=100 psf, Phi'=31
11 SM 120 pcf C'=0, Phi'=36
12 CL 120 pcf C'=100 psf, Phi'=31
13 SCB Wall 130 pcf C'=0, Phi'=35

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 16, Section at Sta. 1043+88 Existing Conditions WSE at 200yr	FIGURE B16b-E3
			TASK ORDER 1	ANALYZED MW and MC		
			DATE 02/09/2011	CHECKED GTH		

Slope Stability Analysis Results, Critical Slip Surface

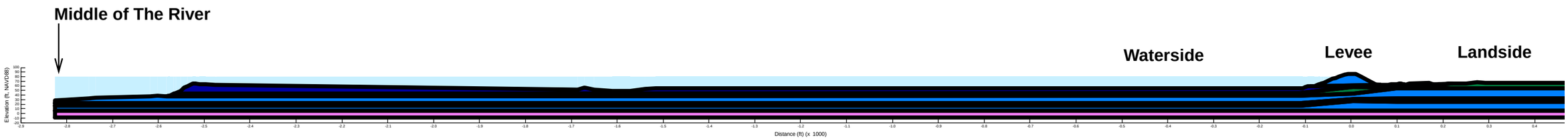


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 110 pcf C'=0, Phi'=32
2 SM 120 pcf C'=0, Phi'=34
3 ML 120 pcf C'=50 psf, Phi'=32
4 SM 110 pcf C'=0, Phi'=30
5 SC 110 pcf C'=0, Phi'=30
6 SM 110 pcf C'=0, Phi'=30
7 CL 115 pcf C'=0, Phi'=31
8 SM 120 pcf C'=0, Phi'=35
9 SC 120 pcf C'=0, Phi'=35
10 CL 120 pcf C'=100 psf, Phi'=31
11 SM 120 pcf C'=0, Phi'=36
12 CL 120 pcf C'=100 psf, Phi'=31
13 SCB Wall 130 pcf C'=0, Phi'=35

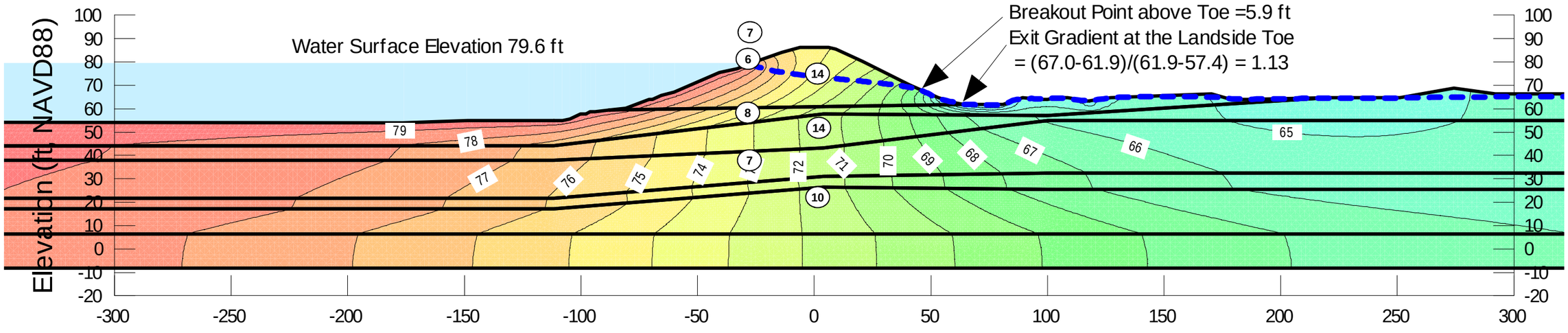
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN MW ANALYZED MW and MC CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 16, Section at Sta. 1043+88 Existing Conditions WSE at 200yr+3 ft	FIGURE B16b-E4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25

(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25

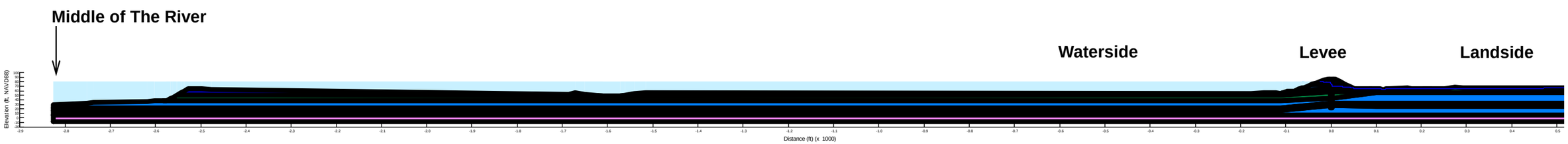
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25

(10*) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25

(14) Silty Sand to Sand, 30-49% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25

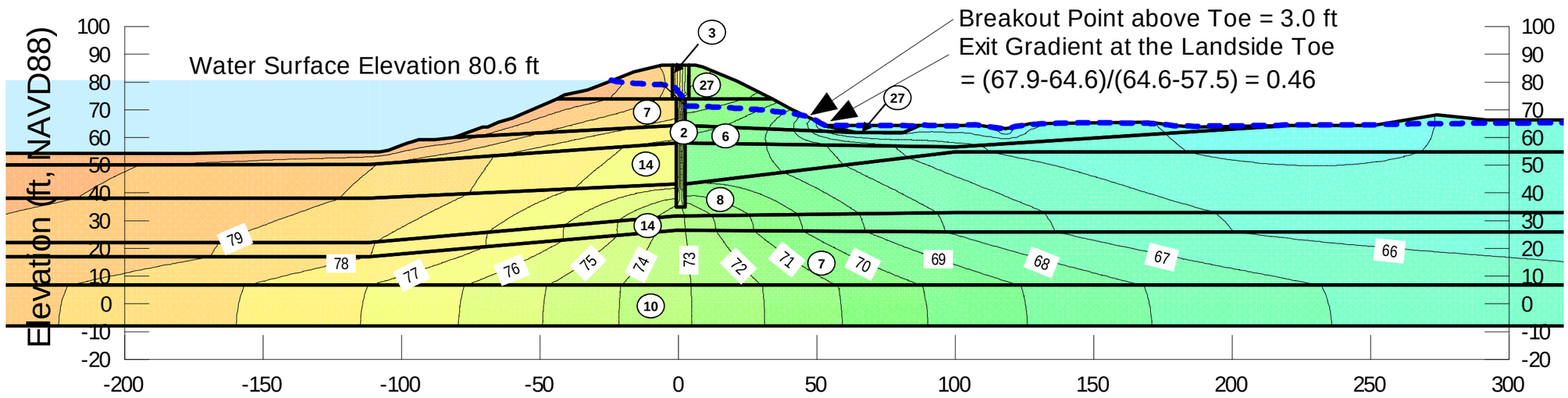
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 17, Section at Sta. 1108+86 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED NT	FIGURE B17-E1
			DATE 02/09/2011	CHECKED GTH	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



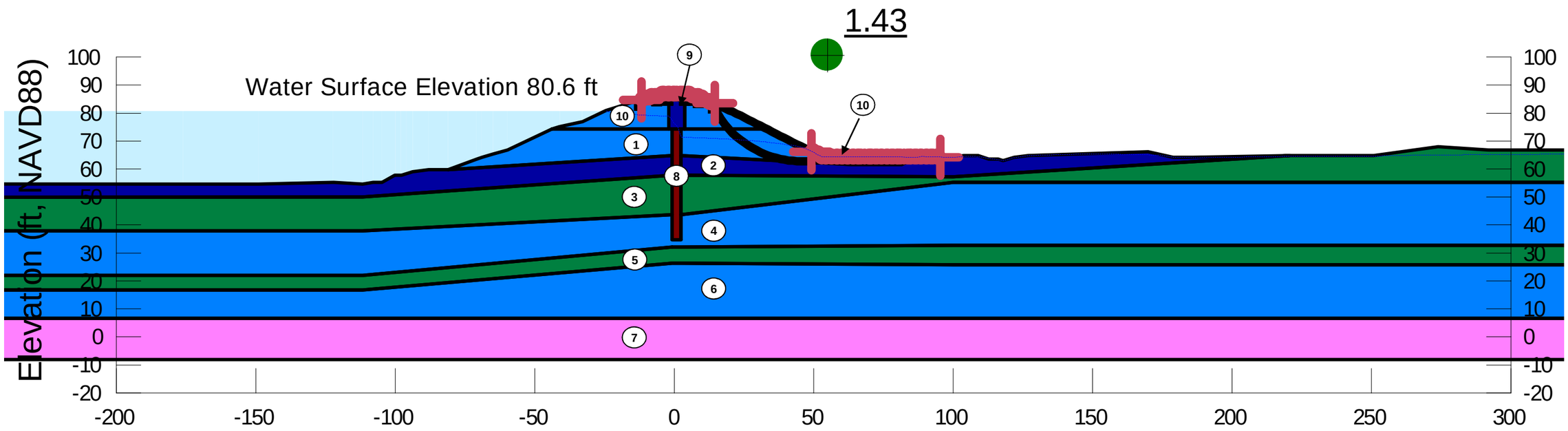
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25
(10*) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(27) Regrade ML,		Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SEEPAGE ANALYSIS Reach 17, Section at Sta. 1108+86 Alternative 1: Cutoff Wall and Filled Depression WSE at 200yr+1 ft	FIGURE B17-A1
			TASK ORDER 1	ANALYZED NT		
			DATE 02/09/2011	CHECKED GTH		

Slope Stability Analysis Results,
Critical Slip Surface

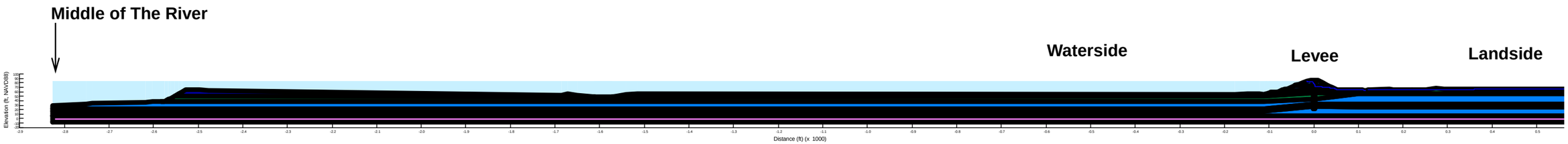


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50 psf, Phi'=32
2 CL 110 pcf C'=100 psf, Phi'=31
3 SM 125 pcf C'=0, Phi'=36
4 ML 115 pcf C'=50 psf, Phi'=32
5 SM 120 pcf C'=0, Phi'=36
6 ML 115 pcf C'=50 psf, Phi'=32
7 SM 120 pcf C'=0, Phi'=36
8 SB Wall 100 pcf C'=300 psf, Phi'=0
9 Clay Cap 120 pcf C'=100 psf, Phi'=32
10 Regrade ML 120 pcf C'=50 psf, Phi'=32

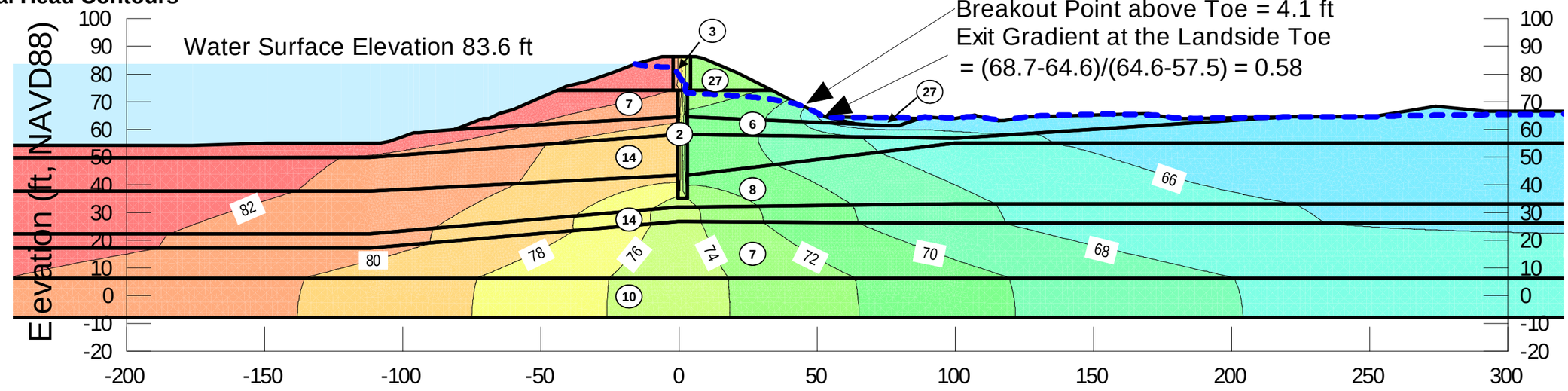
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN NT ANALYZED NT CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 17, Section at Sta. 1108+86 Alternative 1: Cutoff Wall and Filled Depression WSE at 200yr+1 ft	FIGURE B17-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



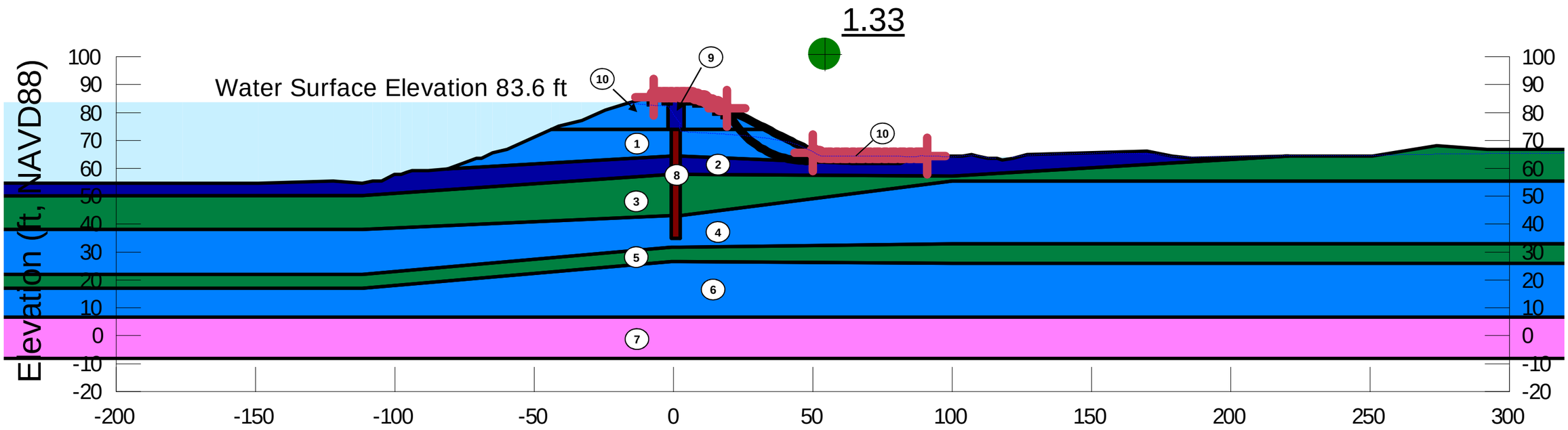
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(10*) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(27) Regrade ML,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN NT TASK ORDER 1 / ANALYZED NT DATE 02/09/2011 / CHECKED GTH	STEADY-STATE SEEPAGE ANALYSIS Reach 17, Section at Sta. 1108+86 Alternative 1: Cutoff Wall and Filled Depression WSE at 200yr+4 ft	FIGURE B17-A3

Slope Stability Analysis Results,
Critical Slip Surface



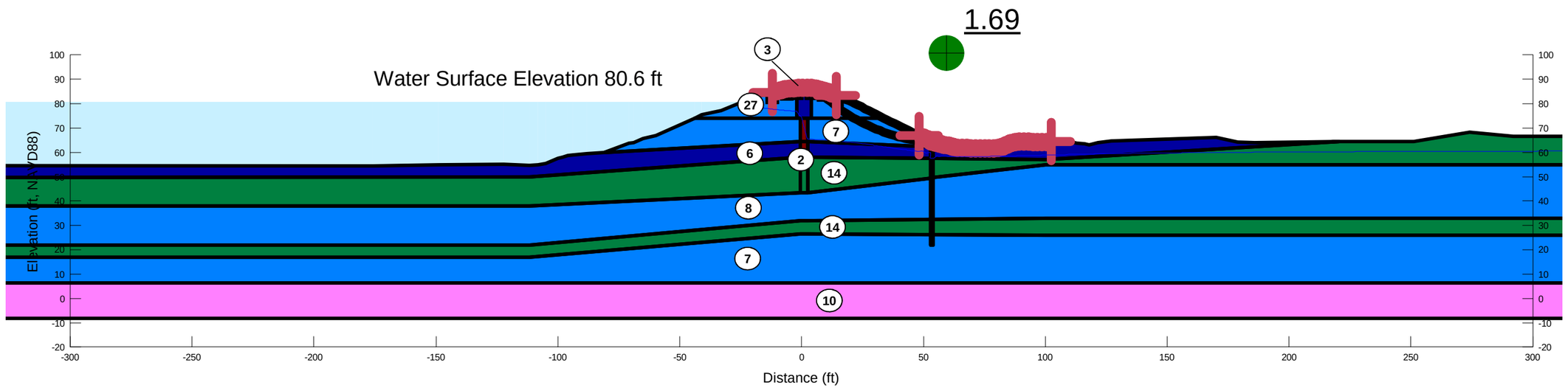
Distance (ft)

Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50 psf, Phi'=32
2 CL 110 pcf C'=100 psf, Phi'=31
3 SM 125 pcf C'=0, Phi'=36
4 ML 115 pcf C'=50 psf, Phi'=32
5 SM 120 pcf C'=0, Phi'=36
6 ML 115 pcf C'=50 psf, Phi'=32
7 SM 120 pcf C'=0, Phi'=36
8 SB Wall 100 pcf C'=300 psf, Phi'=0
9 Clay Cap 120 pcf C'=100 psf, Phi'=32
10 Regrade ML 120 pcf C'=50 psf, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 17, Section at Sta. 1108+86 Alternative 1: Cutoff Wall and Filled Depression WSE at 200yr+4 ft	FIGURE B17-A4
			TASK ORDER 1	ANALYZED NT		
			DATE 02/09/2011	CHECKED GTH		

Slope Stability Analysis Results,
Critical Slip Surface

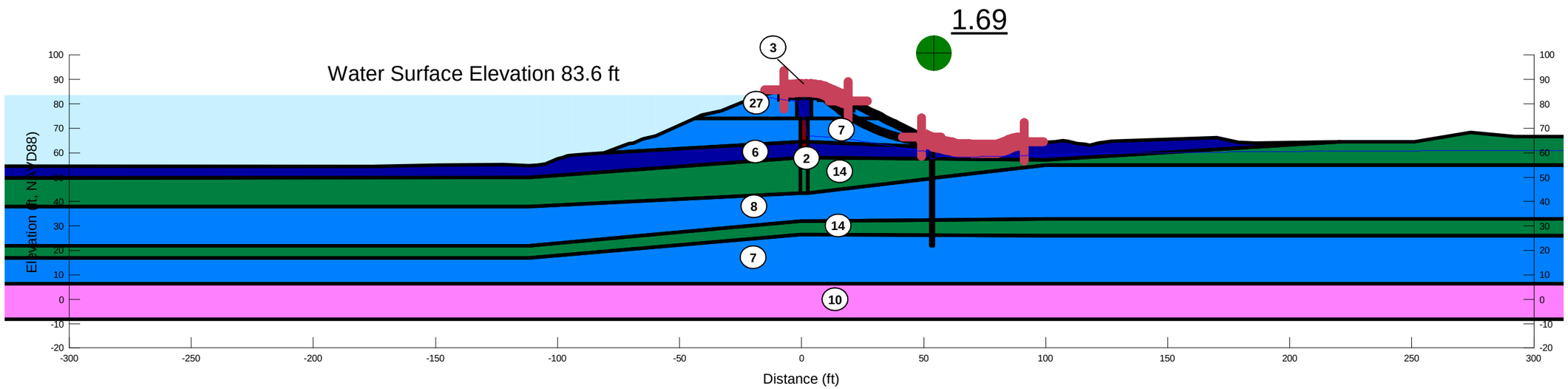


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50 psf, Phi'=32
2 CL 110 pcf C'=100 psf, Phi'=31
3 SM 120 pcf C'=0, Phi'=36
4 ML 115 pcf C'=50 psf, Phi'=32
5 SM 120 pcf C'=0, Phi'=36
6 ML 115 pcf C'=50 psf, Phi'=32
7 SM 120 pcf C'=0, Phi'=36
8 SB Wall 100 pcf C'=300 psf, Phi'=0
9 Clay Cap 120 pcf C'=100 psf, Phi'=32
10 Regrade ML 120 pcf C'=50 psf, Phi'=32
11 Relief Well 120 pcf C'=0, Phi'=33

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN NT ANALYZED NT CHECKED GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 17, Section at Sta. 1108+86 Alternative 2: Shallow Cutoff Wall and Relief well WSE at 200yr+1 ft	FIGURE B17-A5

Slope Stability Analysis Results,
Critical Slip Surface

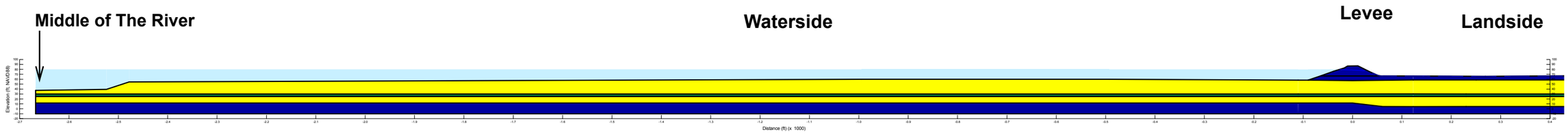


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50 psf, Phi'=32
2 CL 110 pcf C'=100 psf, Phi'=31
3 SM 120 pcf C'=0, Phi'=36
4 ML 115 pcf C'=50 psf, Phi'=32
5 SM 120 pcf C'=0, Phi'=36
6 ML 115 pcf C'=50 psf, Phi'=32
7 SM 120 pcf C'=0, Phi'=36
8 SB Wall 100 pcf C'=300 psf, Phi'=0
9 Clay Cap 120 pcf C'=100 psf, Phi'=32
10 Regrade ML 120 pcf C'=50 psf, Phi'=32
11 Relief Well 120 pcf C'=0, Phi'=33

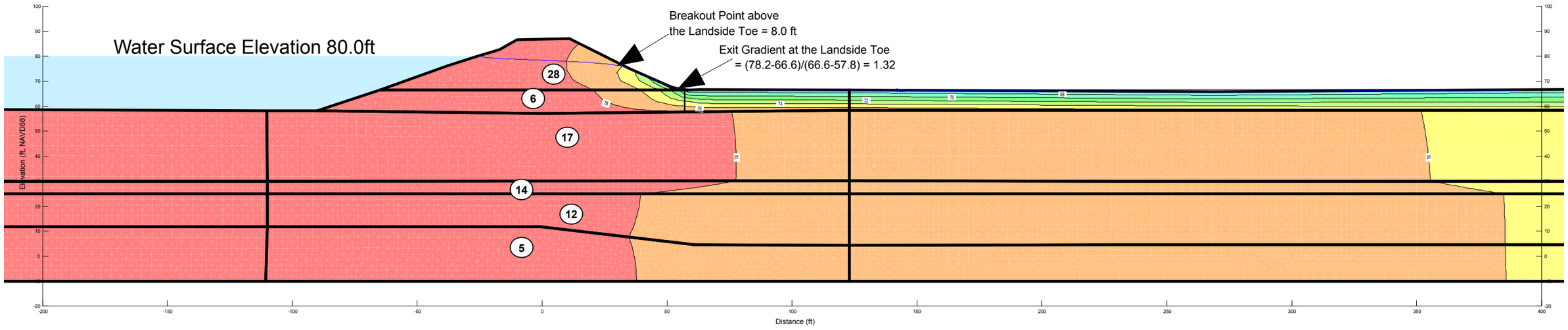
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 17, Section at Sta. 1108+86 Alternative 2: Shallow Cutoff Wall and Relief Well WSE at 200yr+4 ft	FIGURE B17-A6
			TASK ORDER 1	ANALYZED NT		
			DATE 02/09/2011	CHECKED GTH		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



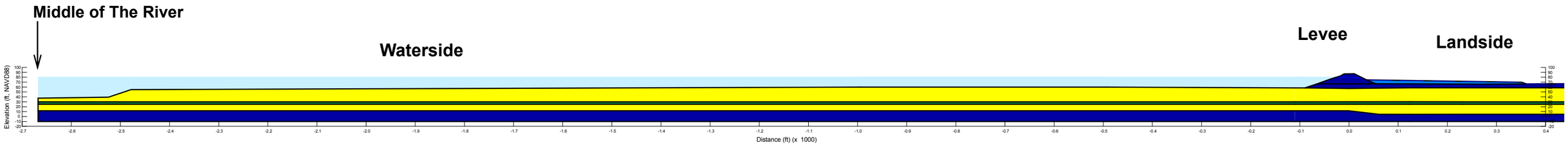
Material ID and Type, Hydrulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(12) Clayey Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25

NOTE: Head Contour Interval 2.0 ft

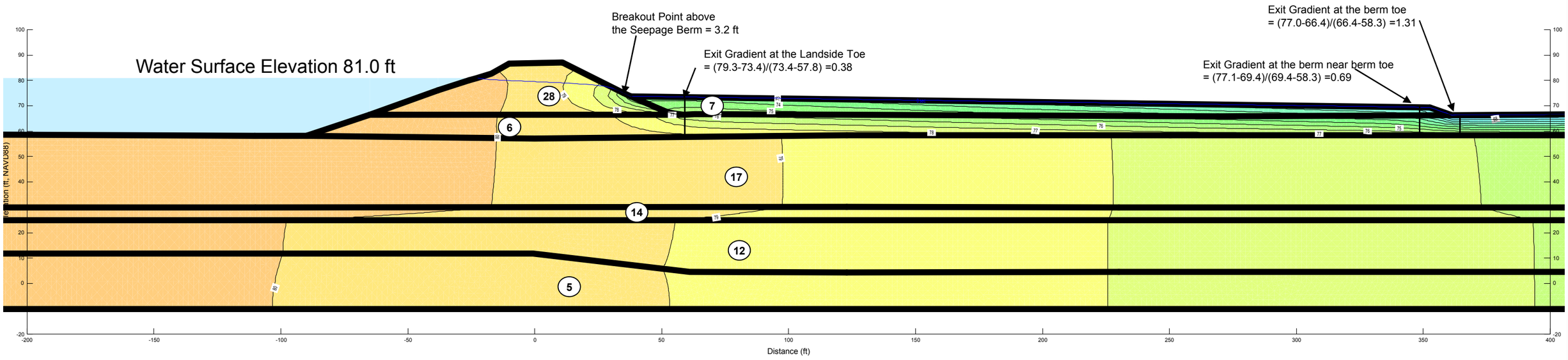
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 18, Section at Sta. 1138+86 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED TK	FIGURE B18-E1
			DATE 12/20/2010	CHECKED TSAI	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



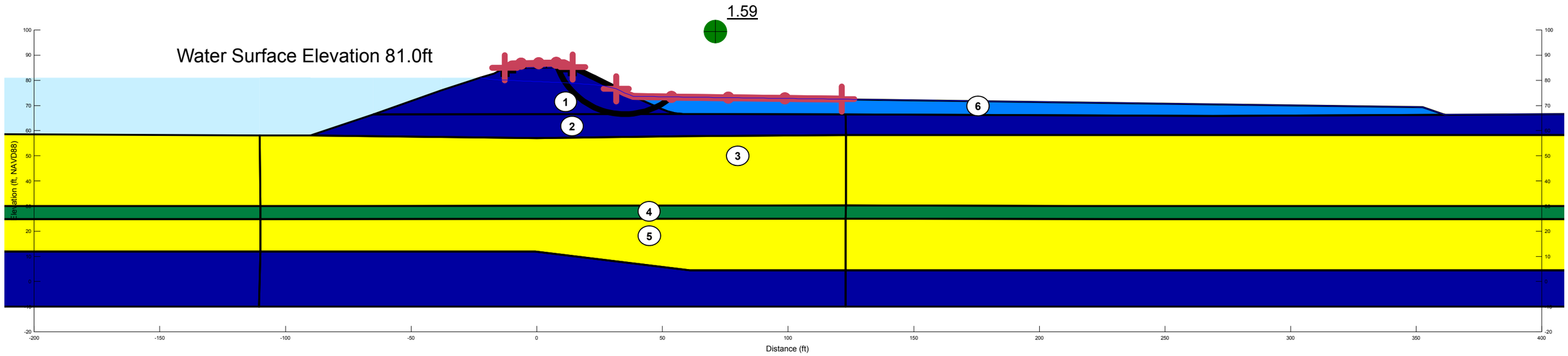
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(12) Clayey Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(14) Silty Sand to Sand, 30-49% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) (2) 0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 18, Section at Sta. 1138+86 Alternative 1 – Undrained Seepage Berm WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED TK	FIGURE B18-A1
			DATE 12/20/2010	CHECKED TSAI	

Slope Stability Analysis Results, Critical Slip Surface

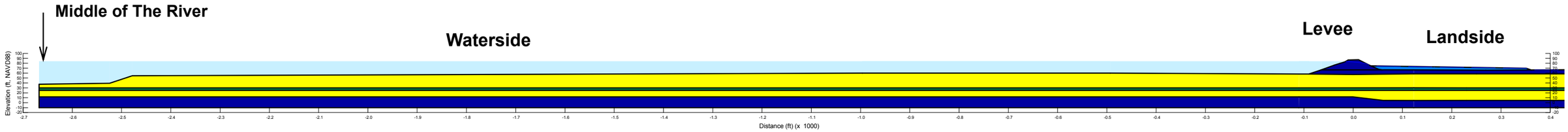


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL	115 pcf	C'=100 psf	Phi'=31
2 CL	115 pcf	C'=100 psf	Phi'=31
3 SP-SM	120 pcf	C'=0 psf	Phi'=30
4 SM	125 pcf	C'=0 psf	Phi'=36
5 SP-SM	125 pcf	C'=0 psf	Phi'=36
6 ML	115 pcf	C'=50 psf	Phi'=32

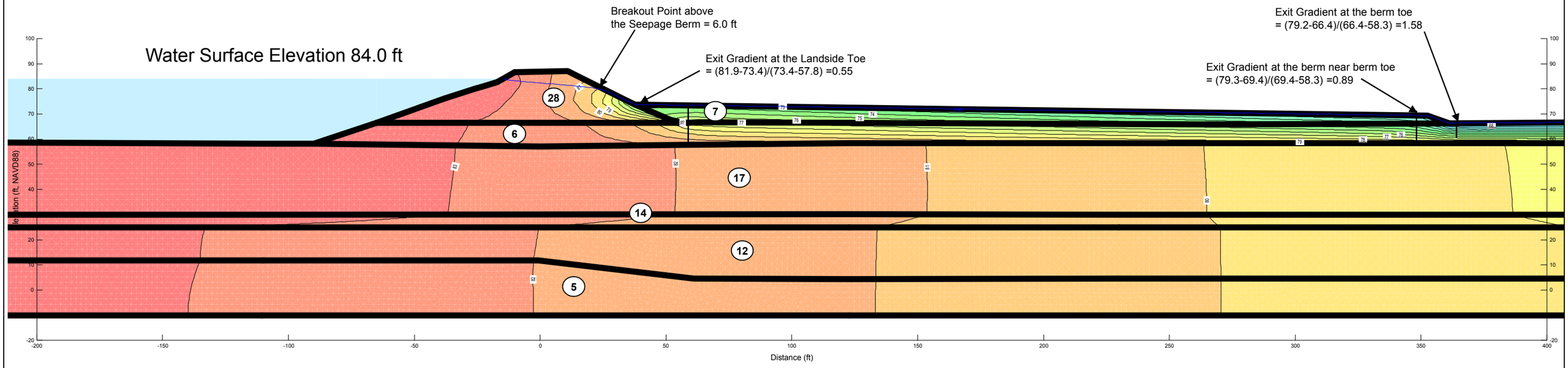
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 18, Section at Sta. 1138+86 Alternative 1 – Undrained Seepage Berm WSE at 200yr+1 ft	FIGURE B18-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



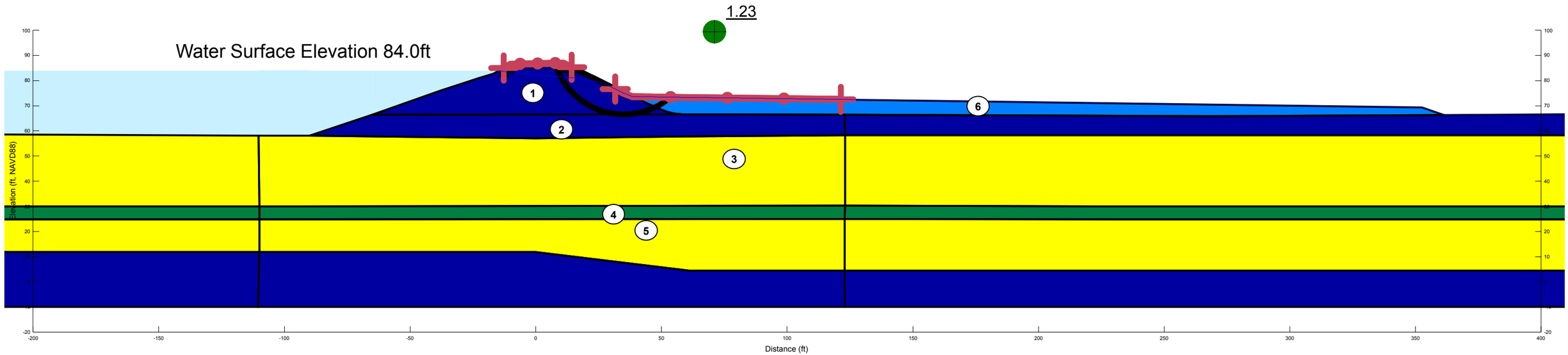
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(12) Clayey Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(14) Silty Sand to Sand, 30-49% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) (2) 0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 18, Section at Sta. 1138+86 Alternative 1 – Undrained Seepage Berm WSE at 200yr+4 ft	FIGURE B18-A3

Slope Stability Analysis Results, Critical Slip Surface

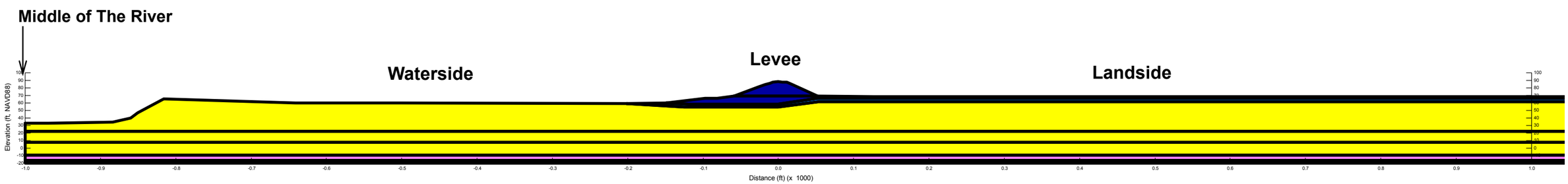


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1	CL	115 pcf	C'=100 psf Phi'=31
2	CL	115 pcf	C'=100 psf Phi'=31
3	SP-SM	120 pcf	C'=0 psf Phi'=30
4	SM	125 pcf	C'=0 psf Phi'=36
5	SP-SM	125 pcf	C'=0 psf Phi'=36
6	ML	120 pcf	C'=50 psf Phi'=32

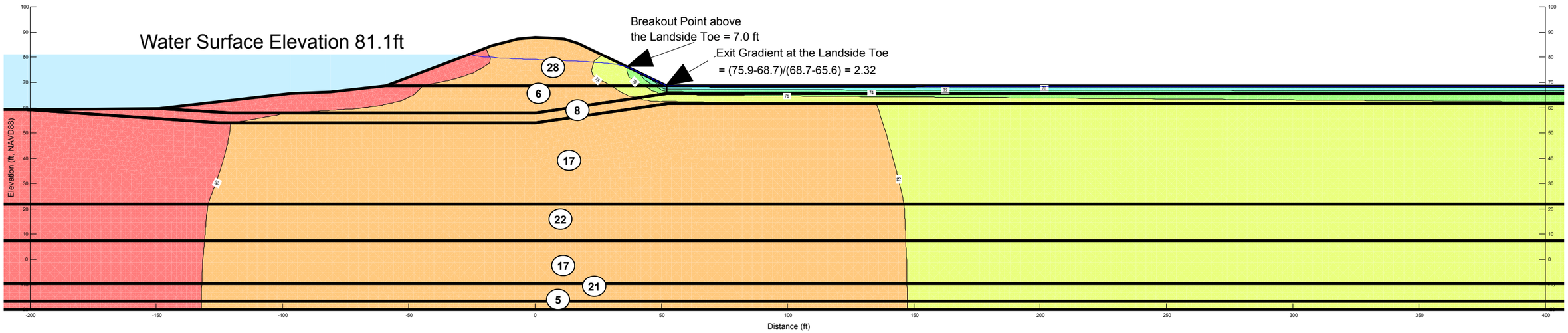
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 18, Section at Sta. 1138+86 Alternative 1 – Undrained Seepage Berm WSE at 200yr+4 ft	FIGURE B18-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



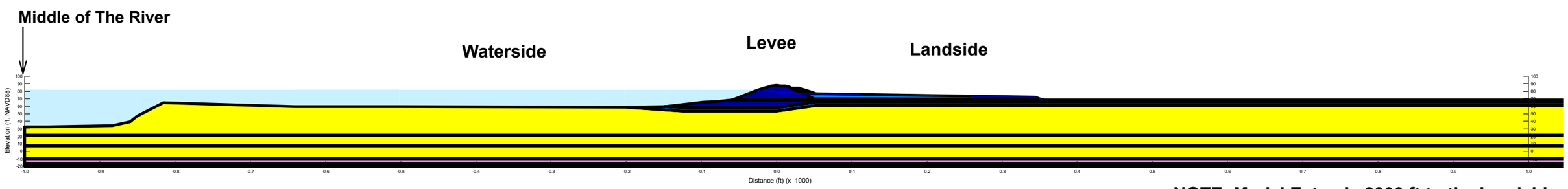
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(21) Clayey Gravel to Gravel,	8-12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25

NOTE: Head Contour Interval 2.0 ft

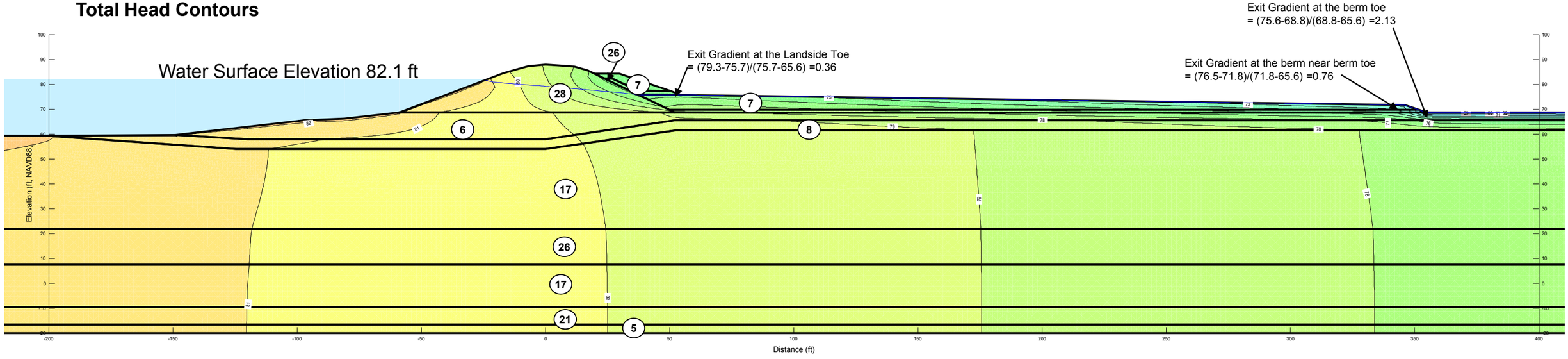
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK
			TASK ORDER 1	ANALYZED TK
			DATE 12/20/2010	CHECKED TSAI
	STEADY-STATE SEEPAGE ANALYSIS Reach 19, Section at Sta. 1238+85 Existing Conditions WSE at 200yr		FIGURE B19-E1	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



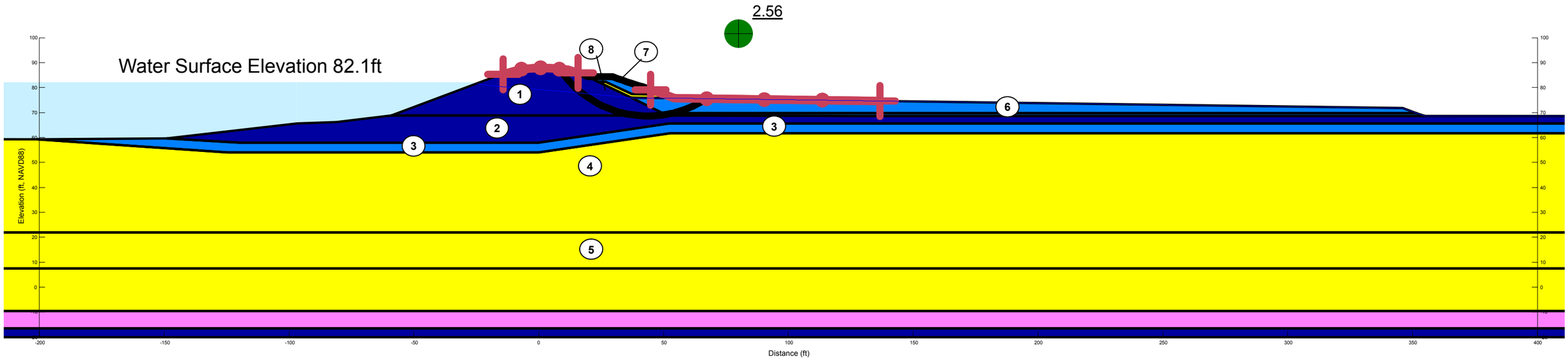
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(21) Clayey Gravel to Gravel,	8-12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN TK TASK ORDER 1 / ANALYZED TK DATE 02/03/2011 / CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 19, Section at Sta. 1238+85 Alternative 1 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+1 ft	FIGURE B19-A1

Slope Stability Analysis Results, Critical Slip Surface

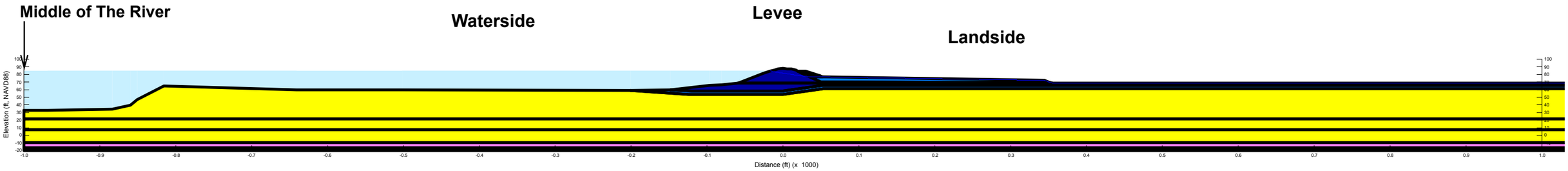


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1	CL	115 pcf	C'=100 psf	Phi'=31
2	CL	115 pcf	C'=100 psf	Phi'=31
3	ML	120 pcf	C'=0 psf	Phi'=32
4	SP-SM	120 pcf	C'=0 psf	Phi'=33
5	GP	130 pcf	C'=0 psf	Phi'=36
6	ML	120 pcf	C'=50 psf	Phi'=32
7	ML	120 pcf	C'=50 psf	Phi'=32
8	GP	130 pcf	C'=0 psf	Phi'=36

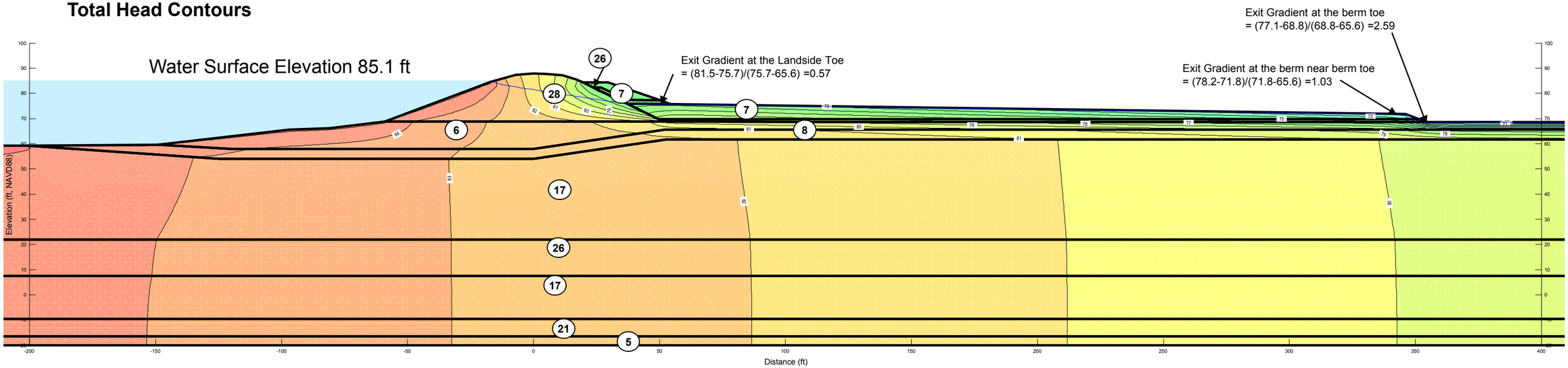
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 19, Section at Sta. 1238+85 Alternative 1 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+1 ft	FIGURE B19-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



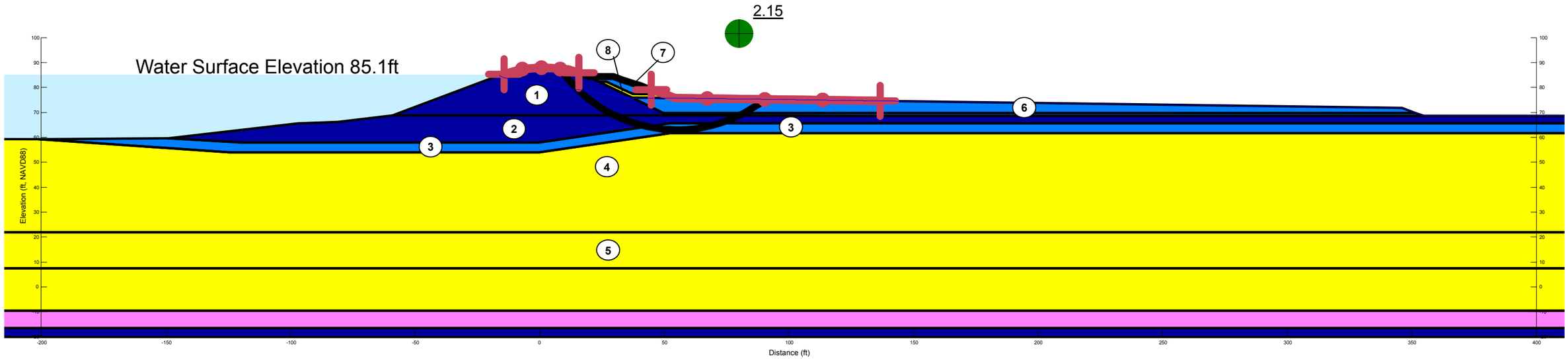
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(21) Clayey Gravel to Gravel, 8-12% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(22) Clayey Gravel to Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 19, Section at Sta. 1238+85 Alternative 1 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+4 ft	FIGURE B19-A3

Slope Stability Analysis Results, Critical Slip Surface

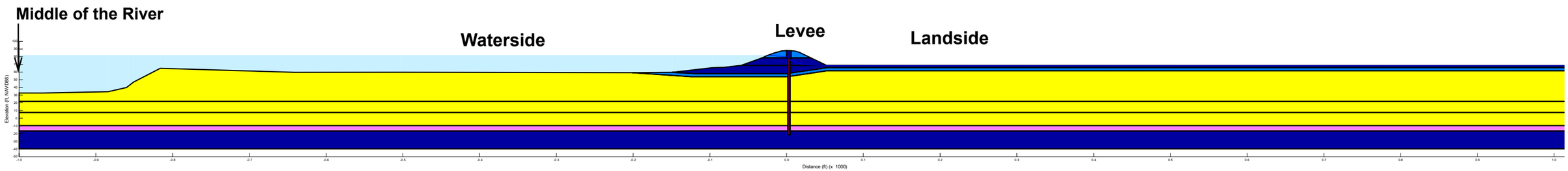


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL	115 pcf	C'=100 psf	Phi'=31
2 CL	115 pcf	C'=100 psf	Phi'=31
3 ML	120 pcf	C'=0 psf	Phi'=32
4 SP-SM	120 pcf	C'=0 psf	Phi'=33
5 GP	130 pcf	C'=0 psf	Phi'=36
6 ML	120 pcf	C'=50 psf	Phi'=32
7 ML	120 pcf	C'=50 psf	Phi'=32
8 GP	130 pcf	C'=0 psf	Phi'=36

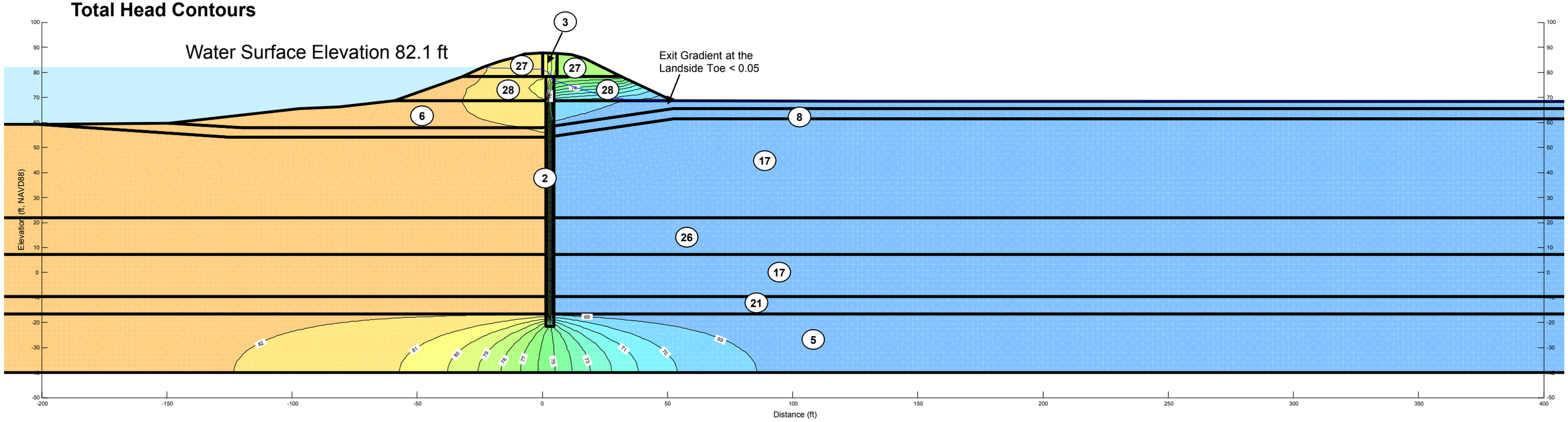
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 19, Section at Sta. 1238+85 Alternative 1 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+4 ft	FIGURE B19-A4

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



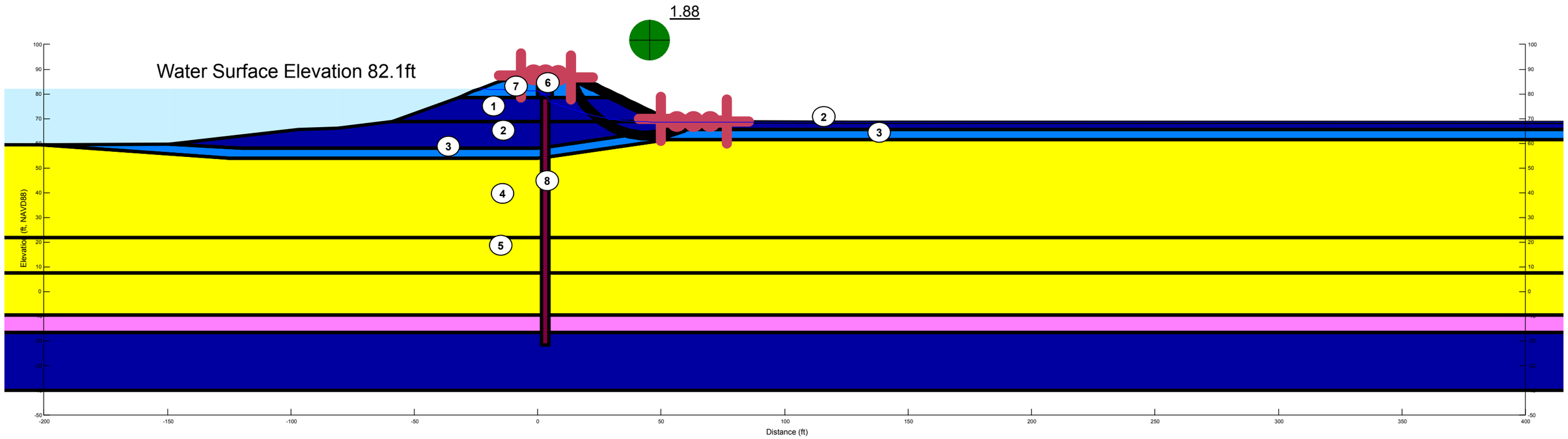
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB), Kh=0.00028 ft/day (=1x10-7 cm/s) 1
(3) New Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(21) Clayey Gravel to Gravel, 8-12% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(27) Regraded Fill, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN TK TASK ORDER 1 / ANALYZED TK DATE 12/20/2010 / CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 19, Section at Sta. 1238+85 Alternative 2 – Cutoff Wall WSE at 200yr+1 ft	FIGURE B19-A5

Slope Stability Analysis Results, Critical Slip Surface



Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

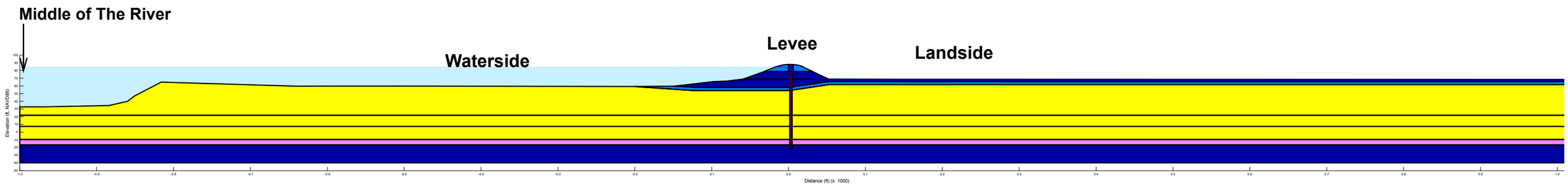
1	CL	115 pcf	C'=100 psf Phi'=31
2	CL	115 pcf	C'=100 psf Phi'=31
3	ML	120 pcf	C'=0 psf Phi'=32
4	SP-SM	120 pcf	C'=0 psf Phi'=33
5	GP	130 pcf	C'=0 psf Phi'=36
6	CL	115 pcf	C'=100 psf Phi'=32
7	ML	120 pcf	C'=50 psf Phi'=32
8	SB	100 pcf	C'=300 psf Phi'=0

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK

STEADY-STATE SLOPE STABILITY ANALYSIS
Reach 19, Section at Sta. 1238+85
Alternative 2 – Cutoff Wall
WSE at 200yr+1 ft

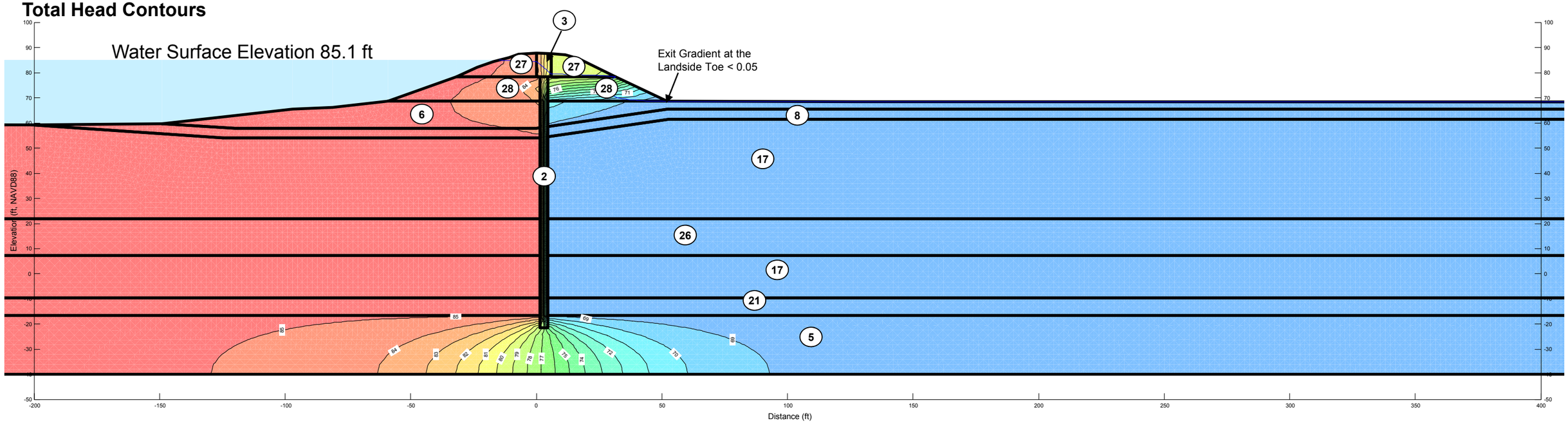
FIGURE B19-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(21) Clayey Gravel to Gravel,	8-12% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day (=3x10-2 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(27) Regraded Fill,		Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency

FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT
Geotechnical Analyses for Pre-Design Formulation Report

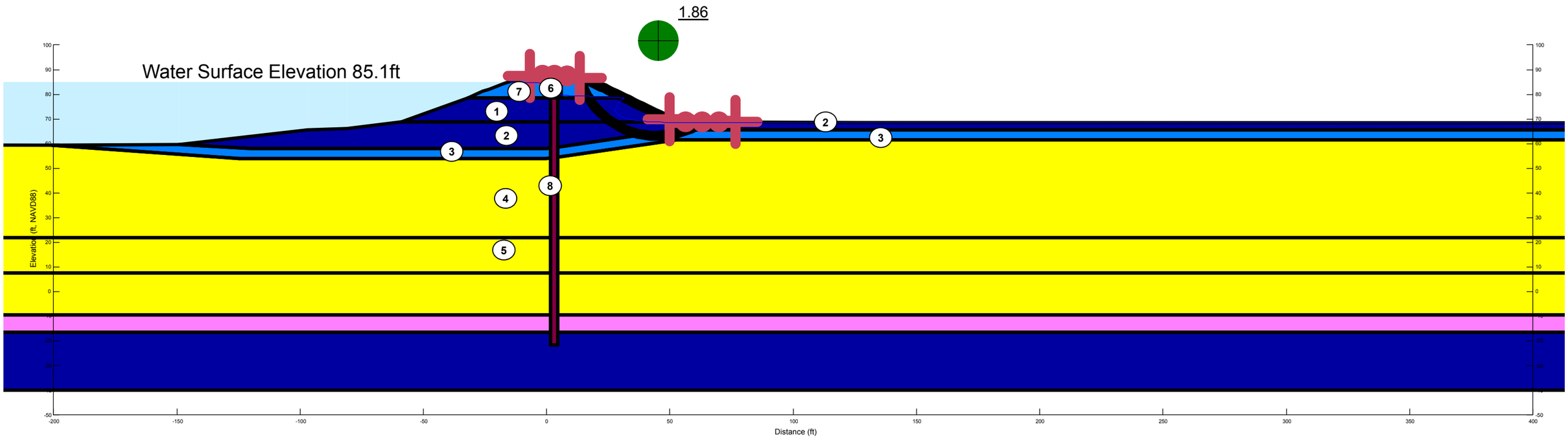
URS
In association with: blackburn consulting

URS PROJECT NO. 17326463	DRAWN TK
TASK ORDER 1	ANALYZED TK
DATE 12/20/2010	CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 19, Section at Sta. 1238+85
Alternative 2 – Cutoff Wall
WSE at 200yr+4 ft

FIGURE B19-A7

Slope Stability Analysis Results, Critical Slip Surface

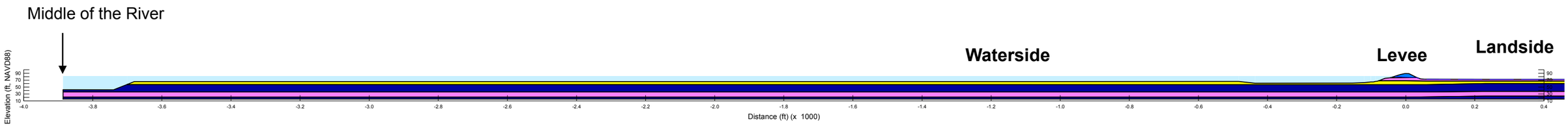


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1	CL	115 pcf	C'=100 psf Phi'=31
2	CL	115 pcf	C'=100 psf Phi'=31
3	ML	120 pcf	C'=0 psf Phi'=32
4	SP-SM	120 pcf	C'=0 psf Phi'=33
5	GP	130 pcf	C'=0 psf Phi'=36
6	CL	115 pcf	C'=100 psf Phi'=32
7	ML	120 pcf	C'=50 psf Phi'=32
8	SB	100 pcf	C'=300 psf Phi'=0

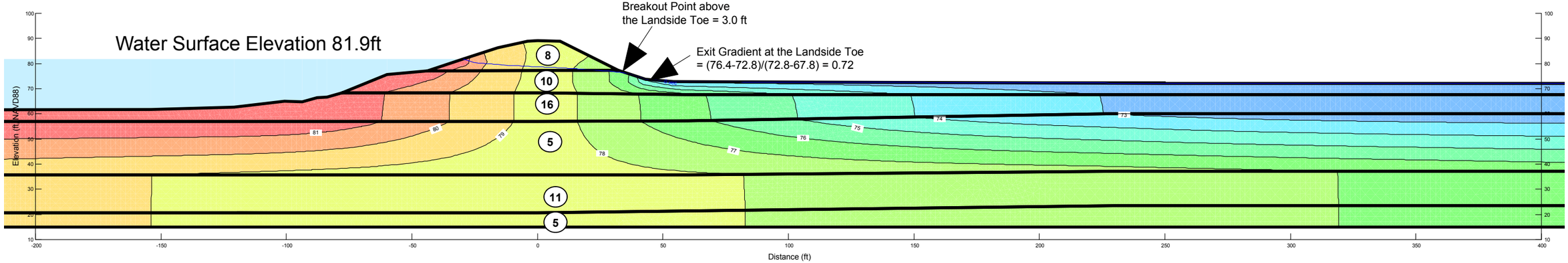
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN TSAI TASK ORDER 1 / ANALYZED TSAI DATE 12/20/2010 / CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 19, Section at Sta. 1238+85 Alternative 2 – Cutoff Wall WSE at 200yr+4 ft	FIGURE B19-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



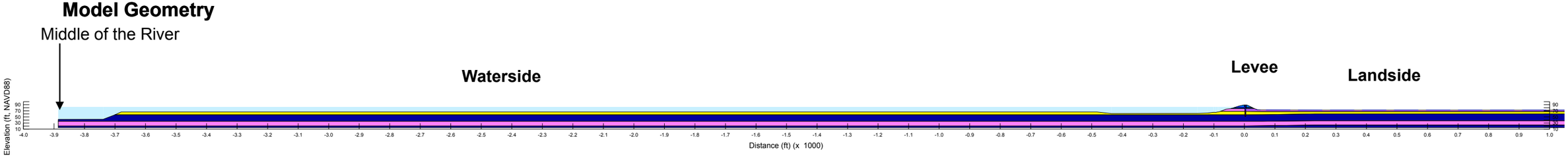
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(10) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

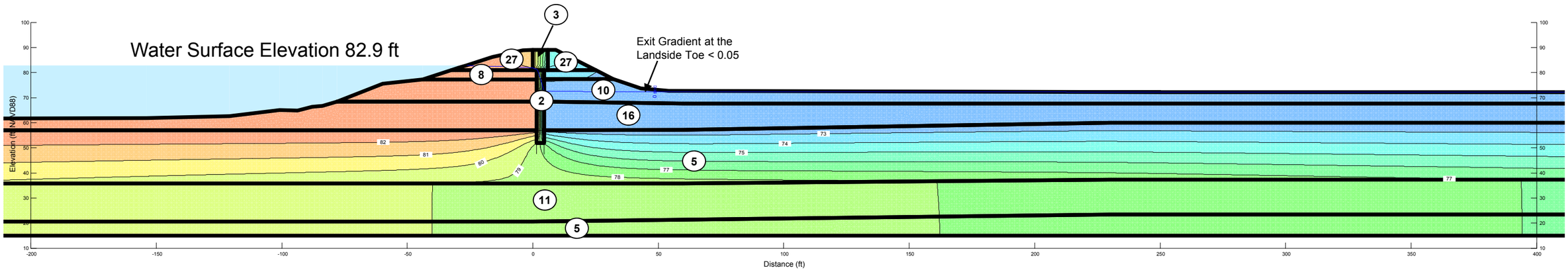
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 20, Section at Sta. 1338+83 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED TK	FIGURE B20-E1
			DATE 02/03/2011	CHECKED TSAI	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(10) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency

FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT
Geotechnical Analyses for Pre-Design Formulation Report

URS

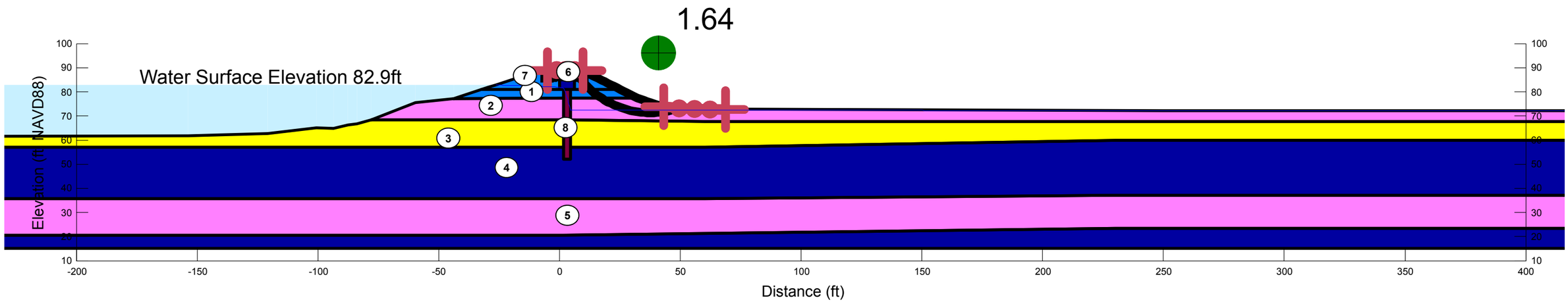
In association with: blackburn consulting

URS PROJECT NO. 17326463	DRAWN TK
TASK ORDER 1	ANALYZED TK
DATE 12/20/2010	CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 20, Section at Sta. 1338+83
Alternative 1 – Cutoff Wall
WSE at 200yr+1 ft

FIGURE B20-A1

Slope Stability Analysis Results, Critical Slip Surface

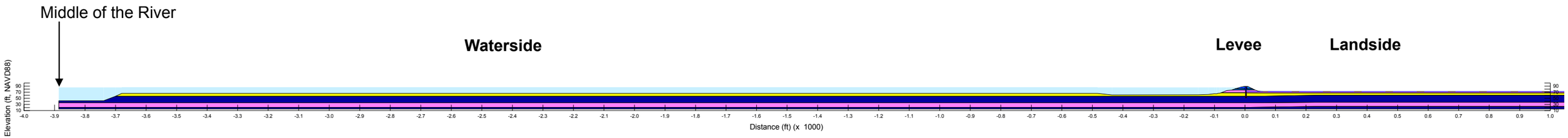


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML	120 pcf	C'=0 psf	Phi'=32
2 SC-SM	120 pcf	C'=0 psf	Phi'=30
3 SP-SM	125 pcf	C'=0 psf	Phi'=36
4 CL	120 pcf	C'=100 psf	Phi'=31
5 SP-SC	125 pcf	C'=0 psf	Phi'=36
6 CL	115 pcf	C'=100 psf	Phi'=32
7 ML	120 pcf	C'=50 psf	Phi'=32
8 SB	100 pcf	C'=300 psf	Phi'=0

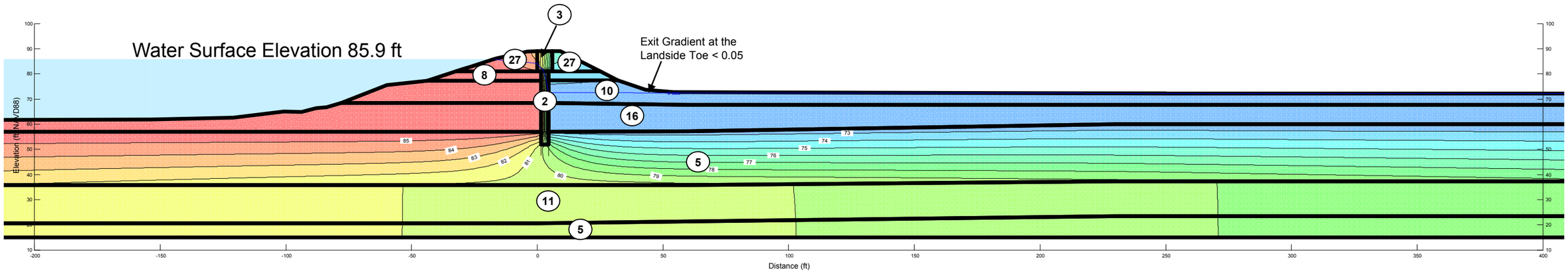
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 20, Section at Sta. 1338+83 Alternative 1 – Cutoff Wall WSE at 200yr+1 ft	FIGURE B20-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(10) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25

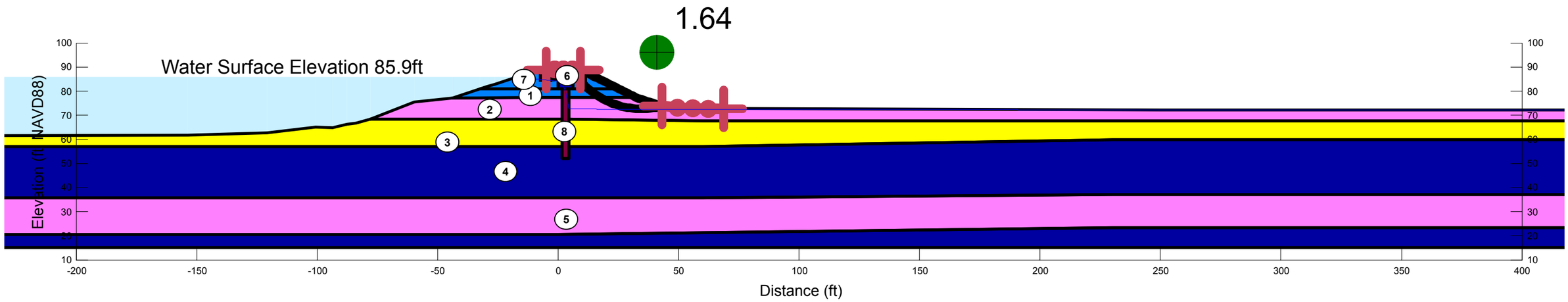
NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 20, Section at Sta. 1338+83
Alternative 1 – Cutoff Wall
WSE at 200yr+4 ft

FIGURE B20-A3

Slope Stability Analysis Results,
Critical Slip Surface

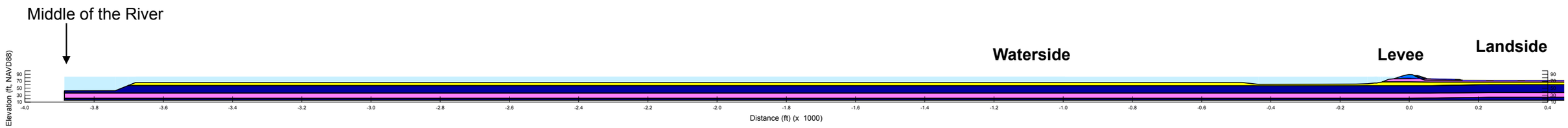


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=0 psf Phi'=32
2 SC-SM 120 pcf C'=0 psf Phi'=30
3 SP-SM 125 pcf C'=0 psf Phi'=36
4 CL 120 pcf C'=100 psf Phi'=31
5 SP-SC 125 pcf C'=0 psf Phi'=36
6 CL 115 pcf C'=100 psf Phi'=32
7 ML 120 pcf C'=50 psf Phi'=32
8 SB 100 pcf C'=300 psf Phi'=0

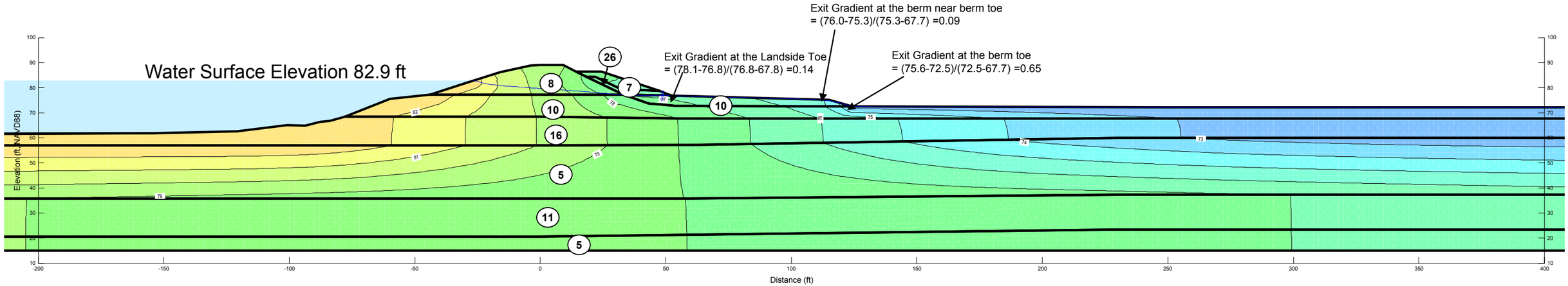
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 20, Section at Sta. 1338+83 Alternative 1 – Cutoff Wall WSE at 200yr+4 ft	FIGURE B20-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 1.0 ft

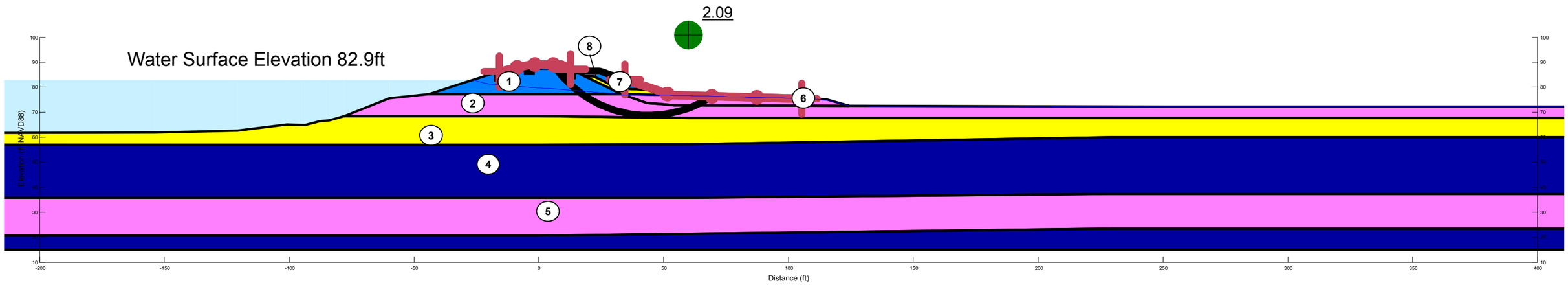
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(10) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 20, Section at Sta. 1338+83 Alternative 2 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED TK	
			DATE 02/03/2011	CHECKED TSAI	

FIGURE B20-A5

Slope Stability Analysis Results, Critical Slip Surface

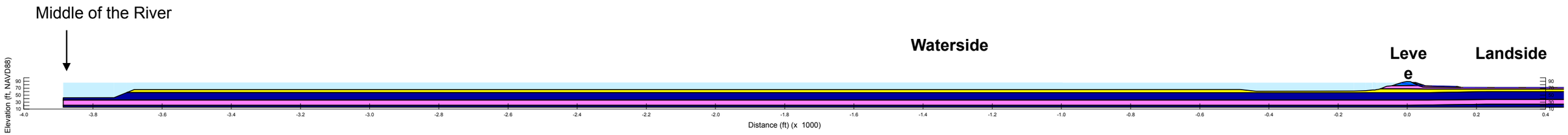


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=0 psf Phi'=32
2 SC-SM 120 pcf C'=0 psf Phi'=30
3 SP-SM 125 pcf C'=0 psf Phi'=36
4 CL 120 pcf C'=100 psf Phi'=31
5 SP-SM 125 pcf C'=0 psf Phi'=36
6 SC-SM 125 pcf C'=0 psf Phi'=35
7 ML 120 pcf C'=50 psf Phi'=32
8 GP 130 pcf C'=0 psf Phi'=36

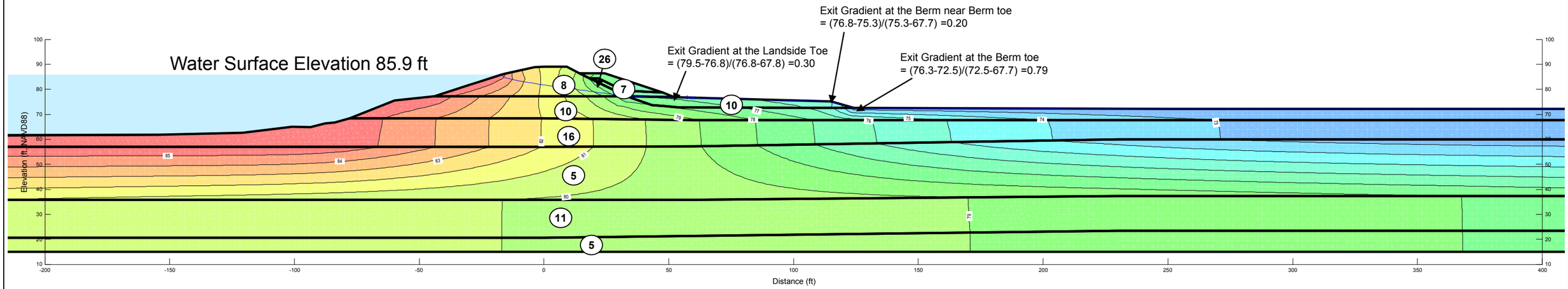
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TSAI ANALYZED TSAI CHECKE TKD	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 20, Section at Sta. 1338+83 Alternative 2 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+1 ft	FIGURE B20-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



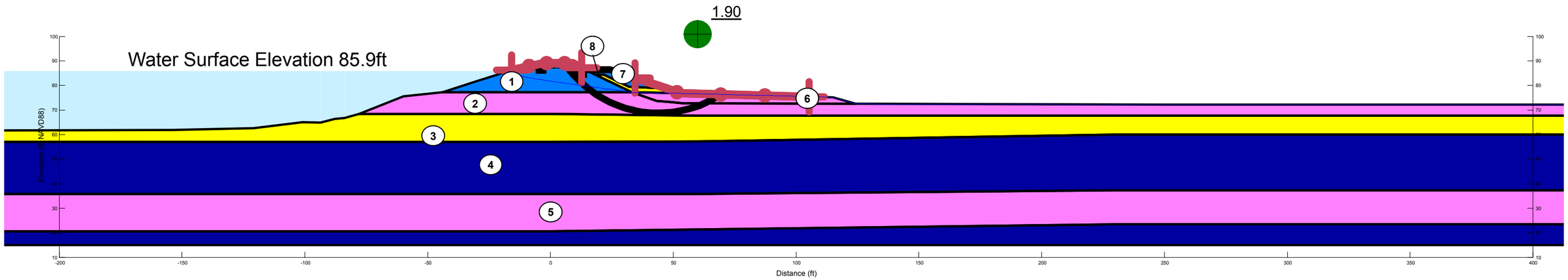
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s)				0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(10) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 20, Section at Sta. 1338+83 Alternative 2 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+4 ft	FIGURE B20-A7

Slope Stability Analysis Results, Critical Slip Surface

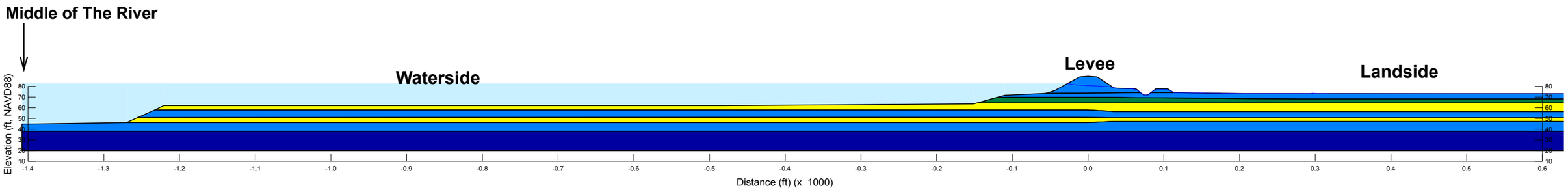


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=0 psf Phi'=32
2 SC-SM 120 pcf C'=0 psf Phi'=30
3 SP-SM 125 pcf C'=0 psf Phi'=36
4 CL 120 pcf C'=100 psf Phi'=31
5 SP-SM 125 pcf C'=0 psf Phi'=36
6 SC-SM 125 pcf C'=0 psf Phi'=35
7 ML 120 pcf C'=50 psf Phi'=32
8 GP 130 pcf C'=0 psf Phi'=36

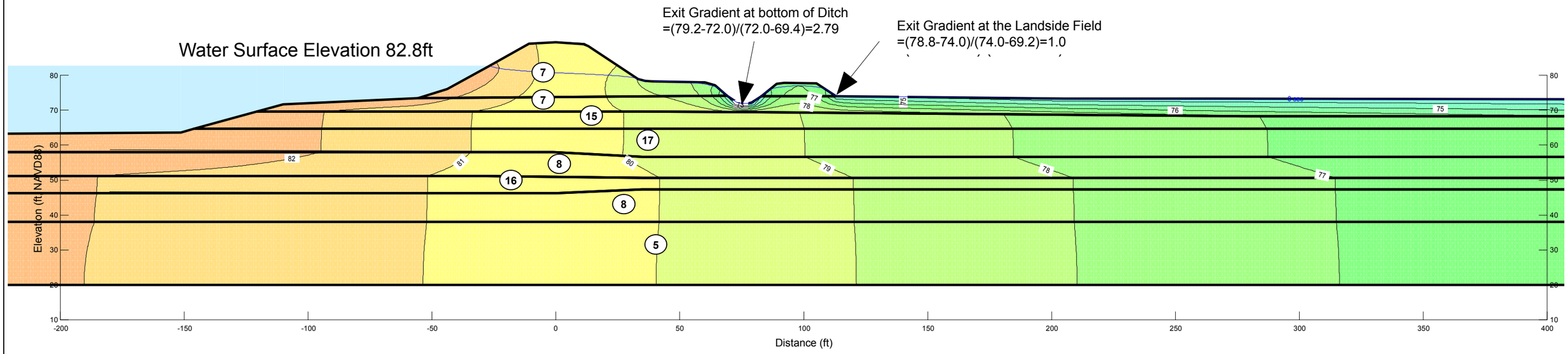
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 20, Section at Sta. 1338+83 Alternative 2 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+4 ft	FIGURE B20-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



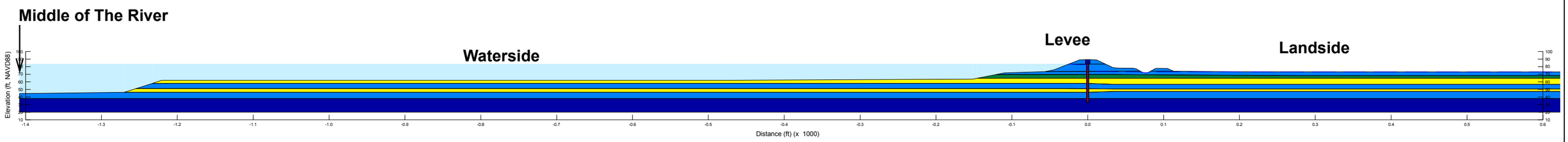
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

NOTE: Head Contour Interval 1.0 ft

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25

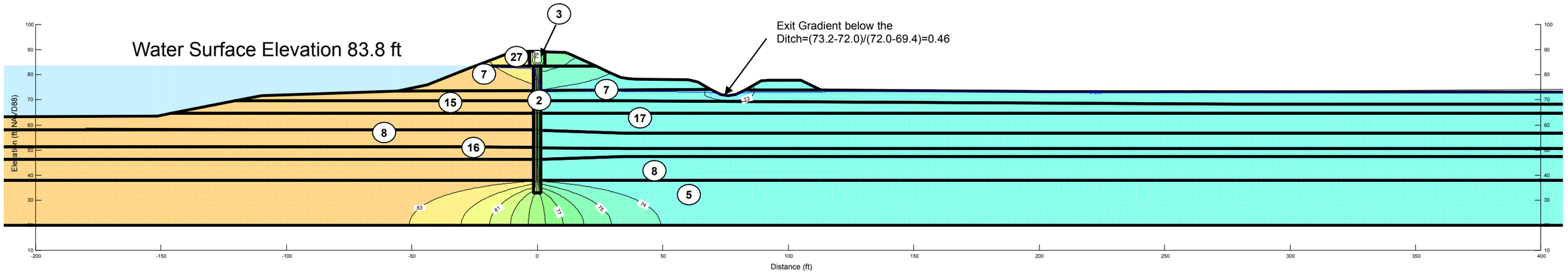
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 21, Section at Sta. 1378+83 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED TK	
			DATE 02/03/2011	CHECKED TSAI	FIGURE B21-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



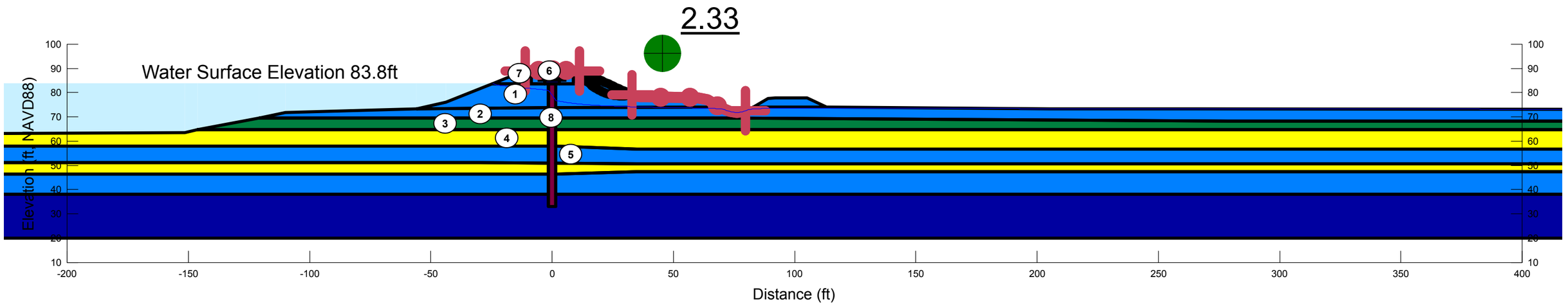
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s)			0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 21, Section at Sta. 1378+83 Alternative 1 – Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED TK	FIGURE B21-A1
			DATE 02/03/2011	CHECKED TSAI	

Slope Stability Analysis Results, Critical Slip Surface



Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

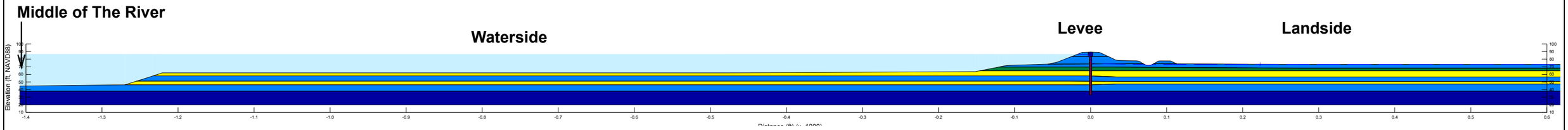
1	ML/CL	115 pcf	C'=100 psf Phi'=31
2	ML/CL	115 pcf	C'=100 psf Phi'=31
3	SM	115 pcf	C'=0 psf Phi'=30
4	SP-SM	120 pcf	C'=0 psf Phi'=34
5	ML	120 pcf	C'=0 psf Phi'=32
6	CL	115 pcf	C'=100 psf Phi'=32
7	ML	120 pcf	C'=50 psf Phi'=32
8	SB	100 pcf	C'=300 psf Phi'=0

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK

STEADY-STATE SLOPE STABILITY ANALYSIS
Reach 21, Section at Sta. 1378+83
Alternative 1– Cutoff Wall
WSE at 200yr+1 ft

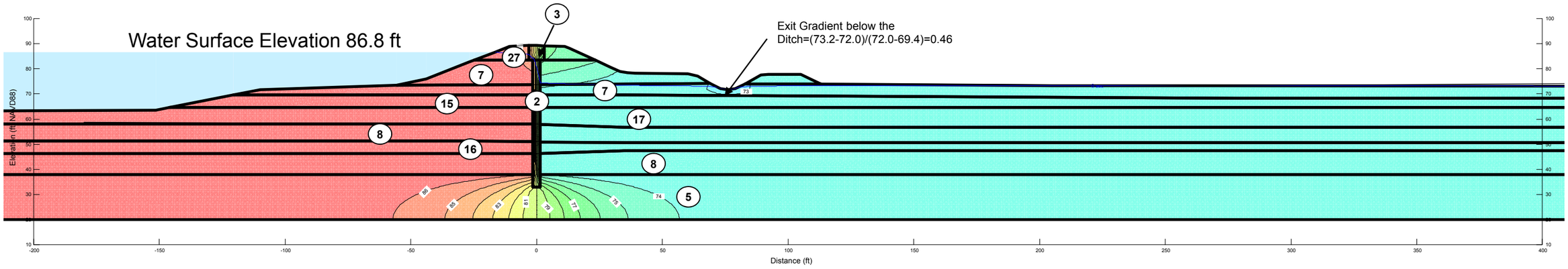
FIGURE B21-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



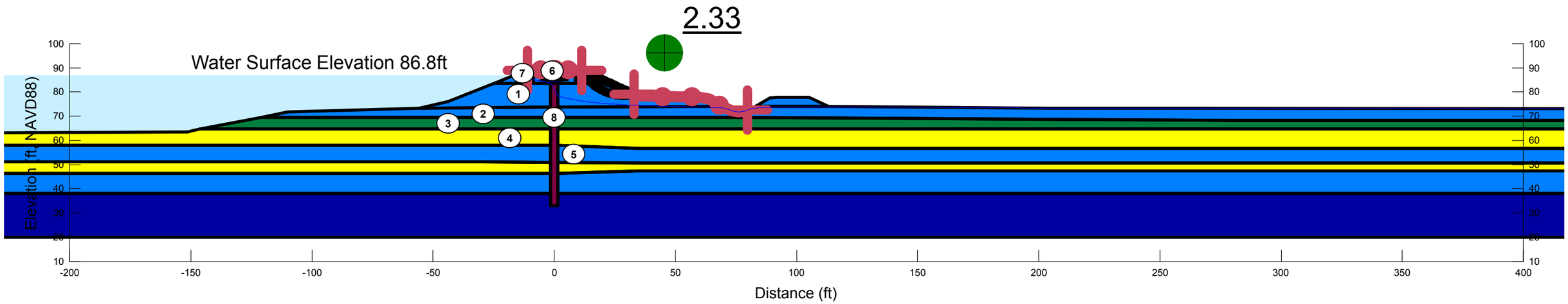
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN TK TASK ORDER 1 / ANALYZED TK DATE 02/03/2011 / CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 21, Section at Sta. 1378+83 Alternative 1 – Cutoff Wall WSE at 200yr+4 ft	FIGURE B21-A3

Slope Stability Analysis Results,
Critical Slip Surface

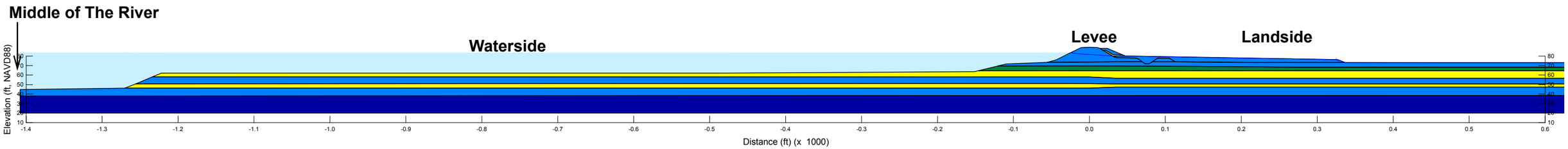


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1	ML/CL	115 pcf	C'=100 psf Phi'=31
2	ML/CL	115 pcf	C'=100 psf Phi'=31
3	SM	115 pcf	C'=0 psf Phi'=30
4	SP-SM	120 pcf	C'=0 psf Phi'=34
5	ML	120 pcf	C'=0 psf Phi'=32
6	CL	115 pcf	C'=100 psf Phi'=32
7	ML	120 pcf	C'=50 psf Phi'=32
8	SB	100 pcf	C'=300 psf Phi'=0

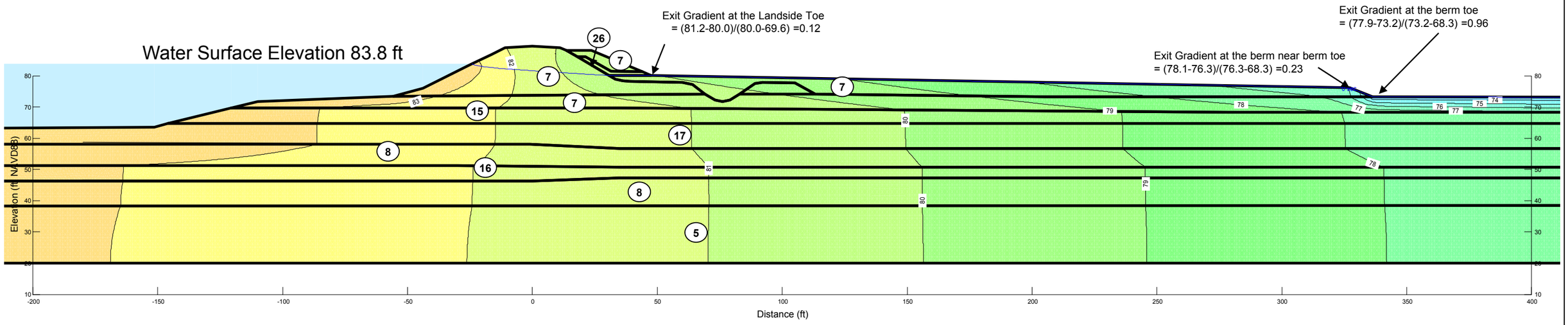
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN TSAI TASK ORDER 1 / ANALYZED TSAI DATE 02/03/2011 / CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 21, Section at Sta. 1378+83 Alternative 1 – Cutoff Wall WSE at 200yr+4 ft	FIGURE B21-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

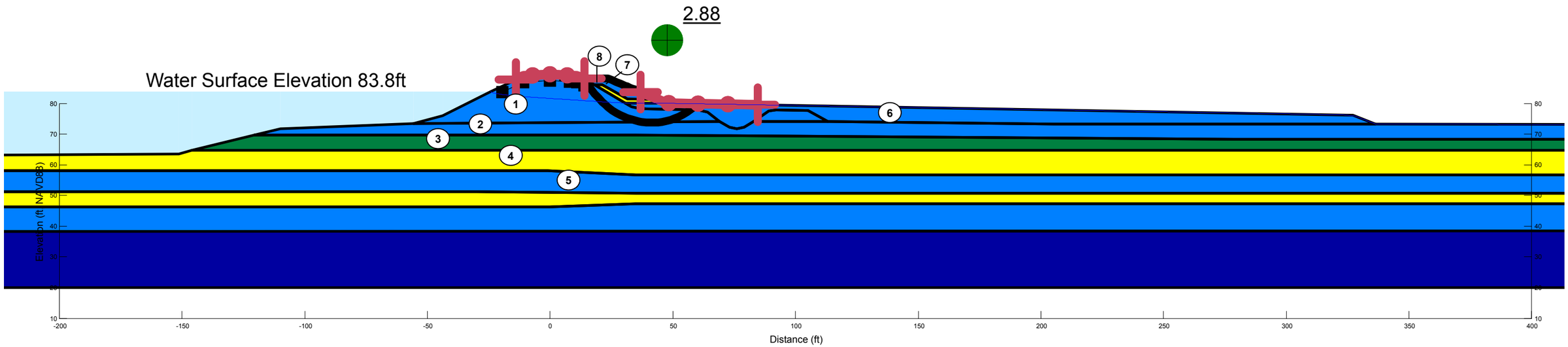
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK
			TASK ORDER 1	ANALYZED TK
			DATE 02/03/2011	CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 21, Section at Sta. 1378+83
Alternative 2 – Undrained Seepage Berm with Drained Stability Berm on Top
WSE at 200yr+1 ft

FIGURE B21-A5

Slope Stability Analysis Results, Critical Slip Surface

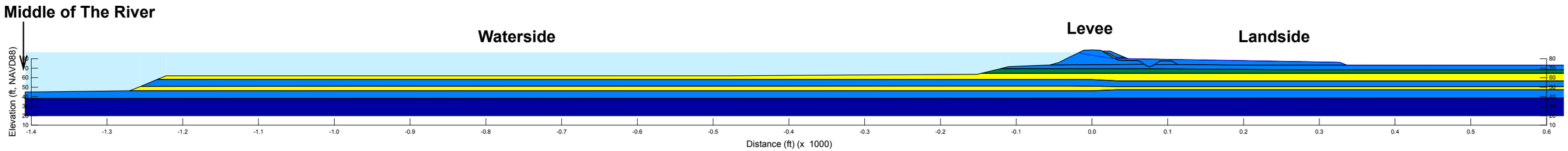


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML/CL	115 pcf	C'=100 psf	Phi'=31
2 ML/CL	115 pcf	C'=100 psf	Phi'=31
3 SM	115 pcf	C'=0 psf	Phi'=30
4 SP-SM	120 pcf	C'=0 psf	Phi'=34
5 ML	120 pcf	C'=0 psf	Phi'=32
6 ML	120 pcf	C'=50 psf	Phi'=32
7 ML	120 pcf	C'=50 psf	Phi'=32
8 GP	130 pcf	C'=0 psf	Phi'=36

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TSAI	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 21, Section at Sta. 1378+83 Alternative 2 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED TSAI	FIGURE B21-A6
			DATE 02/03/2011	CHECKED TK	

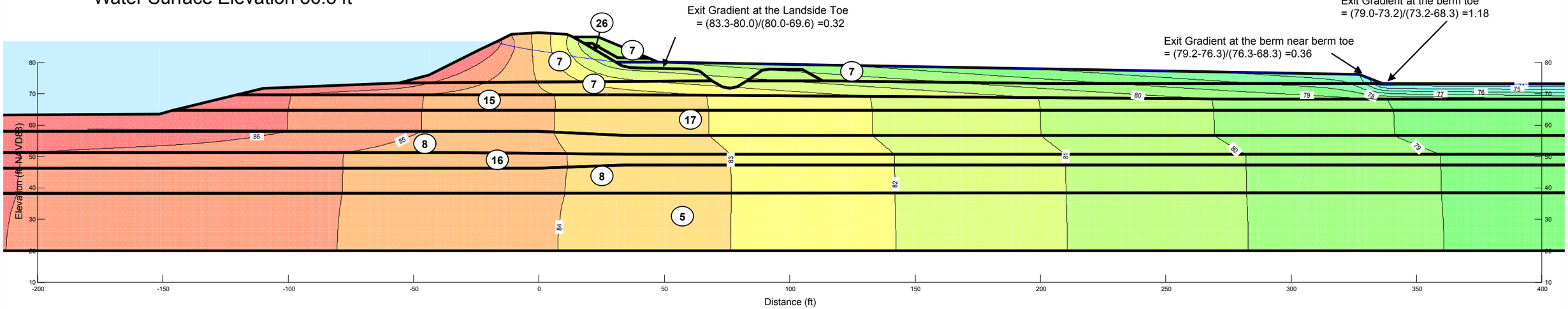
Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours

Water Surface Elevation 86.8 ft



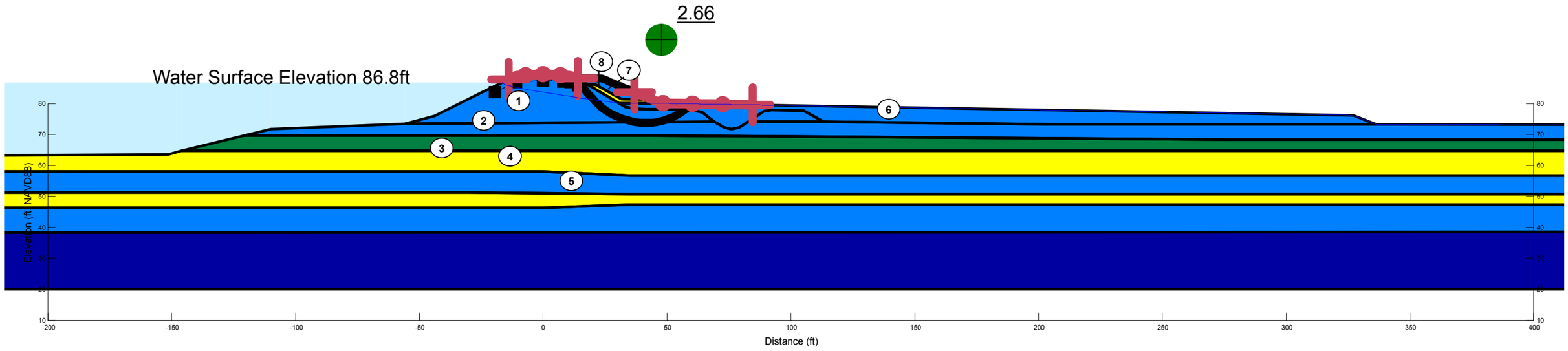
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TASI	STEADY-STATE SEEPAGE ANALYSIS Reach 21, Section at Sta. 1378+83 Alternative 2 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+4 ft	FIGURE B21-A7

Slope Stability Analysis Results,
Critical Slip Surface

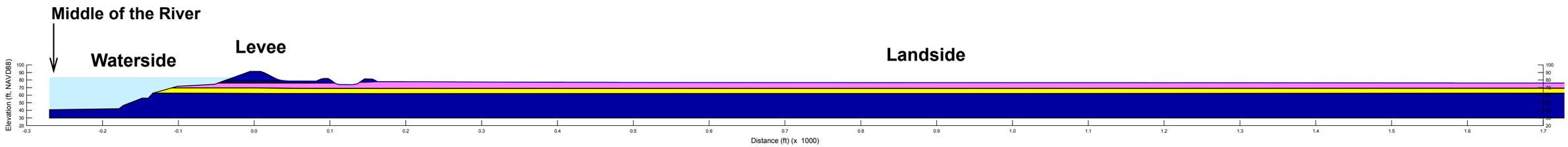


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML/CL	115 pcf	C'=100 psf	Phi'=31
2 ML/CL	115 pcf	C'=100 psf	Phi'=31
3 SM	115 pcf	C'=0 psf	Phi'=30
4 SP-SM	120 pcf	C'=0 psf	Phi'=34
5 ML	120 pcf	C'=0 psf	Phi'=32
6 ML	120 pcf	C'=50 psf	Phi'=32
7 ML	120 pcf	C'=50 psf	Phi'=32
8 GP	130 pcf	C'=0 psf	Phi'=36

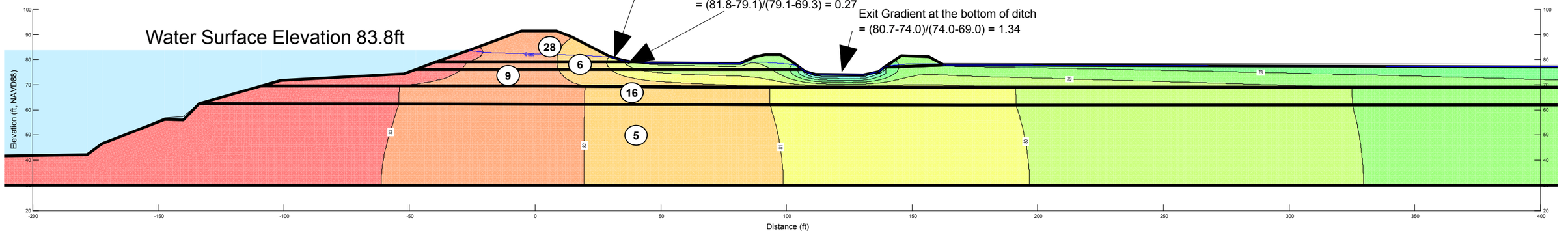
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TSAI	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 21, Section at Sta. 1378+83 Alternative 2 – Undrained Seepage Berm with Drained Stability Berm on Top WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED TSAI	FIGURE B21-A8
			DATE 02/03/2011	CHECKED TK	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

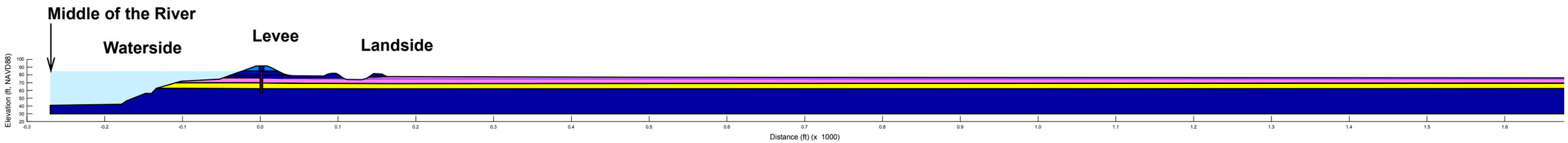
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(9) Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 22, Section at Sta. 1468+83
Existing Conditions
WSE at 200yr

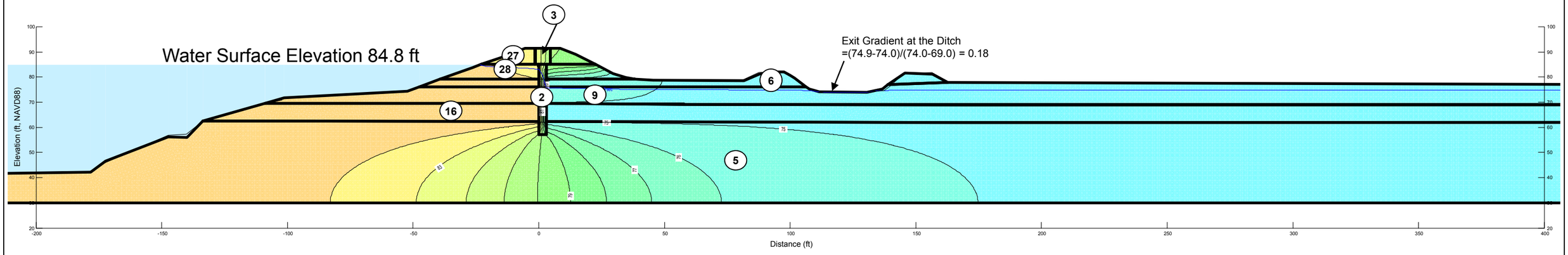
FIGURE B22-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(9) Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25

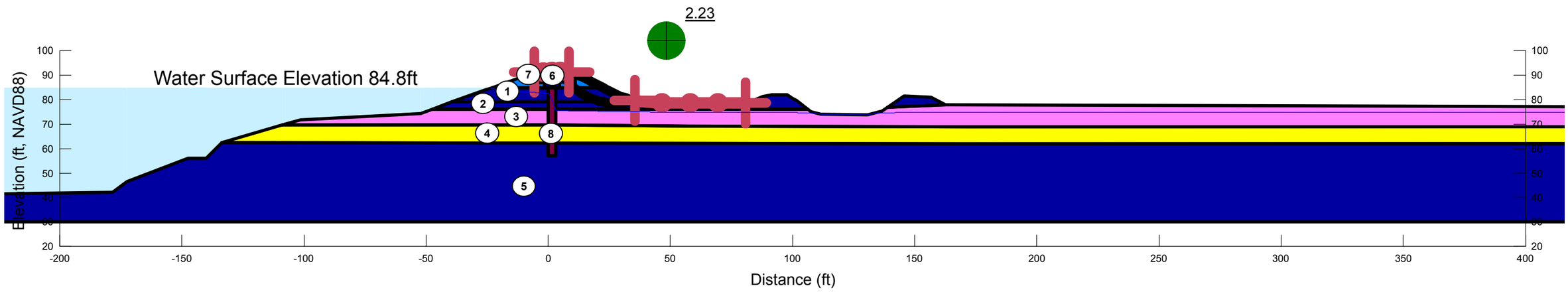
NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 22, Section at Sta. 1468+83
Alternative 1– Cutoff Wall
WSE at 200yr+1 ft

FIGURE B22-A1

Slope Stability Analysis Results,
Critical Slip Surface

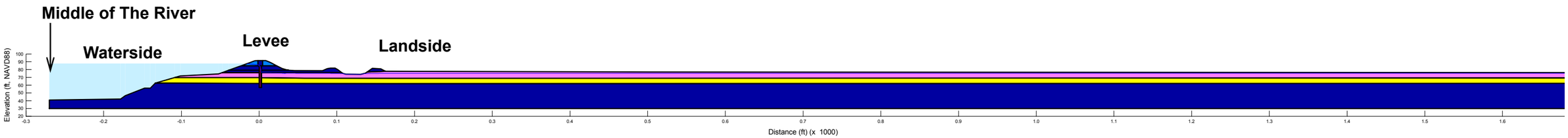


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=100 psf Phi'=31
3 SC-SM 120 pcf C'=0 psf Phi'=32
4 SP-SM 125 pcf C'=0 psf Phi'=36
5 CL 120 pcf C'=0 psf Phi'=30
6 CL 115 pcf C'=100 psf Phi'=32
7 ML 120 pcf C'=50 psf Phi'=32
8 SB 100 pcf C'=300 psf Phi'=0

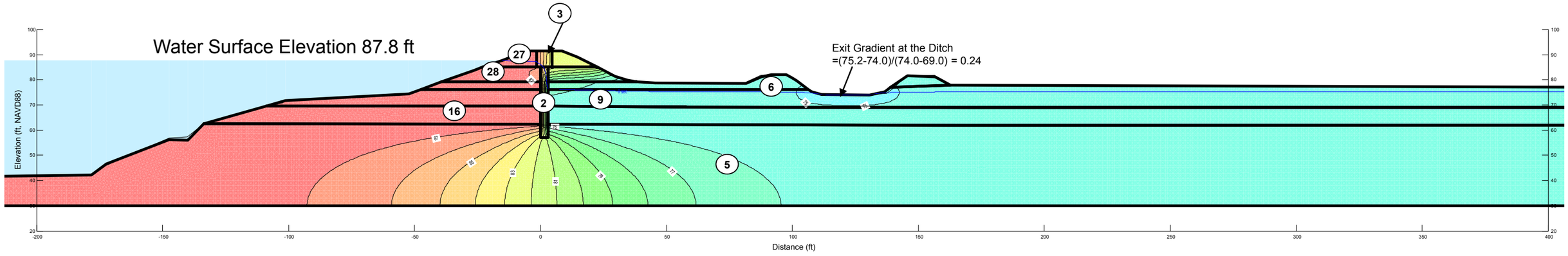
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 22, Section at Sta. 1468+83 Alternative 1 – Cutoff Wall WSE at 200yr+1 ft	FIGURE B22-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

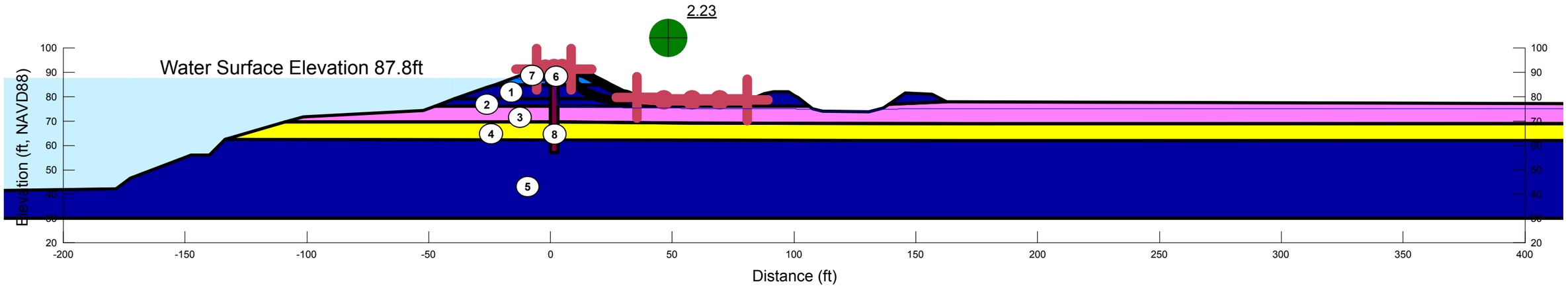
(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(9) Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 22, Section at Sta. 1468+83
Alternative 1 – Cutoff Wall
WSE at 200yr+4 ft

FIGURE B22-A3

Slope Stability Analysis Results,
Critical Slip Surface

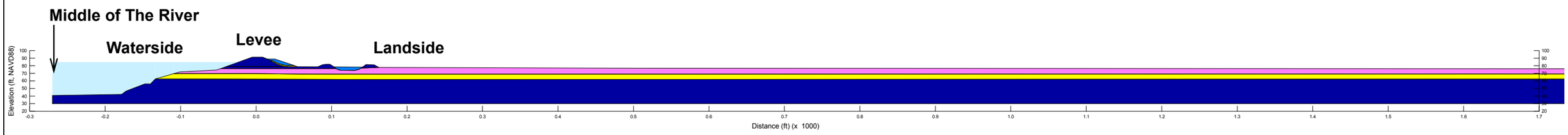


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=100 psf Phi'=31
3 SC-SM 120 pcf C'=0 psf Phi'=32
4 SP-SM 125 pcf C'=0 psf Phi'=36
5 CL 120 pcf C'=0 psf Phi'=30
6 CL 115 pcf C'=100 psf Phi'=32
7 ML 120 pcf C'=50 psf Phi'=32
8 SB 100 pcf C'=300 psf Phi'=0

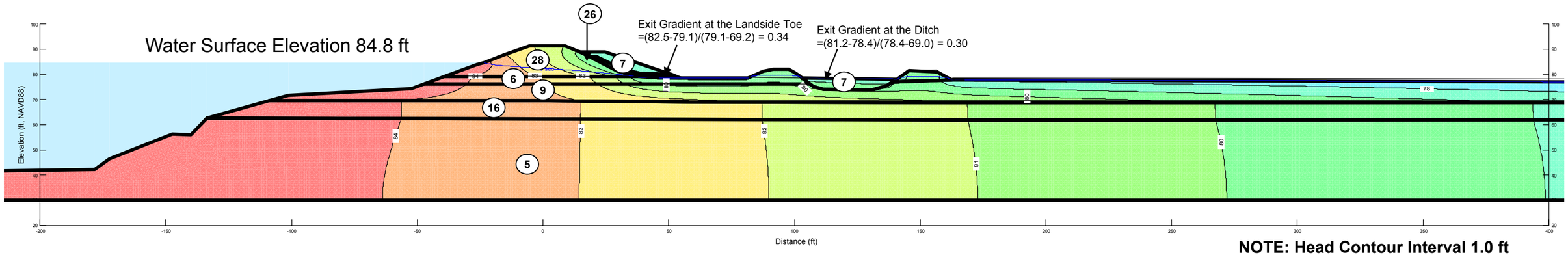
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 22, Section at Sta. 1468+83 Alternative 1 – Cutoff Wall WSE at 200yr+3 ft	FIGURE B22-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



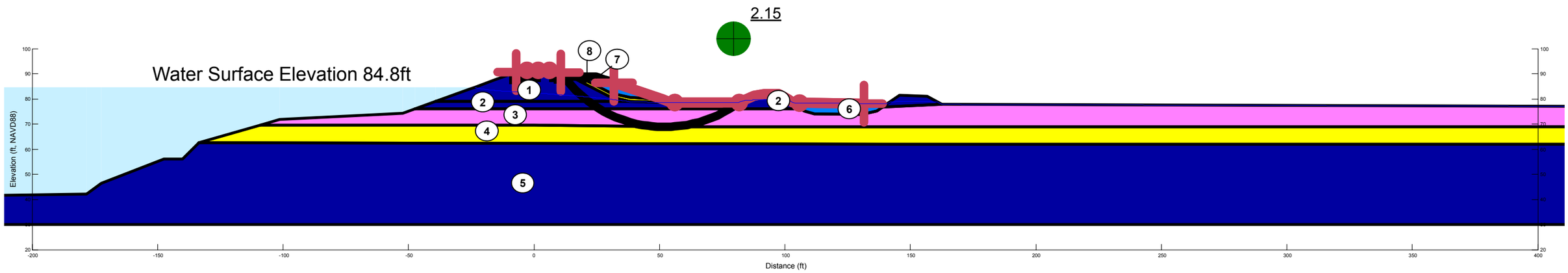
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(9) Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 22, Section at Sta. 1468+83 Alternative 2 – Fill Canal and Drained Stability Berm WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED TK	FIGURE B22-A5
			DATE 12/20/2010	CHECKED TSAI	

Slope Stability Analysis Results, Critical Slip Surface

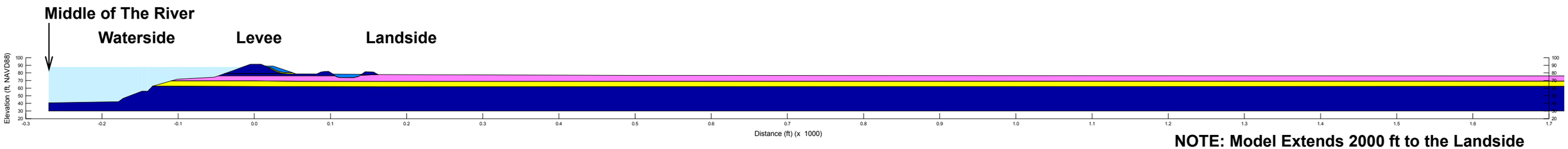


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=100 psf Phi'=31
3 SC-SM 120 pcf C'=0 psf Phi'=32
4 SP-SM 125 pcf C'=0 psf Phi'=36
5 CL 120 pcf C'=0 psf Phi'=30
6 ML 120 pcf C'=50 psf Phi'=32
7 ML 120 pcf C'=50 psf Phi'=32
8 GP 130 pcf C'=0 psf Phi'=36

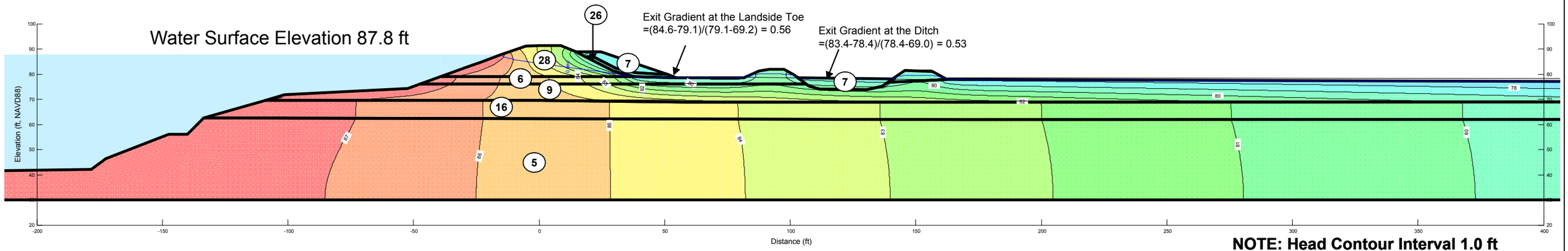
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 22, Section at Sta. 1468+83 Alternative 2 – Fill Canal and Drained Stability Berm WSE at 200yr+1 ft	FIGURE B22-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



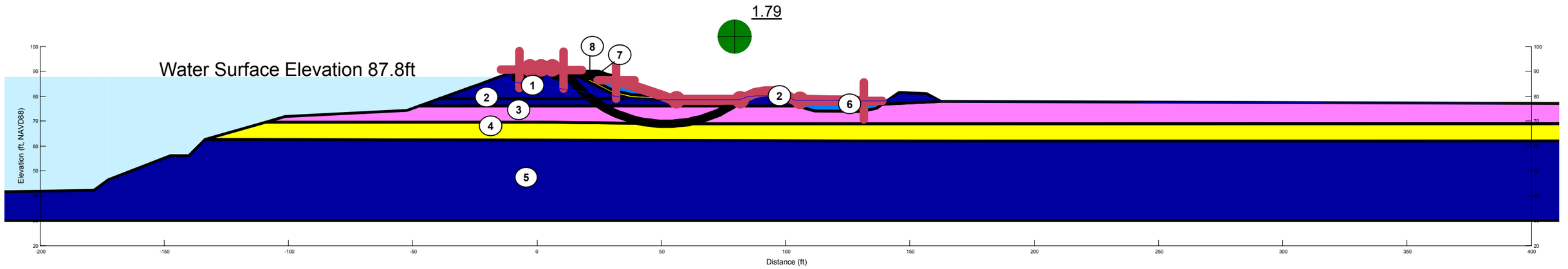
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(9) Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 22, Section at Sta. 1468+83 Alternative 2 – Fill Canal and Drained Stability Berm WSE at 200yr+4 ft	FIGURE B22-A7

Slope Stability Analysis Results, Critical Slip Surface

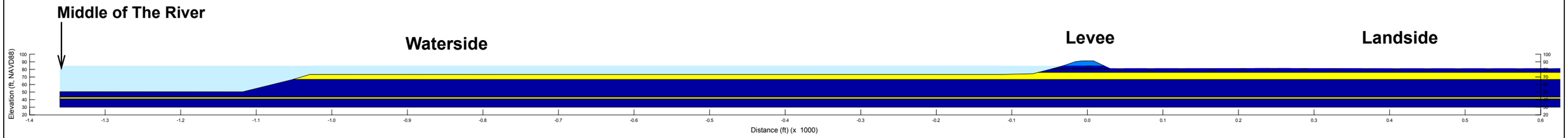


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=100 psf Phi'=31
3 SC-SM 120 pcf C'=0 psf Phi'=32
4 SP-SM 125 pcf C'=0 psf Phi'=36
5 CL 120 pcf C'=0 psf Phi'=30
6 ML 120 pcf C'=50 psf Phi'=32
7 ML 120 pcf C'=50 psf Phi'=32
8 GP 130 pcf C'=0 psf Phi'=36

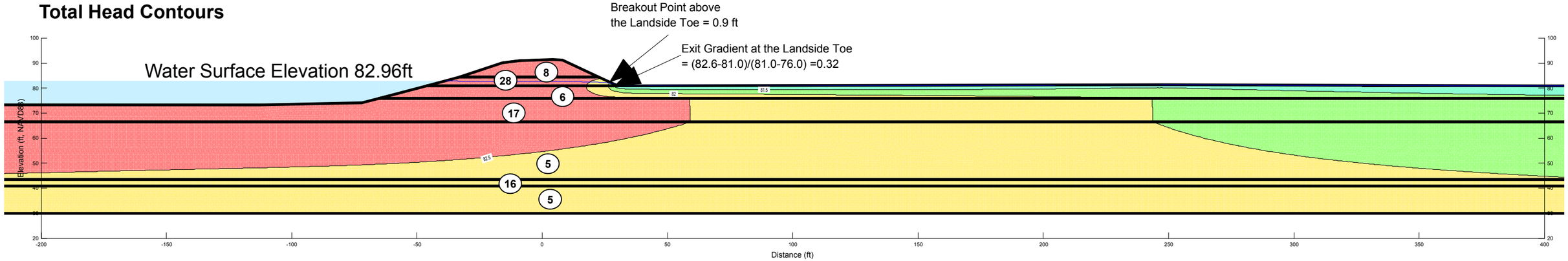
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 22, Section at Sta. 1468+83 Alternative 2 – Fill Canal and Drained Stability Berm WSE at 200yr+4 ft	FIGURE B22-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25

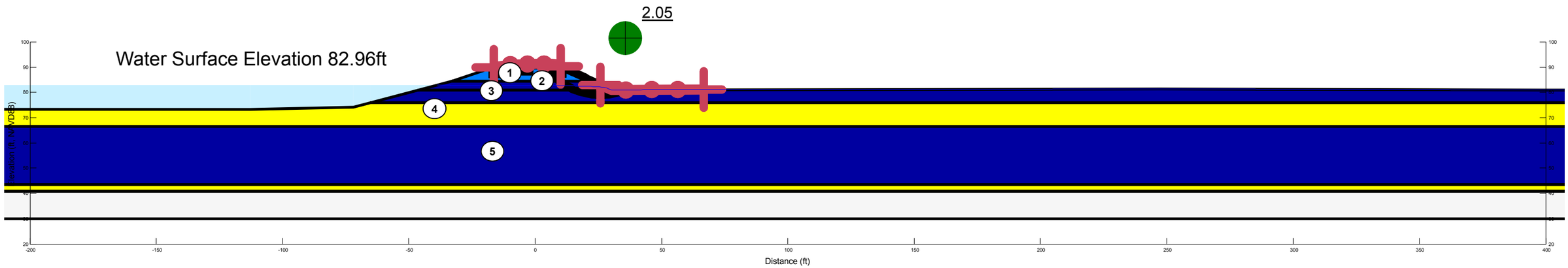
NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 23, Section at Sta. 1508+33
Existing Conditions
WSE at 100yr

FIGURE B23-E1

Slope Stability Analysis Results, Critical Slip Surface

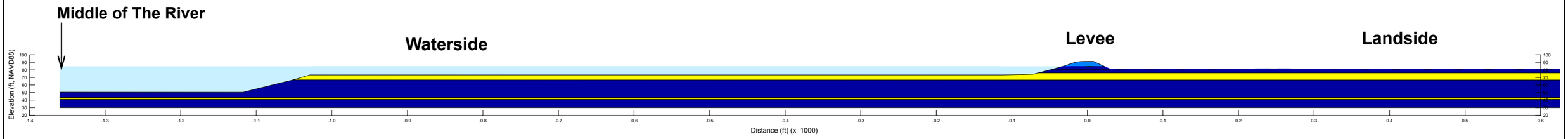


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=0 psf Phi'=32
2 CL-ML 115 pcf C'=100 psf Phi'=31
3 CL-ML 115 pcf C'=100 psf Phi'=31
4 SP-SM 120 pcf C'=0 psf Phi'=35
5 CL 115 pcf C'=100 psf Phi'=31

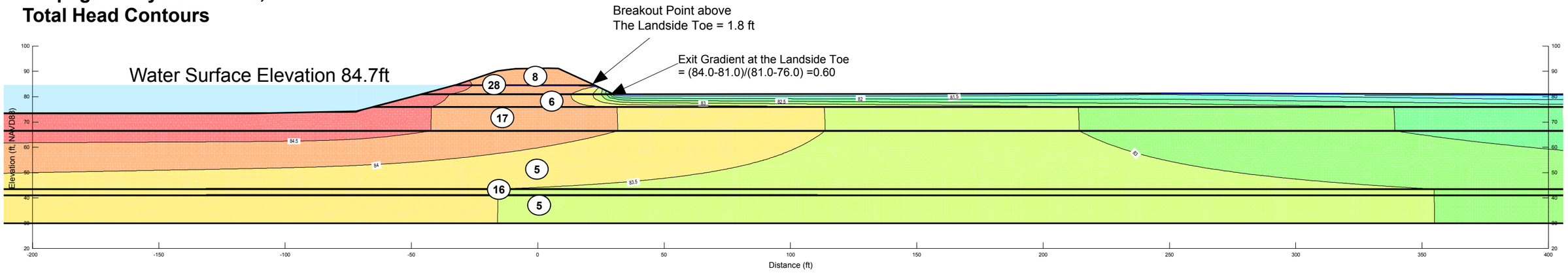
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TSAI	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 23, Section at Sta. 1508+33 Existing Conditions WSE at 100yr
			TASK ORDER 1	ANALYZED TSAI	FIGURE B23-E2
			DATE 02/03/2011	CHECKED TK	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(28) Existing Clay Levee		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25

Sutter Butte Flood Control Agency

FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT
Geotechnical Analyses for Pre-Design Formulation Report

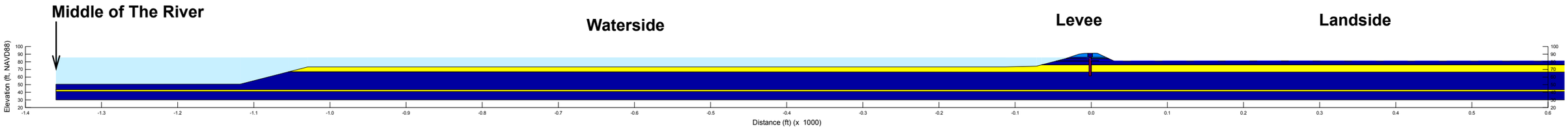
URS
In association with: blackburn consulting

URS PROJECT NO. 17326463	DRAWN TK
TASK ORDER 1	ANALYZED TK
DATE 02/03/2011	CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 23, Section at Sta. 1508+33
Existing Conditions
WSE at 200yr

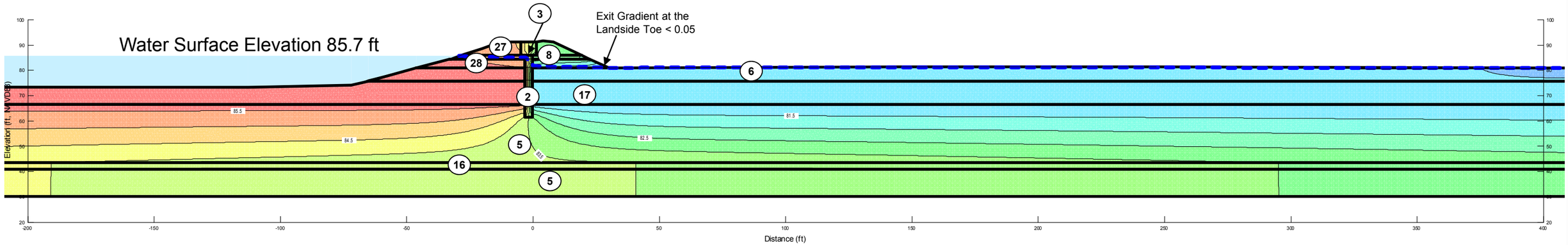
FIGURE B23-E3

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



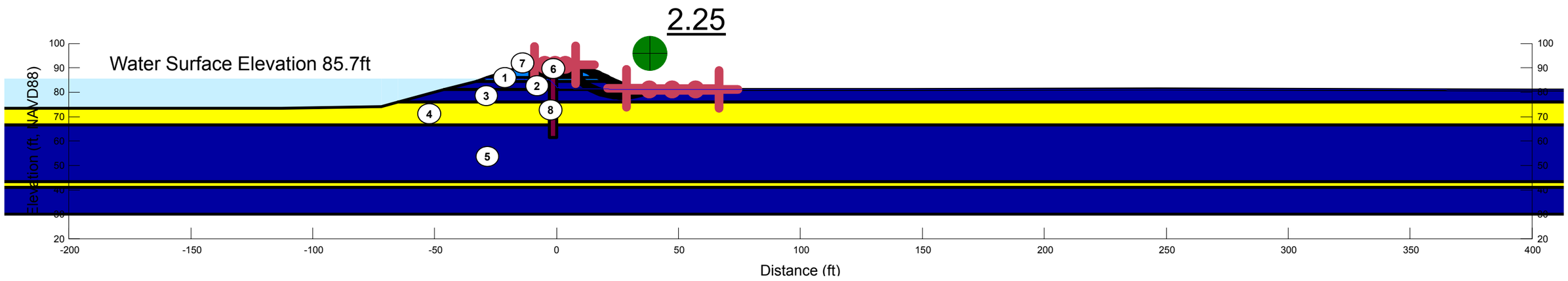
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 23, Section at Sta. 1508+33 Alternative I – Cutoff Wall WSE at 200yr+1 ft	FIGURE B23-A1

Slope Stability Analysis Results, Critical Slip Surface

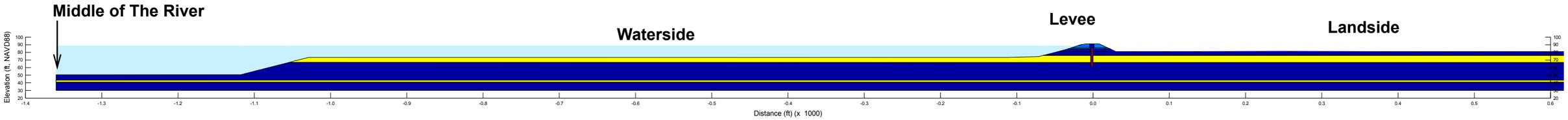


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=0 psf Phi'=32
2 CL-ML 115 pcf C'=100 psf Phi'=31
3 CL-ML 115 pcf C'=100 psf Phi'=31
4 SP-SM 120 pcf C'=0 psf Phi'=35
5 CL 115 pcf C'=100 psf Phi'=31
6 CL 115 pcf C'=100 psf Phi'=32
7 ML 120 pcf C'=50 psf Phi'=32
8 SB 100 pcf C'=300 psf Phi'=0

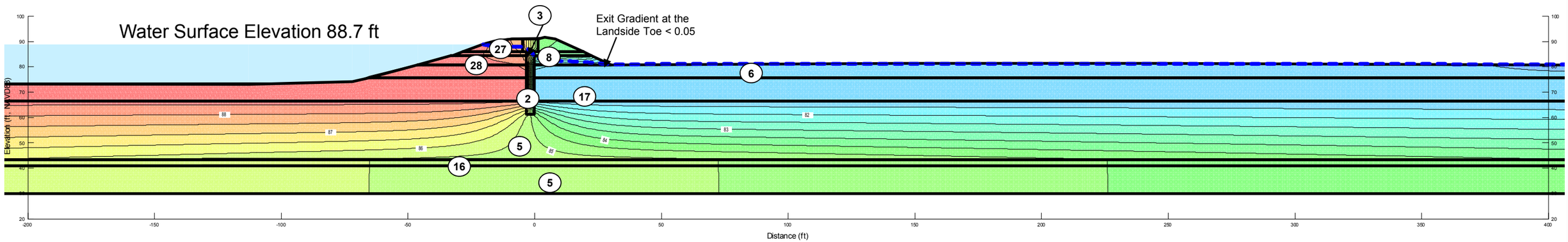
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 23, Section at Sta. 1508+33 Alternative 1 – Cutoff Wall WSE at 200yr+1 ft	FIGURE B23-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



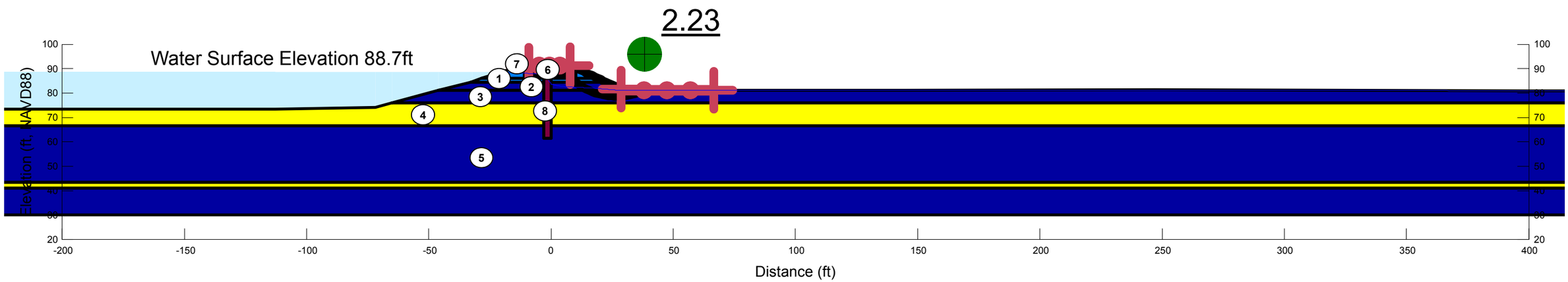
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS S Reach 23, ection at Sta. 1508+33 Alternative 1 – Cutoff Wall WSE at 200yr+4 ft	FIGURE B23-A3

Slope Stability Analysis Results,
Critical Slip Surface

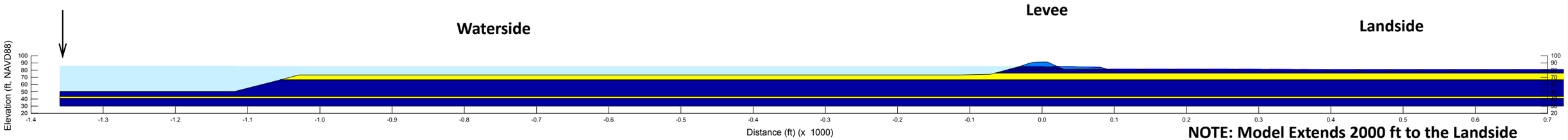


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=0 psf Phi'=32
2 CL-ML 115 pcf C'=100 psf Phi'=31
3 CL-ML 115 pcf C'=100 psf Phi'=31
4 SP-SM 120 pcf C'=0 psf Phi'=35
5 CL 115 pcf C'=100 psf Phi'=31
6 CL 115 pcf C'=100 psf Phi'=32
7 ML 120 pcf C'=50 psf Phi'=32
8 SB 100 pcf C'=300 psf Phi'=0

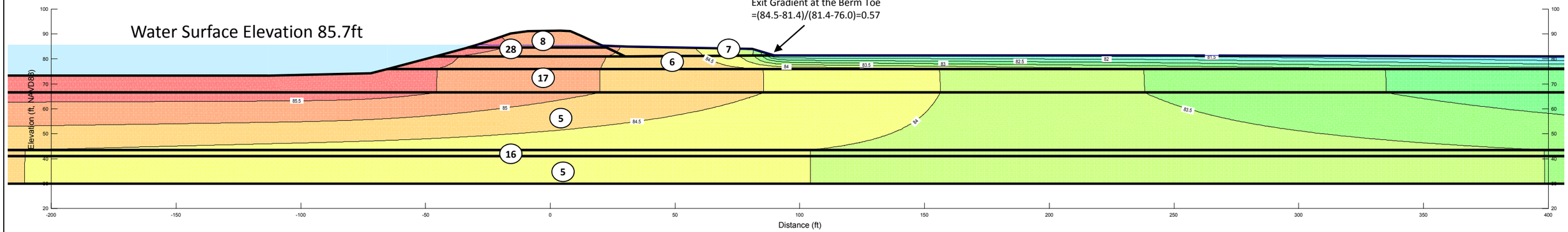
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 23, Section at Sta. 1508+33 Alternative 1– Cutoff Wall WSE at 200yr+4 ft	FIGURE B23-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



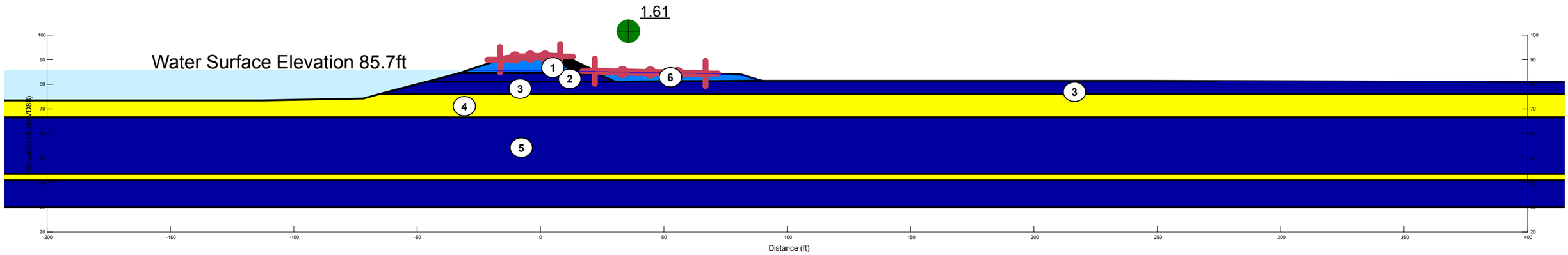
Note: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 23, Section at Sta. 1508+33 Alternative 2 – Undrained Seepage Berm WSE at 200yr+1 ft	FIGURE B23-A5

Slope Stability Analysis Results, Critical Slip Surface

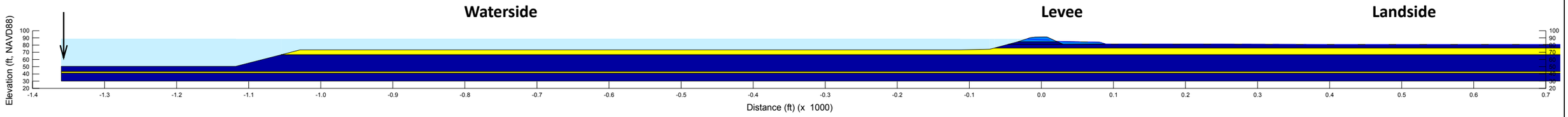


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=0 psf Phi'=32
2 CL-ML 115 pcf C'=100 psf Phi'=31
3 CL-ML 115 pcf C'=100 psf Phi'=31
4 SP-SM 120 pcf C'=0 psf Phi'=35
5 CL 115 pcf C'=100 psf Phi'=31
6 ML 120 pcf C'=50 psf Phi'=32

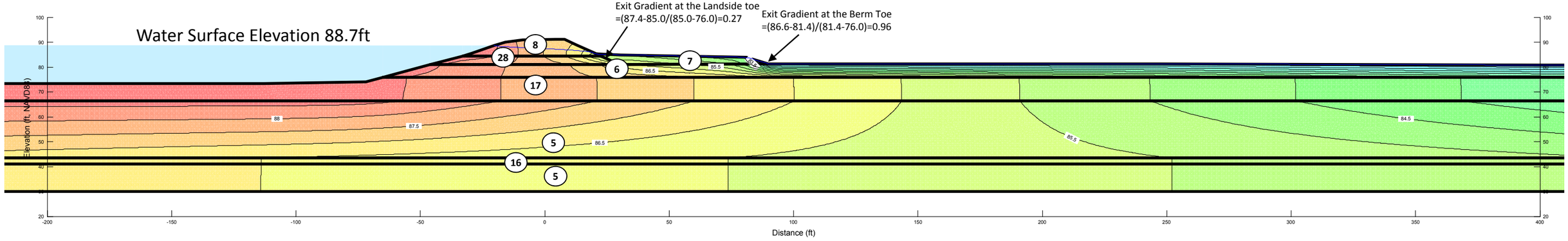
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 23, Section at Sta. 1508+33 Alternative 2 – Undrained Seepage Berm WSE at 200yr+1 ft	FIGURE B23-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



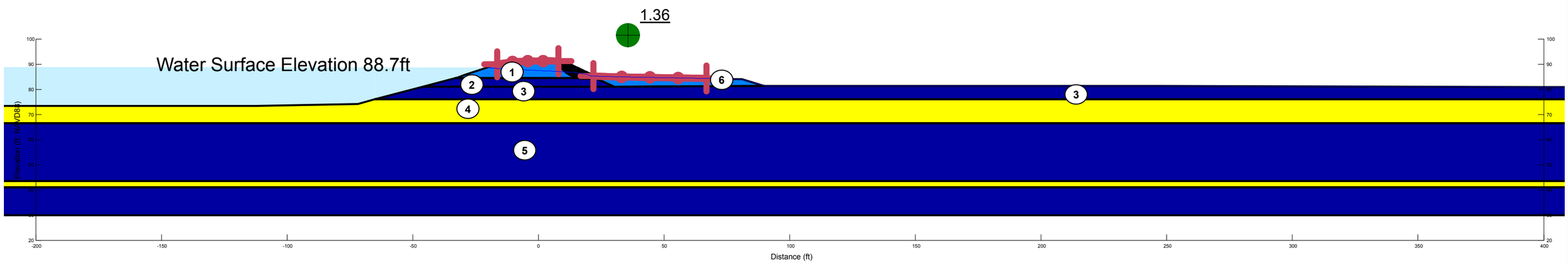
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(28) Existing Clay Levee. Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25

Note: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 23, Section at Sta. 1508+33 Alternative 2 – Undrained Seepage Berm WSE at 200yr+4 ft	FIGURE B23-A7

Slope Stability Analysis Results, Critical Slip Surface

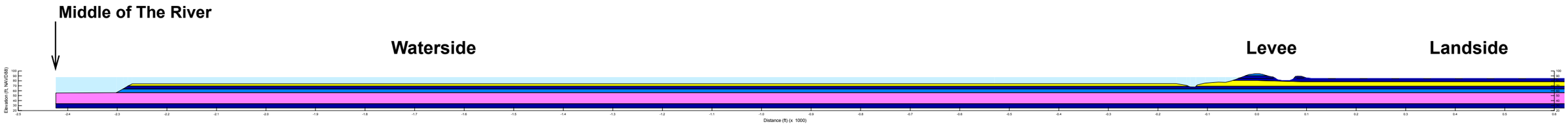


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=0 psf Phi'=32
2 CL-ML 115 pcf C'=100 psf Phi'=31
3 CL-ML 115 pcf C'=100 psf Phi'=31
4 SP-SM 120 pcf C'=0 psf Phi'=35
5 CL 115 pcf C'=100 psf Phi'=31
6 ML 120 pcf C'=50 psf Phi'=32

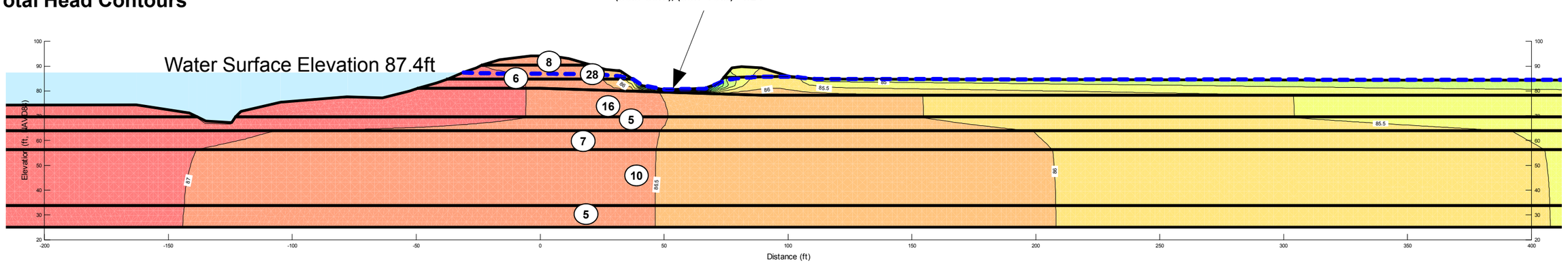
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 23, Section at Sta. 1508+33 Alternative 2 – Undrained Seepage Berm WSE at 200yr+4 ft	FIGURE B23-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



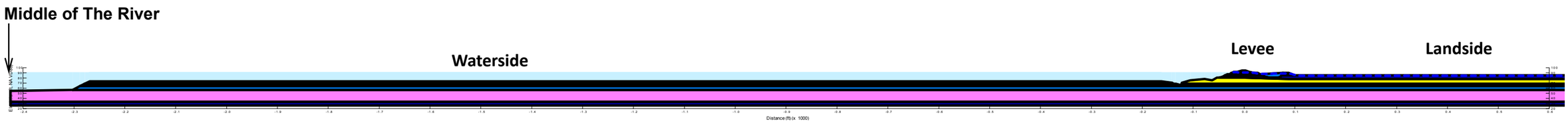
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity(Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(10) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

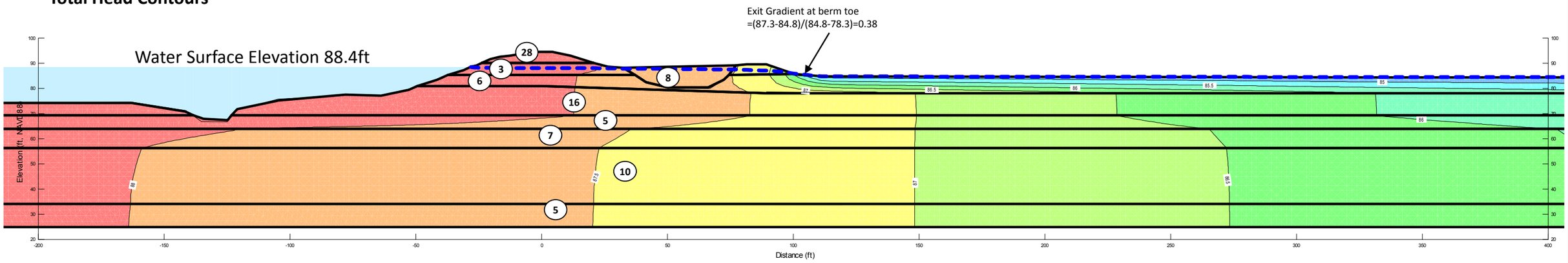
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 24, Section at Sta. 1615+62 Existing Conditions WSE at 200yr	FIGURE B24-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



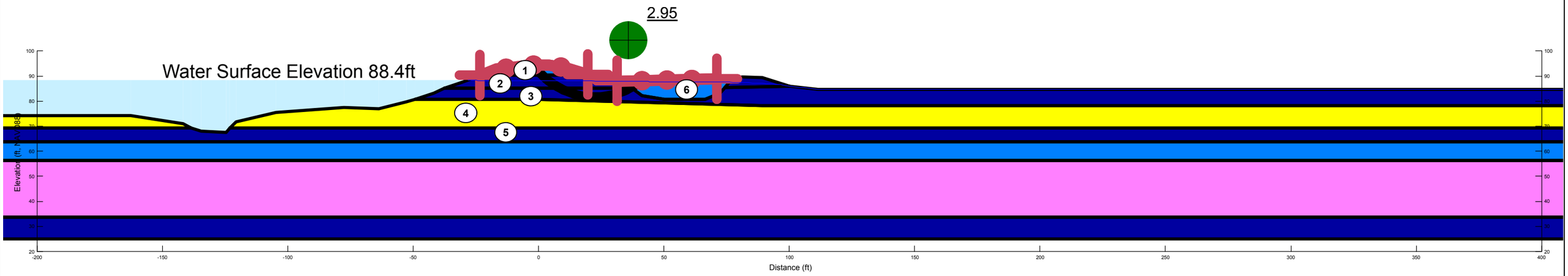
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(10) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) (2) 0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 24, Section at Sta. 1615+62 Alternative 1– Fill Canal WSE at 200yr+1 ft	FIGURE B24-A1

Slope Stability Analysis Results, Critical Slip Surface

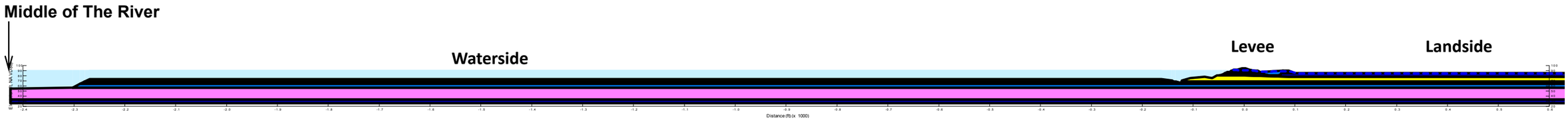


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50 psf Phi'=32
2 CL-ML 115 pcf C'=100 psf Phi'=31
3 CL-ML 115 pcf C'=0 psf Phi'=30
4 SW-SM 120 pcf C'=0 psf Phi'=36
5 CL 115 pcf C'=100 psf Phi'=31
6 ML 120 pcf C'=50 psf Phi'=32

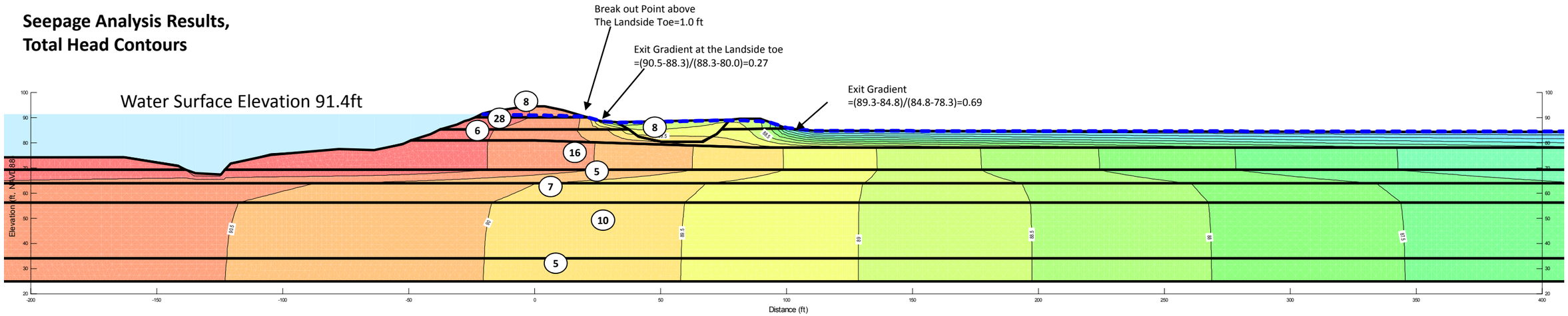
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 24, Section at Sta. 1615+62 Alternative 1– Fill Canal WSE at 200yr+1 ft	FIGURE B24-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



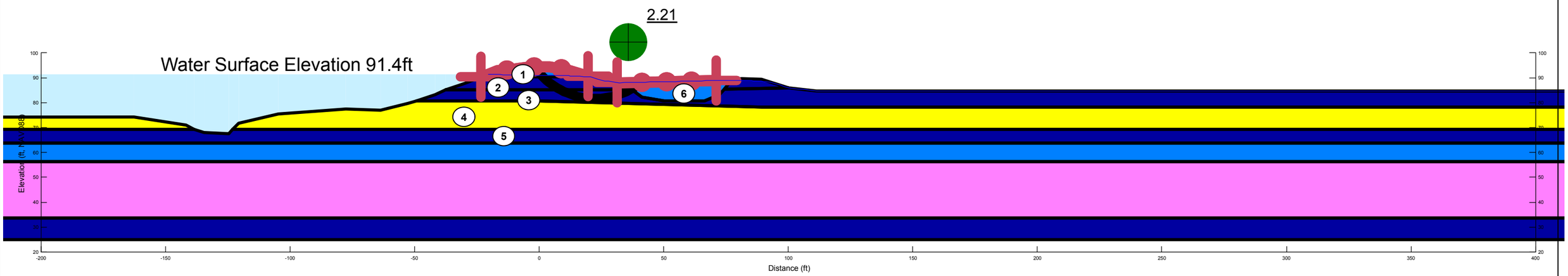
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(10) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) (2) 0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 24, Section at Sta. 1615+62 Alternative 1– Fill Canal WSE at 200yr+4 ft	FIGURE B24-A3

Slope Stability Analysis Results, Critical Slip Surface



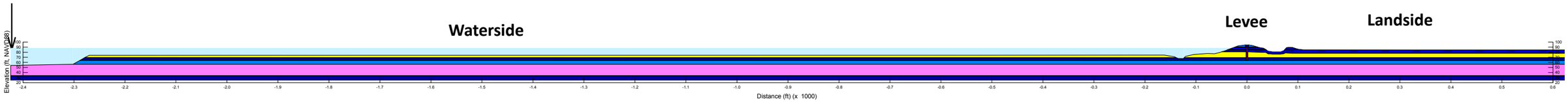
Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50 psf Phi'=32
2 CL-ML 115 pcf C'=100 psf Phi'=31
3 CL-ML 115 pcf C'=0 psf Phi'=30
4 SW-SM 120 pcf C'=0 psf Phi'=36
5 CL 115 pcf C'=100 psf Phi'=31
6 ML 120 pcf C'=50 psf Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 24, Section at Sta. 1615+62 Alternative 1– Fill Canal WSE at 200yr+4 ft	FIGURE B24-A4

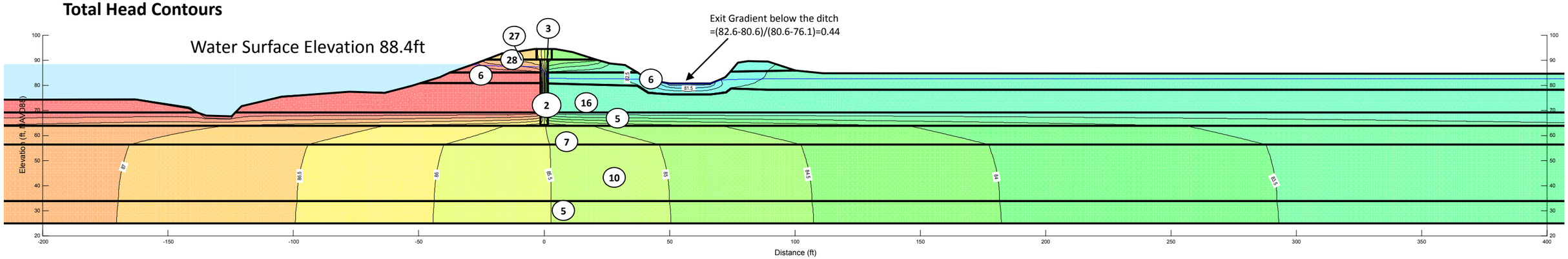
Model Geometry

Middle of The River



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



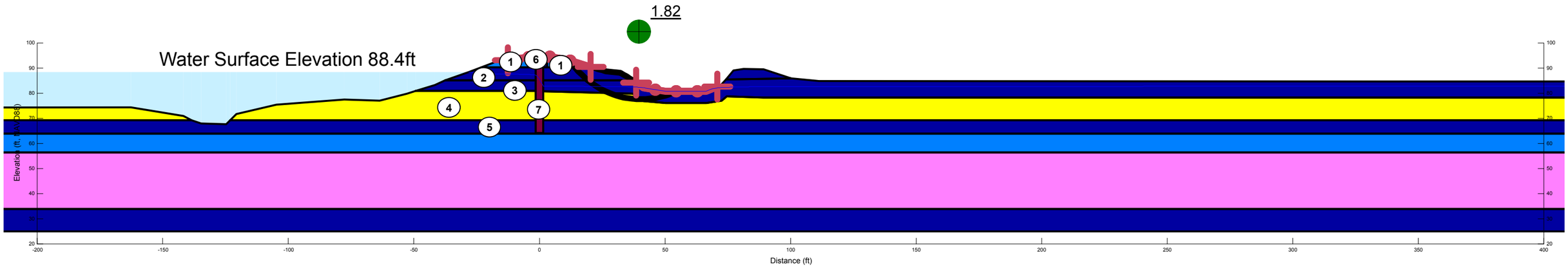
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(10) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 24, Section at Sta. 1615+62 Alternative 2 – Cutoff Wall with Reconfiguration of Canal Bottom WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED TK	FIGURE B24-A5
			DATE 02/03/2011	CHECKED TSAI	

Slope Stability Analysis Results, Critical Slip Surface



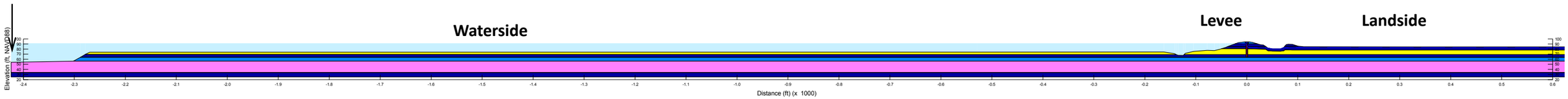
Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50 psf Phi'=32
2 CL-ML 115 pcf C'=100 psf Phi'=31
3 CL-ML 115 pcf C'=0 psf Phi'=30
4 SW-SM 120 pcf C'=0 psf Phi'=36
5 CL 115 pcf C'=100 psf Phi'=31
6 CL 115 pcf C'=100 psf Phi'=32
7 SB 100 pcf C'=300 psf Phi'=0

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 24, Section at Sta. 1615+62 Alternative 2 – Cutoff Wall with Reconfiguration of Canal Bottom WSE at 200yr+1 ft	FIGURE B24-A6

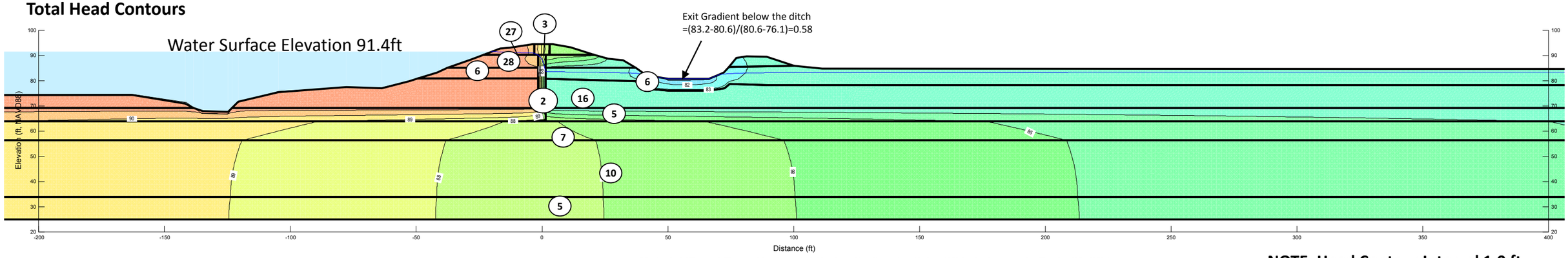
Model Geometry

Middle of The River



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



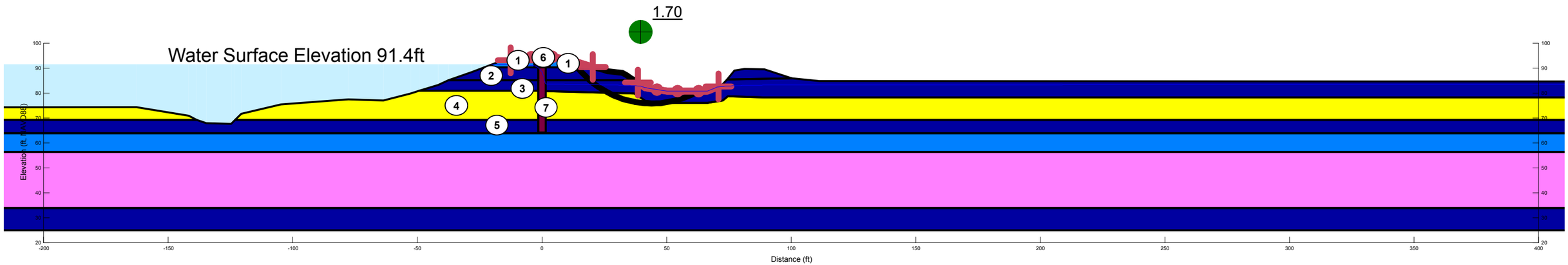
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

NOTE: Head Contour Interval 1.0 ft

(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(10) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day (=5x10-3 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day (=1x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 24, Section at Sta. 1615+62 Alternative 2 – Cutoff Wall with Reconfiguration of Canal Bottom WSE at 200yr+4 ft	FIGURE B24-A7

Slope Stability Analysis Results, Critical Slip Surface

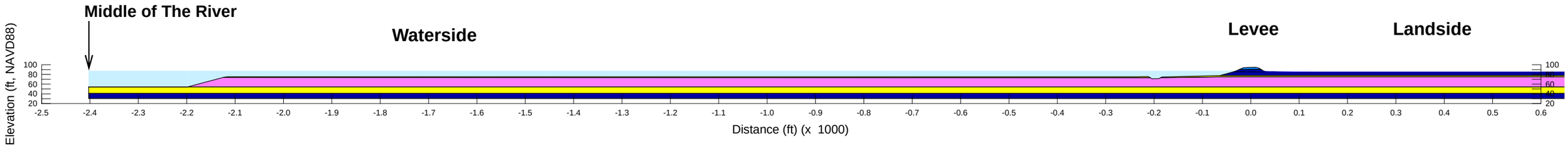


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50 psf Phi'=32
2 CL-ML 115 pcf C'=100 psf Phi'=31
3 CL-ML 115 pcf C'=0 psf Phi'=30
4 SW-SM 120 pcf C'=0 psf Phi'=36
5 CL 115 pcf C'=100 psf Phi'=31
6 CL 115 pcf C'=100 psf Phi'=32
7 SB 100 pcf C'=300 psf Phi'=0

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 24, Section at Sta. 1615+62 Alternative 2 – Cutoff Wall with Reconfiguration of Canal Bottom WSE at 200yr+4 ft	FIGURE B24-A8

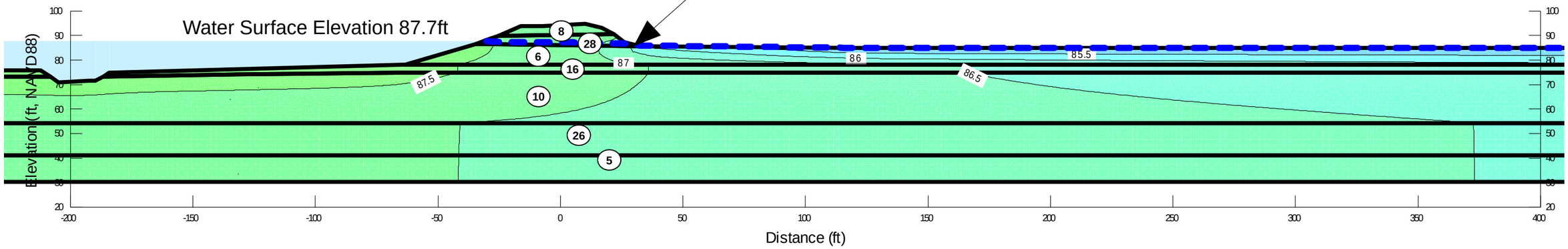
Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours

Exit Gradient at the Landside Toe
= (87.0-85.8)/(85.8-77.8) =0.15



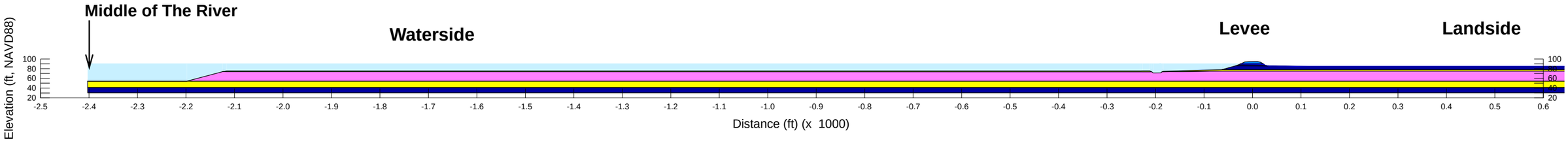
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(10) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) (2) 0.25

NOTE: Head Contour Interval 0.5 ft

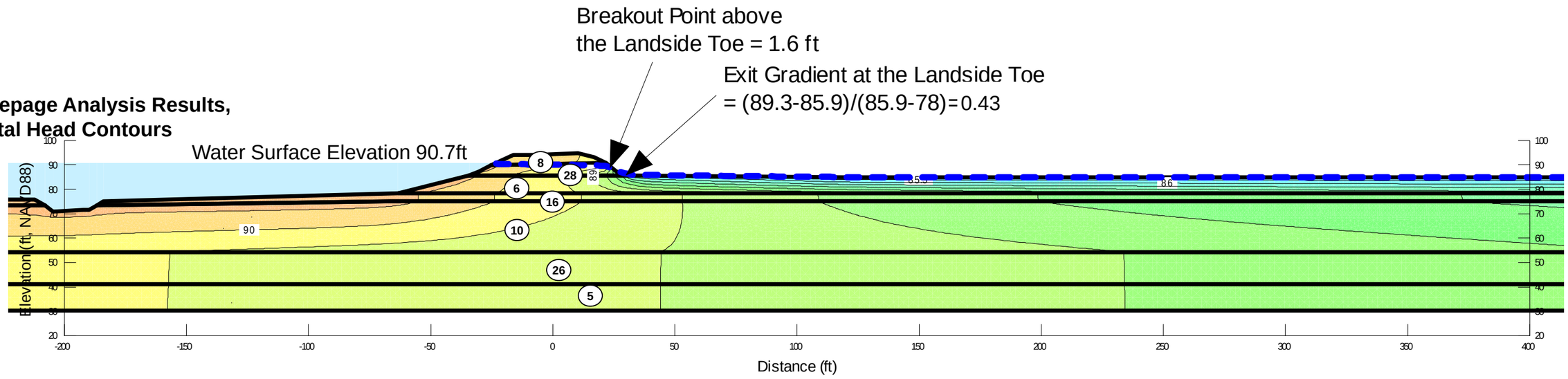
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 25, Section at Sta. 1645+86 Existing Conditions WSE at 200yr	FIGURE B25-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

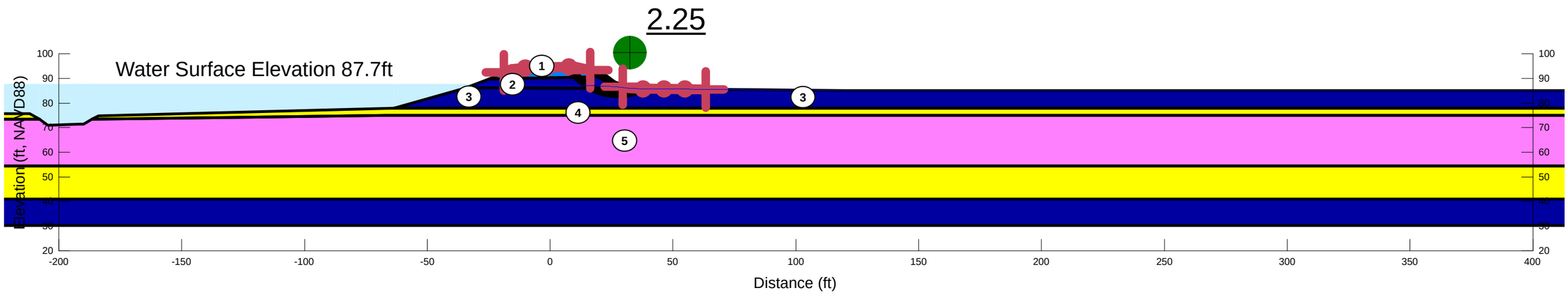
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(10) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s) (2)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 25, Section at Sta. 1645+86
Existing Conditions
WSE at 200yr+3

FIGURE B25-E2

Slope Stability Analysis Results,
Critical Slip Surface

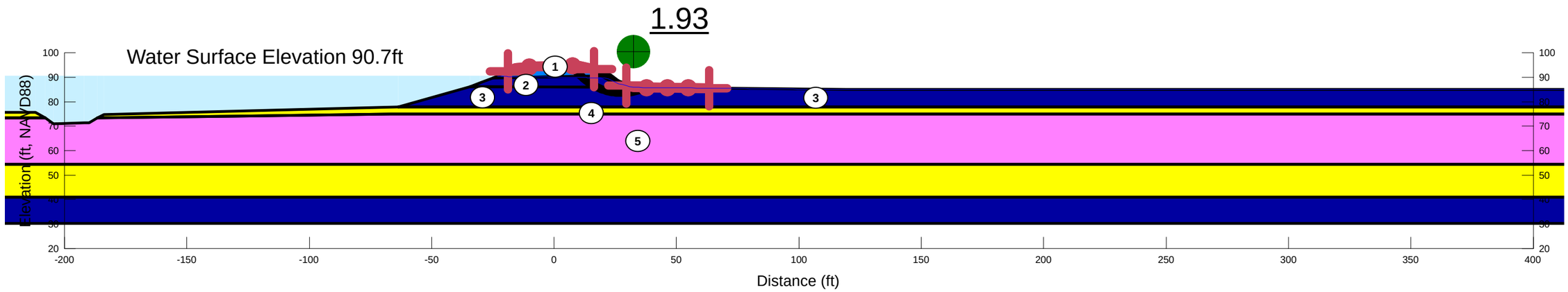


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML	115 pcf	C'=50 psf	Phi'=32
2 CL	115 pcf	C'=100 psf	Phi'=31
3 CL	115 pcf	C'=100 psf	Phi'=31
4 SP-SM	120 pcf	C'=0 psf	Phi'=36
5 SC-SM	120 pcf	C'=0 psf	Phi'=36

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 25, Section at Sta. 1645+86 Existing Condition WSE at 200yr	FIGURE B25-E3

Slope Stability Analysis Results,
Critical Slip Surface

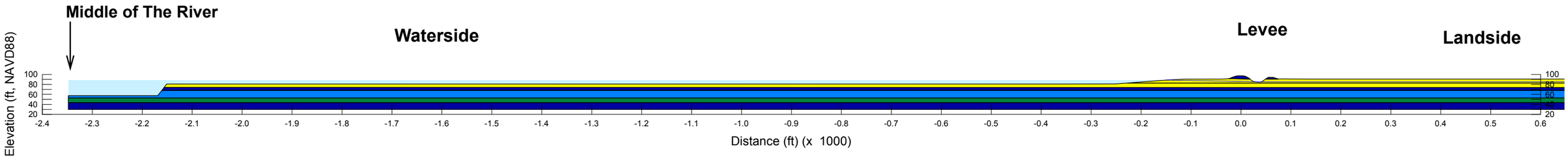


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML	115 pcf	C'=50 psf	Phi'=32
2 CL	115 pcf	C'=100 psf	Phi'=31
3 CL	115 pcf	C'=100 psf	Phi'=31
4 SP-SM	120 pcf	C'=0 psf	Phi'=36
5 SC-SM	120 pcf	C'=0 psf	Phi'=36

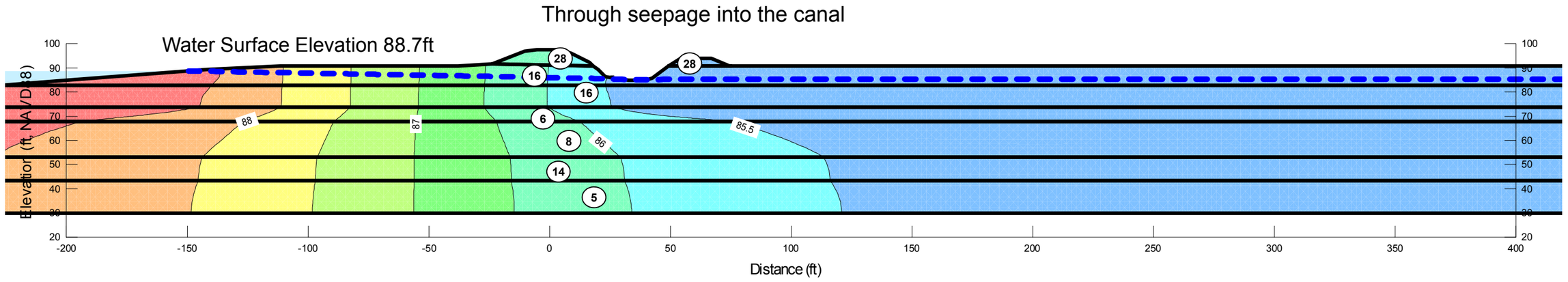
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 25, Section at Sta. 1645+86 Existing Condition WSE at 200yr + 3 ft	FIGURE B25-E4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



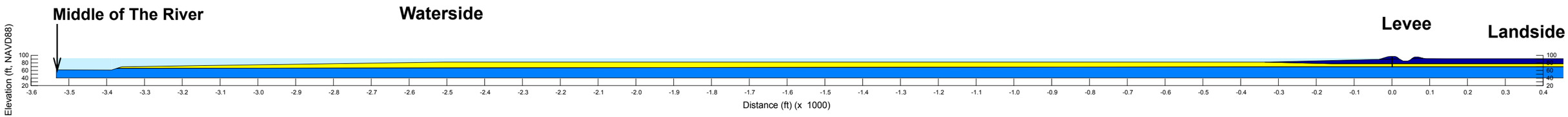
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

NOTE: Head Contour Interval 0.5 ft

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(14) Silty Sand to Sand, 30-49% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

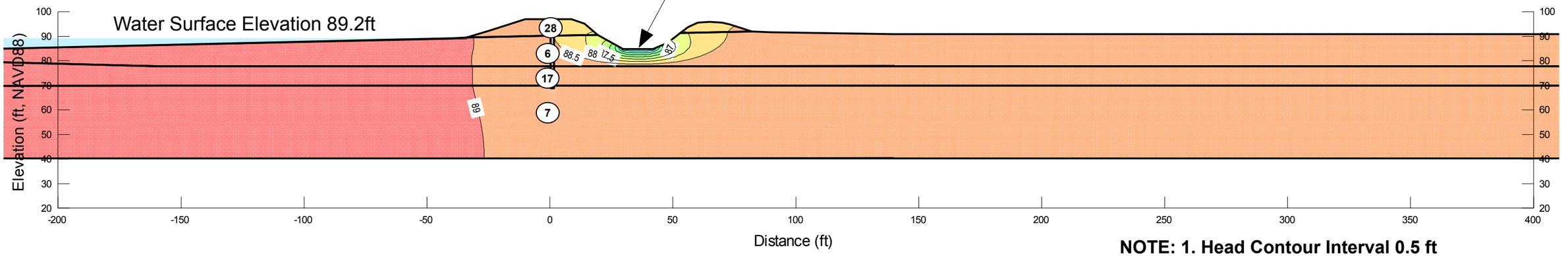
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 26, Section at Sta. 1698+85 Existing Conditions WSE at 200yr	FIGURE B26-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



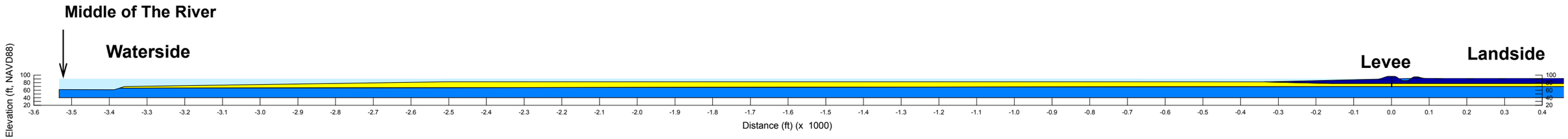
NOTE: 1. Head Contour Interval 0.5 ft
2. Existing cutoff wall was not considered effective in the model

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(28) Existing Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

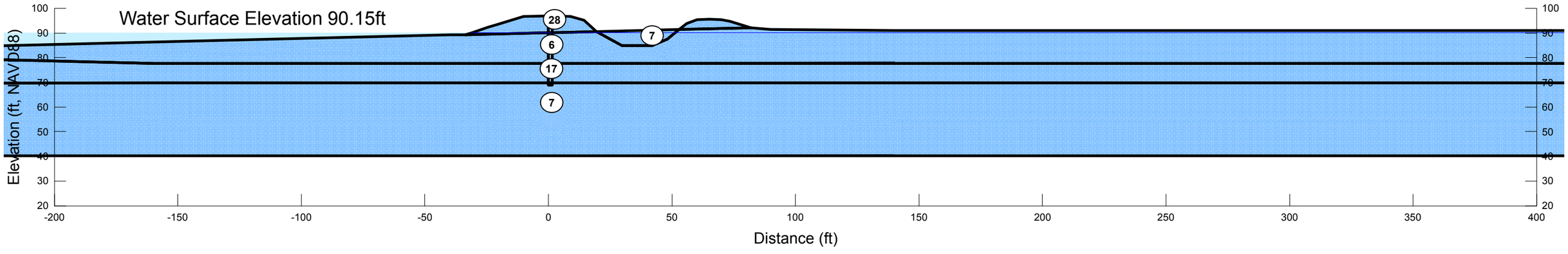
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 27, Section at Sta. 1708+87 Existing Conditions WSE at 200yr	FIGURE B27-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours

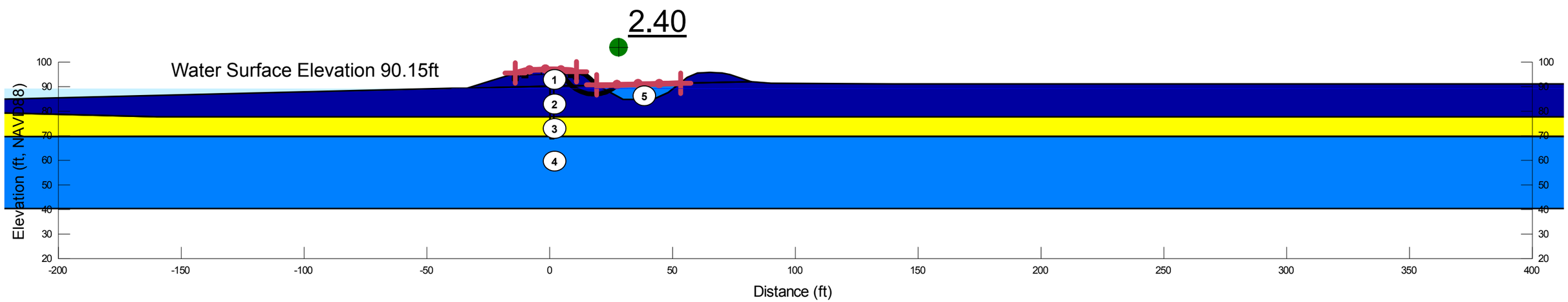


Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(28) Existing Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 27, Section at Sta. 1708+87 Alternative 1 – Fill Canal WSE at 200yr+1 ft	FIGURE B27-A1

Slope Stability Analysis Results,
Critical Slip Surface

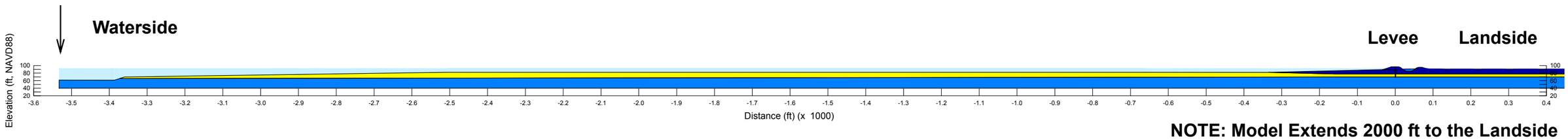


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL	115 pcf	C'=100 psf	Phi'=31
2 CL	115 pcf	C'=0 psf	Phi'=30
3 SP	120 pcf	C'=0 psf	Phi'=36
4 ML	120 pcf	C'=50 psf	Phi'=32
5 ML	120 pcf	C'=50 psf	Phi'=32

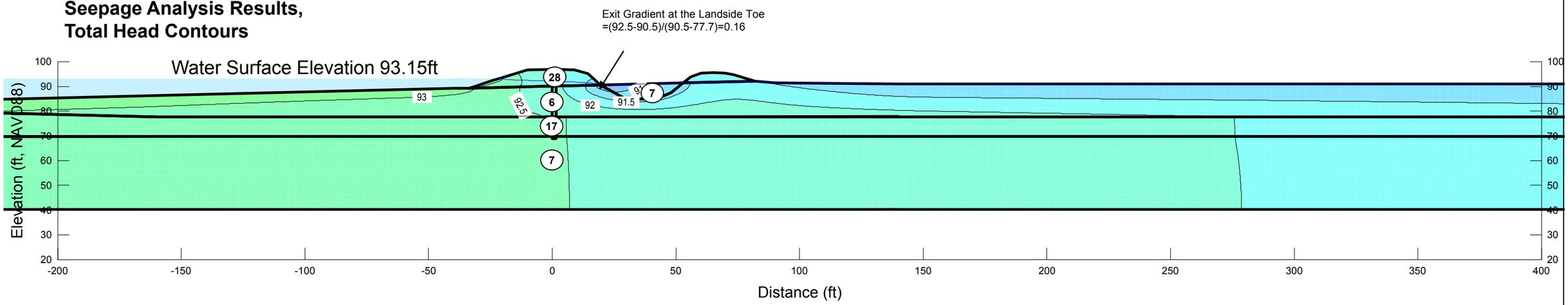
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 27, Section at Sta. 1708+87 Alternative 1 – Fill Canal WSE at 200yr+1 ft	FIGURE B27-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



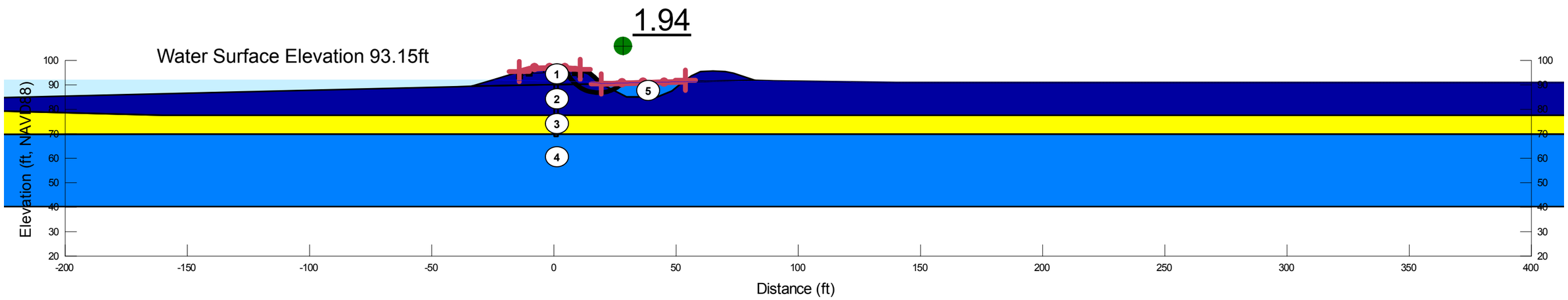
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(28) Existing Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 27, Section at Sta. 1708+87 Alternative 1 – Fill Canal WSE at 200yr+4 ft	FIGURE B27-A3

Slope Stability Analysis Results,
Critical Slip Surface

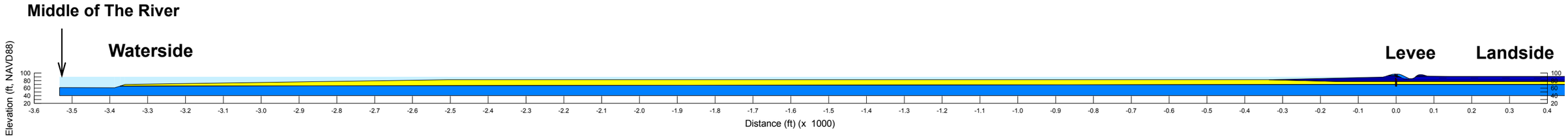


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=0 psf Phi'=30
3 SP 120 pcf C'=0 psf Phi'=36
4 ML 120 pcf C'=50 psf Phi'=32
5 ML 120 pcf C'=50 psf Phi'=32

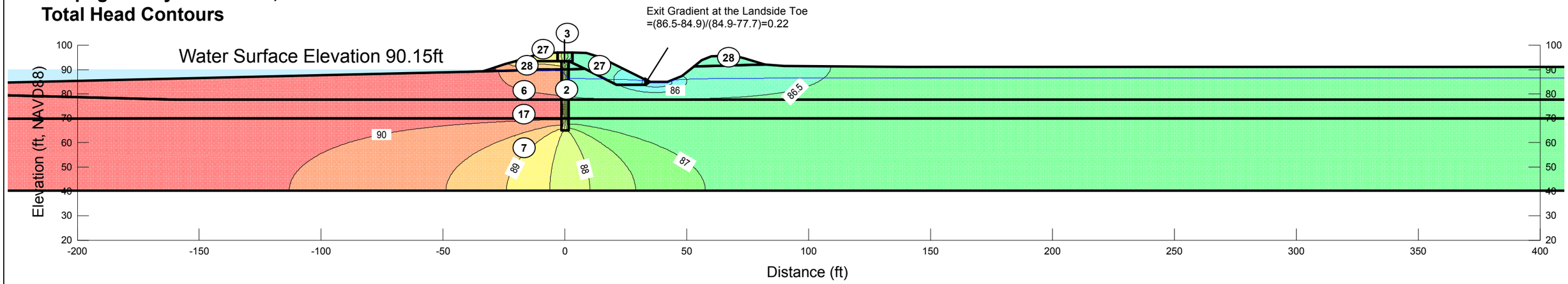
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 27, Section at Sta. 1708+87 Alternative 1 – Fill Canal WSE at 200yr+4 ft	FIGURE B27-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



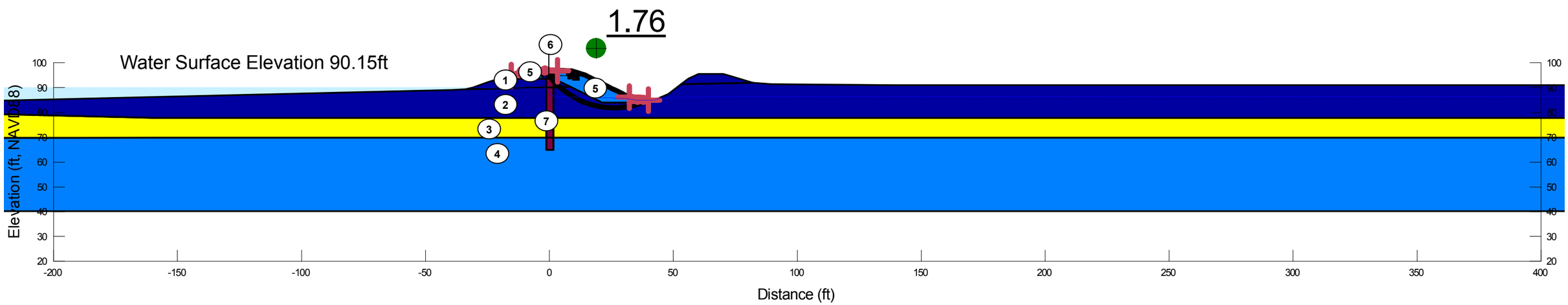
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

NOTE: Head Contour Interval 0.5 ft

(2) Slurry Wall (SB), Kh=0.00028 ft/day (=1x10-7 cm/s) 1
(3) New Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(28) Existing Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(27) Regrade Fill, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 27, Section at Sta. 1708+87 Alternative 2 – Cutoff Wall and Reconstruct the Landside Slope WSE at 200yr+1 ft	FIGURE B27-A5
			TASK ORDER 1	ANALYZED TK		
			DATE 02/03/2011	CHECKED TSAI		

Slope Stability Analysis Results,
Critical Slip Surface

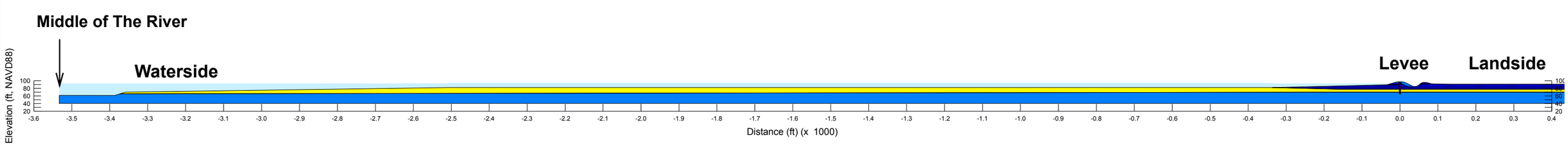


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL	115 pcf	C'=100 psf	Phi'=31
2 CL	115 pcf	C'=0 psf	Phi'=30
3 SP	120 pcf	C'=0 psf	Phi'=36
4 ML	120 pcf	C'=50 psf	Phi'=32
5 ML	120 pcf	C'=50 psf	Phi'=32
6 CL	115 pcf	C'=100 psf	Phi'=32
7 SB	100 pcf	C'=300 psf	Phi'=0

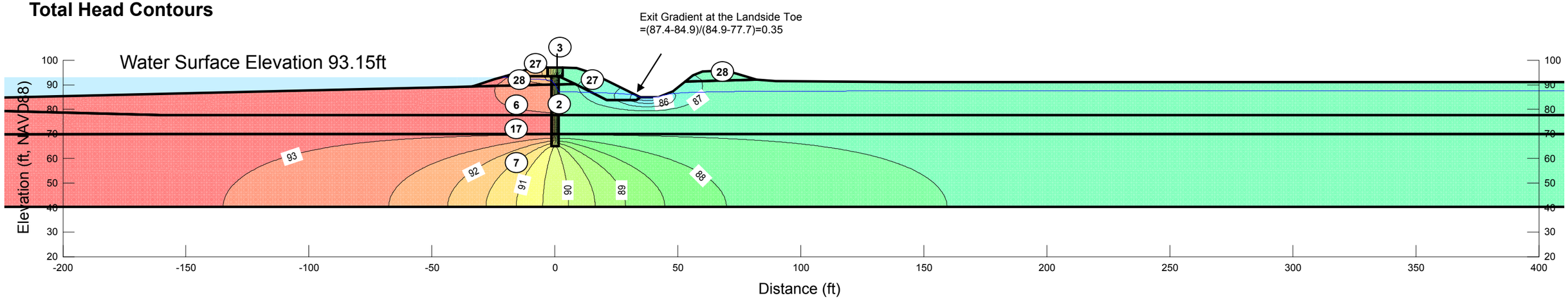
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 27, Section at Sta. 1708+87 Alternative 2 – Cutoff Wall and Reconstruct the Landside Slope WSE at 200yr+1 ft	FIGURE B27-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



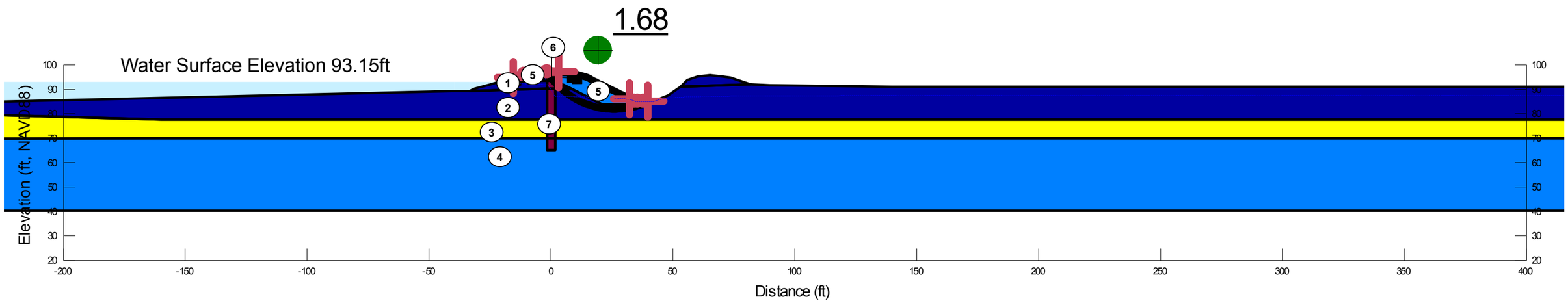
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB), Kh=0.00028 ft/day (=1x10-7 cm/s) 1
(3) New Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(28) Existing Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(27) Regrade Fill, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TK	STEADY-STATE SEEPAGE ANALYSIS Reach 27, Section at Sta. 1708+87 Alternative 2 – Cutoff Wall and Reconstruct the Landside Slope WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED TK	
			DATE 02/03/2011	CHECKED TSAI	FIGURE B27-A7

Slope Stability Analysis Results,
Critical Slip Surface

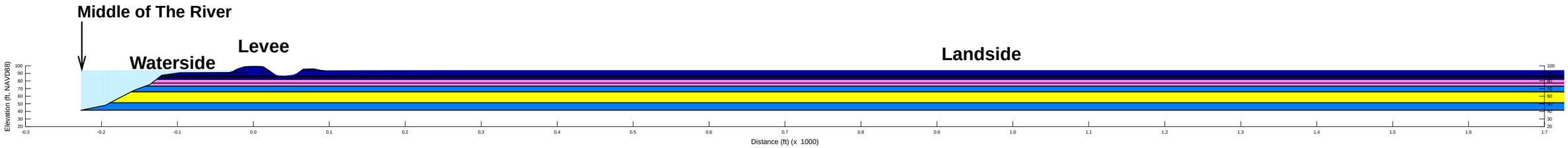


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL	115 pcf	C'=100 psf	Phi'=31
2 CL	115 pcf	C'=0 psf	Phi'=30
3 SP	120 pcf	C'=0 psf	Phi'=36
4 ML	120 pcf	C'=50 psf	Phi'=32
5 ML	120 pcf	C'=50 psf	Phi'=32
6 CL	115 pcf	C'=100 psf	Phi'=32
7 SB	100 pcf	C'=300 psf	Phi'=0

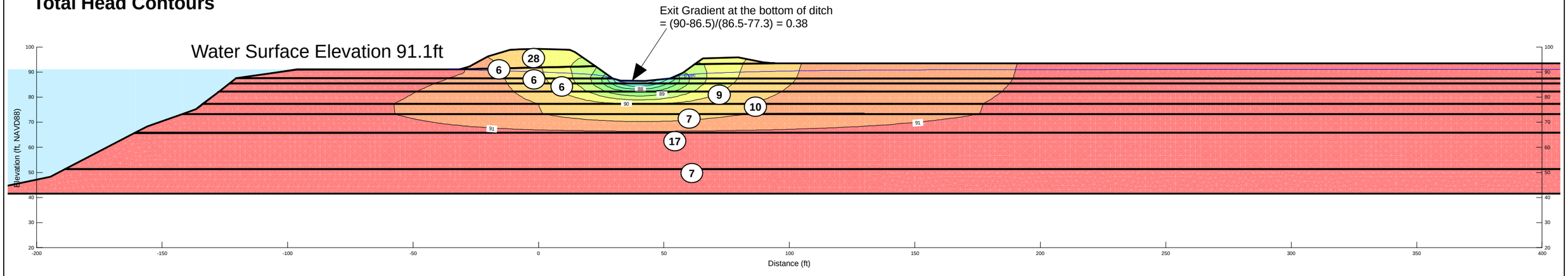
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 27, Section at Sta. 1708+87 Alternative 2 – Cutoff Wall and Reconstruct the Landside Slope WSE at 200yr+4 ft	FIGURE B27-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



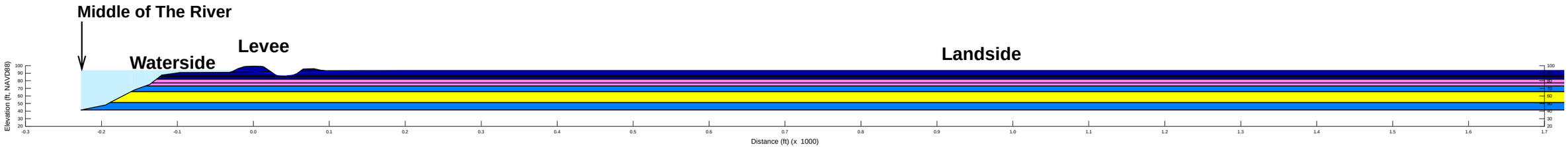
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(9) Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(10) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(27) Clay Blanket (stiff) Kh=0.028 ft/day (=1x10-5 cm/s) (2) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

NOTE: Head Contour Interval 0.5 ft

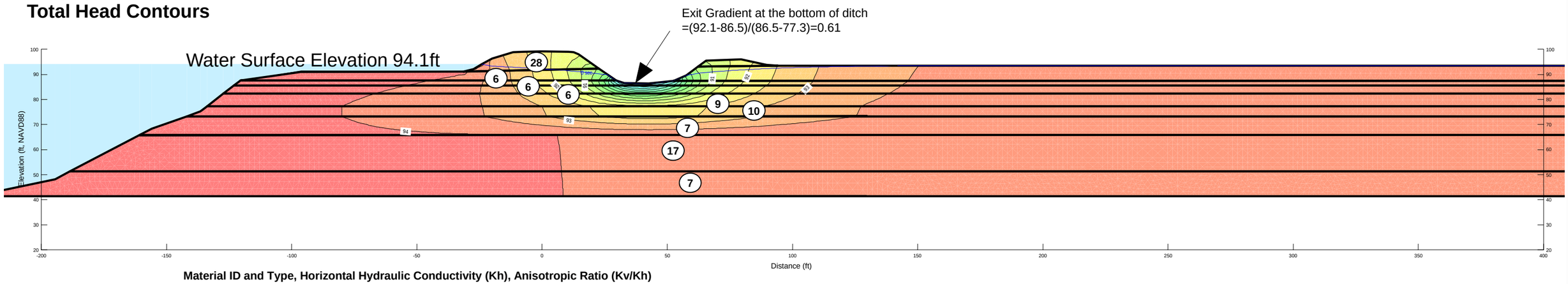
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 28, Section at Sta. 1760+87 Existing Conditions WSE at 200yr	FIGURE B28-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



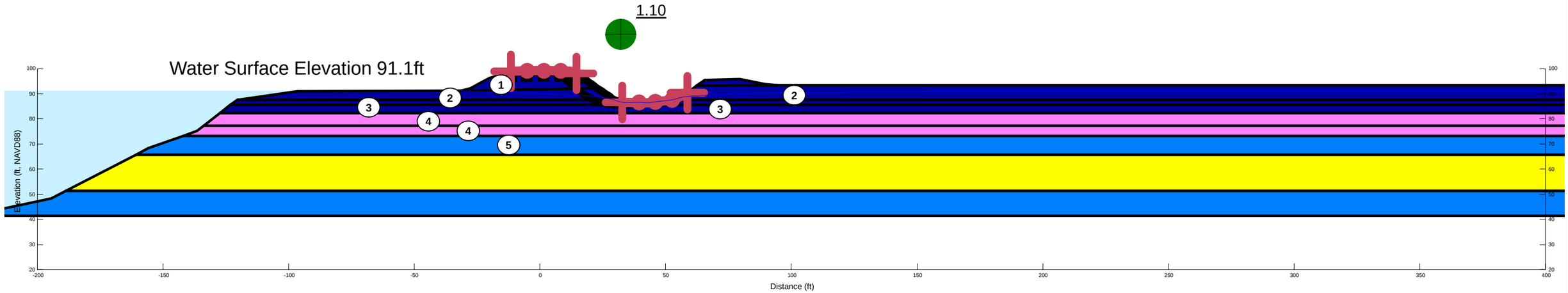
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(9) Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(10) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(27) Clay Blanket (stiff) Kh=0.028 ft/day (=1x10-5 cm/s) (2) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 28, Section at Sta. 1760+87 Existing Conditions WSE at 200yr+3 ft	FIGURE B28-E2

Slope Stability Analysis Results, Critical Slip Surface

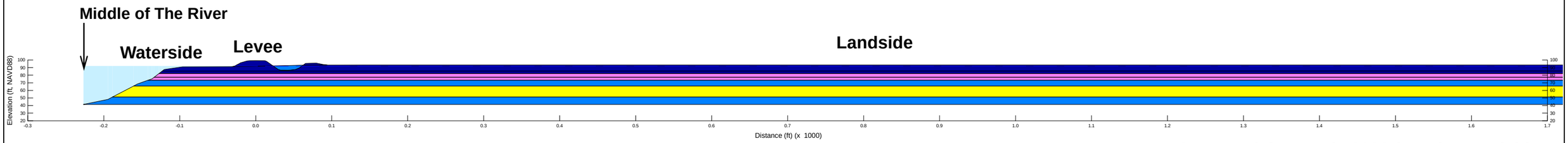


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=0 psf Phi'=30
3 CL 115 pcf C'=100 psf Phi'=31
4 SC-SM 120 pcf C'=0 psf Phi'=36
5 ML 120 pcf C'=0 psf Phi'=32

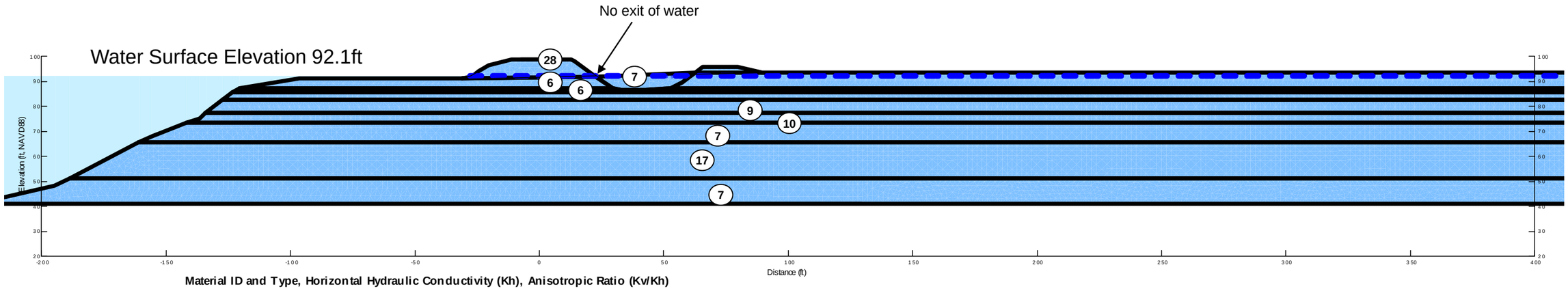
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 28, Section at Sta. 1760+87 Existing Conditions WSE at 200yr	FIGURE B28-E3

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours

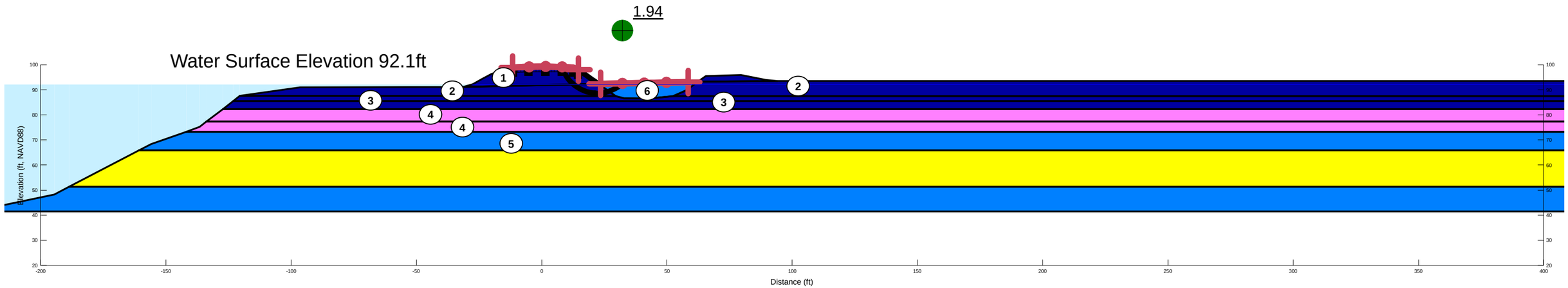


Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(9) Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(10) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(27) Clay Blanket (stiff) Kh=0.028 ft/day (=1x10-5 cm/s) (2) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 28, Section at Sta. 1760+87 Alternative 1 – Fill Canal WSE at 200yr+1 ft	FIGURE B28-A1

Slope Stability Analysis Results, Critical Slip Surface

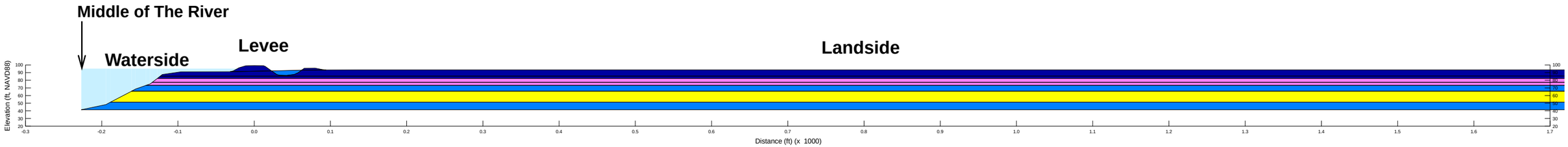


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=0 psf Phi'=30
3 CL 115 pcf C'=100 psf Phi'=31
4 SC-SM 120 pcf C'=0 psf Phi'=36
5 ML 120 pcf C'=0 psf Phi'=32
6 ML 120 pcf C'=50 psf Phi'=32

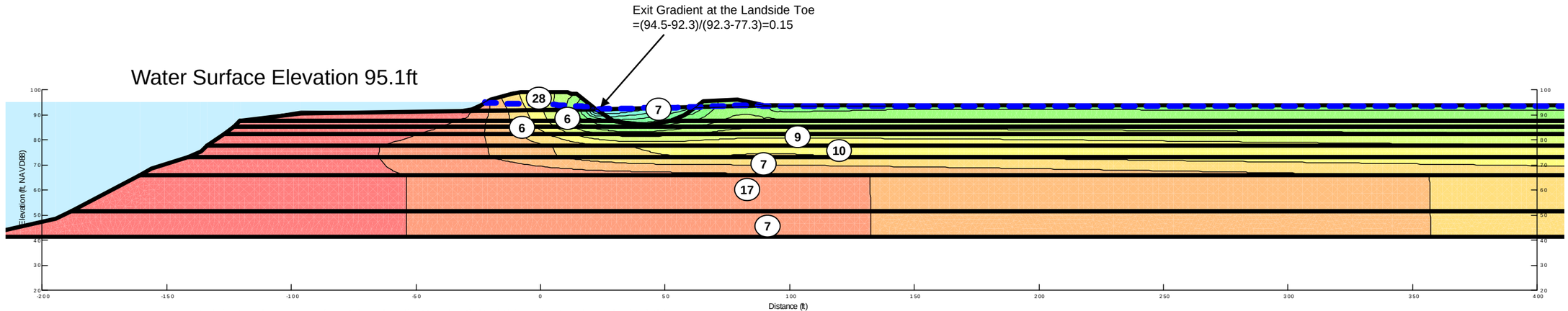
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 28, Section at Sta. 1760+87 Alternative 1 – Fill Canal WSE at 200yr+1 ft	FIGURE B28-A2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



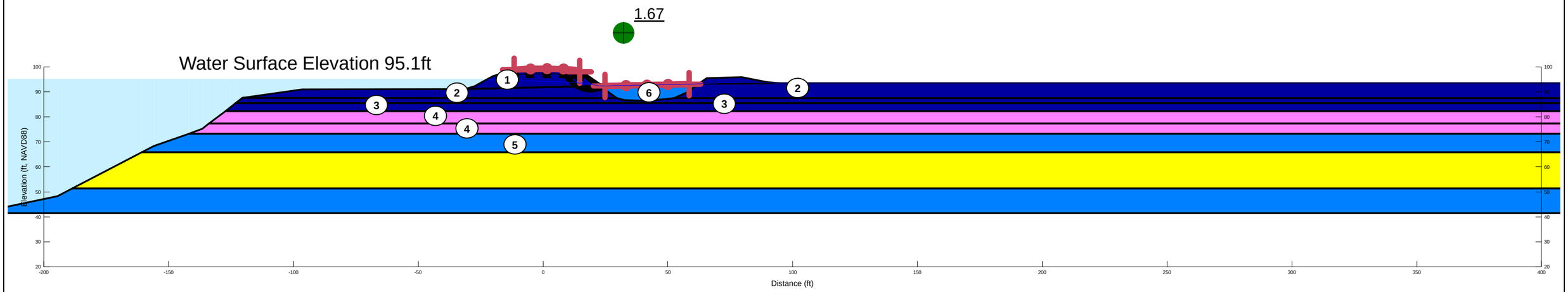
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(9) Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(10) Clayey Sand to Sand, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(27) Clay Blanket (stiff) Kh=0.028 ft/day (=1x10-5 cm/s) (2) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/03/2011	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 28, Section at Sta. 1760+87 Alternative 1 – Fill Canal WSE at 200yr+4 ft	FIGURE B28-A3

Slope Stability Analysis Results, Critical Slip Surface

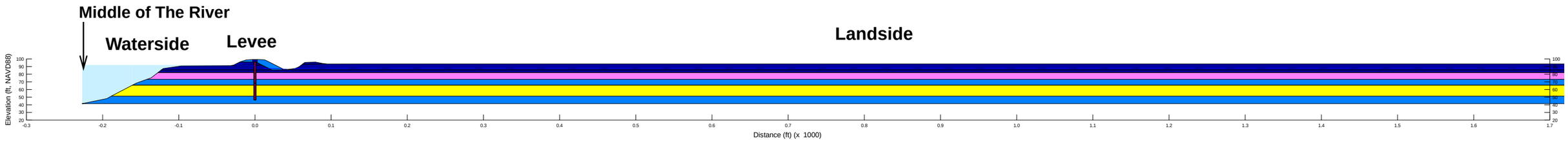


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=0 psf Phi'=30
3 CL 115 pcf C'=100 psf Phi'=31
4 SC-SM 120 pcf C'=0 psf Phi'=36
5 ML 120 pcf C'=0 psf Phi'=32
6 ML 120 pcf C'=50 psf Phi'=32

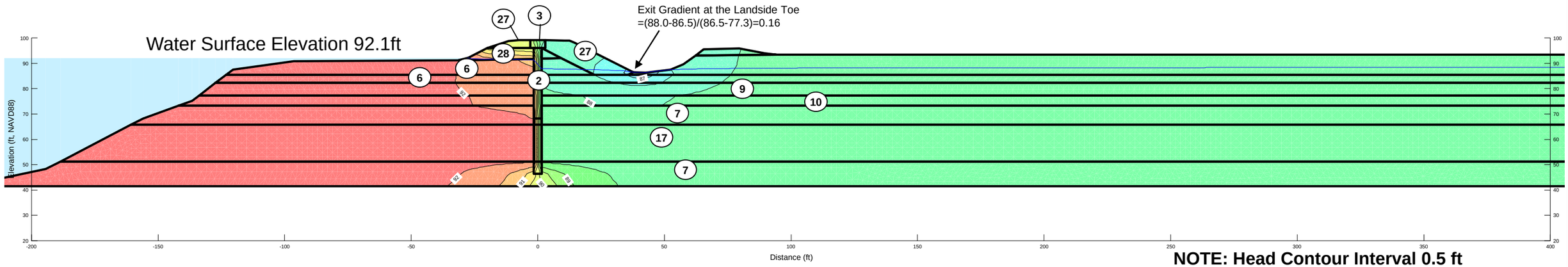
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 28, Section at Sta. 1760+87 Alternative 1 – Fill Canal WSE at 200yr+4 ft	FIGURE B28-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),	Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(9) Clayey Sand to Sand, 30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(10) Clayey Sand to Sand, 13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand, 3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(28) Existing Clay Levee,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(27) Regrade Fill,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency

FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT
Geotechnical Analyses for Pre-Design Formulation Report

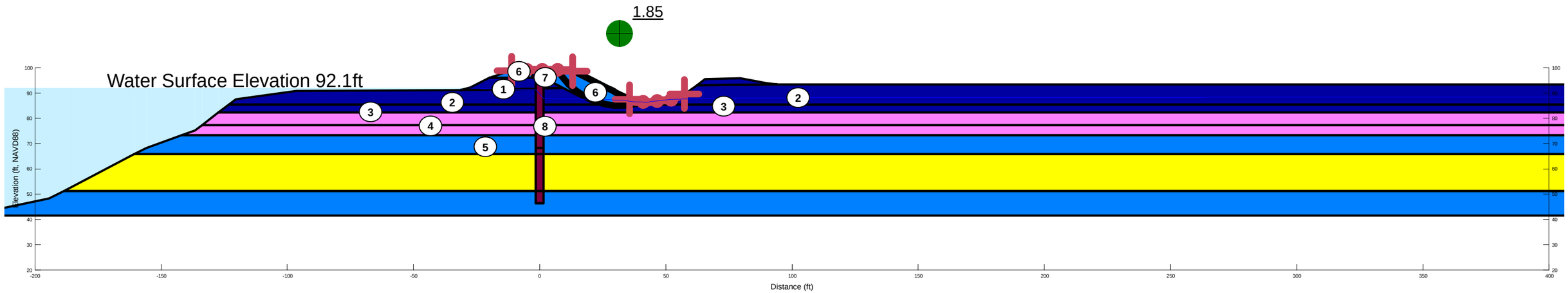
URS
In association with: blackburn consulting

URS PROJECT NO. 17326463	DRAWN TK
TASK ORDER 1	ANALYZED TK
DATE 02/03/2011	CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 28, Section at Sta. 1760+87
Alternative 2 – Cutoff Wall and Reconstruct the Landside Slope
WSE at 200yr+1 ft

FIGURE B28-A5

Slope Stability Analysis Results, Critical Slip Surface

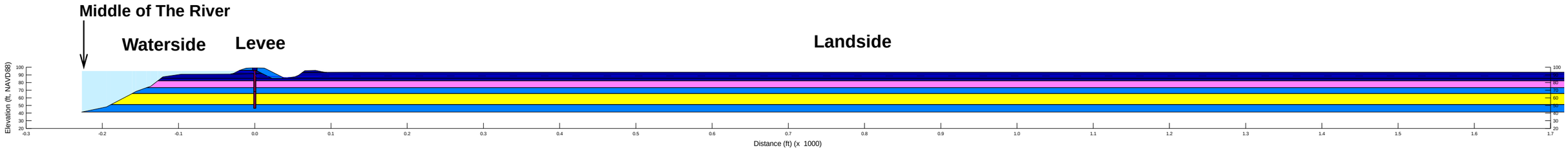


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=0 psf Phi'=30
3 CL 115 pcf C'=100 psf Phi'=31
4 SC 120 pcf C'=0 psf Phi'=36
5 ML 120 pcf C'=0 psf Phi'=32
6 ML 120 pcf C'=50 psf Phi'=32
7 CL 115 pcf C'=100 psf Phi'=32
8 SB 100 pcf C'=300 psf Phi'=0

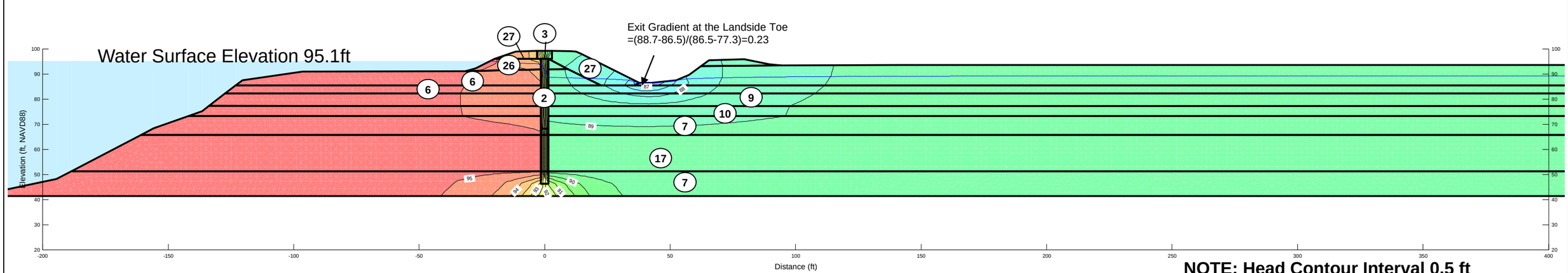
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 28, Section at Sta. 1760+87 Alternative 2 – Cutoff Wall and Reconstruct the Landside Slope WSE at 200yr+1 ft	FIGURE B28-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(9) Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(10) Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(28) Existing Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(27) Regrade Fill,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency

FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT
Geotechnical Analyses for Pre-Design Formulation Report

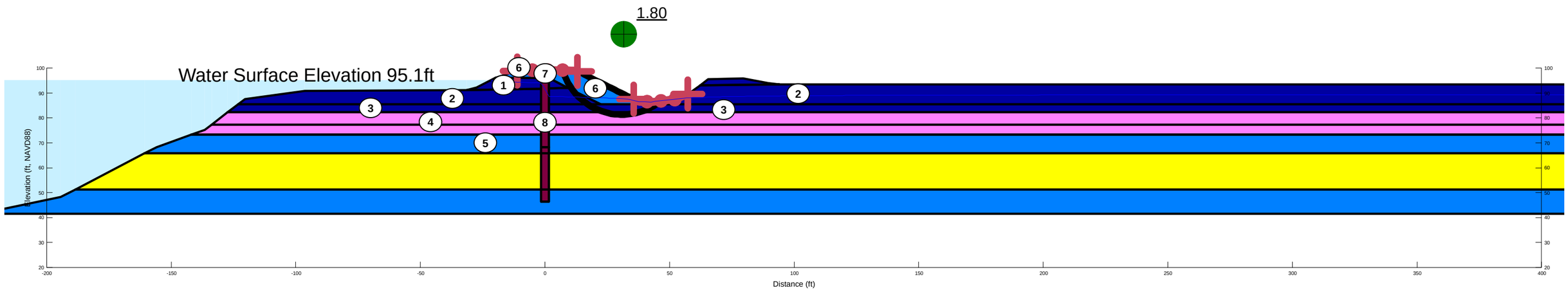
URS
In association with: blackburn consulting

URS PROJECT NO. 17326463	DRAWN TK
TASK ORDER 1	ANALYZED TK
DATE 02/03/2011	CHECKED TSAI

STEADY-STATE SEEPAGE ANALYSIS
Reach 28, Section at Sta. 1760+87
Alternative 2 – Cutoff Wall and Reconstruct the Landside Slope
WSE at 200yr+4 ft

FIGURE B28-A7

Slope Stability Analysis Results, Critical Slip Surface

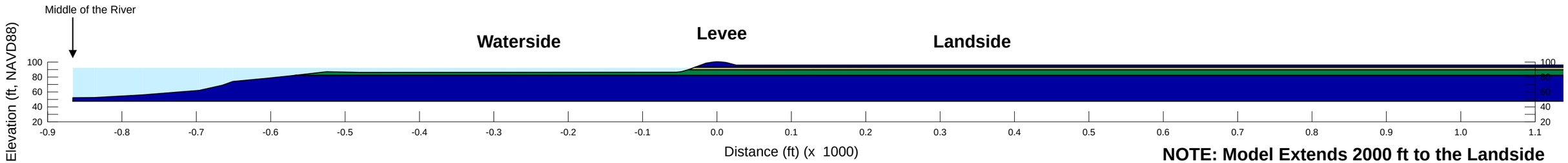


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 CL 115 pcf C'=0 psf Phi'=30
3 CL 115 pcf C'=100 psf Phi'=31
4 SC 120 pcf C'=0 psf Phi'=36
5 ML 120 pcf C'=0 psf Phi'=32
6 ML 120 pcf C'=50 psf Phi'=32
7 CL 115 pcf C'=100 psf Phi'=32
8 SB 100 pcf C'=300 psf Phi'=0

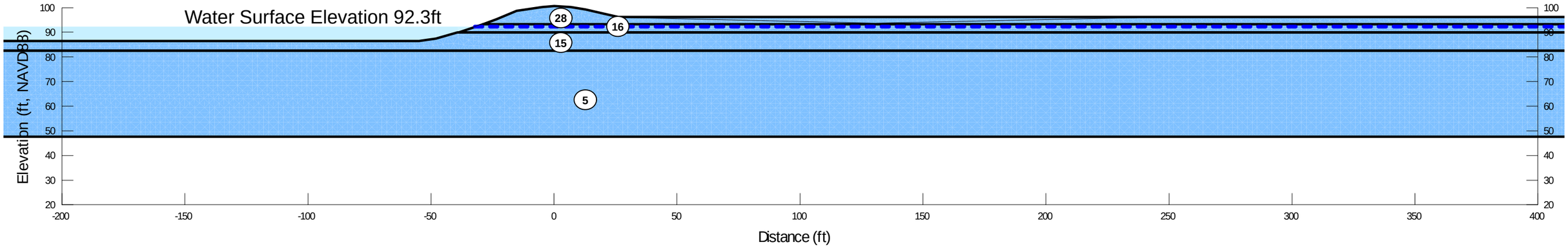
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/11/2011	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 28, Section at Sta. 1760+87 Alternative 2 – Cutoff Wall and Reconstruct the Landside Slope WSE at 200yr+4 ft	FIGURE B28-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours

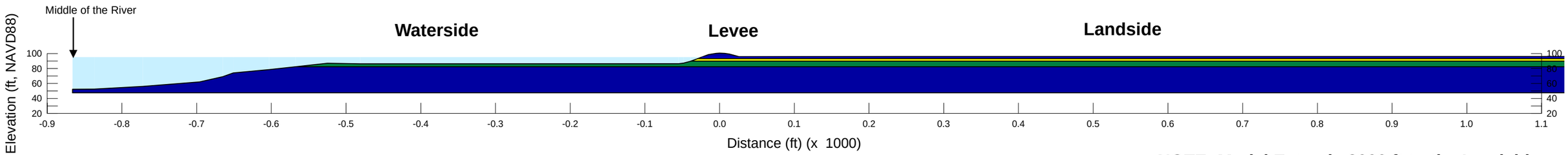


Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

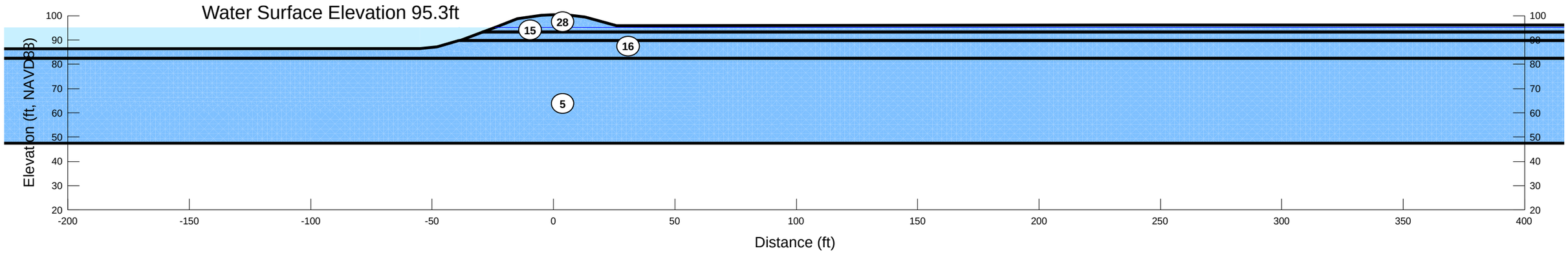
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN TK TASK ORDER 1 / ANALYZED TK DATE 12/20/2010 / CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 29, Section at Sta. 1788+81 Existing Conditions WSE at 200yr	FIGURE B29-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours

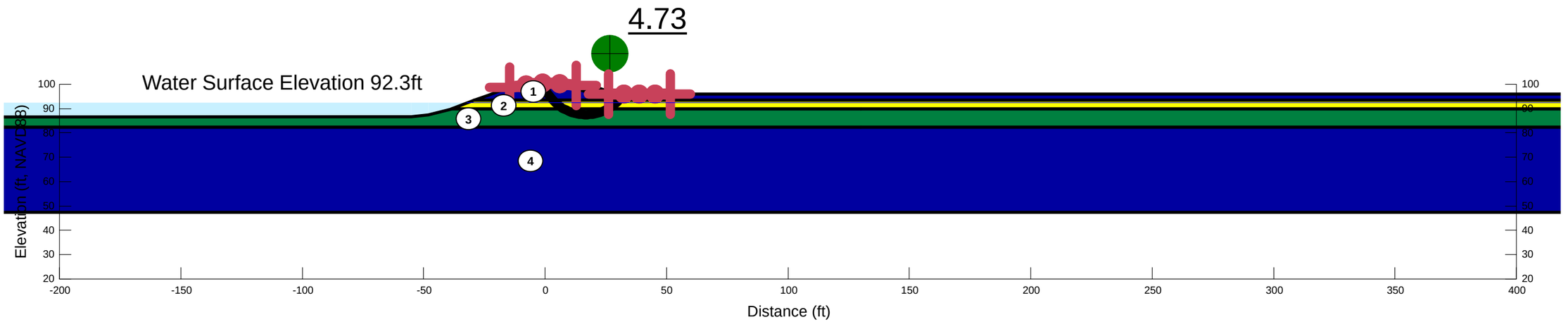


Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(28) Existing Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TK ANALYZED TK CHECKED TSAI	STEADY-STATE SEEPAGE ANALYSIS Reach 29, Section at Sta. 1788+81 Existing Conditions WSE at 200yr+3ft	FIGURE B29-E2

Slope Stability Analysis Results,
Critical Slip Surface

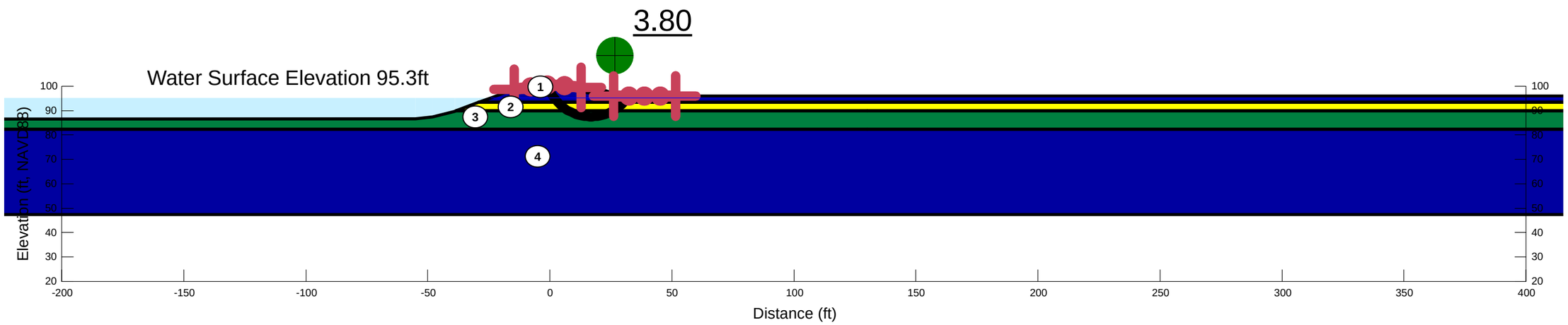


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL	115 pcf	C'=100 psf	Phi'=31
2 SM	120 pcf	C'=0 psf	Phi'=32
3 SC-SM	115 pcf	C'=0 psf	Phi'=25
4 CL	115 pcf	C '=100 psf	Phi'=31

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/20/2010	DRAWN TSAI ANALYZED TSAI CHECKED TK	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 29, Section at Sta. 1788+81 Existing Condition WSE at 200yr	FIGURE B29-E3

Slope Stability Analysis Results,
Critical Slip Surface

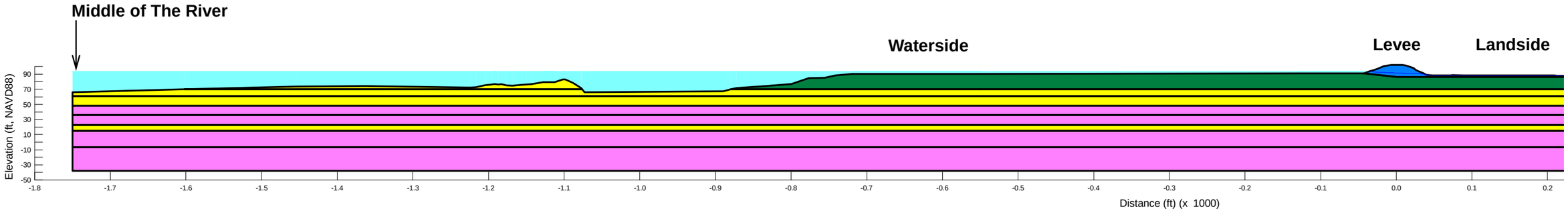


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100 psf Phi'=31
2 SM 120 pcf C'=0 psf Phi'=32
3 SC-SM 115 pcf C'=0 psf Phi'=25
4 CL 115 pcf C '=100 psf Phi'=31

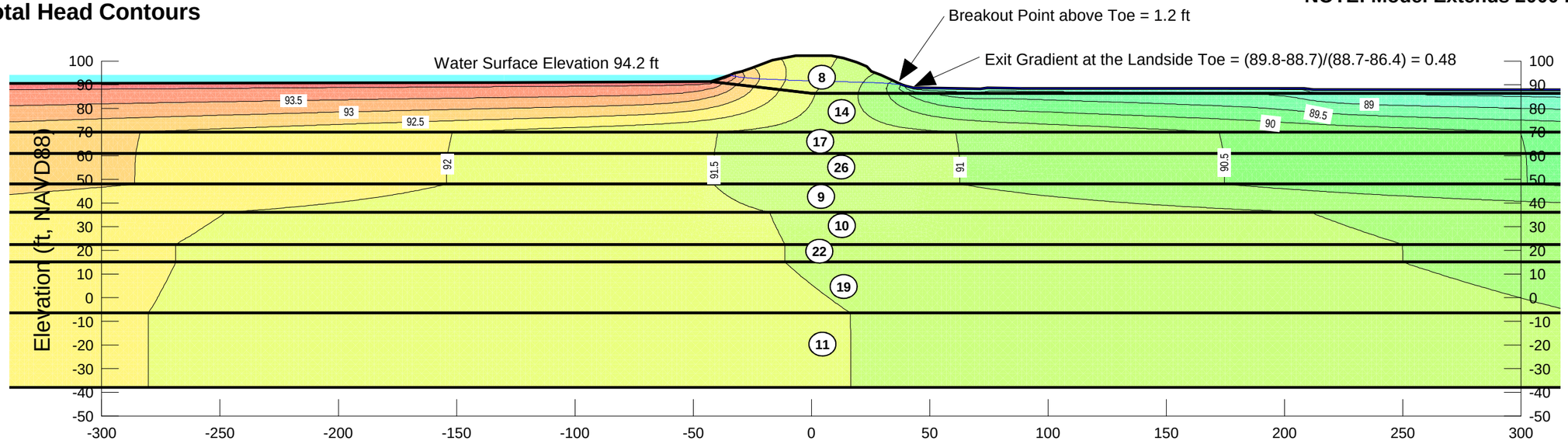
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN TSAI	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 29, Section at Sta. 1788+81 Existing Condition WSE at 200yr +3ft
			TASK ORDER 1	ANALYZED TSAI	FIGURE B29-E4
			DATE 12/20/2010	CHECKED TK	

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

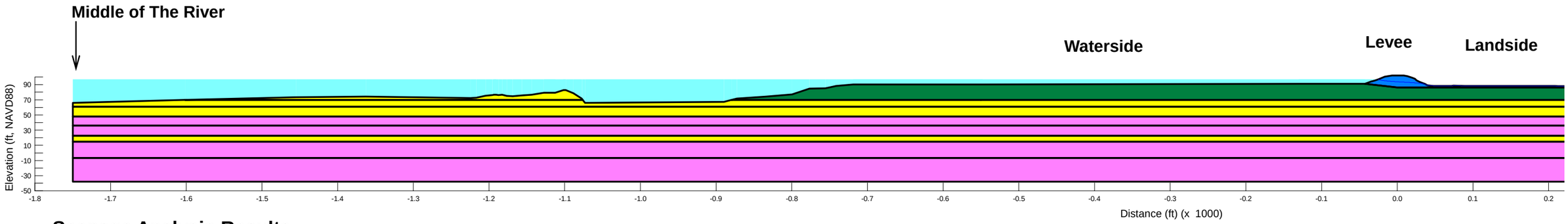
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(10)*Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(19) Clayey Gravel to Gravel,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW
			TASK ORDER 1	ANALYZED MW
			DATE 02/09/2011	CHECKED NT

STEADY-STATE SEEPAGE ANALYSIS
Reach 30, Section at Sta. 1826+94
Existing Conditions
WSE at 200yr

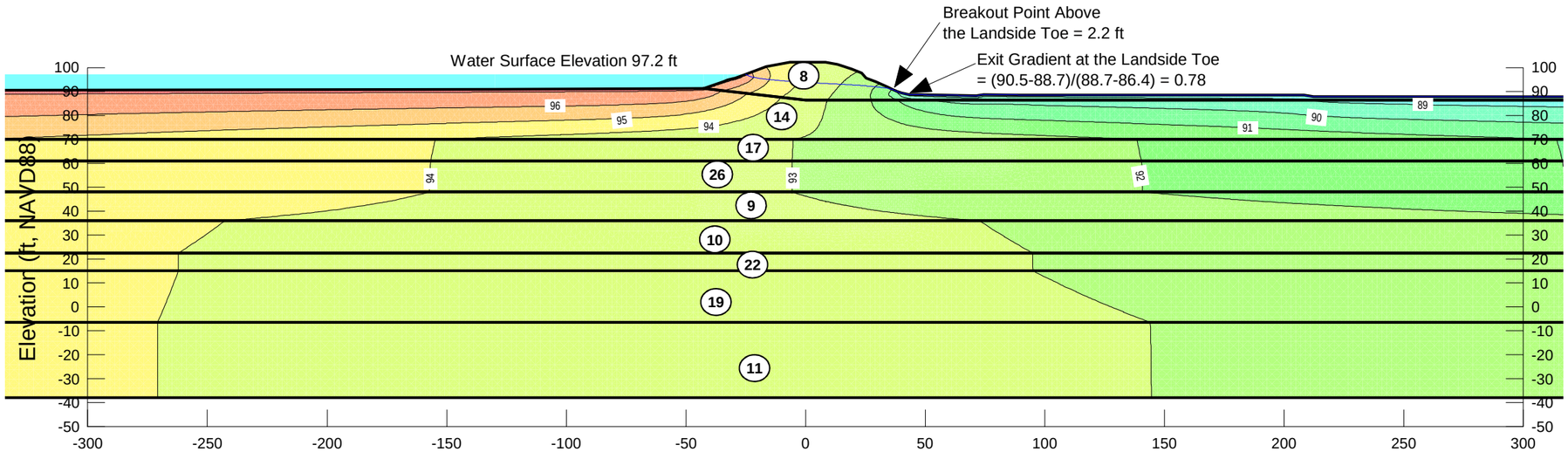
FIGURE B30-E1

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



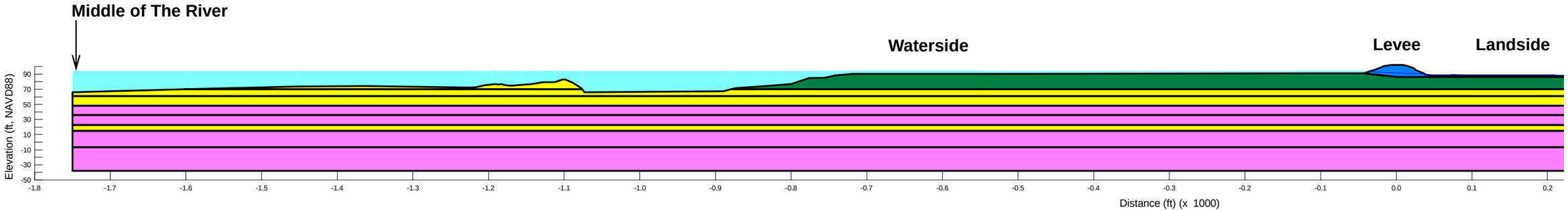
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(10)*Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(19) Clayey Gravel to Gravel,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

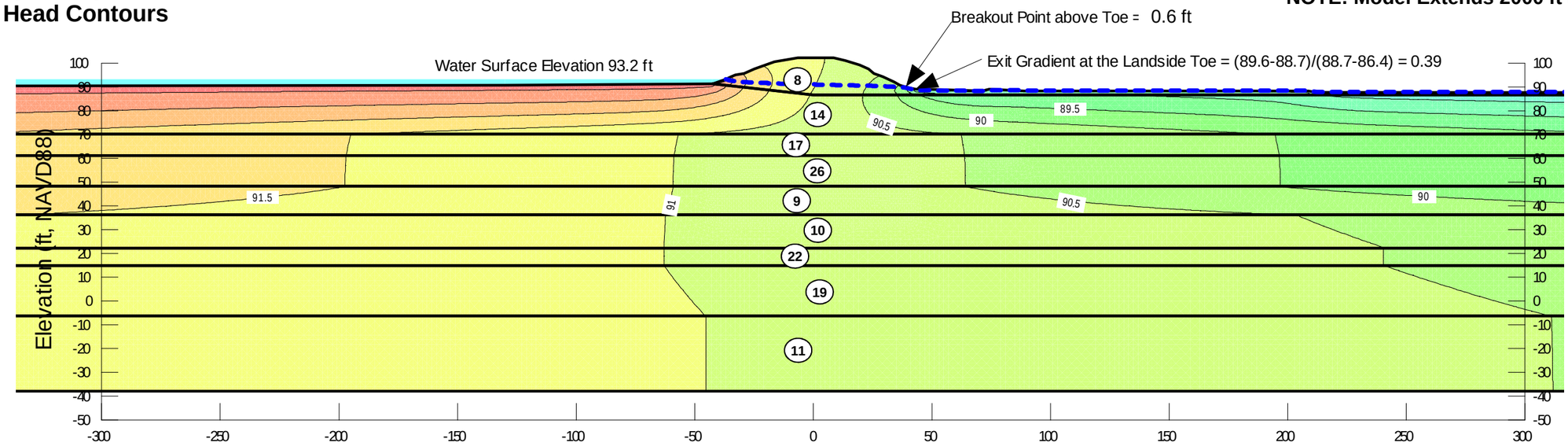
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/09/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 30, Section at Sta. 1826+94 Existing Conditions WSE at 200yr +3 ft	FIGURE B30-E2

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

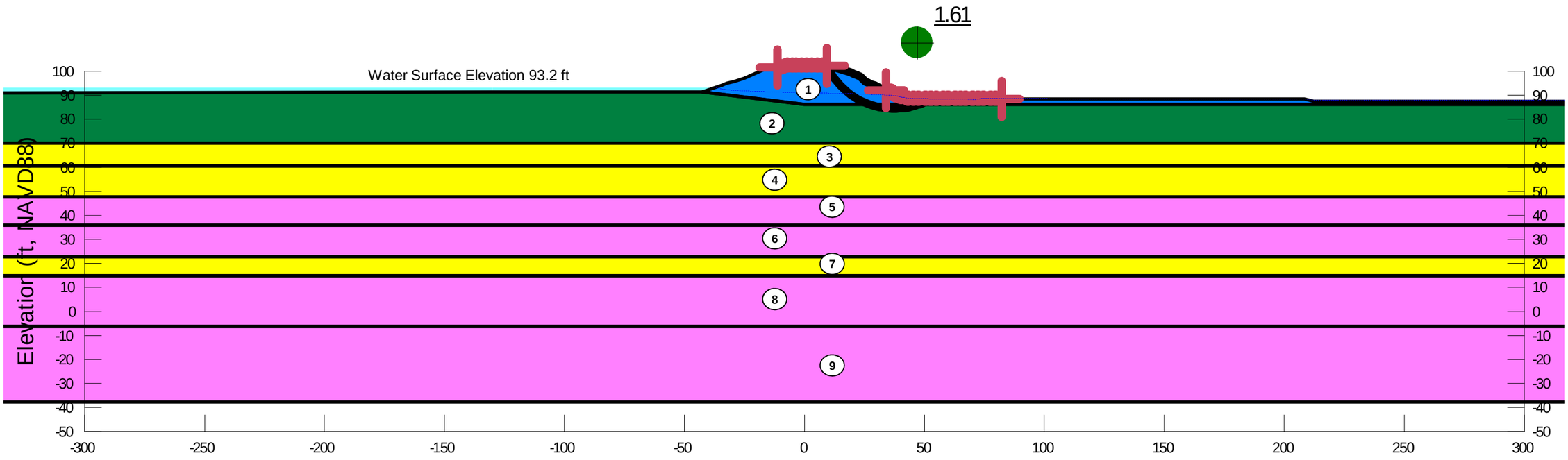
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(10)*Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(19) Clayey Gravel to Gravel,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/08/2011	DRAWN MW ANALYZED MW CHECKED NT

STEADY-STATE SEEPAGE ANALYSIS
Reach 30, Section at Sta. 1826+94
Existing Conditions
WSE at 100yr

FIGURE B30-E3

Slope Stability Analysis Results,
Critical Slip Surface

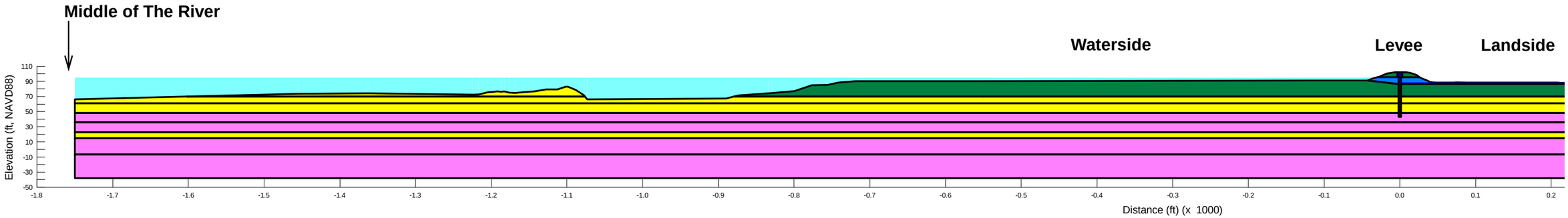


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C' =50 psf, Phi' =32
2 SM 120 pcf C' =0 psf, Phi' =32
3 SP 120 pcf C' =0 psf, Phi' =34
4 GP 130 pcf C' =0 psf, Phi' =36
5 SC 120 pcf C' =0 psf, Phi' =34
6 SC 120 pcf C' =0 psf, Phi' =34
7 GP-GC 130 pcf C' =0 psf, Phi' =36
8 GC 130 pcf C' =0 psf, Phi' =36
9 SW-SC 120 pcf C' =0 psf, Phi' =34

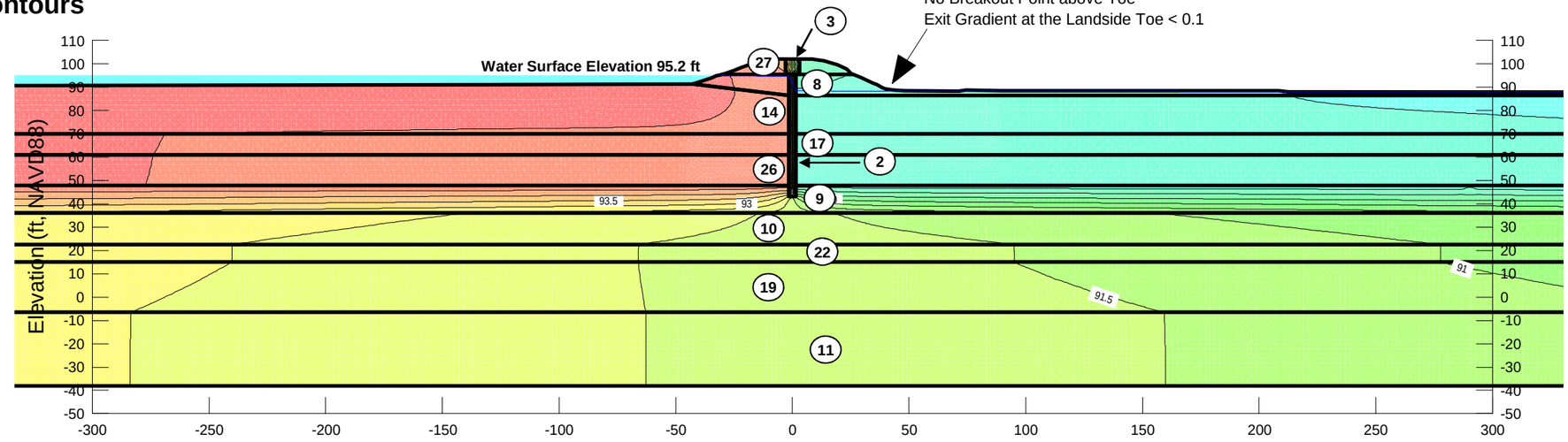
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 30, Section at Sta. 1826+94** **Existing Conditions** **WSE at 100yr**	**FIGURE B30-E4**
			TASK ORDER 1	ANALYZED MW		
			DATE 02/08/2011	CHECKED NT		

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

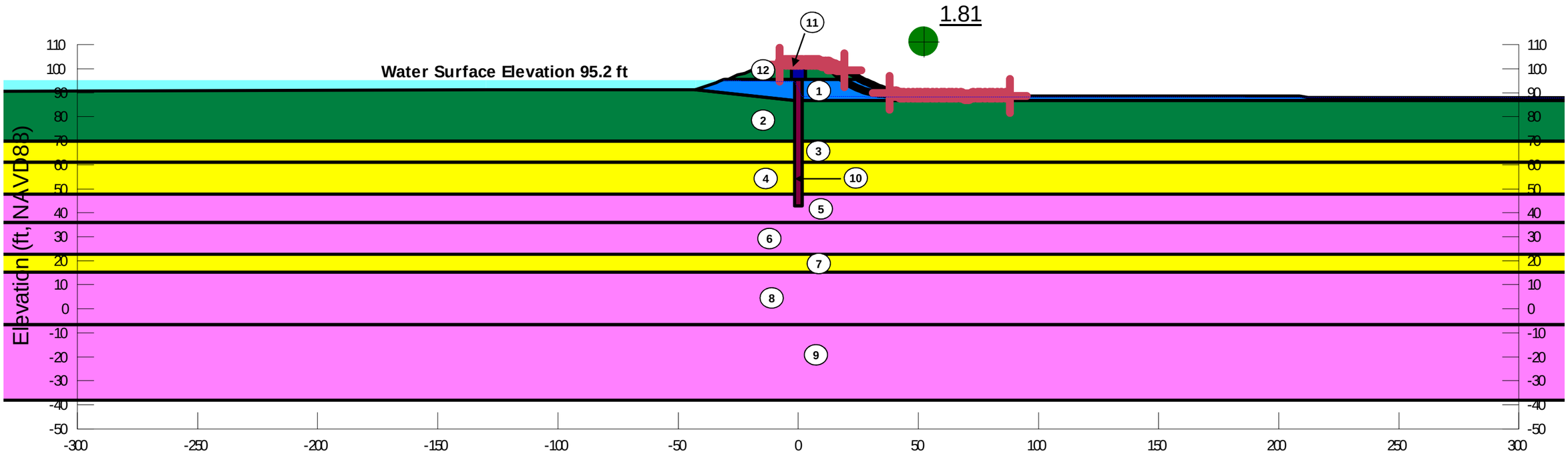
(2) Slurry Wall (SB),		Kh=0.00028 ft/day (=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day (=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day (=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(10)*Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(19) Clayey Gravel to Gravel,	30-49% fines,	Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day (=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day (=3x10-2 cm/s)	0.25
(27) Regrade SM,		Kh=0.085 ft/day (=3x10-5 cm/s)	0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	**STEADY-STATE SEEPAGE ANALYSIS** **Reach 30, Section at Sta. 1826+94** **Alternative 1: Cutoff Wall** **WSE at 200yr+1 ft**
			TASK ORDER 1	ANALYZED MW	
			DATE 02/08/2011	CHECKED NT	

FIGURE B30-A1

Slope Stability Analysis Results, Critical Slip Surface

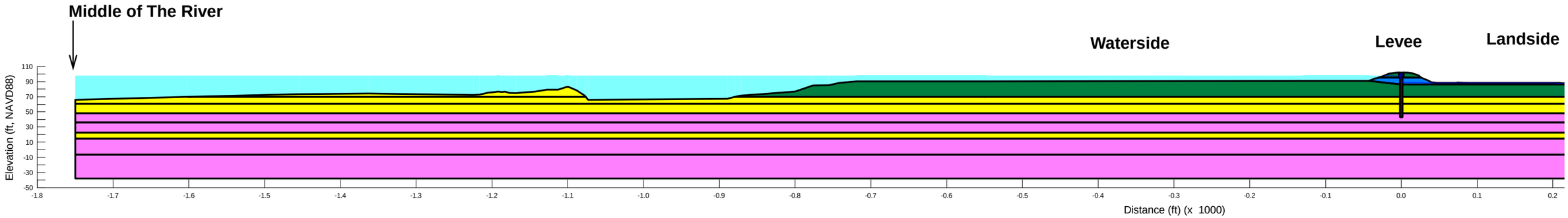


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi'=32
2 SM 120 pcf C'=0, Phi'=32
3 SP 120 pcf C'=0, Phi'=34
4 GP 130 pcf C'=0, Phi'=36
5 SC 120 pcf C'=0, Phi'=34
6 SC 120 pcf C'=0, Phi'=34
7 GP-GC 130 pcf C'=0, Phi'=36
8 GC 130 pcf C'=0, Phi'=36
9 SW-SC 120 pcf C'=0, Phi'=34
10 SB Wall 100 pcf C'=300, Phi'=0
11 SB Wall Cap 120 pcf C'=100, Phi'=32
12 Regrade SM 120 pcf C'=0, Phi'=35

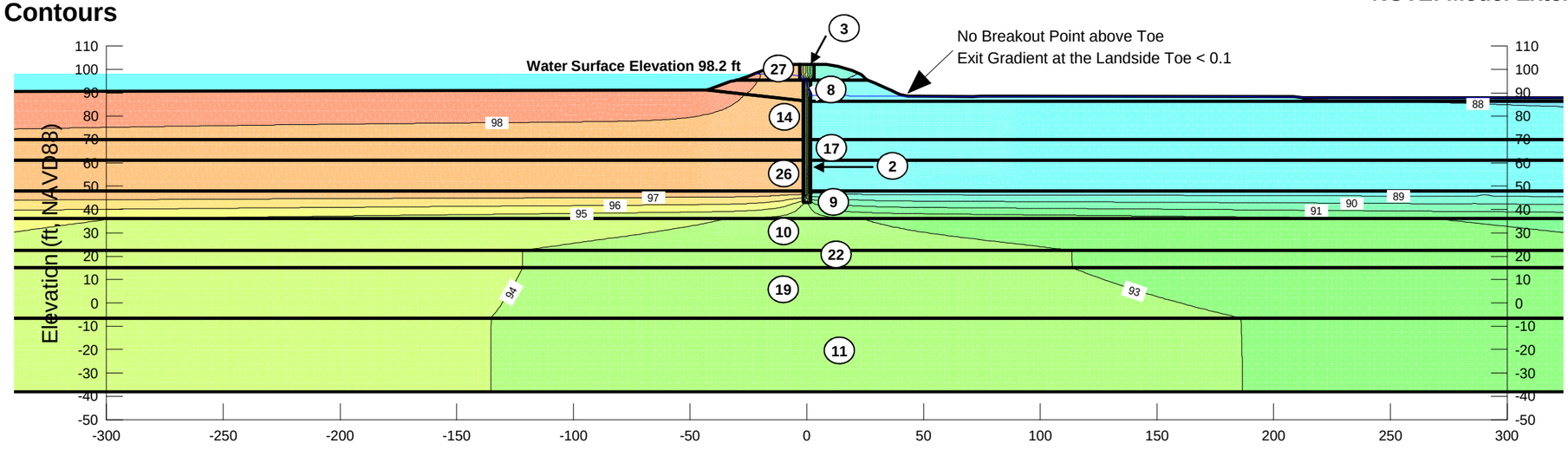
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/08/2011	DRAWN MW ANALYZED MW CHECKED NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 30, Section at Sta. 1826+94 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B30-A2

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



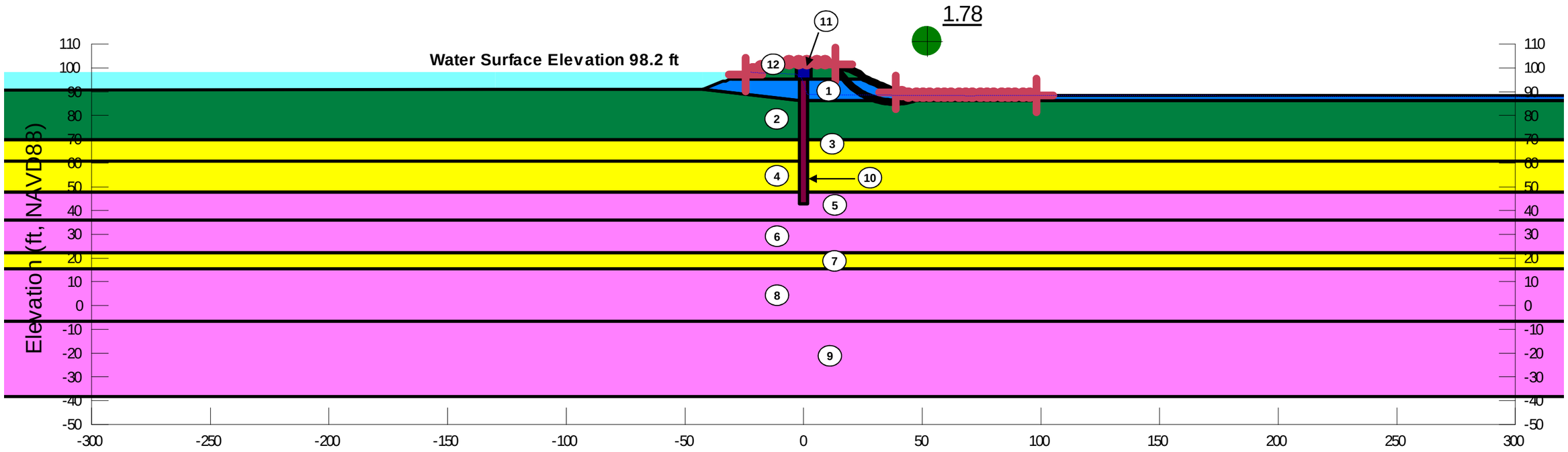
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(10)*Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(19) Clayey Gravel to Gravel,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade SM, Kh=0.085 ft/day (=3x10-5 cm/s)				0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/08/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 30, Section at Sta. 1826+94 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B30-A3

Slope Stability Analysis Results, Critical Slip Surface

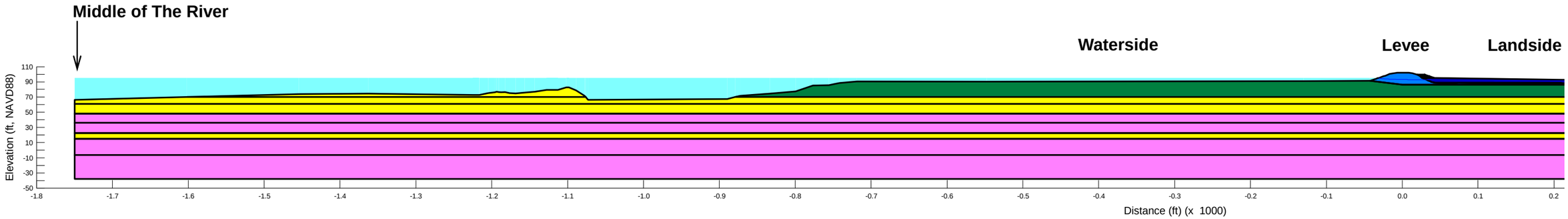


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi'=32
2 SM 120 pcf C'=0, Phi'=32
3 SP 120 pcf C'=0, Phi'=34
4 GP 130 pcf C'=0, Phi'=36
5 SC 120 pcf C'=0, Phi'=34
6 SC 120 pcf C'=0, Phi'=34
7 GP-GC 130 pcf C'=0, Phi'=36
8 GC 130 pcf C'=0, Phi'=36
9 SW-SC 120 pcf C'=0, Phi'=34
10 SB Wall 100 pcf C'=300, Phi'=0
11 SB Wall Cap 120 pcf C'=100, Phi'=32
12 Regrade SM 120 pcf C'=0, Phi'=35

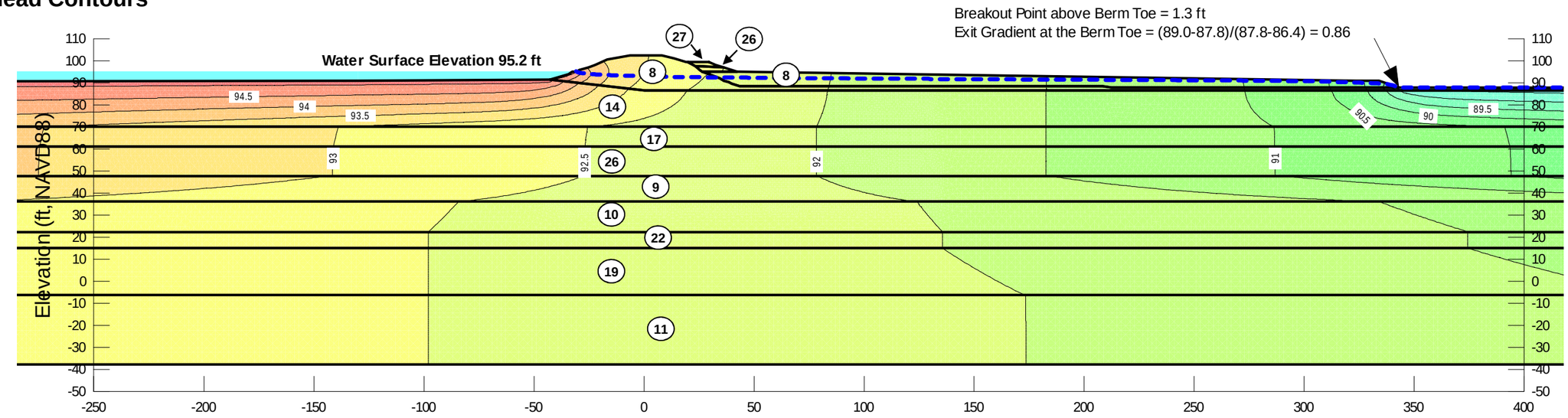
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/08/2011	DRAWN MW ANALYZED MW CHECKED NT	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 30, Section at Sta. 1826+94** **Alternative 1: Cutoff Wall** **WSE at 200yr+4 ft**	**FIGURE B30-A4**

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



NOTE: Head Contour Interval 0.5 ft

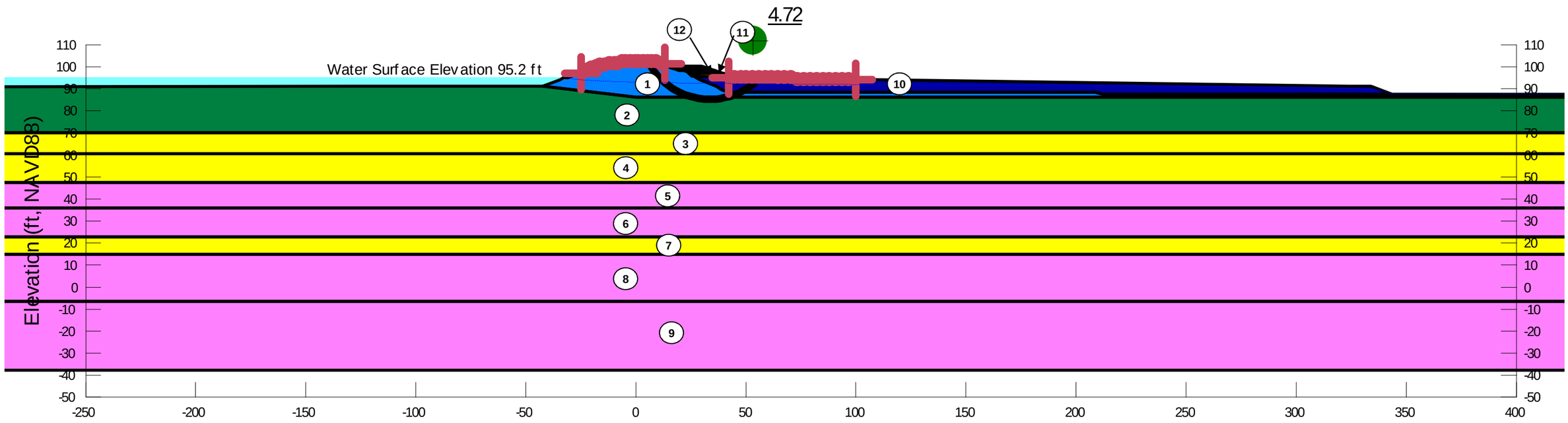
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(10)*Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(19) Clayey Gravel to Gravel,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade SM, Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25		

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/08/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 30, Section at Sta. 1826+94 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft

FIGURE B30-A5

Slope Stability Analysis Results, Critical Slip Surface

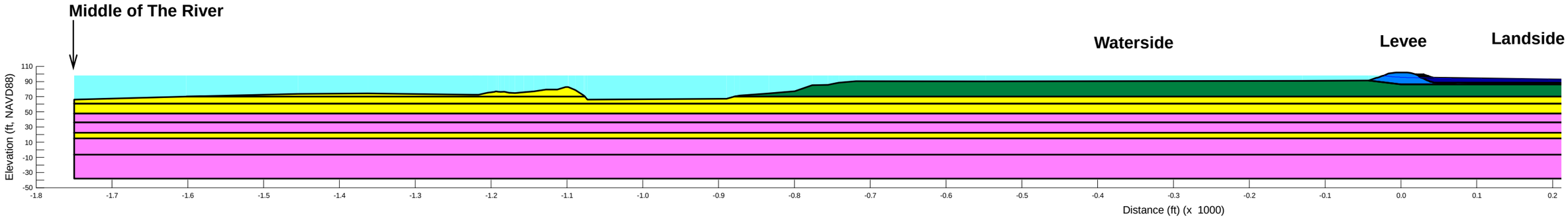


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50 psf, Phi'=32
2 SM 120 pcf C'=0, Phi'=32
3 SP 120 pcf C'=0, Phi'=34
4 GP 130 pcf C'=0, Phi'=36
5 SC 120 pcf C'=0, Phi'=34
6 SC 120 pcf C'=0, Phi'=34
7 GP-GC 130 pcf C'=0, Phi'=36
8 GC 130 pcf C'=0, Phi'=36
9 SW-SC 120 pcf C'=0, Phi'=34
10 ML, New Compacted Berm 120 pcf C'=100 psf, Phi'=32
11 GP 130 pcf C'=0, Phi'=36
12 Regrade SM 120 pcf C'=0, Phi'=35

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/08/2011 / CHECKED NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 30, Section at Sta. 1826+94 Alternative 2: Seepage and Stability berm WSE at 200yr+1 ft	FIGURE B30-A6

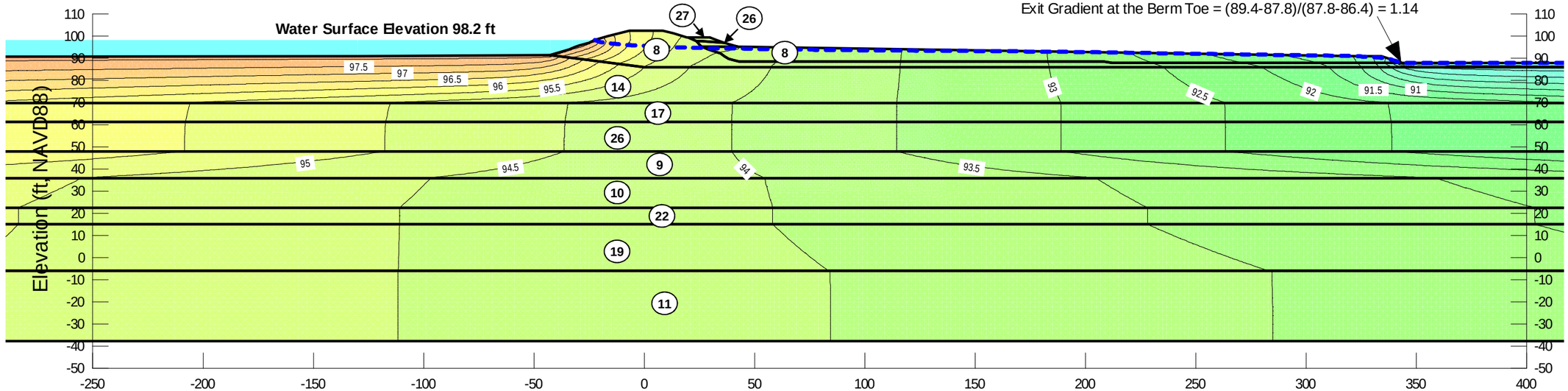
Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside

Breakout at Top of Berm
Exit Gradient at the Berm Toe = (89.4-87.8)/(87.8-86.4) = 1.14



NOTE: Head Contour Interval 0.5 ft

Material ID and Type Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

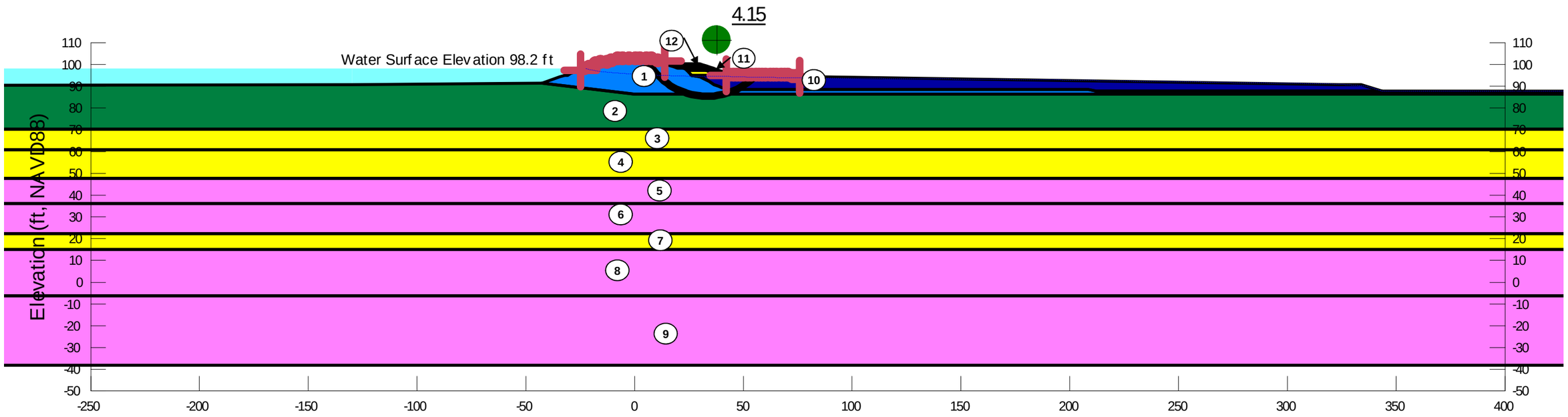
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(10)*Clayey Sand to Sand,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(19) Clayey Gravel to Gravel,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade SM, Kh=0.085 ft/day			(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/08/2011	DRAWN MW ANALYZED MW CHECKED NT

STEADY-STATE SEEPAGE ANALYSIS
Reach 30, Section at Sta. 1826+94
Alternative 2: Seepage and Stability Berm
WSE at 200yr+4 ft

FIGURE B30-A7

Slope Stability Analysis Results,
Critical Slip Surface

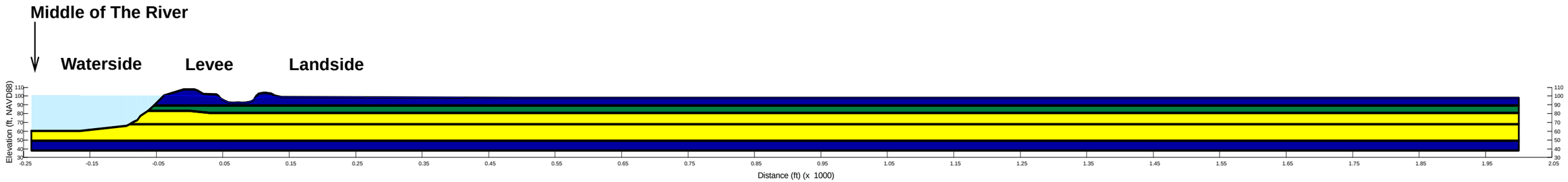


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50 psf, Phi'=32
2 SM 120 pcf C'=0, Phi'=32
3 SP 120 pcf C'=0, Phi'=34
4 GP 130 pcf C'=0, Phi'=36
5 SC 120 pcf C'=0, Phi'=34
6 SC 120 pcf C'=0, Phi'=34
7 GP-GC 130 pcf C'=0, Phi'=36
8 GC 130 pcf C'=0, Phi'=36
9 SW-SC 120 pcf C'=0, Phi'=34
10 ML, New Compacted Berm 120 pcf C'=100 psf, Phi'=32
11 GP 130 pcf C'=0, Phi'=36
12 Regrade SM 120 pcf C'=0, Phi'=35

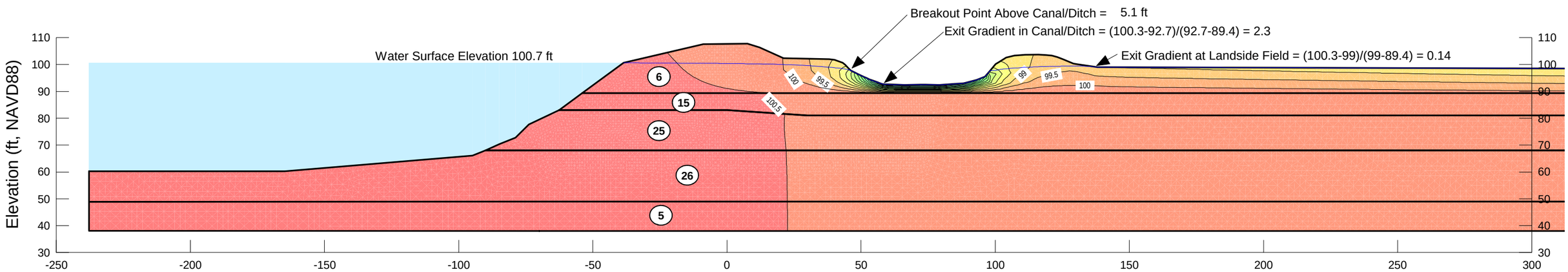
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/08/2011	DRAWN MW ANALYZED MW CHECKED NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 30, Section at Sta. 1826+94 Alternative 2: Seepage and Stability Berm WSE at 200yr+4'	FIGURE B30-A8

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



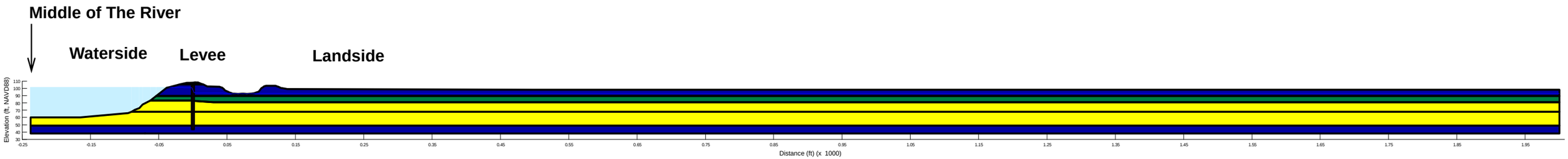
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, 0.25
(25) Silty Gravel to Sandy Gravel, 8- 12% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

NOTE: Head Contour Interval 0.5 ft

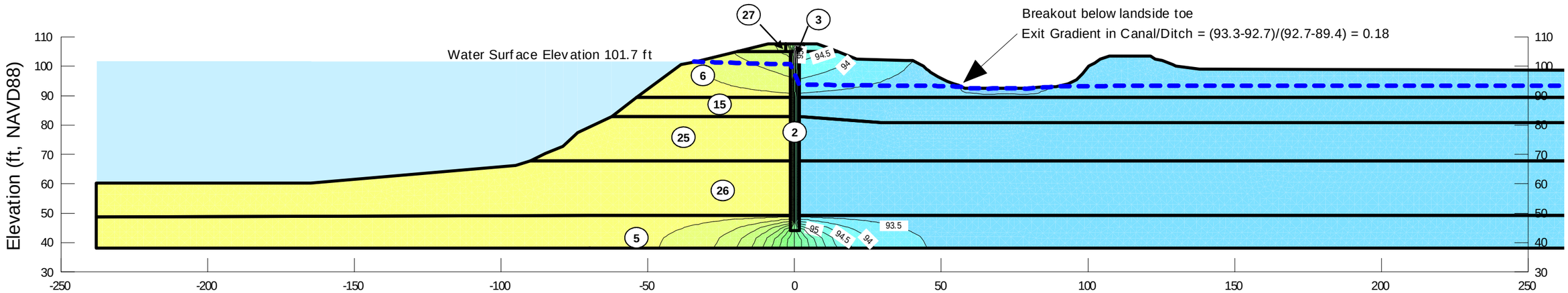
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 31, Section at Sta. 1907+91 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED MW	FIGURE B31-E1
			DATE 02/09/2011	CHECKED NT	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



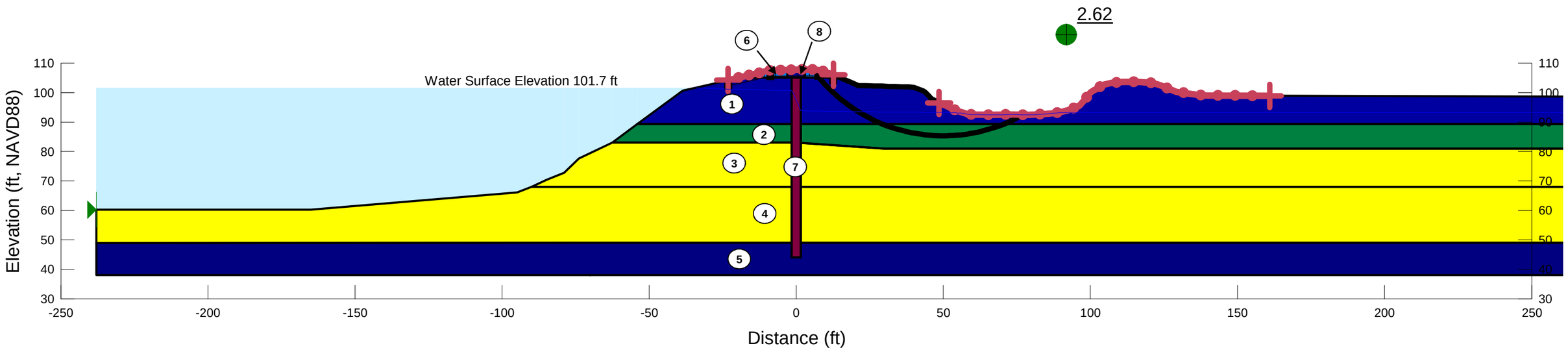
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8ft/day	(=1x10-3cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML,	50-79% fines	Kh=0.085ft/day	(=3x10-5cm/s)	0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	**STEADY-STATE SEEPAGE ANALYSIS** **Reach 31, Section at Sta. 1907+91** **Alternative 1: Cutoff Wall** **WSE at 200yr+1 ft**
			TASK ORDER 1	ANALYZED MW	**FIGURE B31-A1**
			DATE 02/07/2011	CHECKED NT	

Slope Stability Analysis Results, Critical Slip Surface

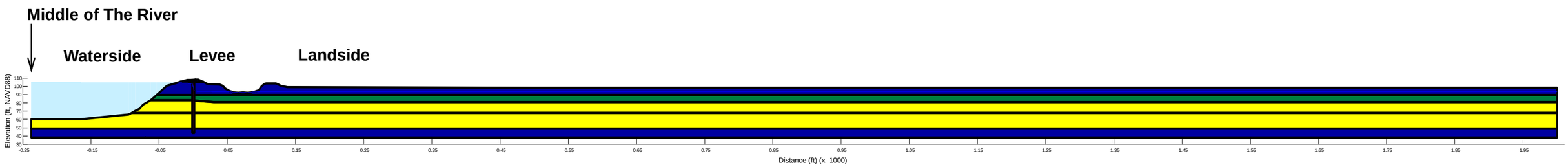


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 120 pcf C'=100, Phi'=31
2 SM 120 pcf C'=0, Phi'=35
3 GW-GM 130 pcf C'=0, Phi'=36
4 GP 130 pcf C'=0, Phi'=36
5 CL 120 pcf C'=100, Phi'=31
6 Regrade ML 120 pcf C'=50, Phi'=32
7 SB Wall 100 pcf C'=300, Phi'=0
8 New Compacted Clay Levee, CL Cap 120 pcf C'=100, Phi'=32

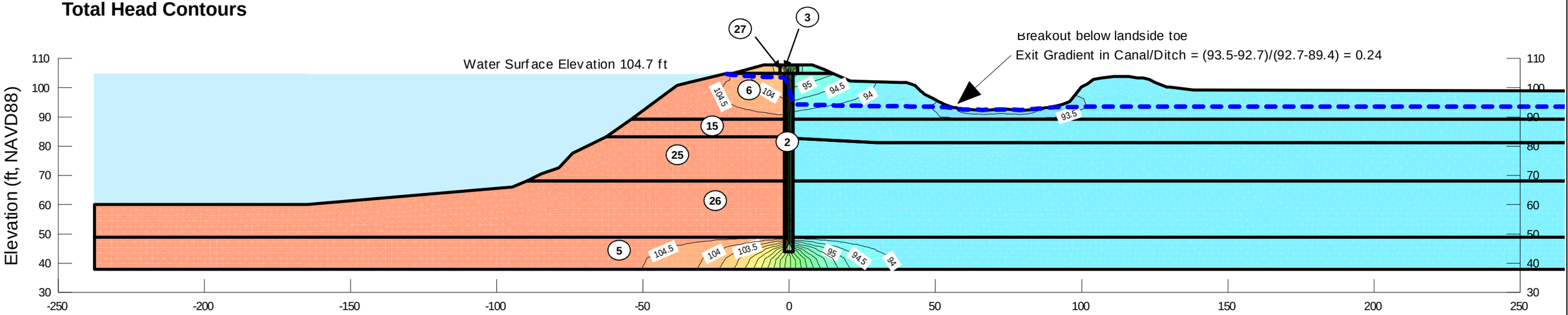
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/07/2011	DRAWN MW ANALYZED MW CHECKED NT	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 31, Section at Sta. 1907+91** **Alternative 1: Cutoff Wall** **WSE at 200yr+1 ft**	**FIGURE B31-A2**

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



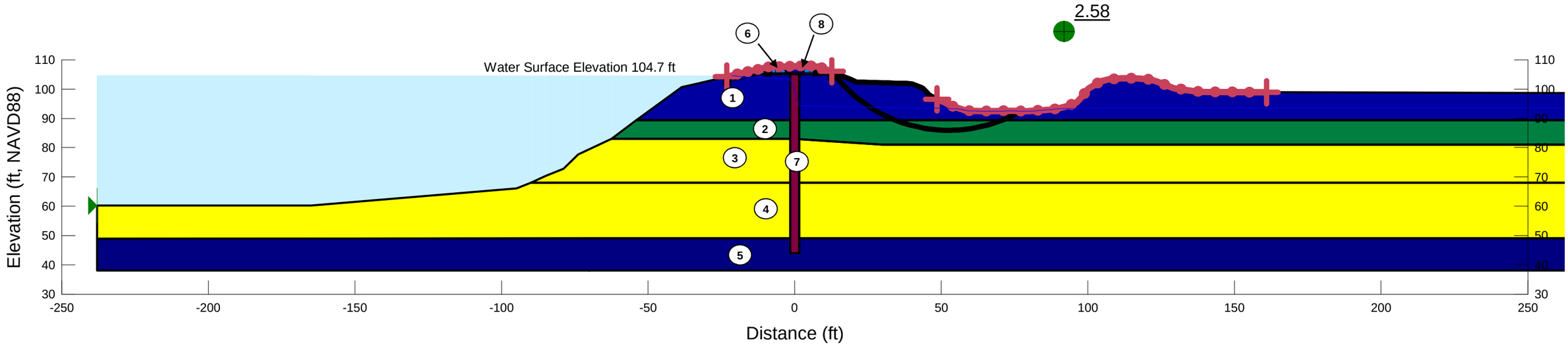
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8ft/day	(=1x10-3cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML,	50-79% fines	Kh=0.085ft/day	(=3x10-5cm/s)	0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/07/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 31, Section at Sta. 1907+91 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B31-A3

Slope Stability Analysis Results, Critical Slip Surface

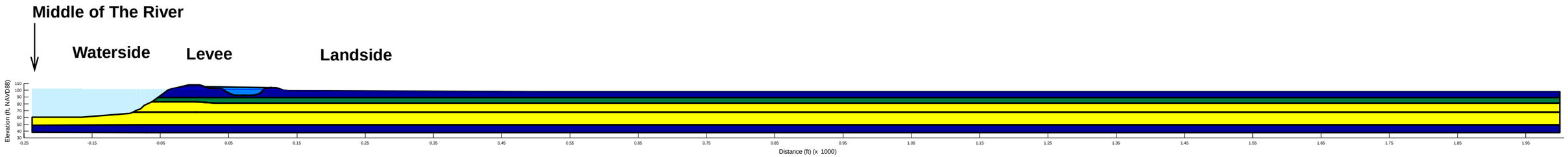


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 120 pcf C'=100, Phi'=31
2 SM 120 pcf C'=0, Phi'=35
3 GW-GM 130 pcf C'=0, Phi'=36
4 GP 130 pcf C'=0, Phi'=36
5 CL 120 pcf C'=100, Phi'=31
6 Regrade ML 120 pcf C'=50, Phi'=32
7 SB Wall 100 pcf C'=300, Phi'=0
8 New Compacted Clay Levee, CL Cap 120 pcf C'=100, Phi'=32

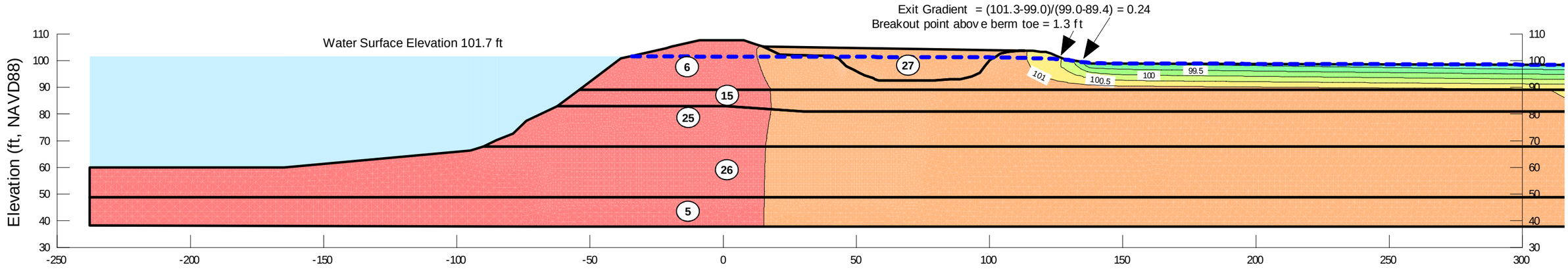
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 31, Section at Sta. 1907+91** **Alternative 1: Cutoff Wall** **WSE at 200yr+4 ft**	**FIGURE B31-A4**
			TASK ORDER 1	ANALYZED MW		
			DATE 02/07/2011	CHECKED NT		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



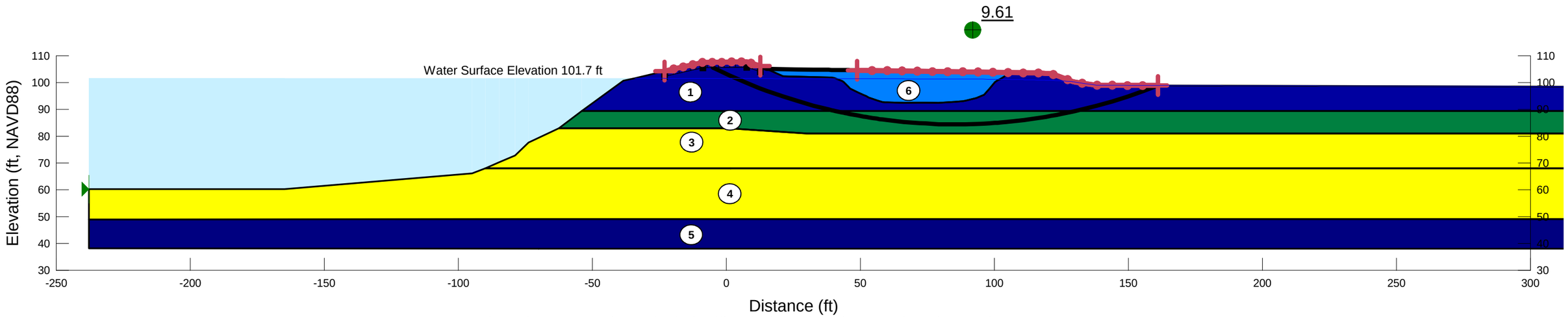
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8ft/day (=1x10-3cm/s) 0.25
(25) Silty Gravel to Sandy Gravel, 8- 12% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(27) Regrade ML, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / TASK ORDER 1 / DATE 02/08/2011	DRAWN MW / ANALYZED MW / CHECKED NT	**STEADY-STATE SEEPAGE ANALYSIS** **Reach 31, Section at Sta. 1907+91** **Alternative 2 Filled Canal** **WSE at 200yr+1 ft**	**FIGURE B31-A5**

Slope Stability Analysis Results,
Critical Slip Surface

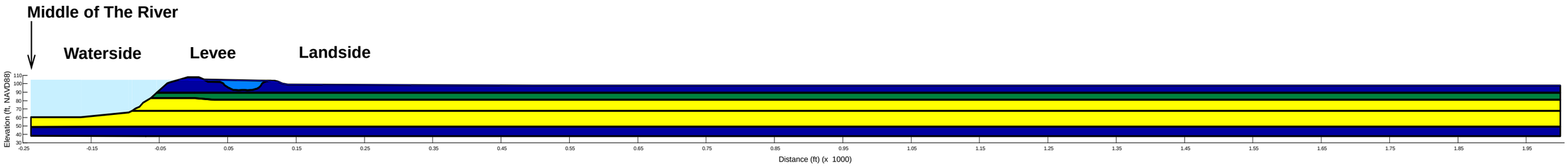


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 120 pcf C'=100, Phi'=31
2 SM 120 pcf C'=0, Phi'=35
3 GW-GM 130 pcf C'=0, Phi'=36
4 GP 130 pcf C'=0, Phi'=36
5 CL 120 pcf C'=100, Phi'=31
6 Regrade ML 120 pcf C'=50, Phi'=32

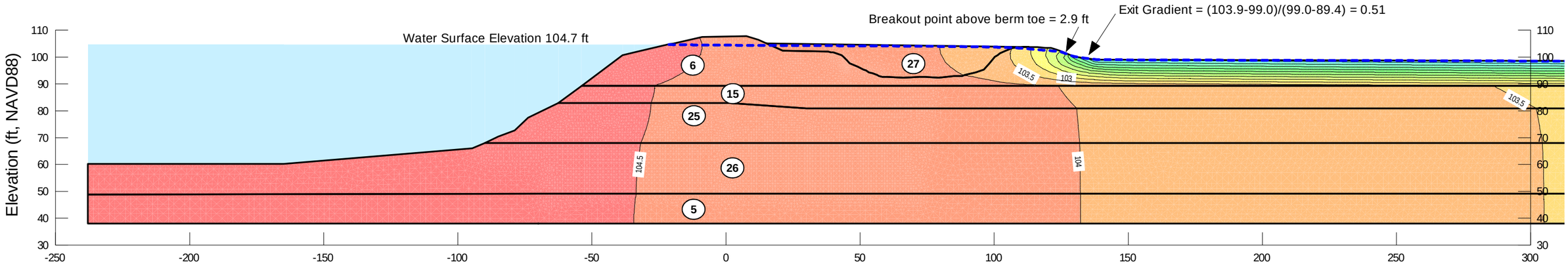
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/08/2011	DRAWN MW ANALYZED MW CHECKED NT	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 31, Section at Sta. 1907+91** **Alternative 2 Filled Canal** **WSE at 200yr+1 ft**	**FIGURE B31-A6**

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



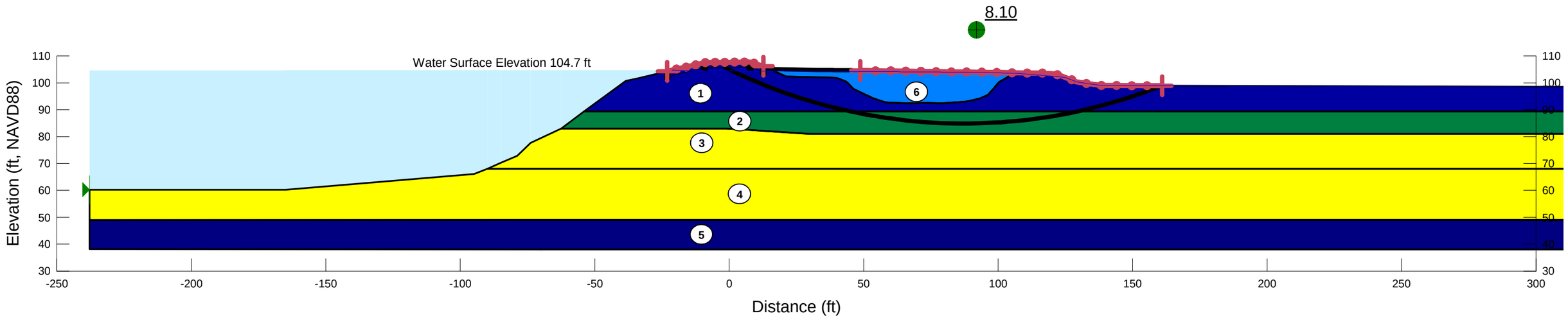
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8ft/day (=1x10-3cm/s) 0.25
(25) Silty Gravel to Sandy Gravel, 8- 12% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(27) Regrade ML, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/08/2011 / CHECKED NT	**STEADY-STATE SEEPAGE ANALYSIS** **Reach 31, Section at Sta. 1907+91** **Alternative 2 Filled Canal** **WSE at 200yr+4 ft**	**FIGURE B31-A7**

Slope Stability Analysis Results, Critical Slip Surface

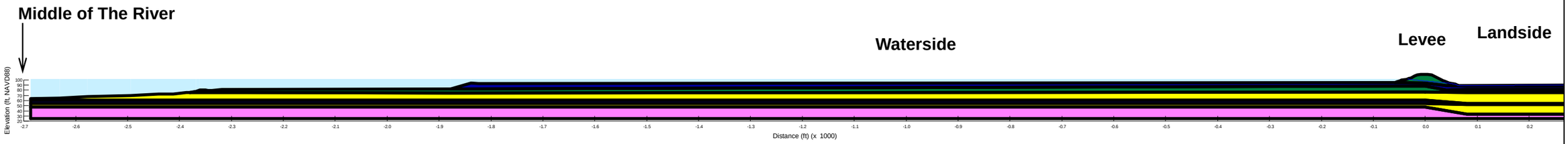


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 120 pcf C'=100, Phi'=31
2 SM 120 pcf C'=0, Phi'=35
3 GW-GM 130 pcf C'=0, Phi'=36
4 GP 130 pcf C'=0, Phi'=36
5 CL 120 pcf C'=100, Phi'=31
6 Regrade ML 120 pcf C'=50, Phi'=32

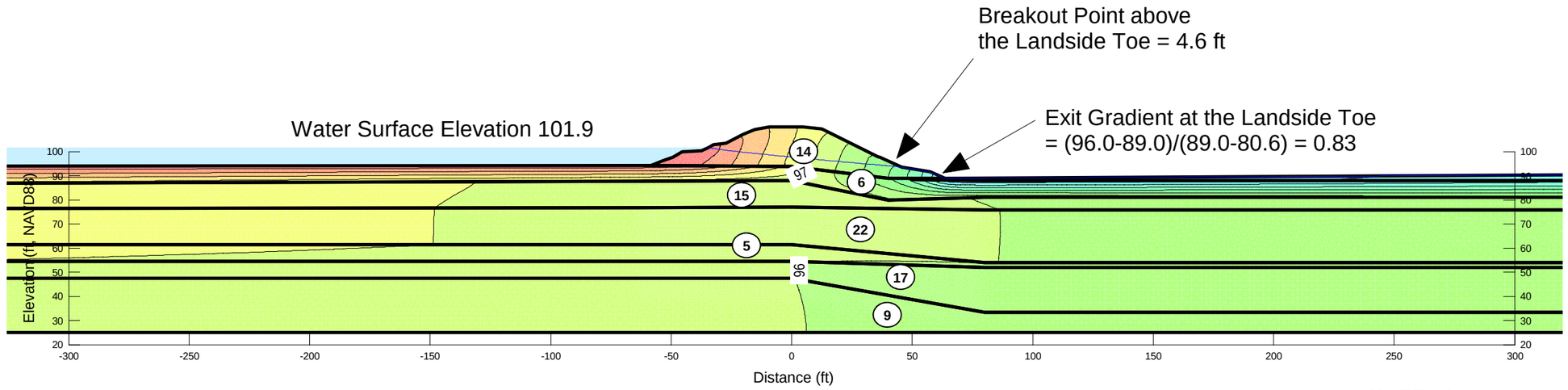
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/08/2011	DRAWN MW ANALYZED MW CHECKED NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 31, Section at Sta. 1907+91 Alternative 2 Filled Canal WSE at 200yr+4 ft	FIGURE B31-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



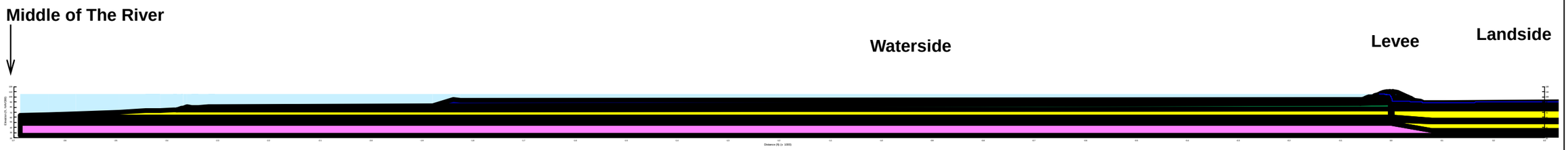
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

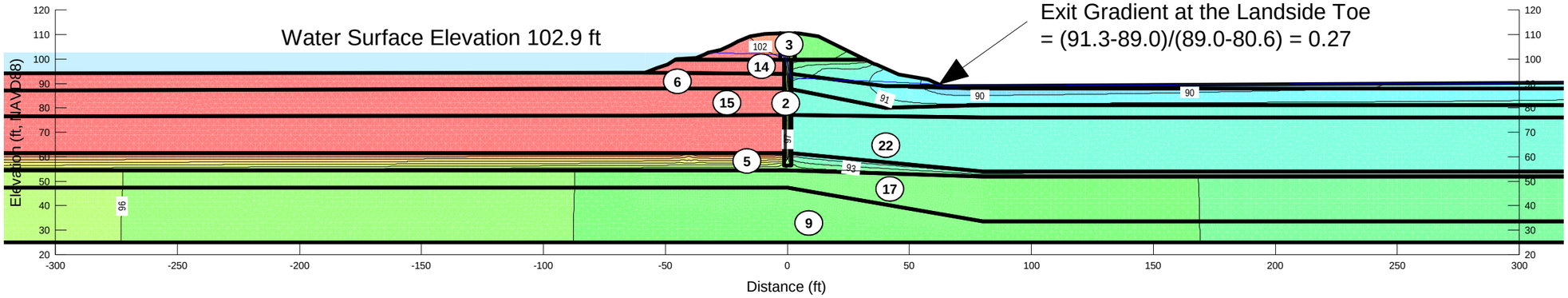
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 2/9/2011 / CHECKED MC	STEADY-STATE SEEPAGE ANALYSIS Reach 32, Section at Sta. 1965+80 Existing Conditions WSE at 200yr	FIGURE B32-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



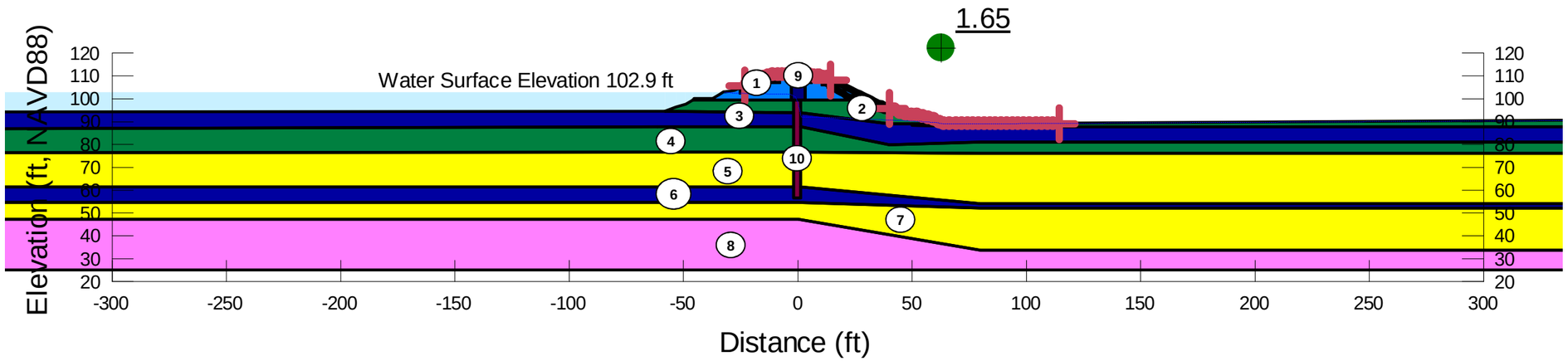
Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML, 50-79% fines,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 2/9/2011 / CHECKED MC	STEADY-STATE SEEPAGE ANALYSIS Reach 32, Section at Sta. 1965+80 Alternative 1: Cutoff Wall WSE at 200yr + 1 ft	FIGURE B32-A1

Slope Stability Analysis Results,
Critical Slip Surface

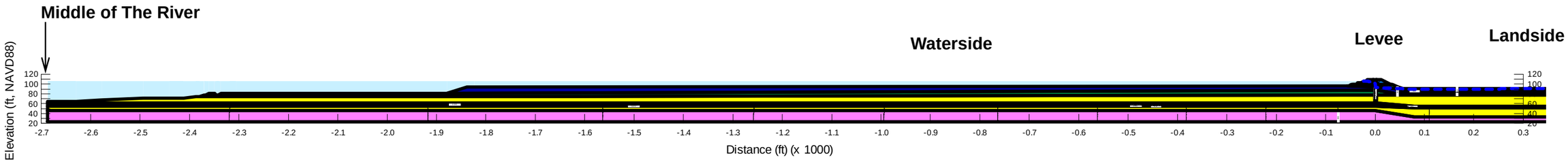


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1Regrade ML 120 pcf C'=50, Phi'=32
2 SM 120 pcf C'=0, Phi'=34
3 CL 115 pcf C'=100, Phi'=31
4 SM 120 pcf C'=0, Phi'=35
5 GW 130 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100, Phi'=31
7 SP-SM 125 pcf C'=0, Phi'=35
8 SC 125 pcf C'=0, Phi'=36
9 Clay Cap 120 pcf C'=100, Phi'=32
10 SB Wall 100 pcf C'=300, Phi'=0

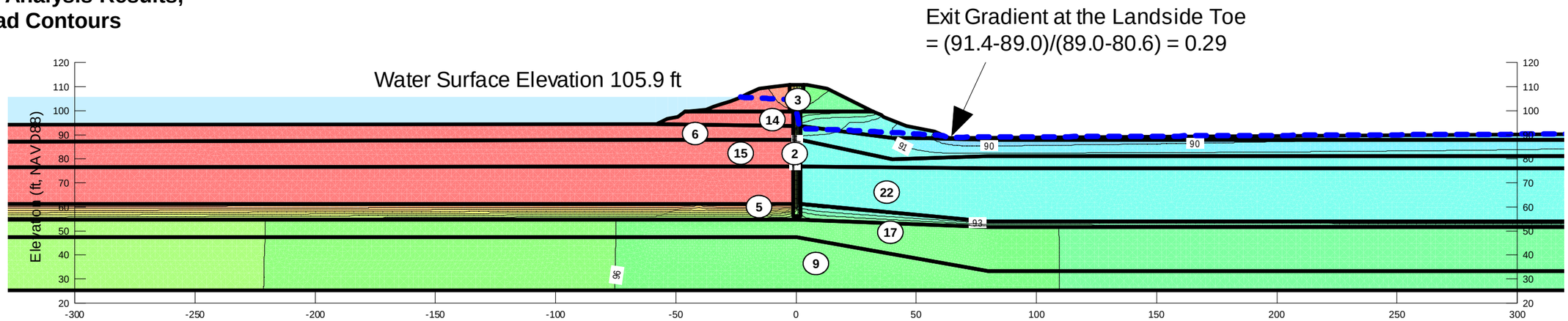
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 32, Section at Sta.1965+80 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B32-A2
			TASK ORDER 1	ANALYZED MW		
			DATE 2/9/2011	CHECKED MC		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



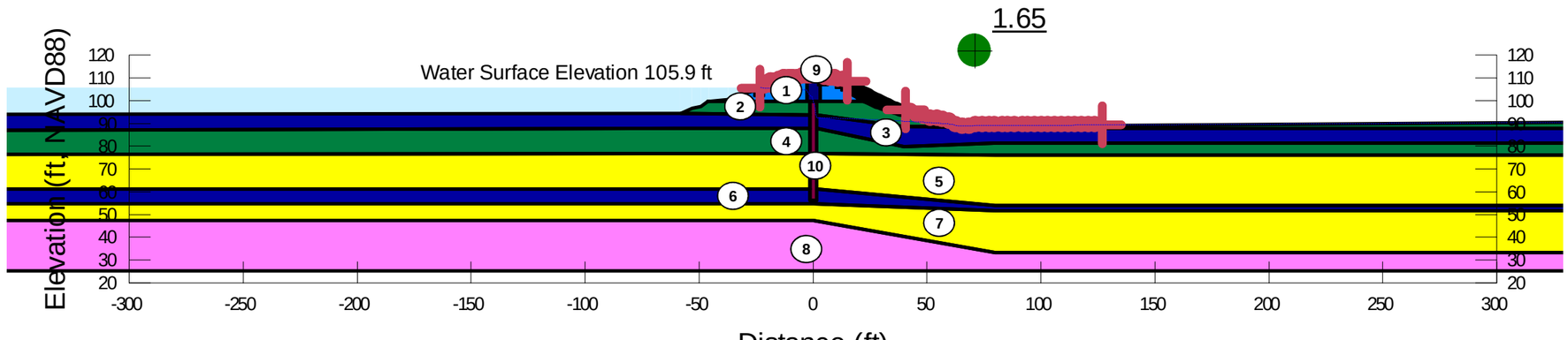
Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(2) Slurry Wall (SB), Kh=0.00028 ft/day (=1x10-7 cm/s) 1
(3) New Compacted Clay Levee, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(9)* Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(14) Silty Sand to Sand, 30-49% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(15) Silty Sand to Sand, 13-29% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(17) Silty Sand to Sand, 3- 7% fines, Kh=28 ft/day (=1x10-2 cm/s) 0.25
(22) Clayey Gravel to Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(27) Regrade ML, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** **Geotechnical Analyses for Pre-Design Formulation Report**	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 2/9/2011	DRAWN MW ANALYZED MW CHECKED MC	**STEADY-STATE SEEPAGE ANALYSIS** **Reach 32, Section at Sta. 1965+80** **Alternative 1: Cutoff Wall** **WSE at 200yr + 4 ft**	**FIGURE B32-A3**

Slope Stability Analysis Results,
Critical Slip Surface

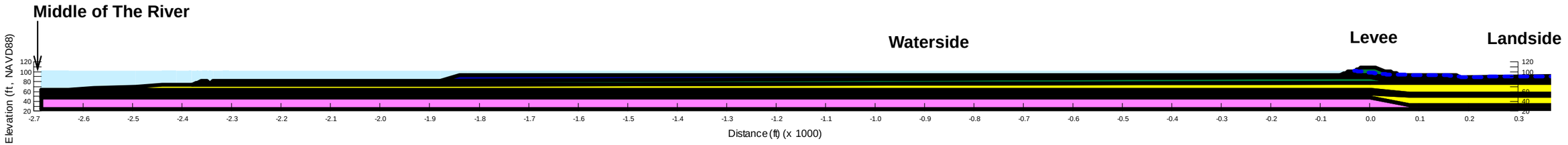


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1Regrade ML 120 pcf C'=50, Phi'=32
2 SM 120 pcf C'=0, Phi'=34
3 CL 115 pcf C'=100, Phi'=31
4 SM 120 pcf C'=0, Phi'=35
5 GW 130 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100, Phi'=31
7 SP-SM 125 pcf C'=0, Phi'=35
8 SC 125 pcf C'=0, Phi'=36
9 Clay Cap 120 pcf C'=100, Phi'=32
10 SB Wall 100 pcf C'=300, Phi'=0

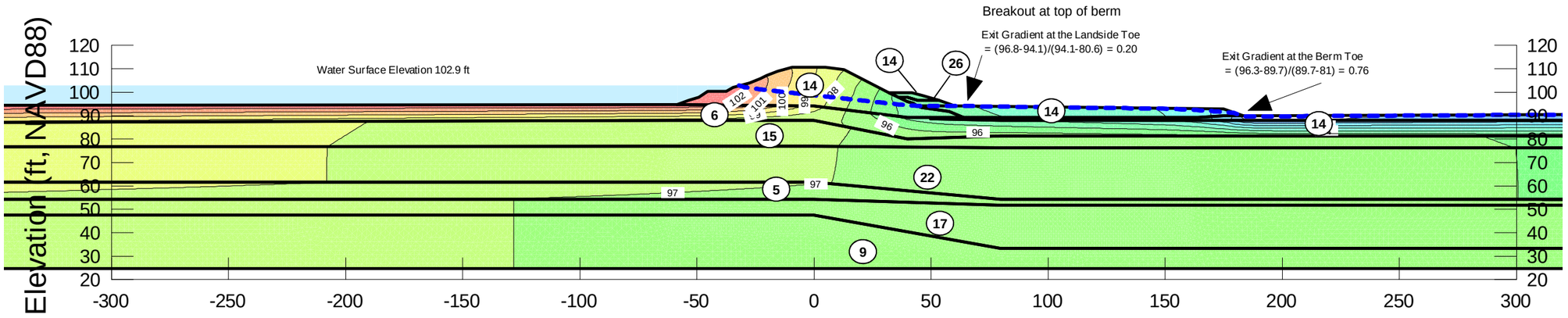
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 32, Section at Sta.1965+80 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B32-A4
			TASK ORDER 1	ANALYZED MW		
			DATE 2/9/2011	CHECKED MC		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

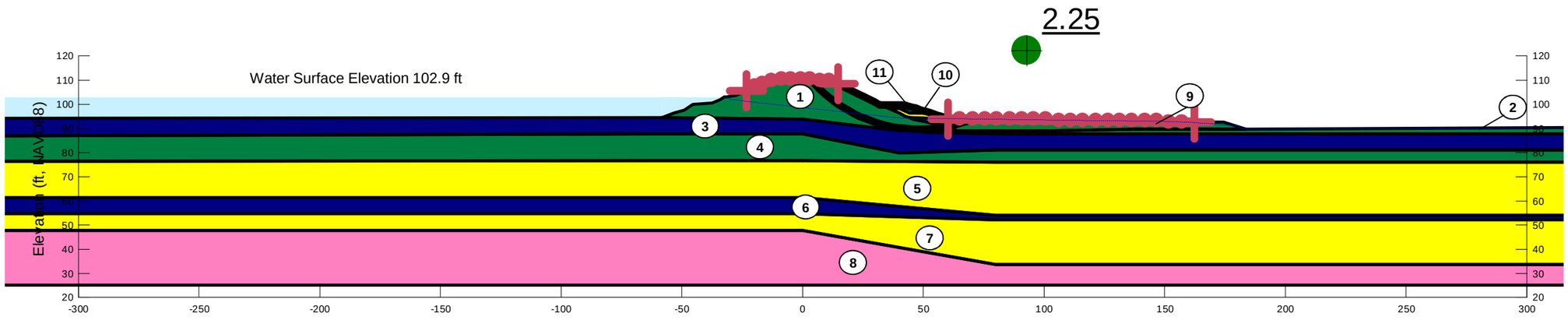
NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW
			TASK ORDER 1	ANALYZED MW
			DATE 2/9/2011	CHECKED MC

STEADY-STATE SEEPAGE ANALYSIS
Reach 32, Section at Sta. 1965+80
Alternative 1: Seepage and Stability Berm
WSE at 200yr +1 ft

FIGURE B32-A5

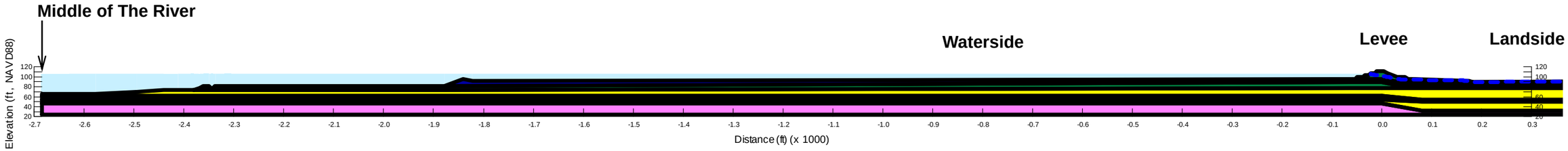
Slope Stability Analysis Results,
Critical Slip Surface



Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)
1 SM 120 pcf C'=0, Phi'=34
2 SM 120 pcf C'=0, Phi'=34
3 CL 115 pcf C'=100, Phi'=31
4 SM 120 pcf C'=0, Phi'=35
5 GW 130 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100, Phi'=31
7 SP-SM 125 pcf C'=0, Phi'=35
8 SC 125 pcf C'=0, Phi'=36
9 Compacted Berm, SM 120 pcf C'=0, Phi'=35
10 GP 130 pcf C'=0, Phi'=36
11 SM 120 pcf C'=0, Phi'=35

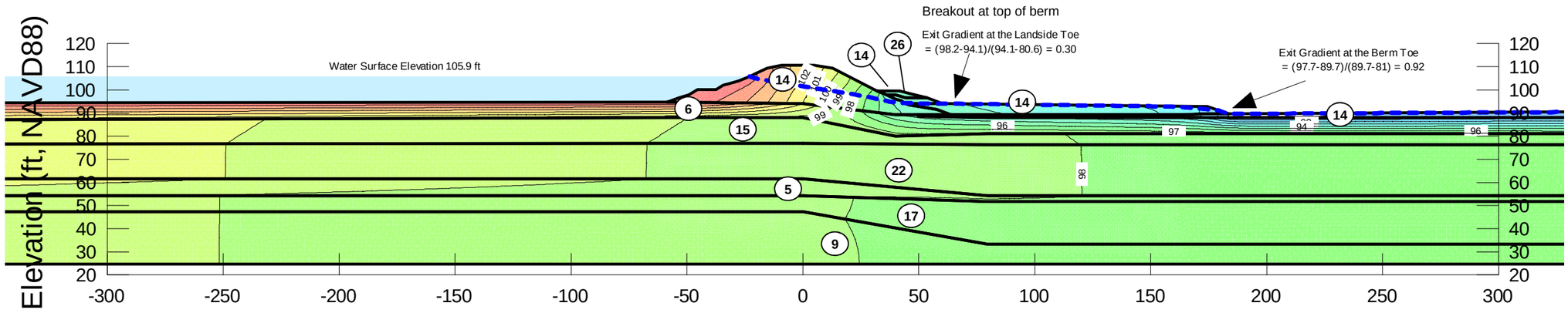
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 32, Section at Sta.1965+80 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED MW	FIGURE B32-A6
			DATE 2/9/2011	CHECKED MC	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



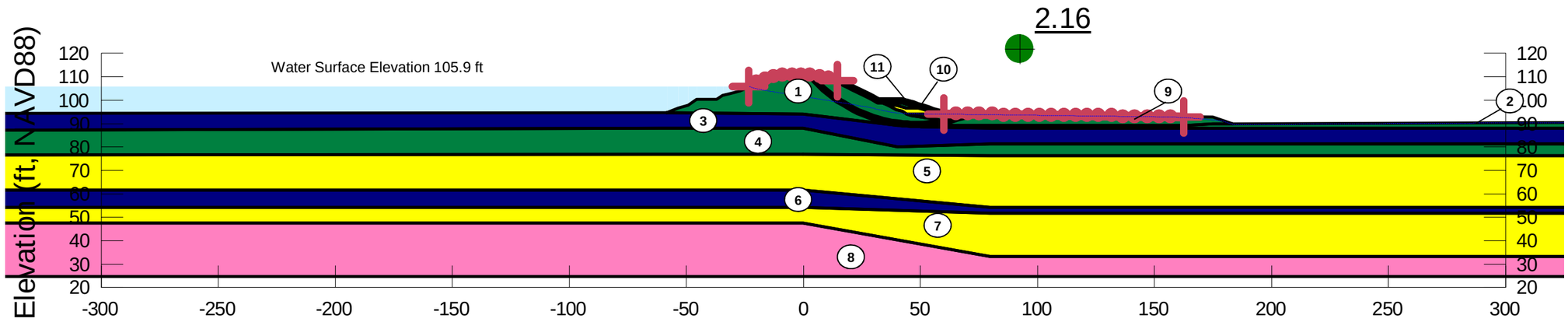
Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 2/9/2011 / CHECKED MC	STEADY-STATE SEEPAGE ANALYSIS Reach 32, Section at Sta. 1965+80 Alternative 2: Seepage and Stability Berm WSE at 200yr +4 ft	FIGURE B32-A7

Slope Stability Analysis Results,
Critical Slip Surface



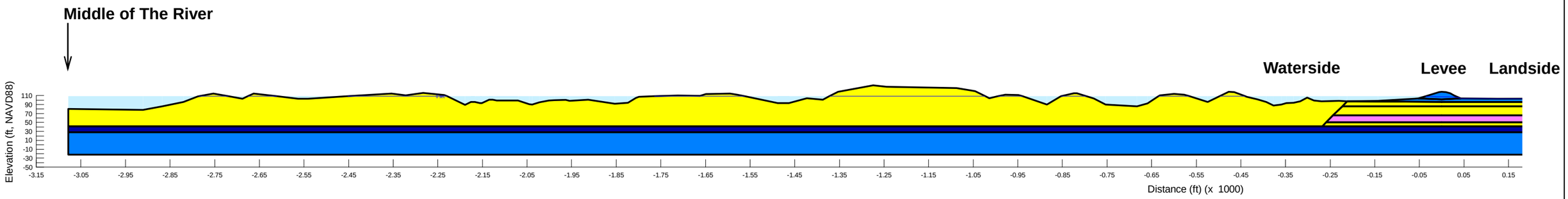
Distance (ft)

Material ID and Type, Unit Weight, Effective Strength Paramters (Cohesion Intercept and Friction Angle)

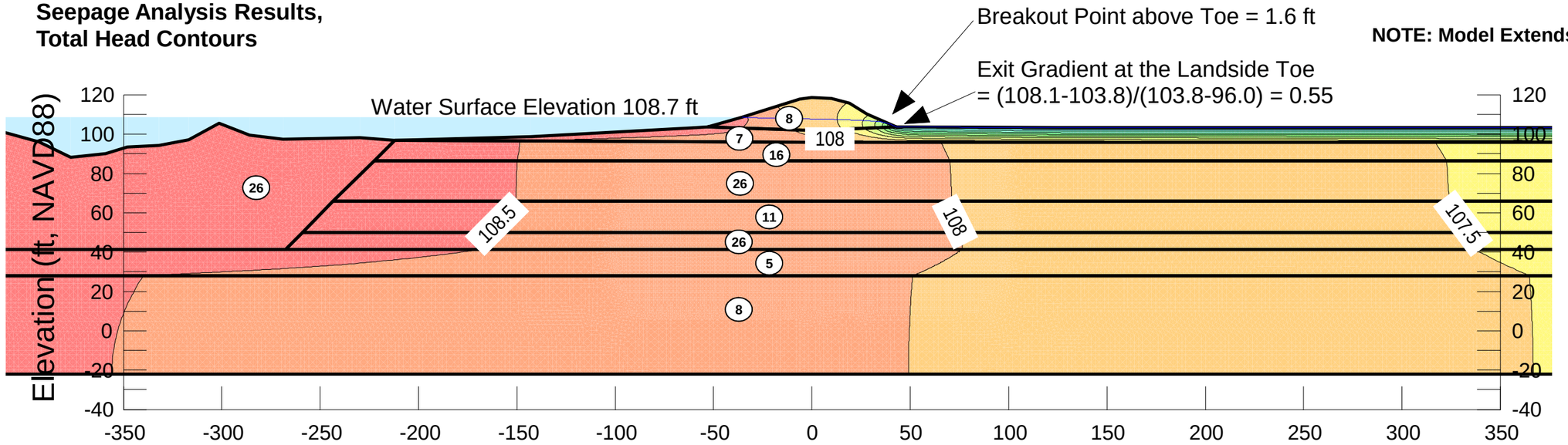
1 SM 120 pcf C'=0, Phi'=34
2 SM 120 pcf C'=0, Phi'=34
3 CL 115 pcf C'=100, Phi'=31
4 SM 120 pcf C'=0, Phi'=35
5 GW 130 pcf C'=0, Phi'=36
6 CL 120 pcf C'=100, Phi'=31
7 SP-SM 125 pcf C'=0, Phi'=35
8 SC 125 pcf C'=0, Phi'=36
9 Compacted Berm, SM 120 pcf C'=0, Phi'=35
10 GP 130 pcf C'=0, Phi'=36
11 SM 120 pcf C'=0, Phi'=35

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 32, Section at Sta.1965+80 Alternative 2: Seepage and Stability Berm WSE at 200yr+4 ft	FIGURE B32-A8
			TASK ORDER 1	ANALYZED MW		
			DATE 2/9/2011	CHECKED MC		

Model Geometry



Seepage Analysis Results, Total Head Contours



NOTE: Model Extends 2000 ft to the Landside

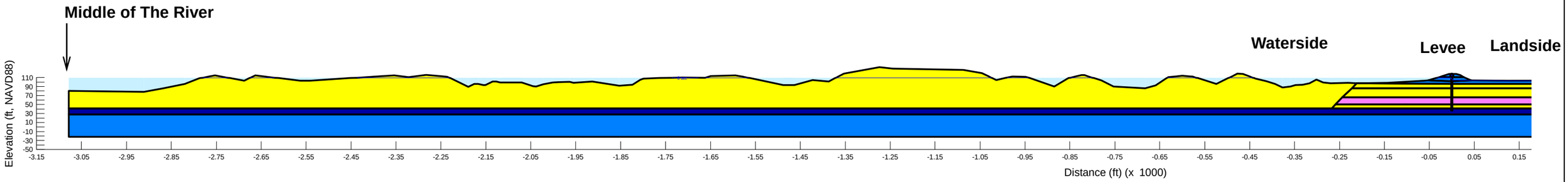
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

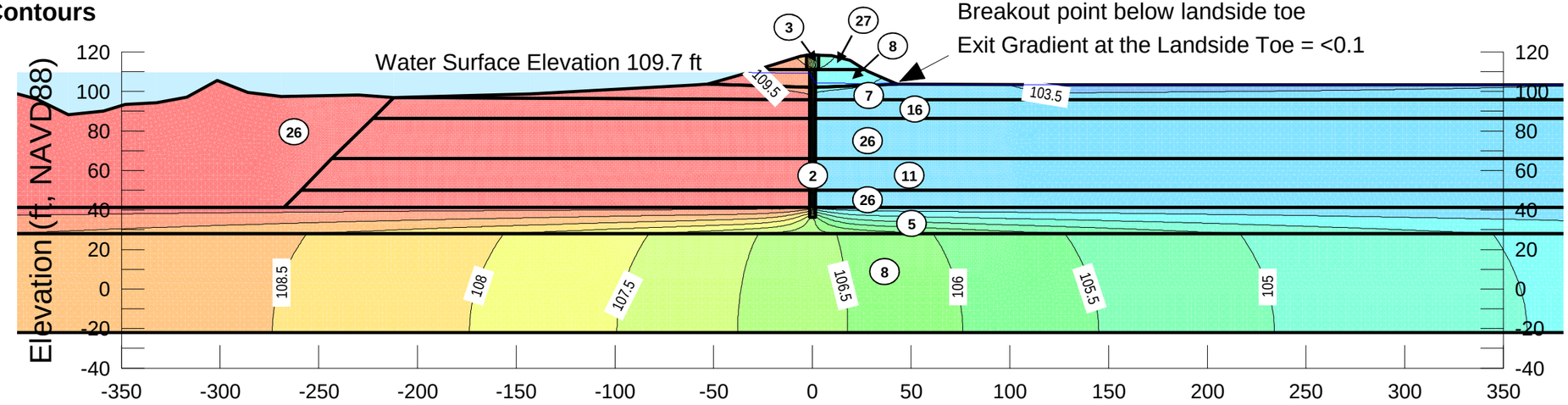
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 33, Section at Sta. 2076+90 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED MW	FIGURE B33-E1
			DATE 02/09/2011	CHECKED NT	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



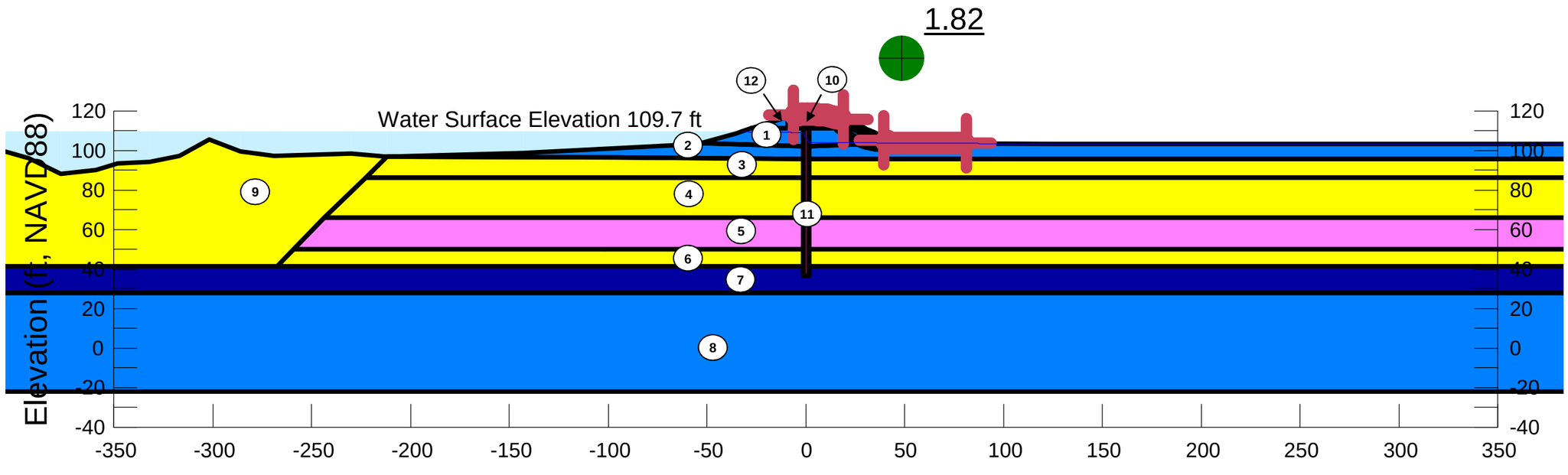
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI>4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML		Kh=0.085ft/day	(=3x10-5cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/09/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 33, Section at Sta. 2076+90 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B33-A1

Slope Stability Analysis Results,
Critical Slip Surface

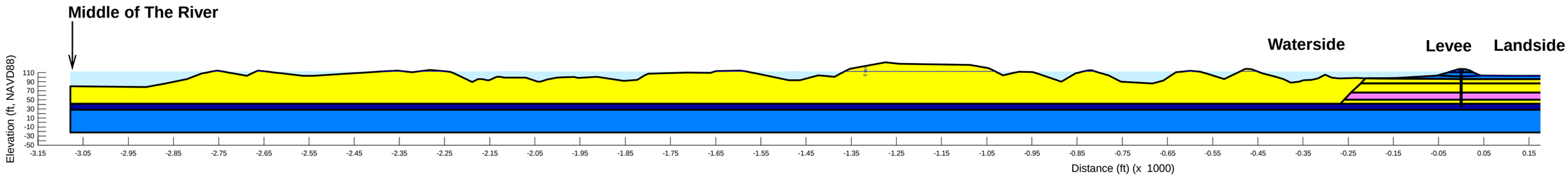


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 ML 120 pcf C'=50, Phi'=32
3 SP-SM 120 pcf C'=0, Phi'=36
4 GP 130 pcf C'=0, Phi'=36
5 SW-SC 125 pcf C'=0, Phi'=36
6 GP 130 pcf C'=0, Phi'=36
7 CL 120 pcf C'=100, Phi'=31
8 ML 120 pcf C'=50, Phi'=32
9 GP 100 pcf C'=0, Phi'=30
10 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
11 SB Wall 100 pcf C' =300 psf, Phi' =0
12 Regrade ML 120 pcf C'=50, Phi'=32

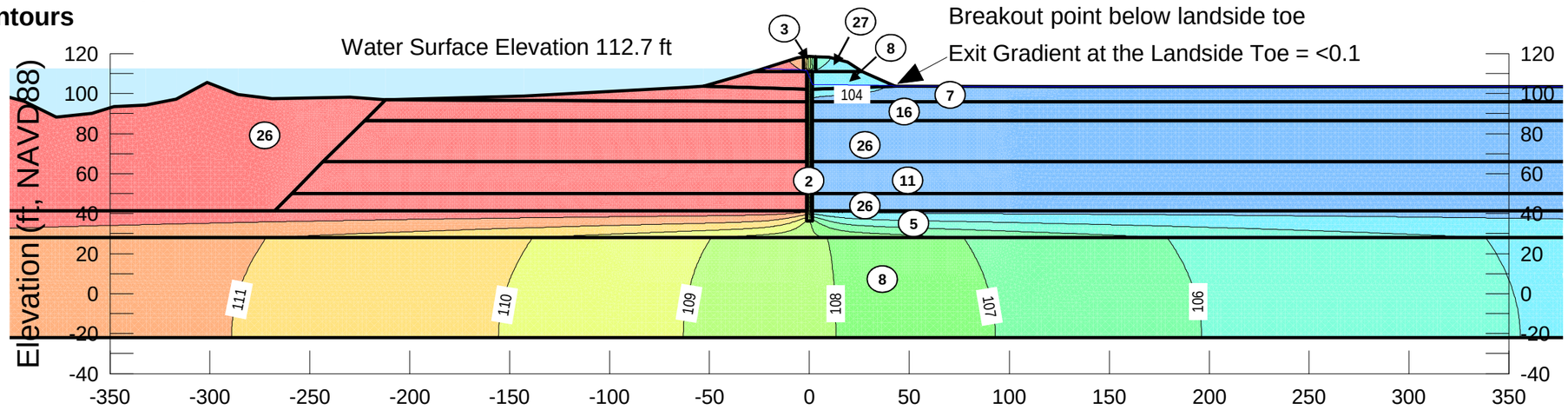
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 33, Section at Sta. 2076+90 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B33-A2
			TASK ORDER 1	ANALYZED MW		
			DATE 02/09/2011	CHECKED NT		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

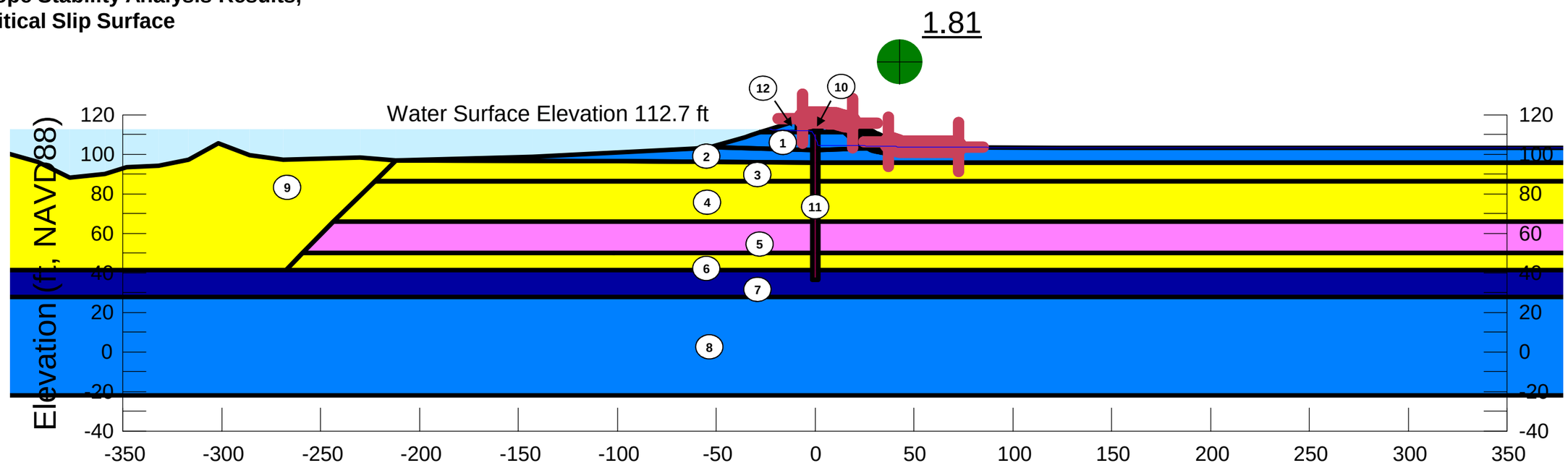
(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML		Kh=0.085ft/day	(=3x10-5cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW
			TASK ORDER 1	ANALYZED MW
			DATE 02/09/2011	CHECKED NT

STEADY-STATE SEEPAGE ANALYSIS
Reach 33, Section at Sta. 2076+90
Alternative 1: Cutoff Wall
WSE at 200yr+4 ft

FIGURE B33-A3

Slope Stability Analysis Results,
Critical Slip Surface



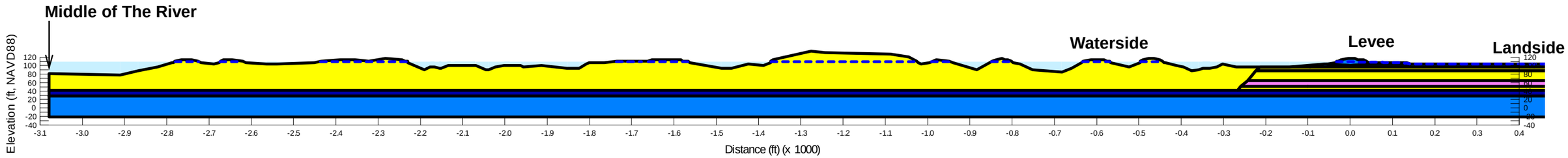
Distance (ft)

Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 ML 120 pcf C'=50, Phi'=32
3 SP-SM 120 pcf C'=0, Phi'=36
4 GP 130 pcf C'=0, Phi'=36
5 SW-SC 125 pcf C'=0, Phi'=36
6 GP 130 pcf C'=0, Phi'=36
7 CL 120 pcf C'=100, Phi'=31
8 ML 120 pcf C'=50, Phi'=32
9 GP 100 pcf C'=0, Phi'=30
10 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
11 SB Wall 100 pcf C' =300 psf, Phi' =0
12 Regrade ML 120 pcf C'=50, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 33, Section at Sta. 2076+90 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B33-A4
			TASK ORDER 1	ANALYZED MW		
			DATE 02/09/2011	CHECKED NT		

Model Geometry



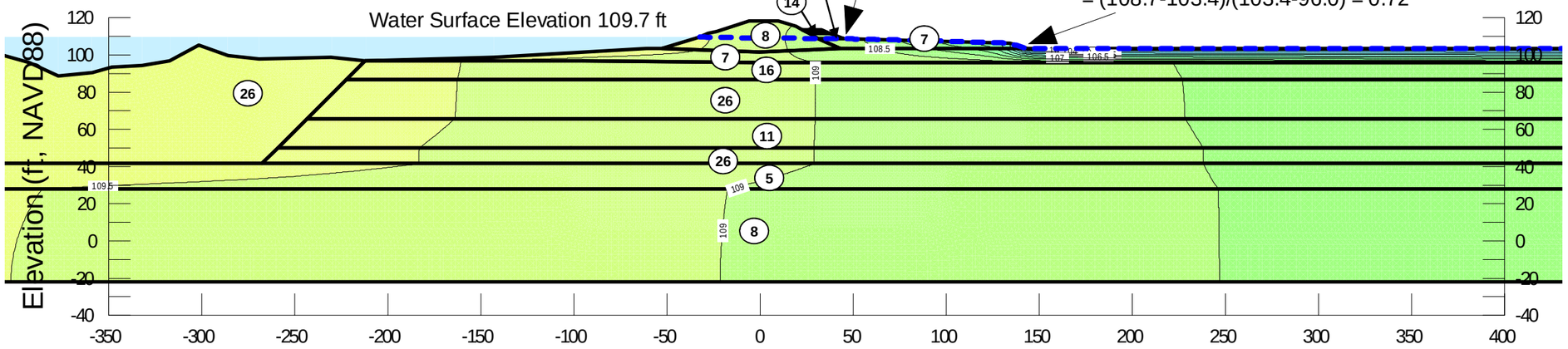
Seepage Analysis Results, Total Head Contours

Breakout at top of berm

Exit Gradient at the Levee Toe
= (109.0-108.8)/(108.8-96.0) = 0.02

Exit Gradient at the Berm Toe
= (108.7-103.4)/(103.4-96.0) = 0.72

NOTE: Model Extends 2000 ft to the Landside



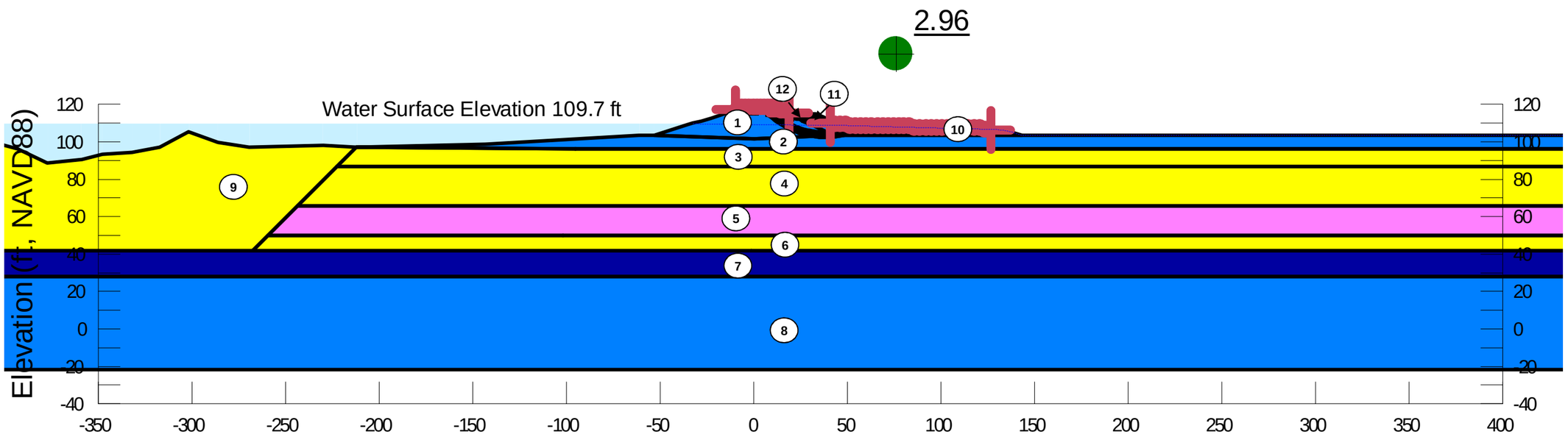
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ration (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(11) Clayey Sand to Sand, 8- 12% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(14) Silty Sand to Sand, 30-49% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach33, Section at Sta. 2076+90 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft	FIGURE B33-A5
			TASK ORDER 1	ANALYZED MW		
			DATE 02/09/2011	CHECKED NT		

Slope Stability Analysis Results,
Critical Slip Surface

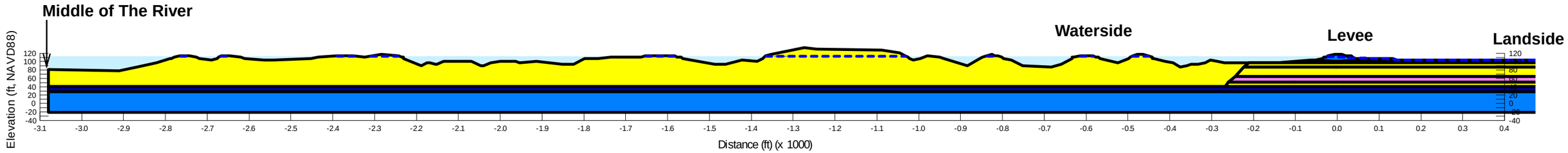


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 ML 120 pcf C'=50, Phi'=32
3 SP-SM 120 pcf C'=0, Phi'=36
4 GP 130 pcf C'=0, Phi'=36
5 SW-SC 125 pcf C'=0, Phi'=36
6 GP 130 pcf C'=0, Phi'=36
7 CL 120 pcf C'=100, Phi'=31
8 ML 120 pcf C'=50, Phi'=32
9 GP 120 pcf C'=0, Phi'=32
11 GP 130 pcf C'=0, Phi'=36
12 SM 120 pcf C'=0, Phi'=35
10 Compacted Berm, ML 120 pcf C'=50, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 33, Section at Sta. 2076+90 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft	FIGURE B33-A6
			TASK ORDER 1	ANALYZED MW		
			DATE 02/09/2011	CHECKED NT		

Model Geometry

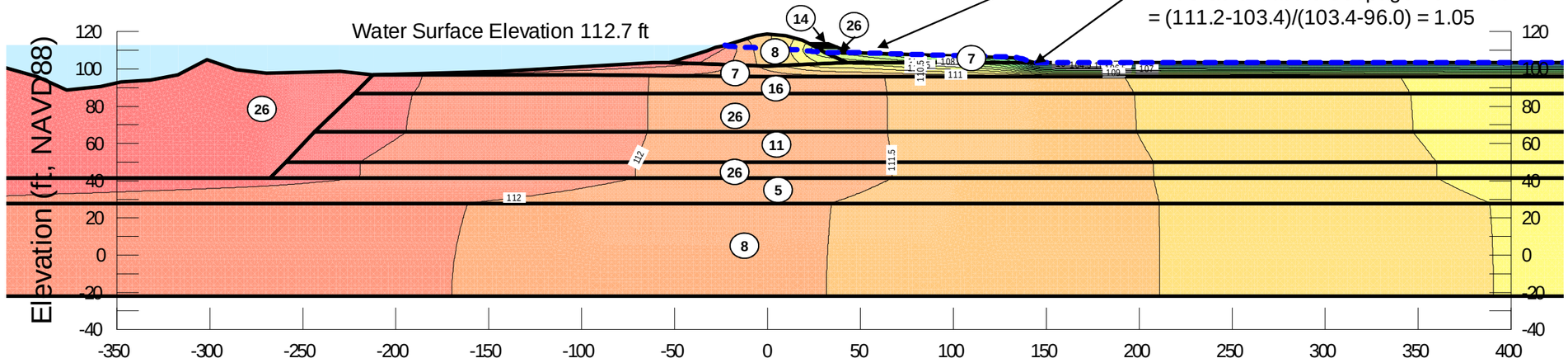


NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours

Breakout at top of berm
Exit Gradient at the Stability Berm Toe
= (111.6-108.8)/(108.8-96) = 0.22

Exit Gradient at the Seepage Berm Toe
= (111.2-103.4)/(103.4-96.0) = 1.05



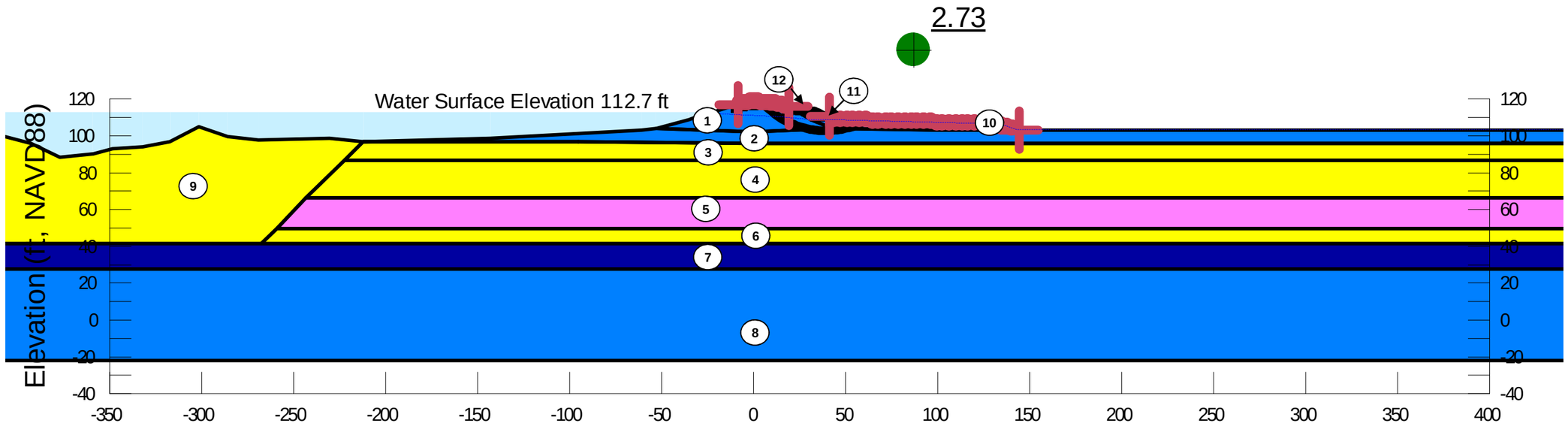
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(11) Clayey Sand to Sand, 8- 12% fines, Kh=2.8 ft/day (=1x10-3 cm/s) 0.25
(14) Silty Sand to Sand, 30-49% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(16) Silty Sand to Sand, 8- 12% fines, Kh=14 ft/day (=5x10-3 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN MW ANALYZED MW CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 33, Section at Sta. 2076+90 Alternative 2: Seepage and Stability Berm WSE at 200yr+4 ft	FIGURE B33-A7

Slope Stability Analysis Results,
Critical Slip Surface

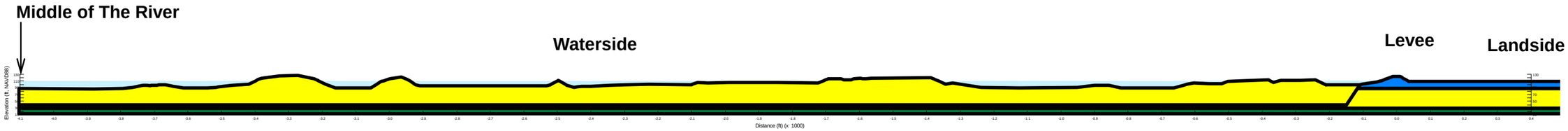


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 ML 120 pcf C'=50, Phi'=32
3 SP-SM 120 pcf C'=0, Phi'=36
4 GP 130 pcf C'=0, Phi'=36
5 SW-SC 125 pcf C'=0, Phi'=36
6 GP 130 pcf C'=0, Phi'=36
7 CL 120 pcf C'=100, Phi'=31
8 ML 120 pcf C'=50, Phi'=32
9 GP 120 pcf C'=0, Phi'=32
11 GP 130 pcf C'=0, Phi'=36
12 SM 120 pcf C'=0, Phi'=35
10 Compacted Berm, ML 120 pcf C'=50, Phi'=32

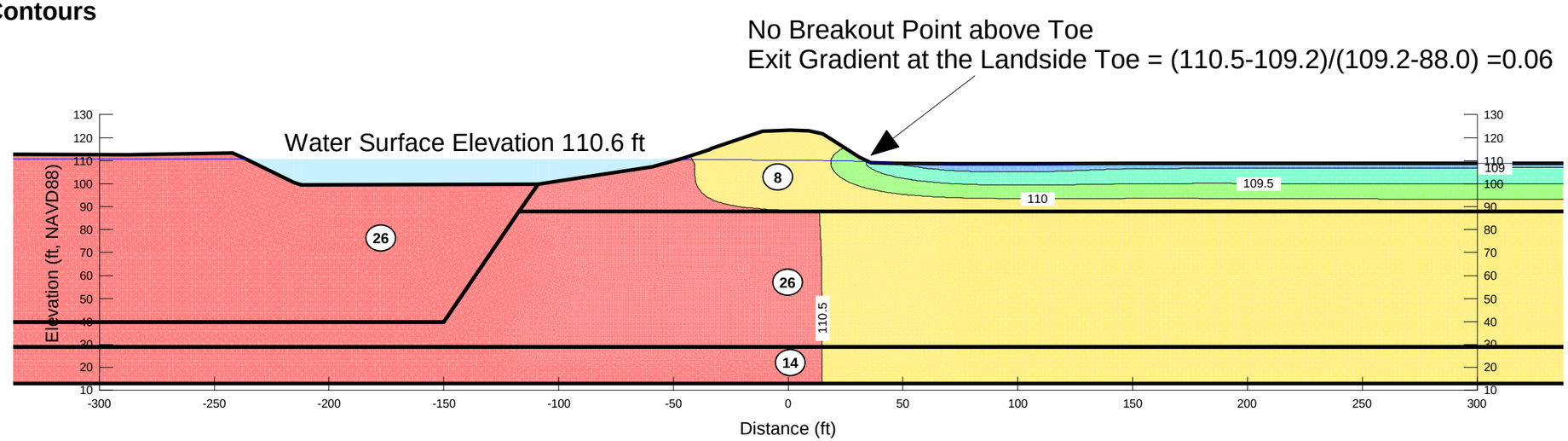
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 33, Section at Sta. 2076+90 Alternative 2: Seepage and Stability Berm WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED MW	FIGURE B33-A8
			DATE 02/09/2011	CHECKED NT	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



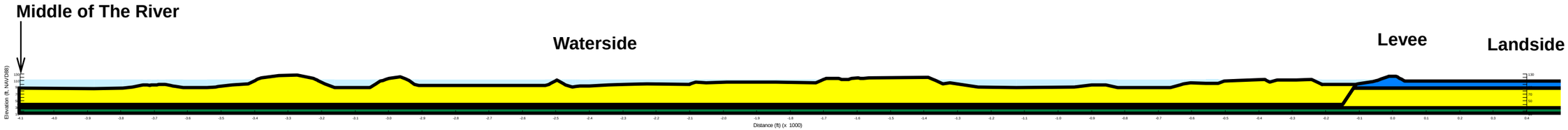
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

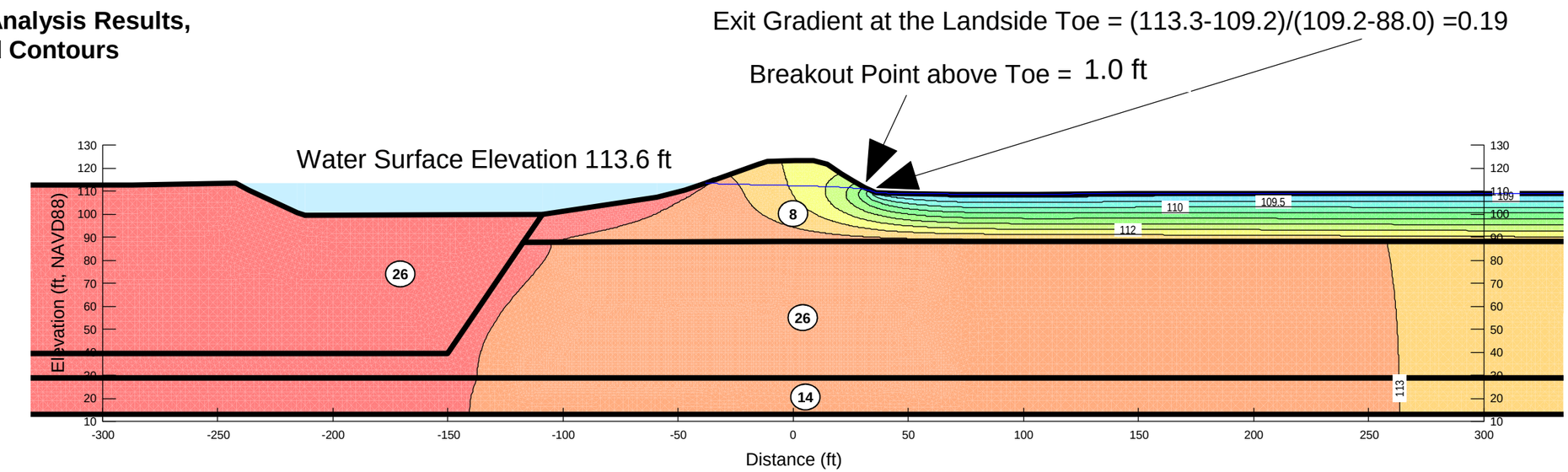
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / TASK ORDER 1 / DATE 02/09/2011	DRAWN GTH / ANALYZED GTH / CHECKED MHW	STEADY-STATE SEEPAGE ANALYSIS Reach 34, Section at Sta. 2138+99 Existing Conditions WSE at 200yr	FIGURE B34-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



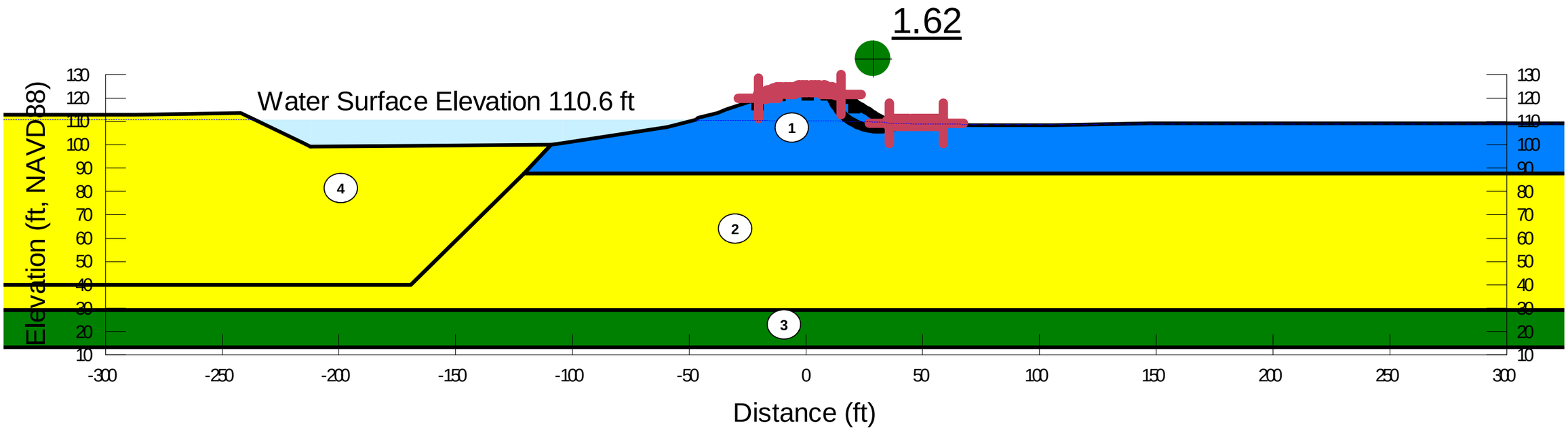
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/09/2011 / CHECKED MHW	STEADY-STATE SEEPAGE ANALYSIS Reach 34, Section at Sta. 2138+99 Existing Conditions WSE at 200yr+3 ft	FIGURE B34-E2

Slope Stability Analysis Results,
Critical Slip Surface



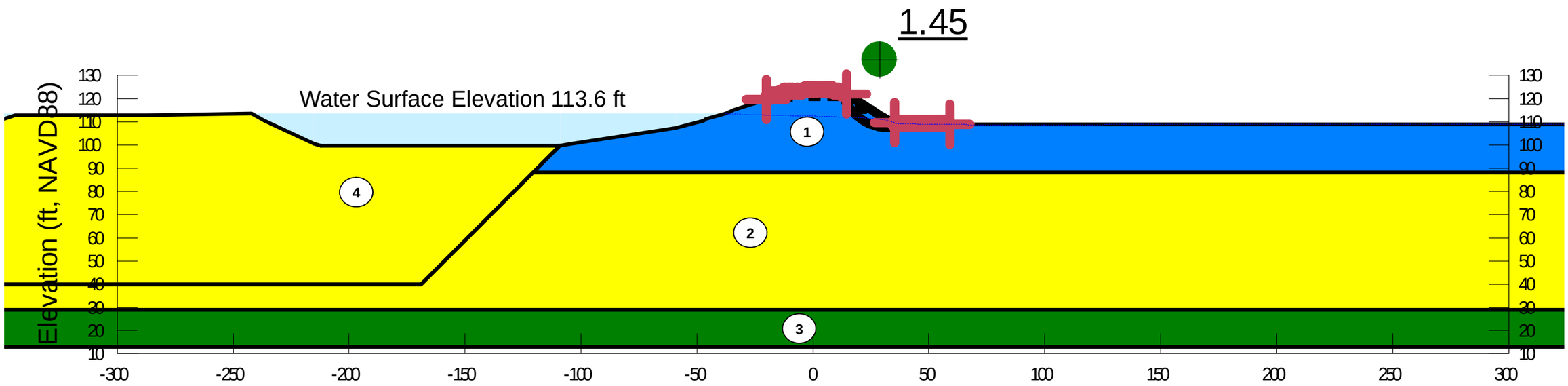
Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1	ML	120 pcf	C=50 psf, phi=32
2	GP	130 pcf	C'=0, Phi'=36
3	SM	125 pcf	C'=0, Phi'=36
4	GP	120 pcf	C'=0, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 34, Section at Sta. 2138+99 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED GTH	
			DATE 02/09/2011	CHECKED MHW	

FIGURE B34-E3

Slope Stability Analysis Results,
Critical Slip Surface

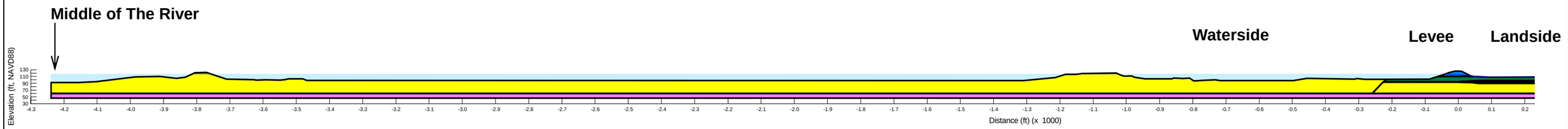


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML	120 pcf	C=50 psf, phi=32
2 GP	130 pcf	C'=0, Phi'=36
3 SM	125 pcf	C'=0, Phi'=36
4 GP	120 pcf	C'=0, Phi'=32

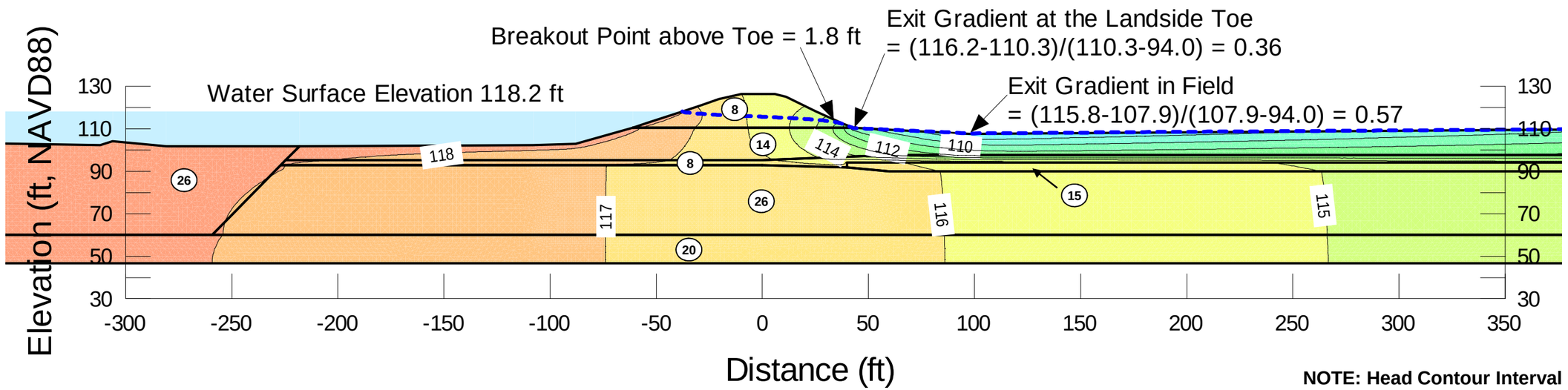
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 34, Section at Sta. 2138+99 Existing Conditions WSE at 200yr+3 ft	FIGURE B34-E4
			TASK ORDER 1	ANALYZED GTH		
			DATE 02/09/2011	CHECKED MHW		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



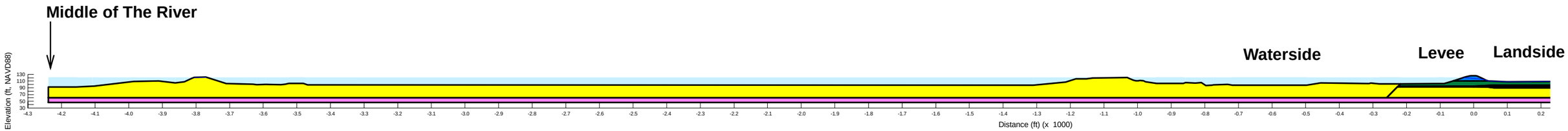
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

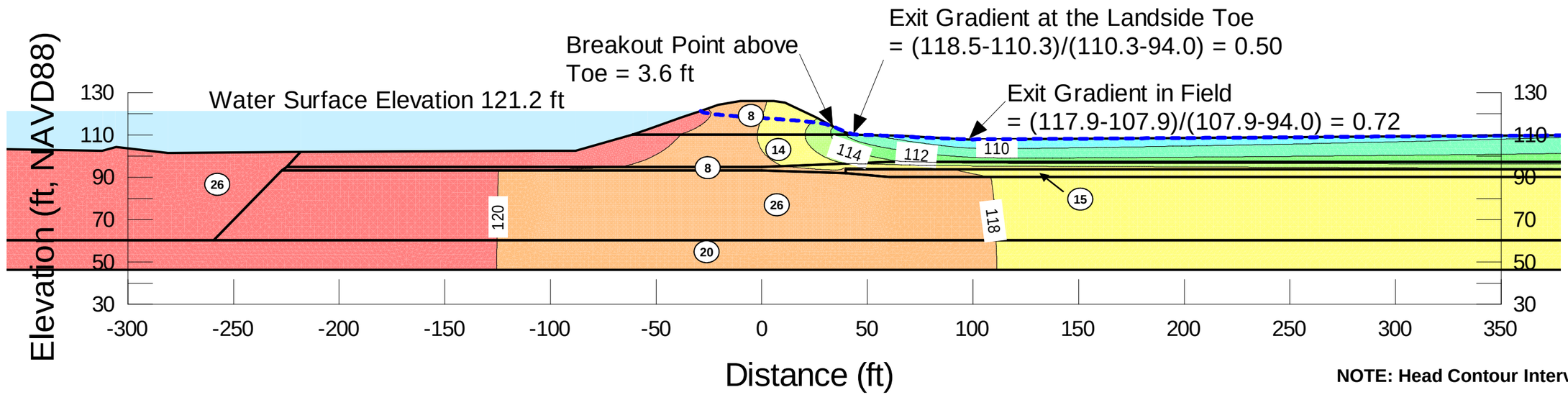
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / TASK ORDER 1 / DATE 02/10/2011	DRAWN MW / ANALYZED MW / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 35, Section at Sta. 2211+30 Existing Conditions WSE at 200 yr	FIGURE B35-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

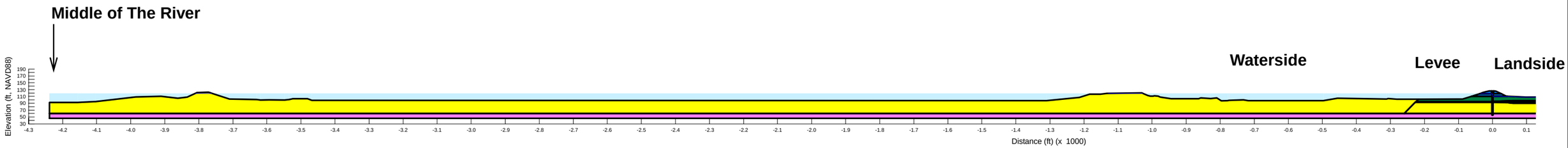
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 35, Section at Sta. 2211+30 Existing Conditions WSE at 200yr+3 ft
			TASK ORDER 1	ANALYZED MW	
			DATE 02/10/2011	CHECKED NT	

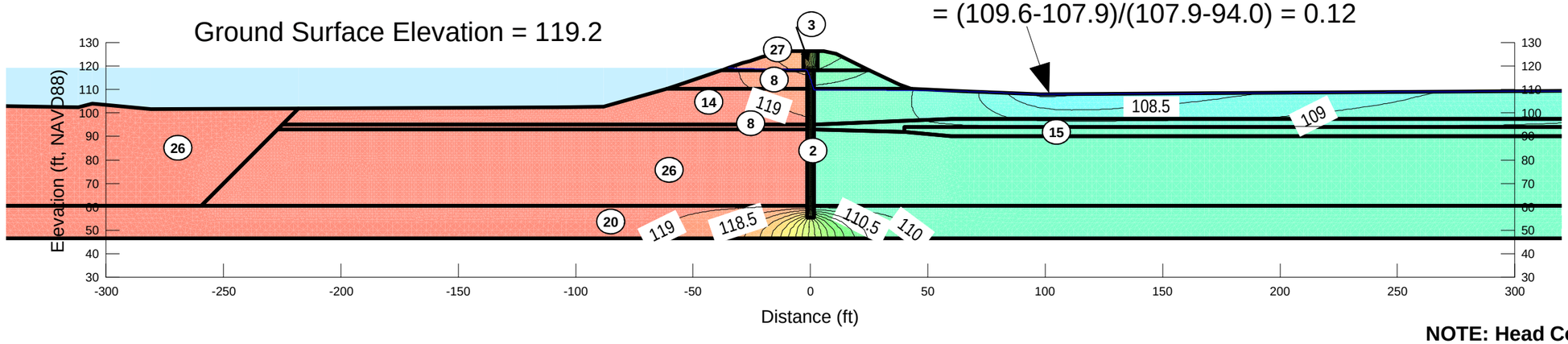
FIGURE B35-E2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



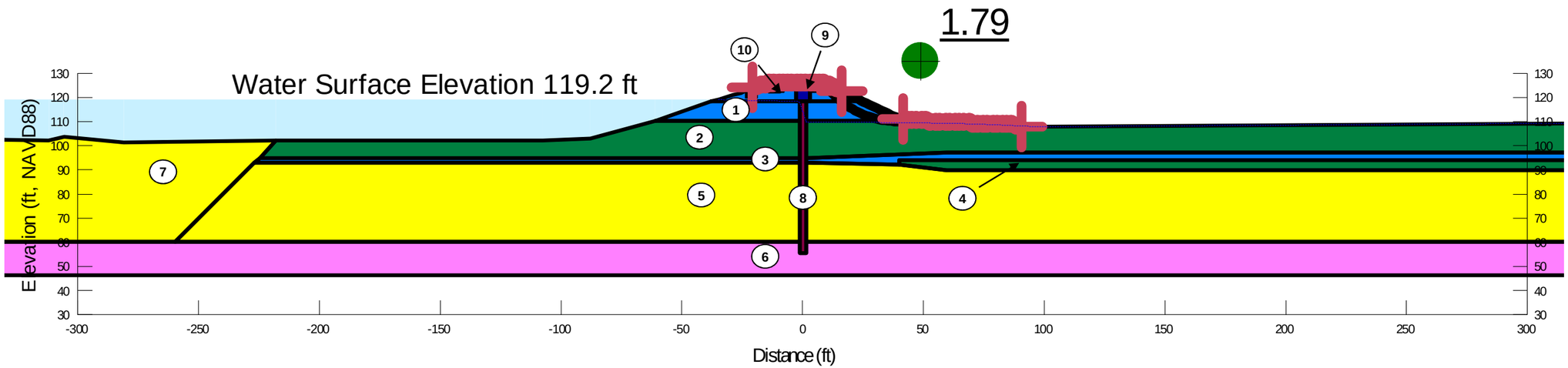
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML, (=3x10-5 cm/s)	0.25			

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 35, Section at Sta. 2211+30 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED MW	FIGURE B35-A1
			DATE 02/10/2011	CHECKED NT	

Slope Stability Analysis Results,
Critical Slip Surface

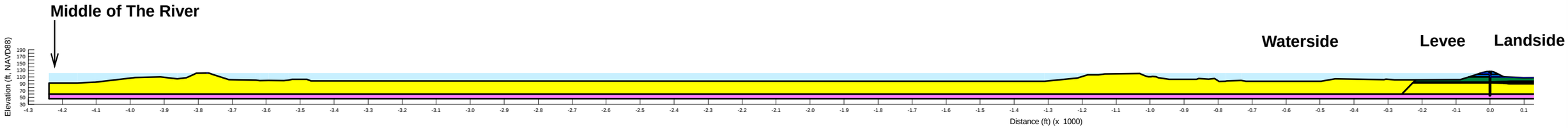


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 SM 120 pcf C'=0, Phi'=36
3 ML 120 pcf C'=0, Phi'=32
4 SM 120 pcf C'=0, Phi'=36
5 GW 130 pcf C'=0, Phi'=36
6 GC 130 pcf C'=0, Phi'=36
7 GP 120 pcf C'=0, Phi'=32
8 SB Wall 100 pcf C'=300, Phi'=0
9 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
10 Regrade ML 120 pcf C'=50, Phi'=32

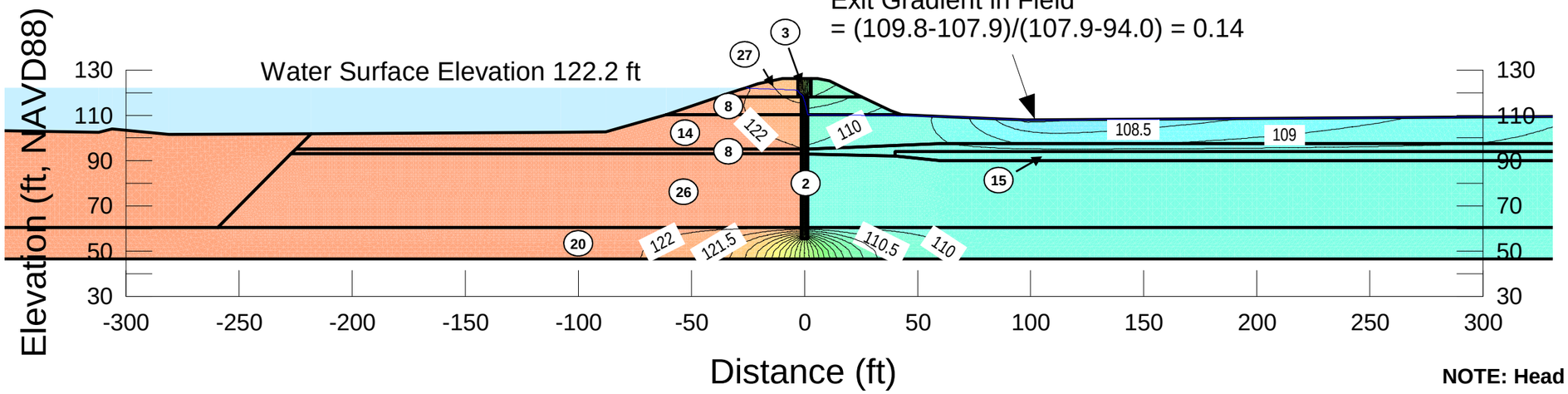
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/10/2011	DRAWN MW ANALYZED MW CHECKED NT	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 35, Section at Sta. 2211+30** **Alternative 1: Cutoff Wall** **WSE at 200yr+1ft**	**FIGURE B35-A2**

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



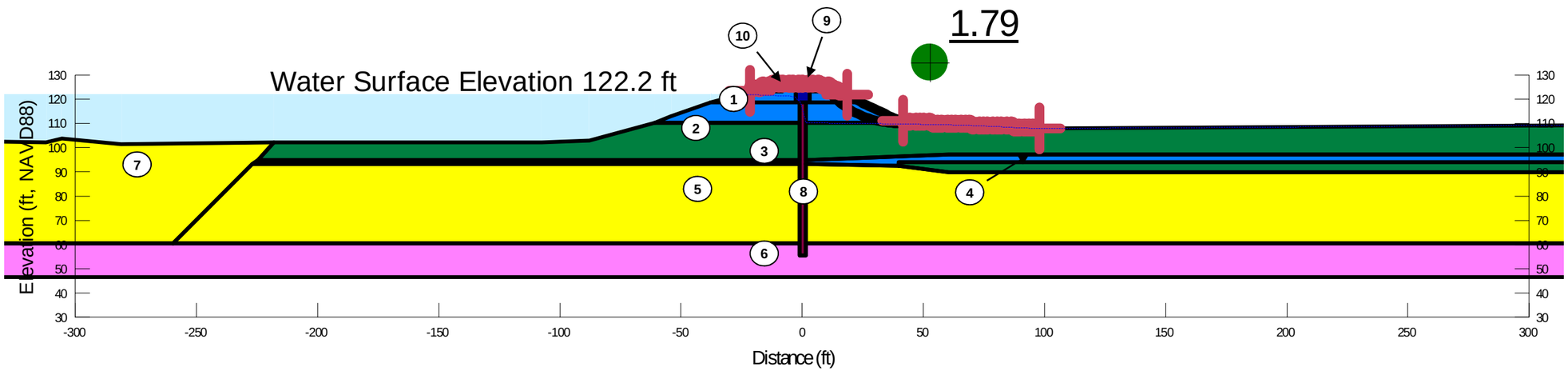
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML, (=3x10-5 cm/s)	0.25			

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/10/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 35, Section at Sta. 2211+30 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B35-A3

Slope Stability Analysis Results,
Critical Slip Surface

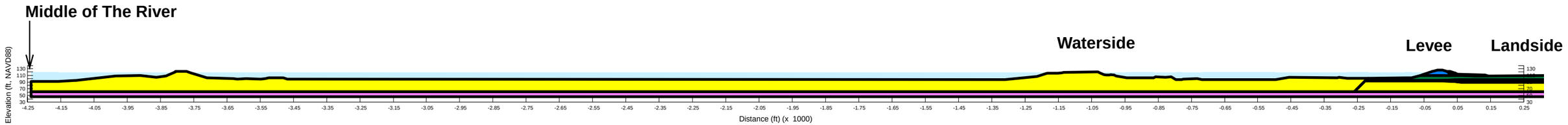


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 SM 120 pcf C'=0, Phi'=36
3 ML 120 pcf C'=0, Phi'=32
4 SM 120 pcf C'=0, Phi'=36
5 GW 130 pcf C'=0, Phi'=36
6 GC 130 pcf C'=0, Phi'=36
7 GP 120 pcf C'=0, Phi'=32
8 SB Wall 100 pcf C'=300, Phi'=0
9 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
10 Regrade ML 120 pcf C'=50, Phi'=32

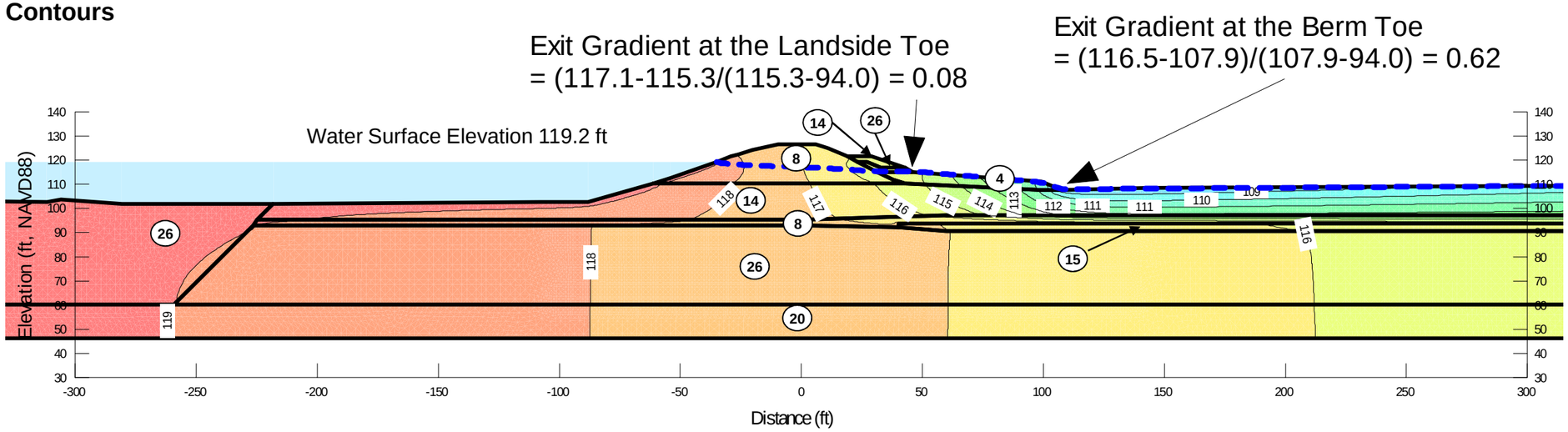
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 35, Section at Sta. 2211+30** **Alternative 1: Cutoff Wall** **WSE at 200yr+4 ft**	**FIGURE B35-A4**
			TASK ORDER 1	ANALYZED MW		
			DATE 02/10/2011	CHECKED NT		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



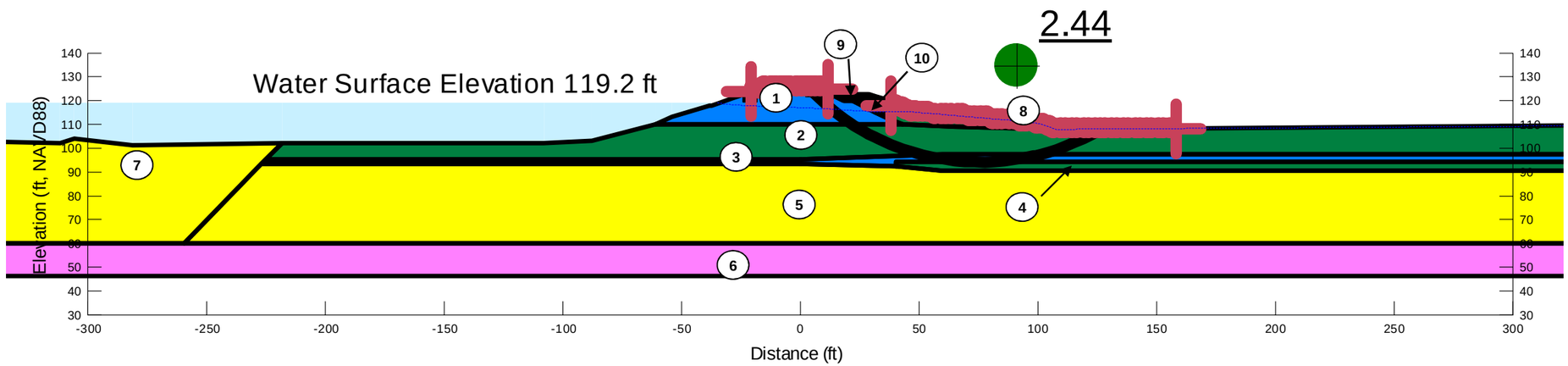
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/10/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 35, Section at Sta. 2211+30 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft	FIGURE B35-A5

Slope Stability Analysis Results,
Critical Slip Surface

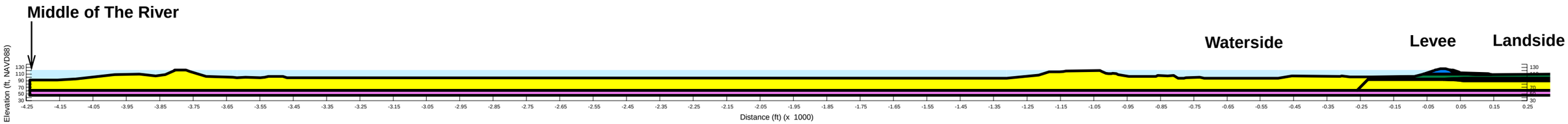


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C' =50 psf, Phi' =32
2 SM 120 pcf C'=0, Phi'=36
3 ML 120 pcf C'=0, Phi'=32
4 SM 120 pcf C'=0, Phi'=36
5 GW 130 pcf C'=0, Phi'=36
6 GC 130 pcf C'=0, Phi'=36
7 GP 120 pcf C'=0, Phi'=32
8 Compacted Berm, SM 120 pcf C'=0, Phi'=35
9 SM 120 pcf C'=0, Phi'=35
10 GP 130 pcf C'=0, Phi'=36

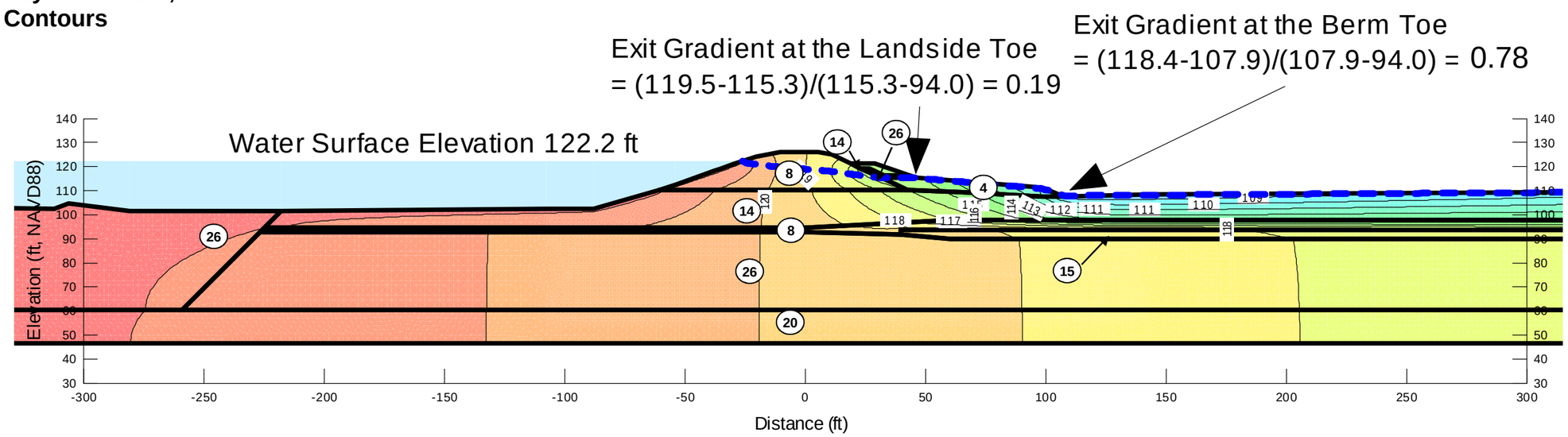
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/10/2011	DRAWN MW ANALYZED MW CHECKED NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 35, Section at Sta. 2211+30 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft	FIGURE B35-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



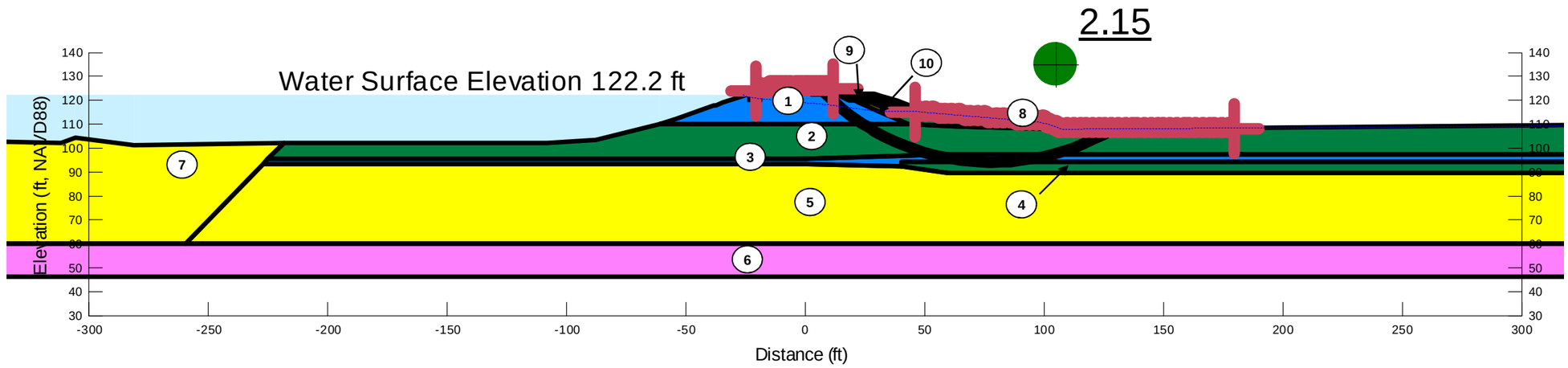
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/10/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 35, Section at Sta. 2211+30 Alternative 2: Seepage and Stability Berm WSE at 200yr+4 ft	FIGURE B35-A7

Slope Stability Analysis Results,
Critical Slip Surface

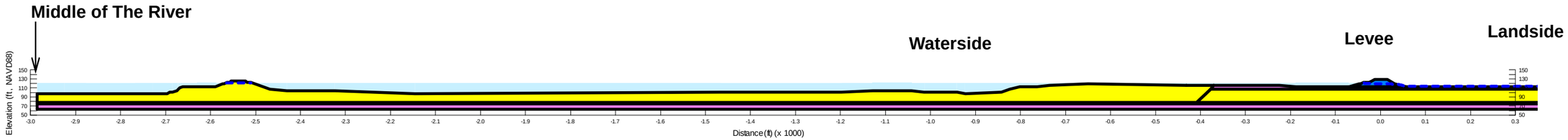


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C' =50 psf, Phi' =32
2 SM 120 pcf C'=0, Phi'=36
3 ML 120 pcf C'=0, Phi'=32
4 SM 120 pcf C'=0, Phi'=36
5 GW 130 pcf C'=0, Phi'=36
6 GC 130 pcf C'=0, Phi'=36
7 GP 120 pcf C'=0, Phi'=32
8 Compacted Berm, SM 120 pcf C'=0, Phi'=35
9 SM 120 pcf C'=0, Phi'=35
10 GP 130 pcf C'=0, Phi'=36

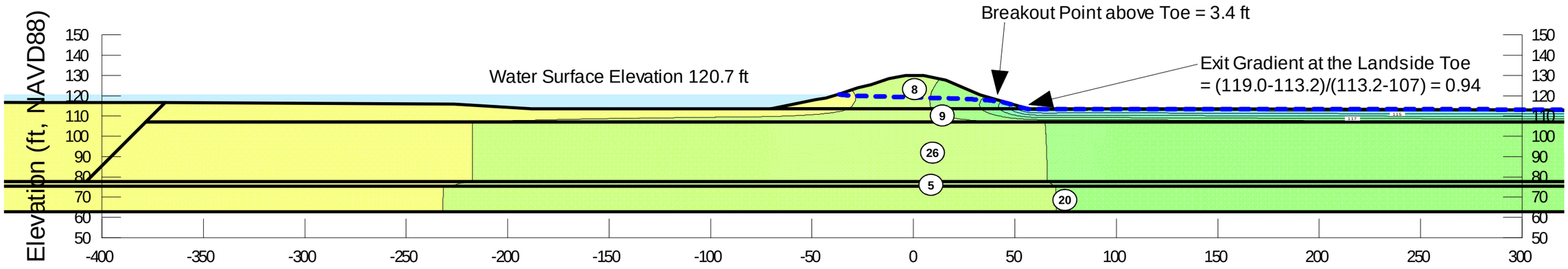
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 35, Section at Sta. 2211+30 Alternative 2: Seepage and Stability Berm WSE at 200yr+4 ft	FIGURE B35-A8
			TASK ORDER 1	ANALYZED MW		
			DATE 02/10/2011	CHECKED NT		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



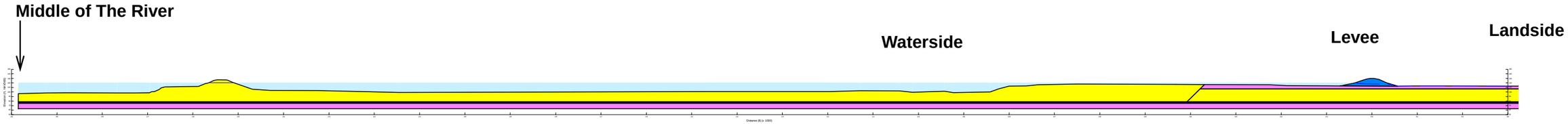
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(9)* Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(20) Clayey Gravel to Gravel, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(22) Clayey Gravel to Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

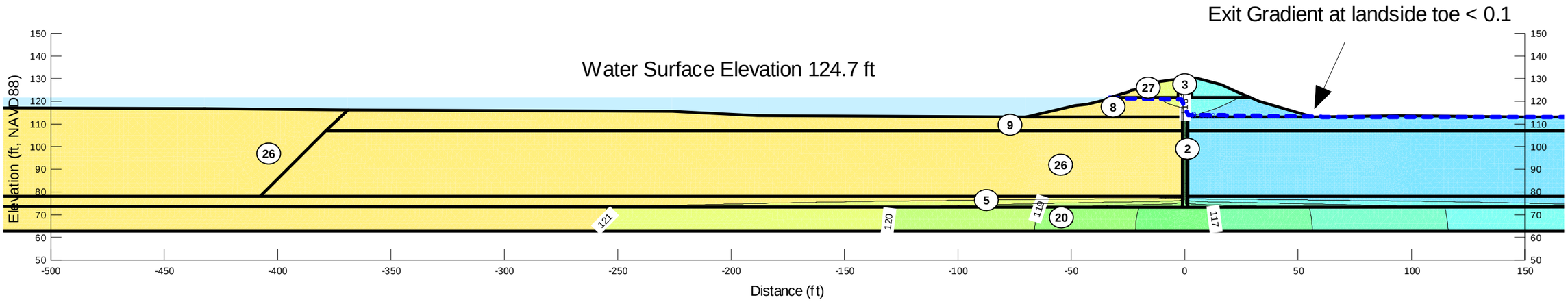
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/09/2011 / CHECKED MC	STEADY-STATE SEEPAGE ANALYSIS Reach 36, Section at Sta. 2250+78 Existing Conditions WSE at 200yr	FIGURE B36-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



Material ID and Type, Horizontal Hydraulic Conductivity (kh) and Anisotropic Ratio (kv/kh)

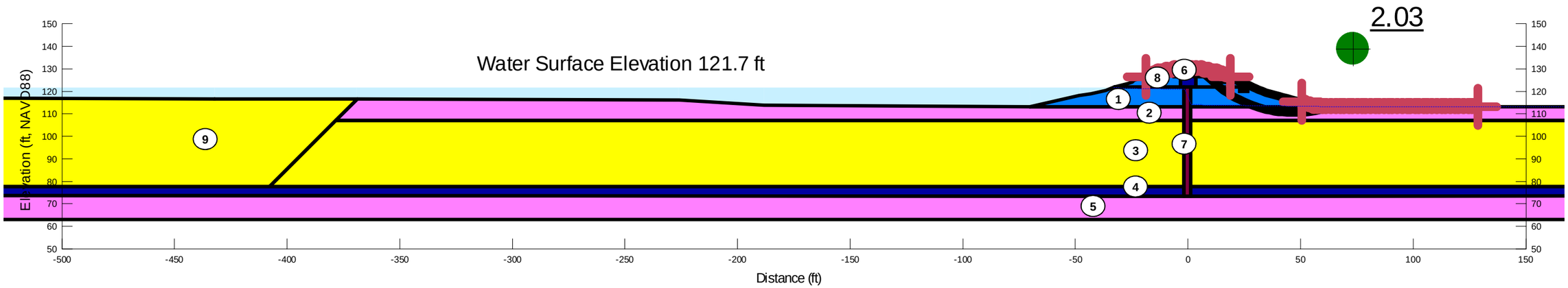
NOTE: Head Contour Interval 0.5 ft

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee, Clay Cap		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML,	,	Kh=0.085 ft/day	(=3x10-5 cm/s) (2)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SEEPAGE ANALYSIS Reach 36, Section at Sta. 2250+78 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED GTH	
			DATE 02/09/2011	CHECKED MC	

FIGURE B36-A1

Slope Stability Analysis Results,
Critical Slip Surface

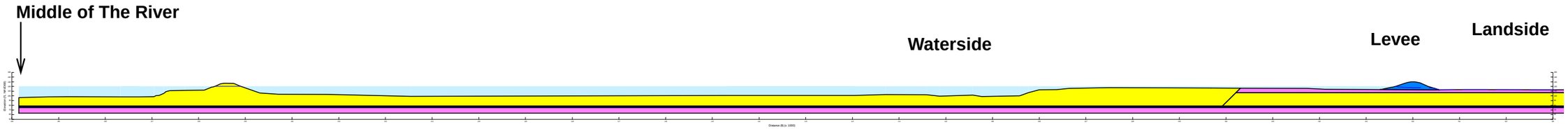


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi=32
2 SC 120 pcf C'=0, Phi'=32
3 GW 130 pcf C'=0, Phi'=36
4 CL 120 pcf C'=100, Phi'=31
5 GW-GC 130 pcf C'=0, Phi'=36
6 Clay Cap 120 pcf C'=100, Phi=32
7 SB Wall 100 pcf C'=300, Phi'=0
8 Regrade ML 120 pcf C'=50, Phi=32
9 GP 120 pcf C'=0, Phi'=32

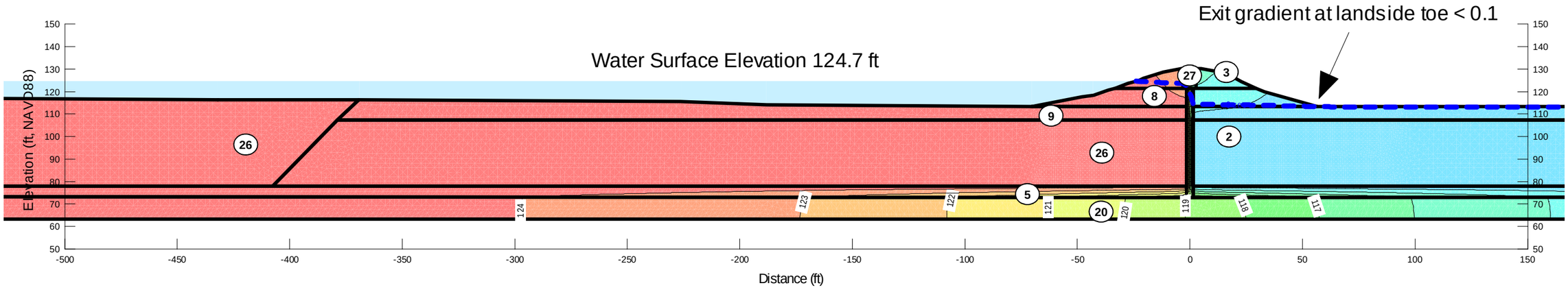
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 36, Section at Sta. 2250+78 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B36-A2
			TASK ORDER 1	ANALYZED GTH		
			DATE 02/09/2011	CHECKED MC		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



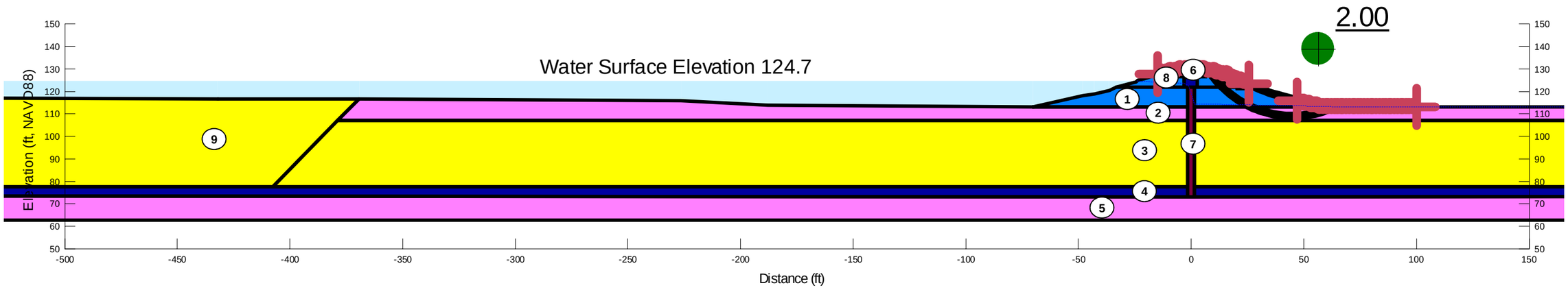
Material ID and Type, Horizontal Hydraulic Conductivity (kh) and Anisotropic Ratio (kv/kh)

NOTE: Head Contour Interval 1.0 ft

(2) Slurry Wall (SB), Kh=0.00028 ft/day (=1x10-7 cm/s) 1
(3) New Compacted Clay Levee, Clay Cap Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(8) Sandy Silt, 50-79% fines, Kh=0.085 ft/day (=3x10-5 cm/s) 0.25
(9)* Clayey Sand to Sand, 30-49% fines, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(20) Clayey Gravel to Gravel, 13-29% fines, Kh=0.28 ft/day (=1x10-4 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25
(27) Regrade ML, , Kh=0.085 ft/day (=3x10-5 cm/s) (2) 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SEEPAGE ANALYSIS Reach 36, Section at Sta. 2250+78 Alternative 1: Cutoff Wall WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED GTH	FIGURE B36-A3
			DATE 02/09/2011	CHECKED MC	

Slope Stability Analysis Results,
Critical Slip Surface

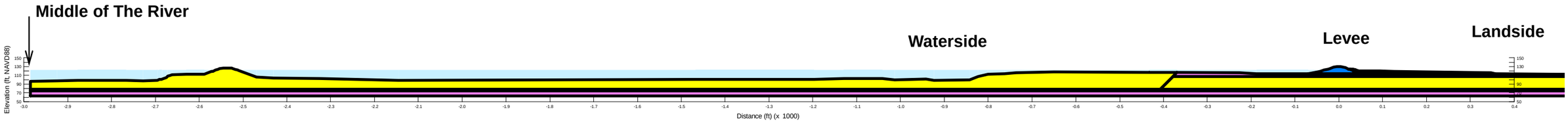


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi=32
2 SC 120 pcf C'=0, Phi'=32
3 GW 130 pcf C'=0, Phi'=36
4 CL 120 pcf C'=100, Phi'=31
5 GW-GC 130 pcf C'=0, Phi'=36
6 Clay Cap 120 pcf C'=100, Phi=32
7 SB Wall 100 pcf C'=300, Phi'=0
8 Regrade ML 120 pcf C'=50, Phi=32
9 GP 120 pcf C'=0, Phi'=32

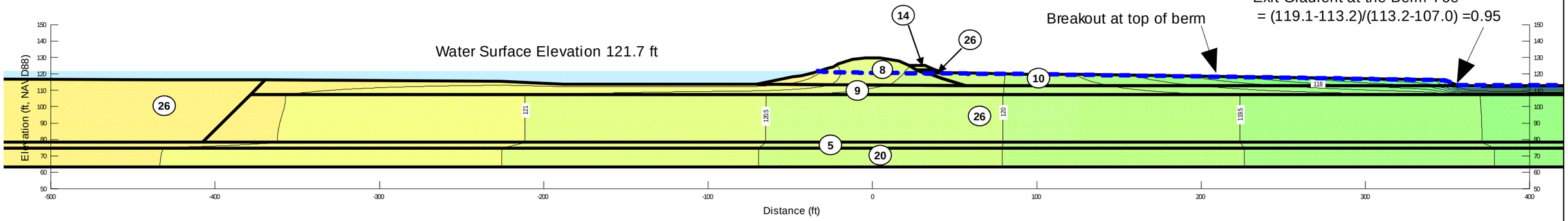
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 36, Section at Sta. 2250+78 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B36-A4
			TASK ORDER 1	ANALYZED GTH		
			DATE 02/09/2011	CHECKED MC		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

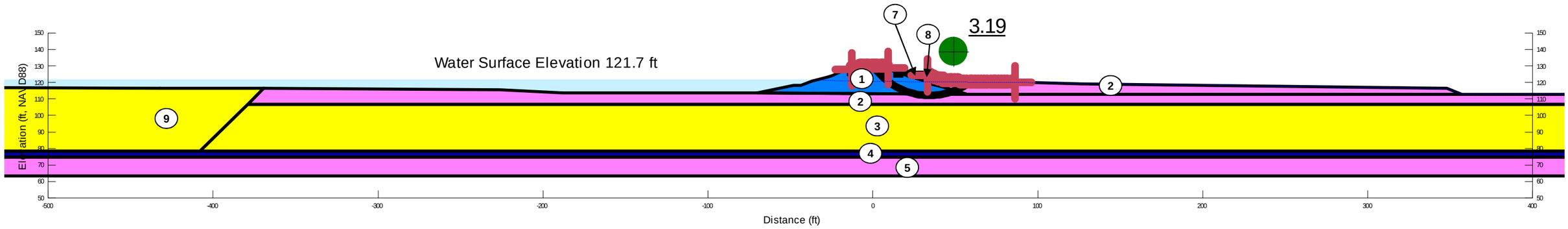
NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / TASK ORDER 1 / DATE 02/09/2011	DRAWN GTH / ANALYZED GTH / CHECKED MC

STEADY-STATE SEEPAGE ANALYSIS
Reach 36, Section at Sta. 2250+78
Alternative 2: Seepage and Stability Berm
WSE at 200yr + 1 ft

FIGURE B36-A5

Slope Stability Analysis Results, Critical Slip Surface

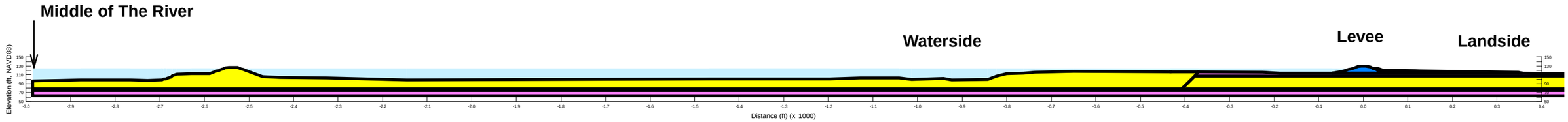


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi=32
2 SC 120 pcf C'=0, Phi'=32
3 GW 130 pcf C'=0, Phi'=36
4 CL 120 pcf C'=100, Phi'=31
5 GW-GC 130 pcf C'=0, Phi'=36
7 SM 120 pcf C'=0, Phi'=35
8 GP 130 pcf C'=0, Phi'=36
9 GP 120 pcf C'=0, Phi'=32

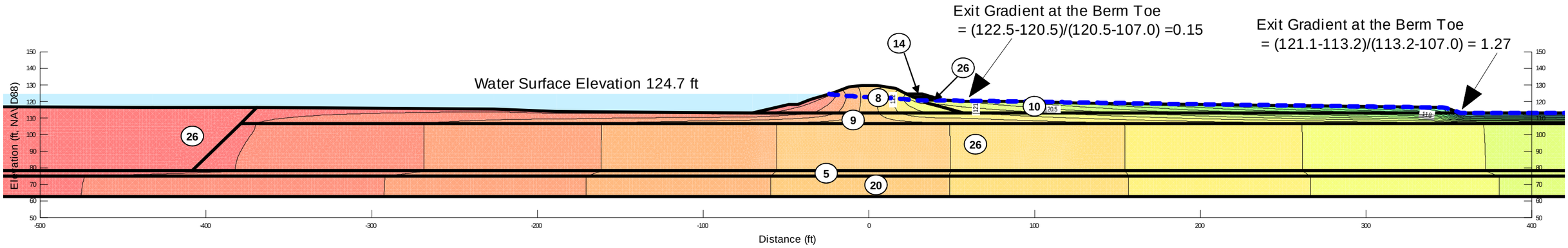
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN GTH ANALYZED GTH CHECKED MC	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 36, Section at Sta. 2250+78 Alternative 2: Seepage and Stability Berm WSE at 200yr + 1 ft	FIGURE B36-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



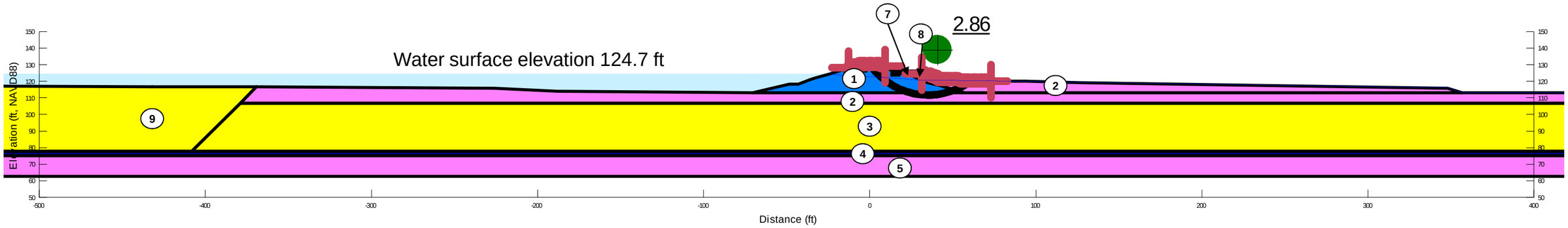
Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/09/2011 / CHECKED MC	STEADY-STATE SEEPAGE ANALYSIS Reach 36, Section at Sta. 2250+78 Alternative 2: Seepage and Stability Berm WSE at 200yr + 4 ft	FIGURE B36-A7

Slope Stability Analysis Results, Critical Slip Surface

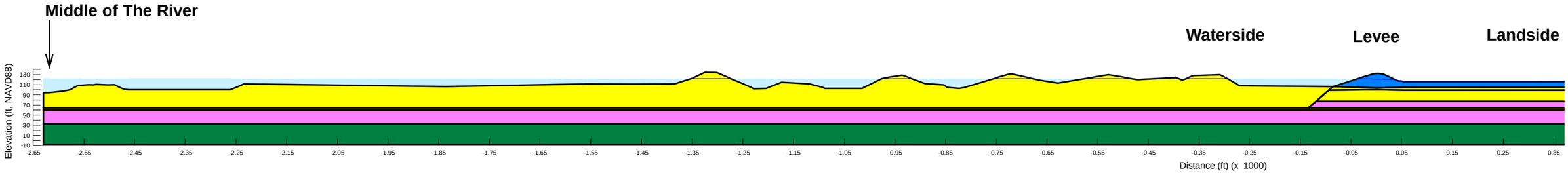


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 115 pcf C'=50, Phi=32
2 SC 120 pcf C'=0, Phi'=32
3 GW 130 pcf C'=0, Phi'=36
4 CL 120 pcf C'=100, Phi'=31
5 GW-GC 130 pcf C'=0, Phi'=36
7 SM 120 pcf C'=0, Phi'=35
8 GP 130 pcf C'=0, Phi'=36
9 GP 120 pcf C'=0, Phi'=32

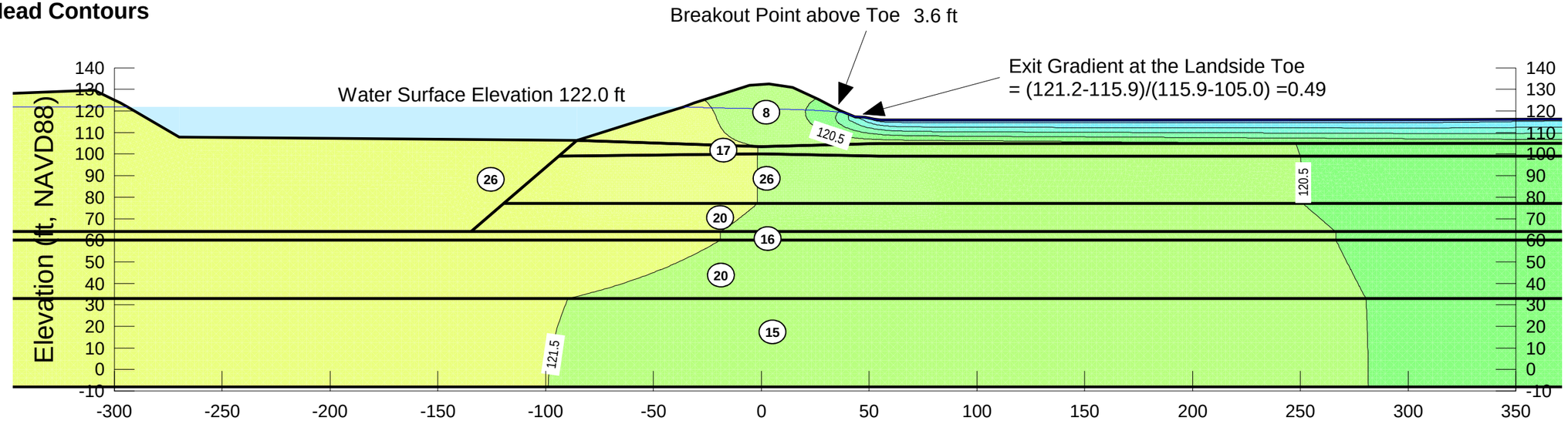
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN GTH ANALYZED GTH CHECKED MC	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 36, Section at Sta. 2250+78 Alternative 2: Seepage and Stability Berm WSE at 200yr + 4 ft	FIGURE B36-A8

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



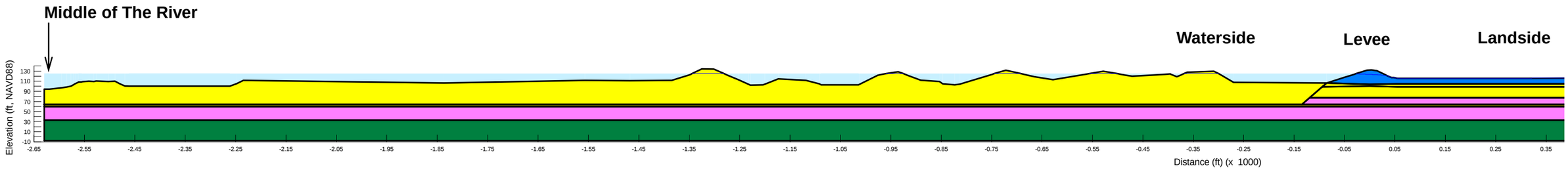
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

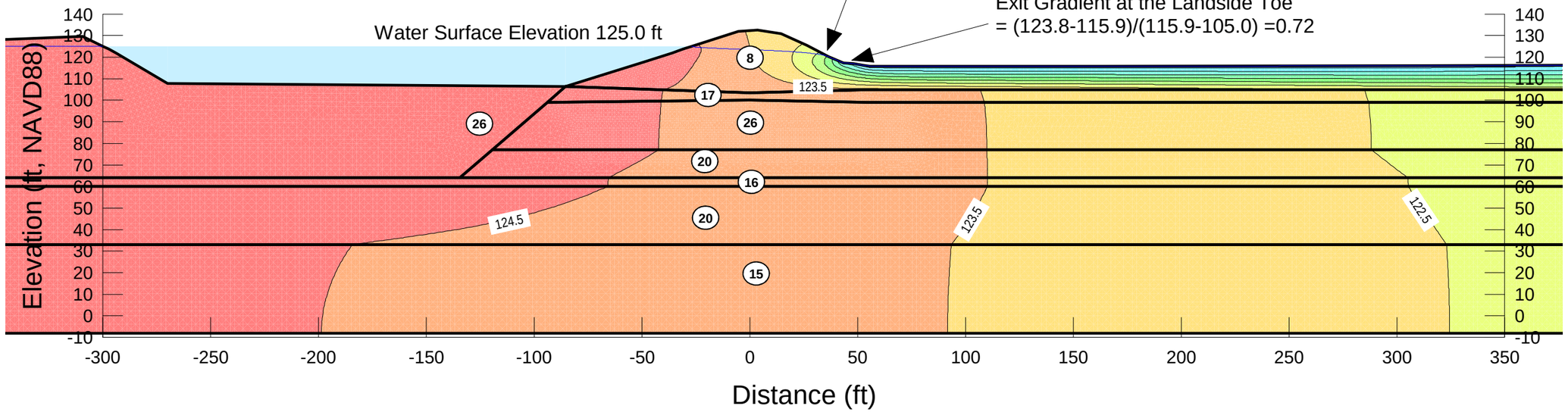
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/09/2011 / CHECKED MT	STEADY-STATE SEEPAGE ANALYSIS Reach 37, Section at Sta. 2276+76 Existing Conditions WSE at 200yr	FIGURE B37-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



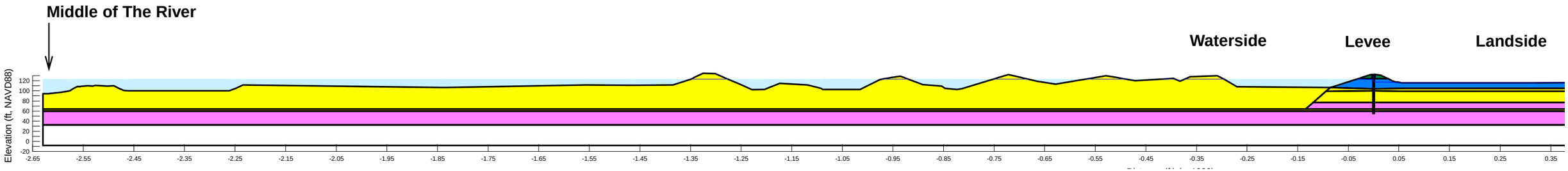
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

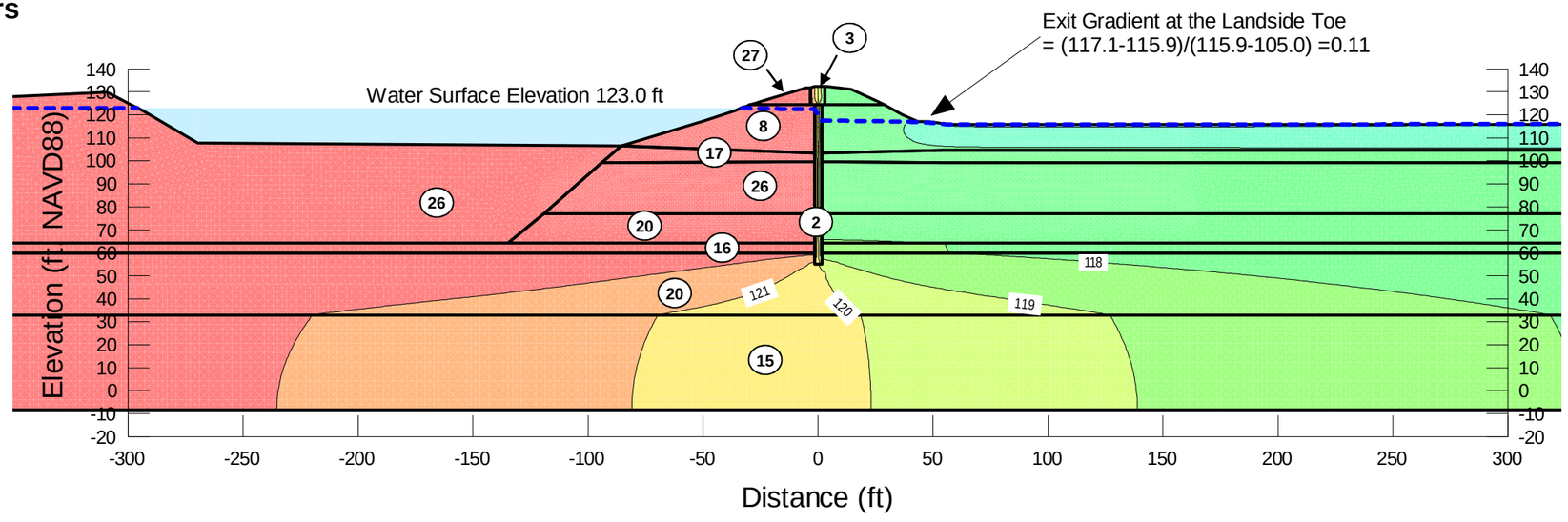
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/09/2011 / CHECKED MT	STEADY-STATE SEEPAGE ANALYSIS Reach 37, Section at Sta. 2276+76 Existing Conditions WSE at 200yr+3ft	FIGURE B37-E2

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



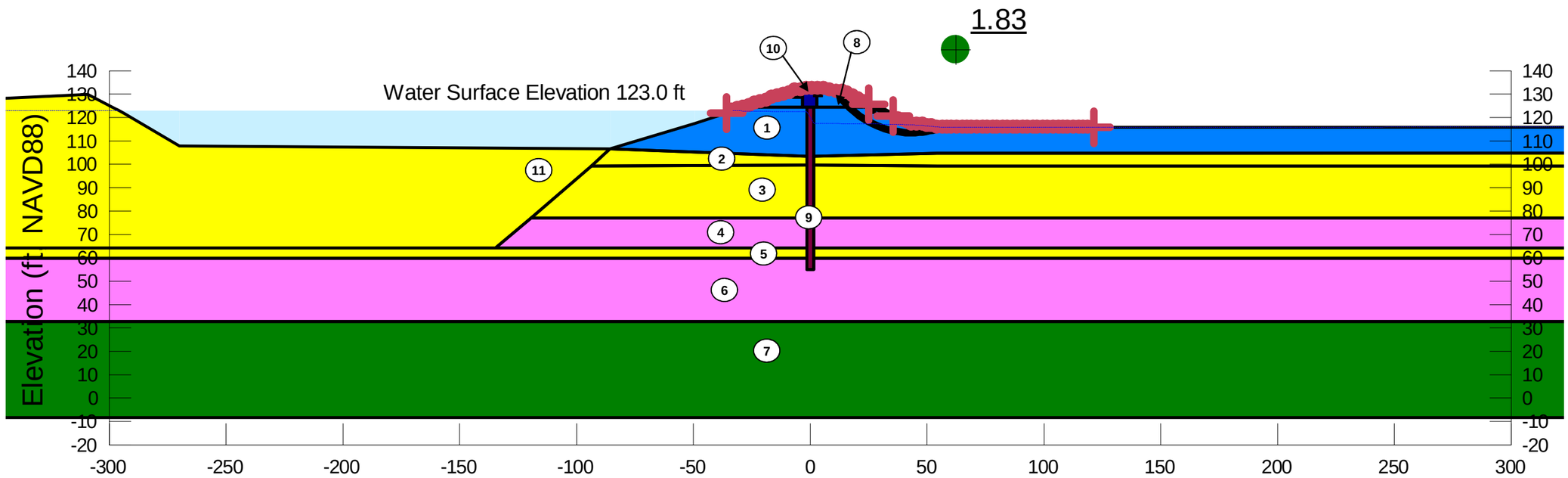
NOTE: Head Contour Interval 0.5 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee, Clay Cap,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 37, Section at Sta. 2276+76 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED MW	FIGURE B37-A1
			DATE 02/09/2011	CHECKED MT	

Slope Stability Analysis Results,
Critical Slip Surface

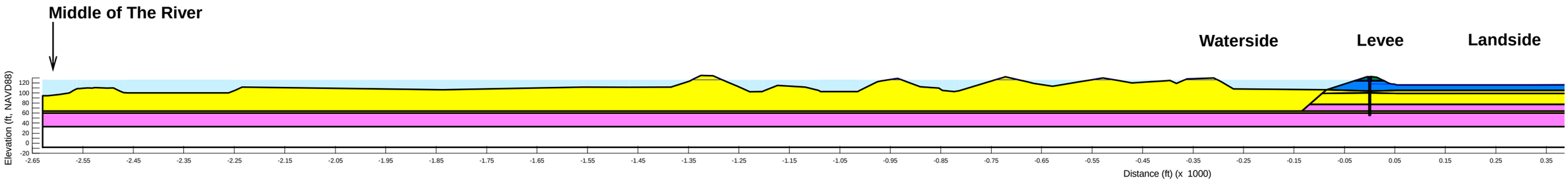


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 SW 120 pcf C'=0, Phi'=32
3 GW 130 pcf C'=0, Phi'=36
4 GC 130 pcf C'=0, Phi'=35
5 SM 125 pcf C'=0, Phi'=34
6 GC 130 pcf C'=0, Phi'=34
7 SM 125 pcf C'=0, Phi'=34
9 SB Wall 100 pcf C'=300, Phi'=0
10 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
11 GP 120 pcf C'=0, Phi'=32
8 Regrade ML 120 pcf C'=50, Phi'=32

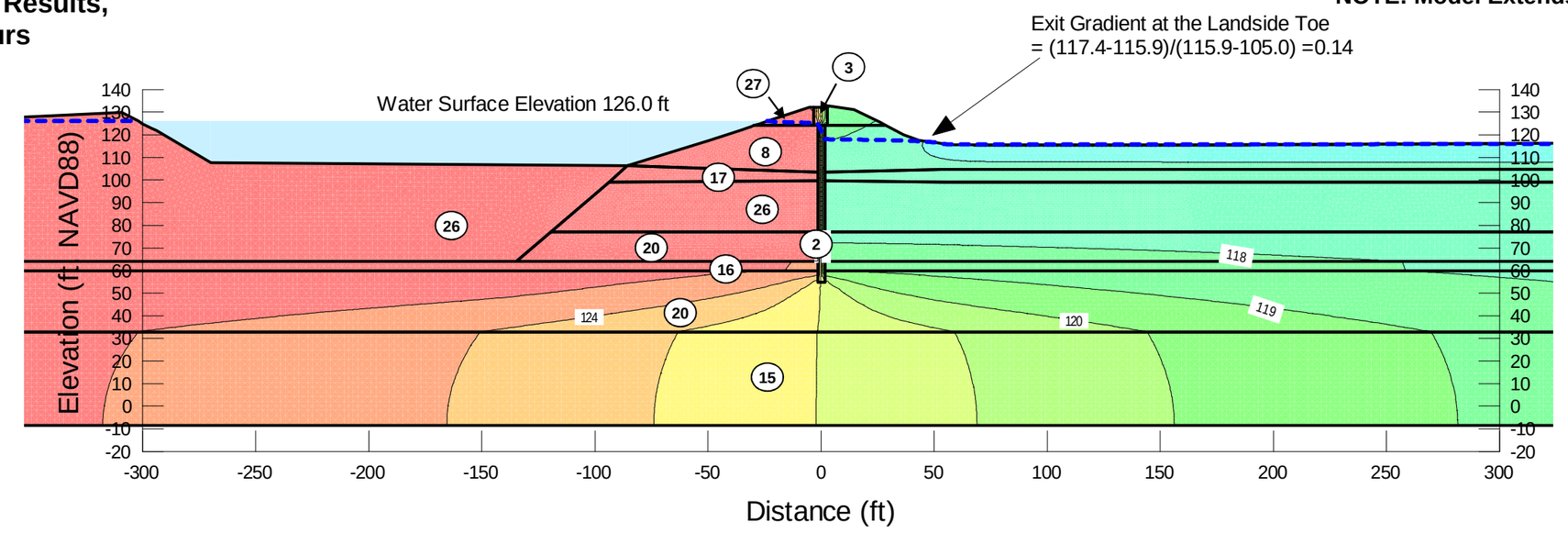
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN MW ANALYZED MW CHECKED MT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 37, Section at Sta. 2276+76 Alternative 1: Cutoff Wall WSE at 200yr+1 ft	FIGURE B37-A2

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



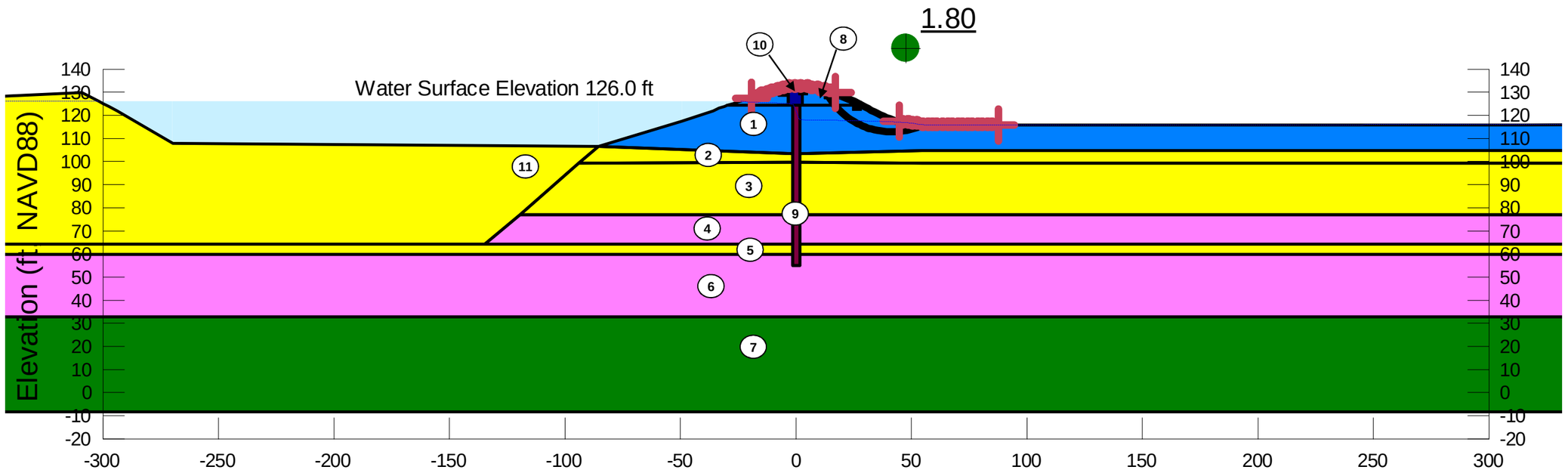
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee, Clay Cap,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/09/2011 / CHECKED MT	STEADY-STATE SEEPAGE ANALYSIS Reach 37, Section at Sta. 2276+76 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B37-A3

Slope Stability Analysis Results,
Critical Slip Surface

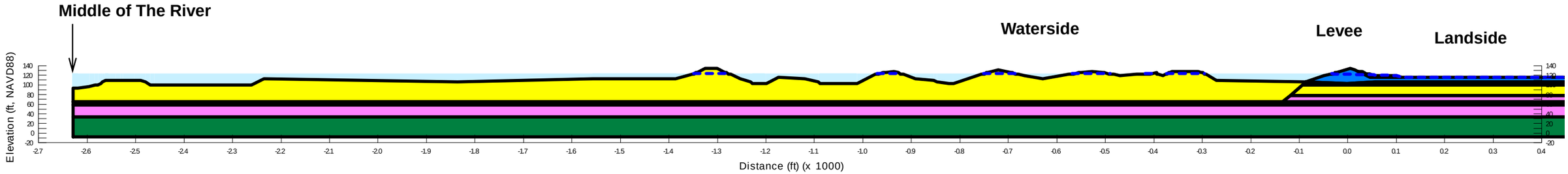


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 SW 120 pcf C'=0, Phi'=32
3 GW 130 pcf C'=0, Phi'=36
4 GC 130 pcf C'=0, Phi'=35
5 SM 125 pcf C'=0, Phi'=34
6 GC 130 pcf C'=0, Phi'=34
7 SM 125 pcf C'=0, Phi'=34
9 SB Wall 100 pcf C'=300, Phi'=0
10 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
11 GP 120 pcf C'=0, Phi'=32
8 Regrade ML 120 pcf C'=50, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 37, Section at Sta. 2276+76 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B37-A4
			TASK ORDER 1	ANALYZED MW		
			DATE 02/09/2011	CHECKED MT		

Model Geometry



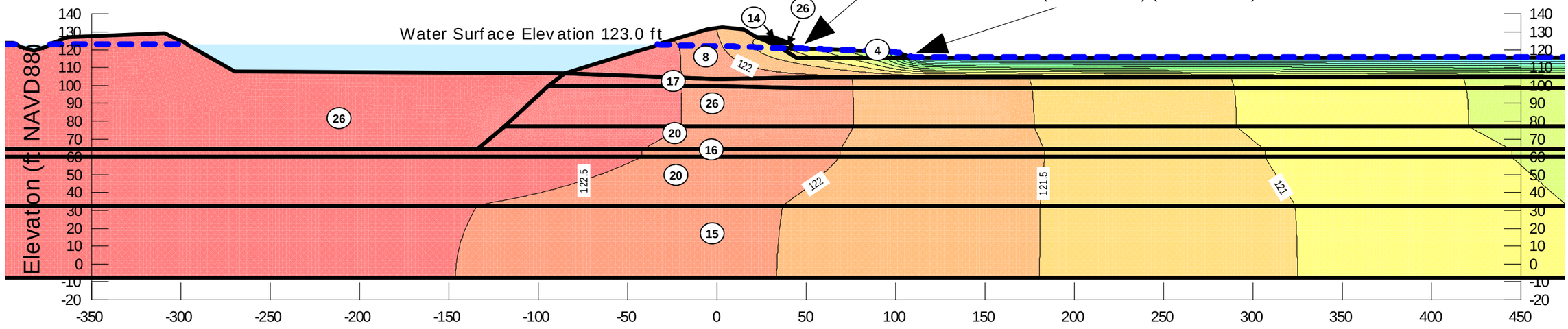
Seepage Analysis Results, Total Head Contours

Breakout at top of berm

Exit Gradient at the Levee Toe
= (122.1-120.5)/(120.5-105.0) =0.10

Exit Gradient at the Berm Toe
= (121.8-116.0)/(116.0-105.0) =0.53

NOTE: Model Extends 2000 ft to the Landside



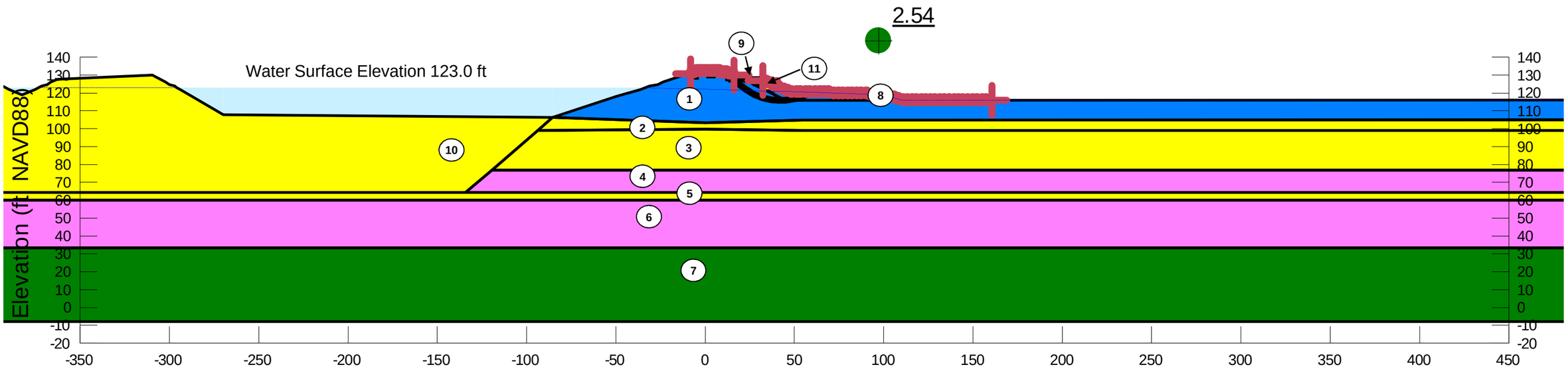
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

NOTE: Head Contour Interval 0.5 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 37, Section at Sta. 2276+76 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED MW	FIGURE B37-A5
			DATE 12/21/2010	CHECKED MT	

Slope Stability Analysis Results,
Critical Slip Surface

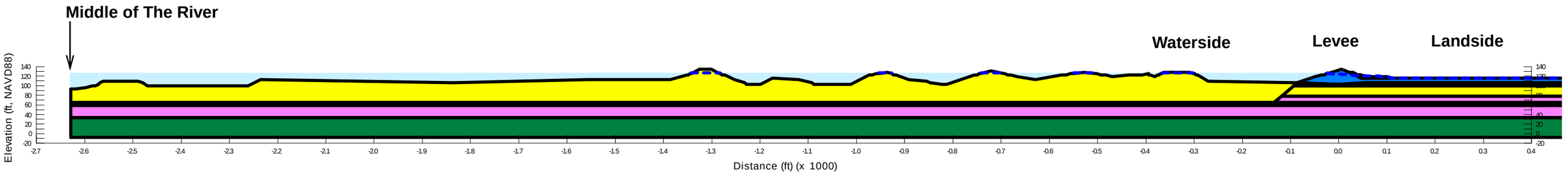


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 SW 120 pcf C'=0, Phi'=32
3 GW 130 pcf C'=0, Phi'=36
4 GC 130 pcf C'=0, Phi'=35
5 SM 125 pcf C'=0, Phi'=34
6 GC 130 pcf C'=0, Phi'=34
7 SM 125 pcf C'=0, Phi'=34
9 SM 125 pcf C'=0, Phi'=35
10 GP 120 pcf C'=0, Phi'=32
11 GP 130 pcf C'=0, Phi'=36
8 New Compacted ML Berm 120 pcf C'=50, Phi'=32

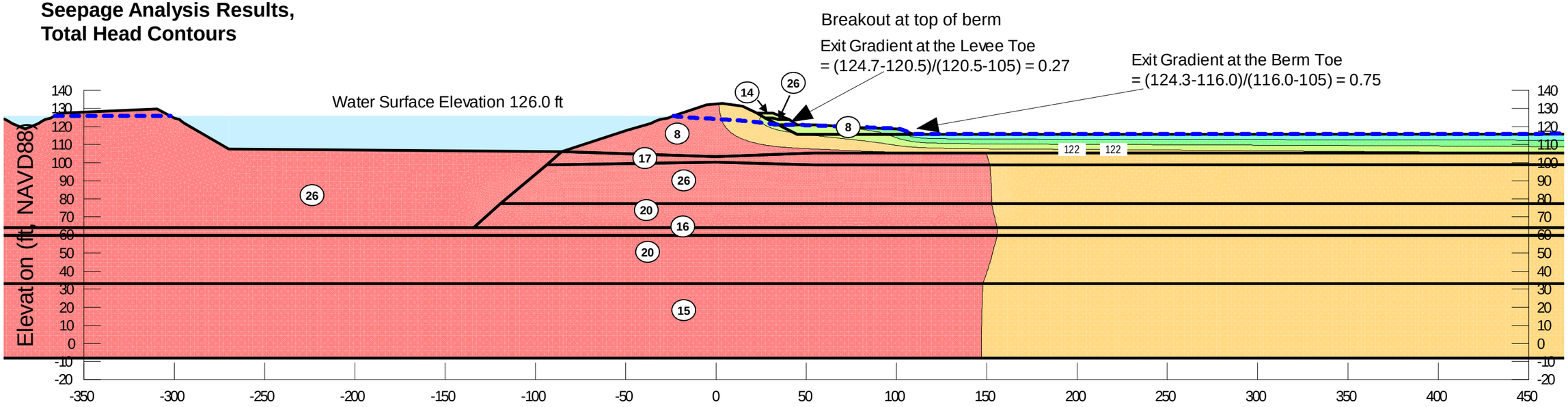
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 12/21/2010	DRAWN MW ANALYZED MW CHECKED MT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 37, Section at Sta. 2276+76 Alternative 2: Seepage and Stability Berm WSE at 200yr+1 ft	FIGURE B37-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



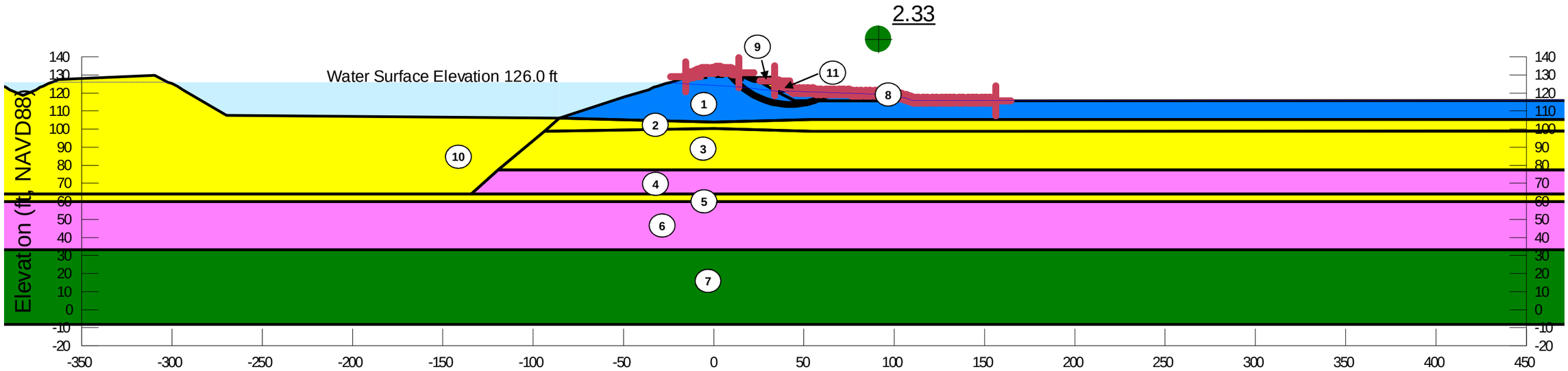
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(16) Silty Sand to Sand,	8- 12% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(17) Silty Sand to Sand,	3- 7% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

NOTE: Head Contour Interval 1.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/09/2011 / CHECKED MT	STEADY-STATE SEEPAGE ANALYSIS Reach 37, Section at Sta. 2276+76 Alternative 2: Seepage and Stability Berm WSE at 200yr+4 ft	FIGURE B37-A7

Slope Stability Analysis Results,
Critical Slip Surface

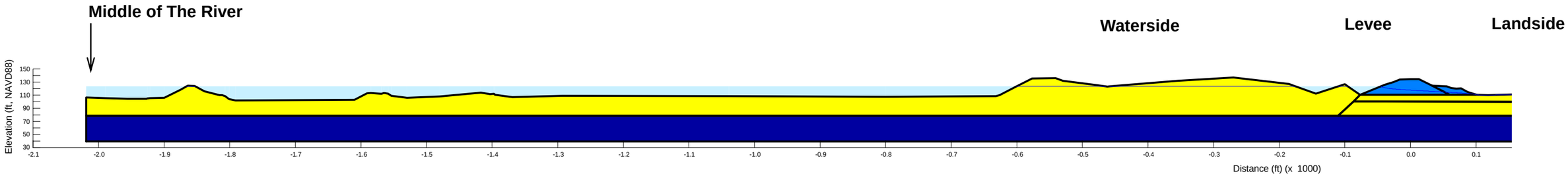


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 SW 120 pcf C'=0, Phi'=32
3 GW 130 pcf C'=0, Phi'=36
4 GC 130 pcf C'=0, Phi'=35
5 SM 125 pcf C'=0, Phi'=34
6 GC 130 pcf C'=0, Phi'=34
7 SM 125 pcf C'=0, Phi'=34
9 SM 125 pcf C'=0, Phi'=35
10 GP 120 pcf C'=0, Phi'=32
11 GP 130 pcf C'=0, Phi'=36
8 New Compacted ML Berm 120 pcf C'=50, Phi'=32

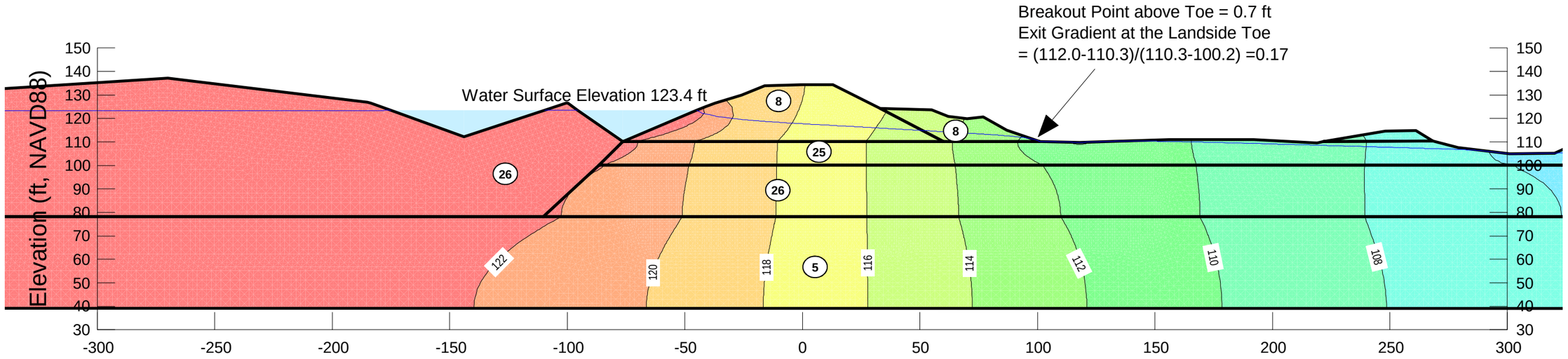
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 37, Section at Sta. 2276+76 Alternative 2: Seepage and Stability Berm WSE at 200yr+4 ft
			TASK ORDER 1	ANALYZED MW	FIGURE B37-A8
			DATE 02/09/2011	CHECKED MT	

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



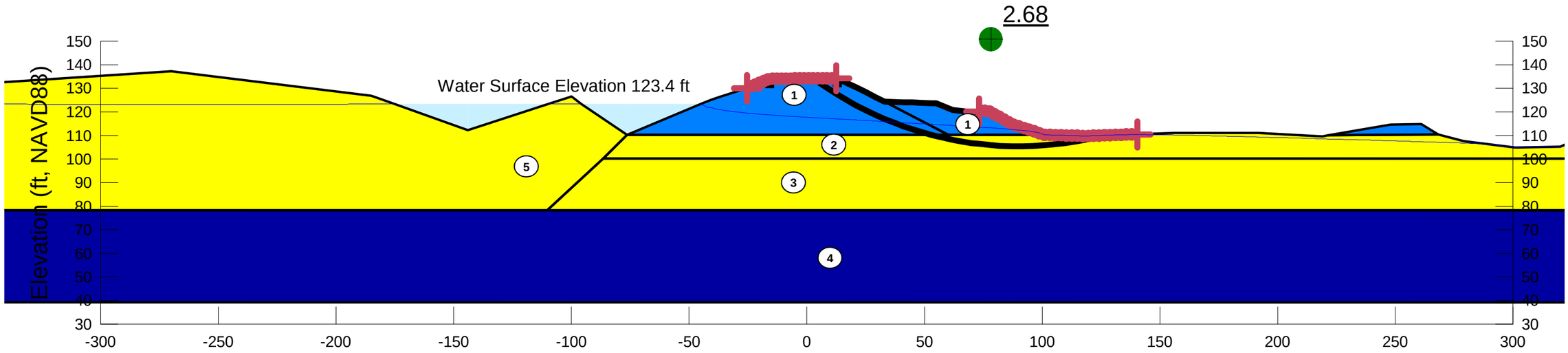
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	(5) Clay	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	(8) Silt	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	(25) Gravel	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	(26) Gravel	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/09/2011 / CHECKED MT	STEADY-STATE SEEPAGE ANALYSIS Reach 38, Section at Sta. 2299+69 Existing Conditions WSE at 200yr	FIGURE B38-E1

Slope Stability Analysis Results,
Critical Slip Surface

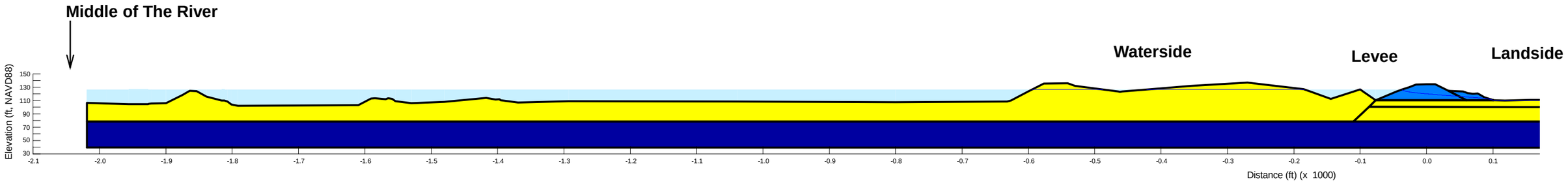


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 GP-GM 125 pcf C'=0, Phi'=36
3 GP 130 pcf C'=0, Phi'=36
4 CL 120 pcf C'=100psf, Phi'=31
5 GP 120 pcf C'=0, Phi'=32

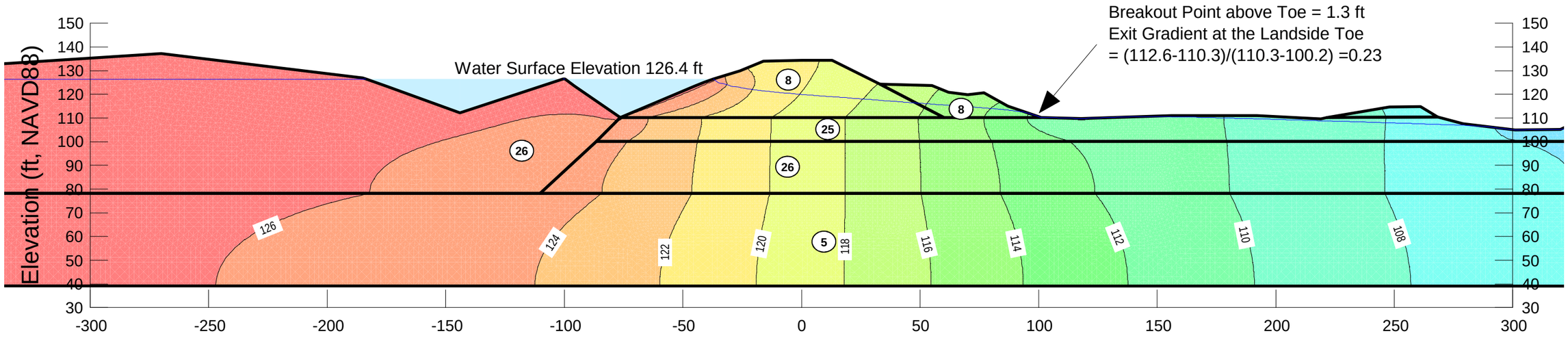
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 38, Section at Sta. 2299+69 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED GTH	FIGURE B38-E2
			DATE 02/09/2011	CHECKED MT	

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



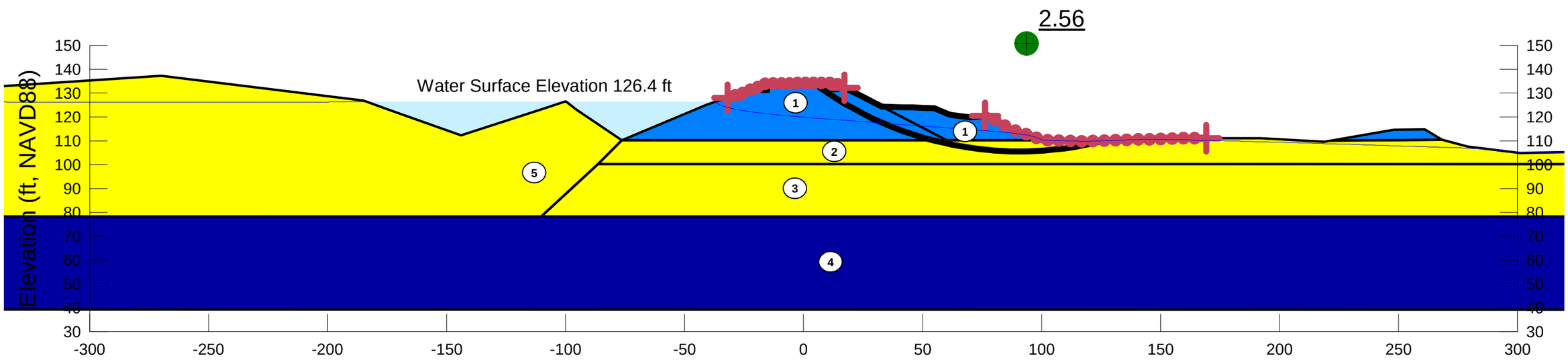
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	(5) Clay 0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	(8) Silt 0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	(25) Gravel 0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	(26) Gravel 0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analysis for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/09/2011 / CHECKE MT	STEADY-STATE SEEPAGE ANALYSIS Reach 38, Section at Sta. 2299+69 Existing Conditions WSE at 200yr+3ft	FIGURE B38-E3

Slope Stability Analysis Results,
Critical Slip Surface

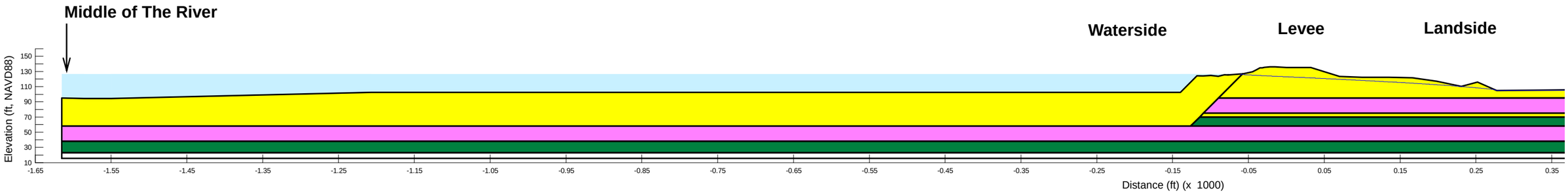


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 ML 120 pcf C'=50, Phi'=32
2 GP-GM 125 pcf C'=0, Phi'=36
3 GP 130 pcf C'=0, Phi'=36
4 CL 120 pcf C'=100psf, Phi'=31
5 GP 120 pcf C'=0, Phi'=32

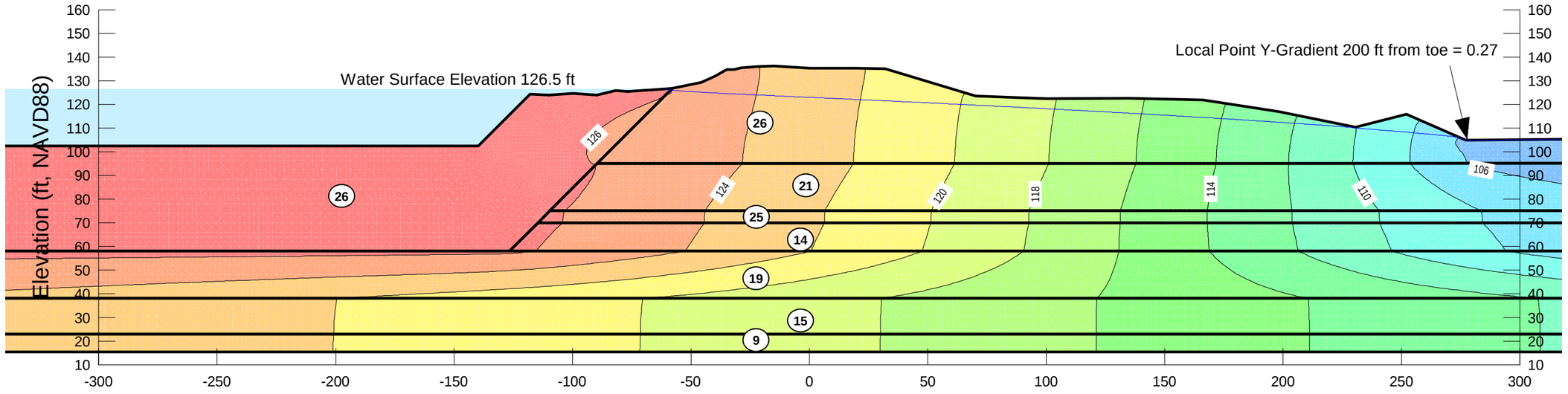
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/09/2011	DRAWN GTH ANALYZED GTH CHECKED MT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 38, Section at Sta. 2299+69 Existing Conditions WSE at 200yr+3 ft	FIGURE B38-E4

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



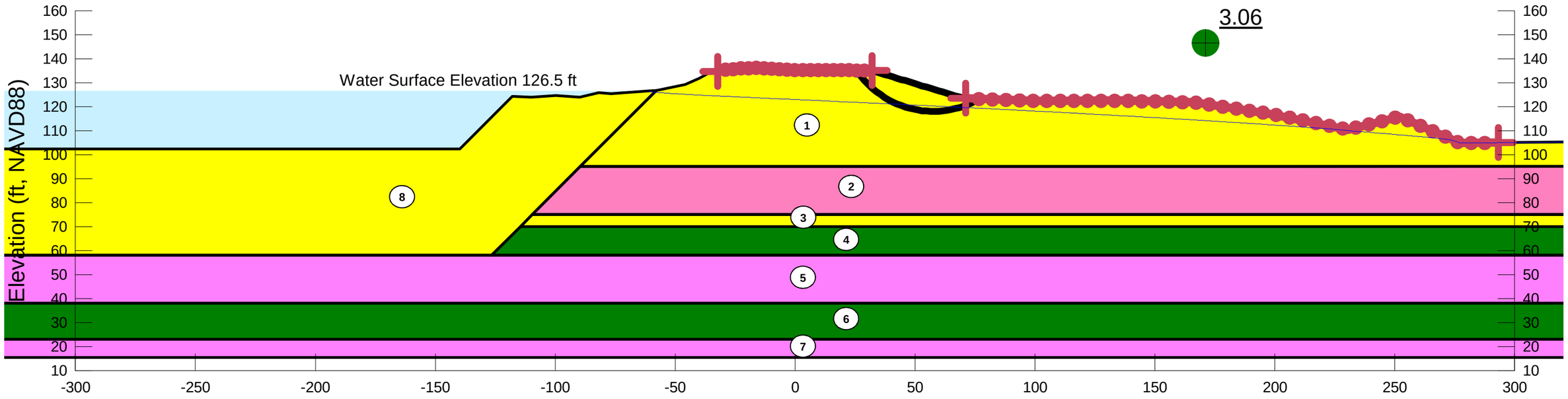
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydrulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(9)*	Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(14)	Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day (=1x10-4 cm/s)	0.25
(15)	Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(19)	Clayey Gravel to Gravel,	30-49% fines,	Kh=0.028 ft/day (=1x10-5 cm/s)	0.25
(21)	Clayey Gravel to Gravel,	8-12% fines,	Kh=2.8 ft/day (=1x10-3 cm/s)	0.25
(25)	Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day (=1x10-2 cm/s)	0.25
(26)	Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day (=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SEEPAGE ANALYSIS Reach 39, Section at Sta. 2314+91 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED GTH	FIGURE B39-E1
			DATE 02/09/2011	CHECKED NT	

Slope Stability Analysis Results,
Critical Slip Surface

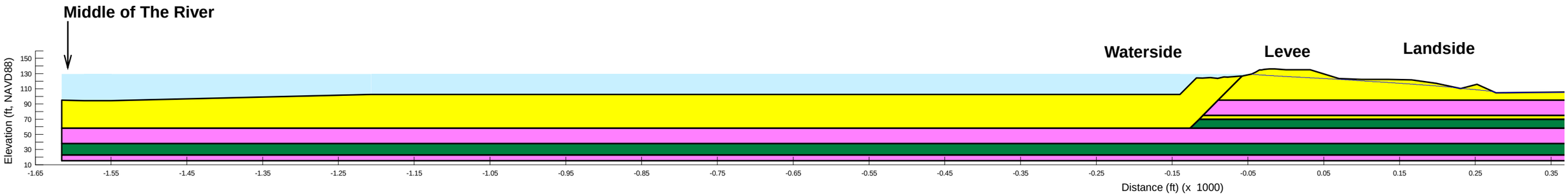


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 GP-GM 130 pcf C'=0, Phi'=35
2 GW-GC 130 pcf C'=0, Phi'=36
3 GP-GM 130 pcf C'=0, Phi'=36
4 SM 120 pcf C'=0, Phi'=33
5 GC 130 pcf C'=0, Phi'=36
6 SM 120 pcf C'=0, Phi'=33
7 SC 120 pcf C'=0, Phi'=33
8 GP 120 pcf C'=0, Phi'=32

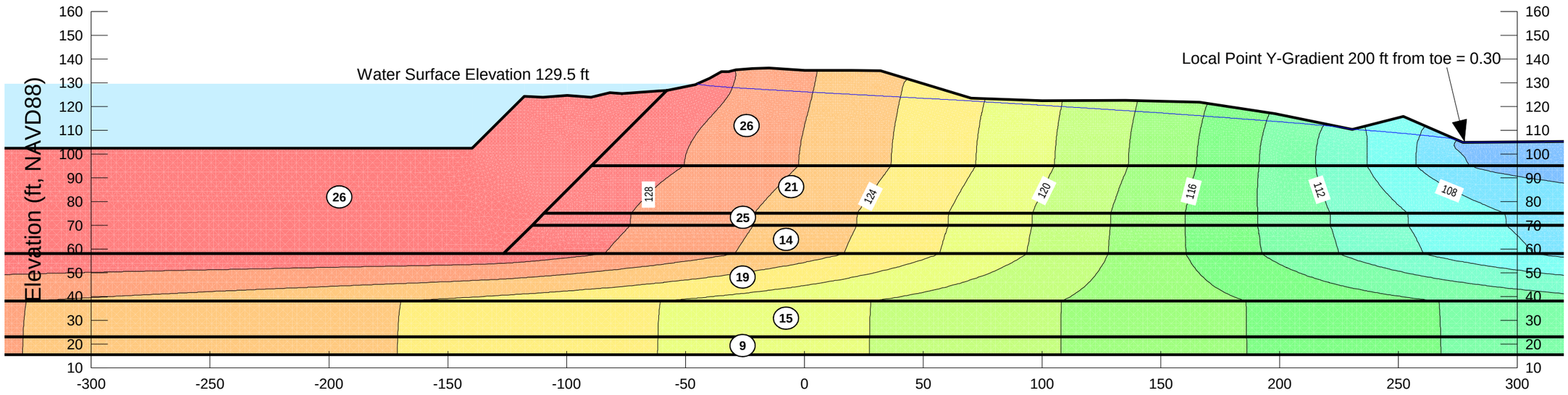
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 39, Section at Sta. 2314+91 Existing Conditions WSE at 200yr	FIGURE B39-E2
			TASK ORDER 1	ANALYZED GTH		
			DATE 02/09/2011	CHECKED NT		

Model Geometry



Seepage Analysis Results, Total Head Contours

NOTE: Model Extends 2000 ft to the Landside



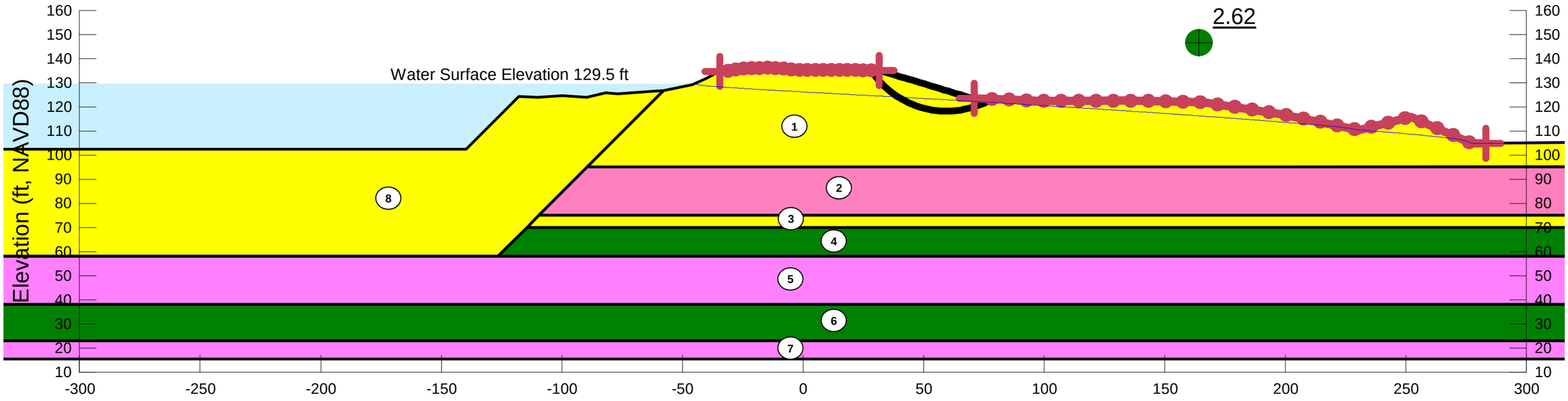
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropy Ratio (Kh/Kv)

NOTE: Head Contour Interval 2.0 ft

(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(19) Clayey Gravel to Gravel,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(21) Clayey Gravel to Gravel,	8-12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/09/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 39, Section at Sta. 2314+91 Existing Conditions WSE at 200yr+3ft	FIGURE B39-E3

Slope Stability Analysis Results,
Critical Slip Surface

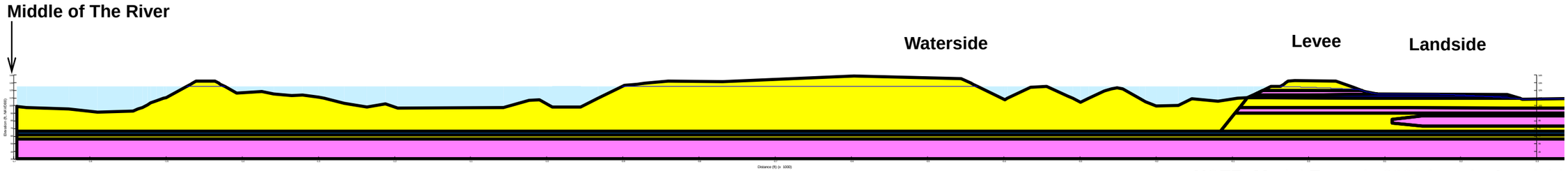


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 GP-GM 130 pcf C'=0, Phi'=35
2 GW-GC 130 pcf C'=0, Phi'=36
3 GP-GM 130 pcf C'=0, Phi'=36
4 SM 120 pcf C'=0, Phi'=33
5 GC 130 pcf C'=0, Phi'=36
6 SM 120 pcf C'=0, Phi'=33
7 SC 120 pcf C'=0, Phi'=33
8 GP 120 pcf C'=0, Phi'=32

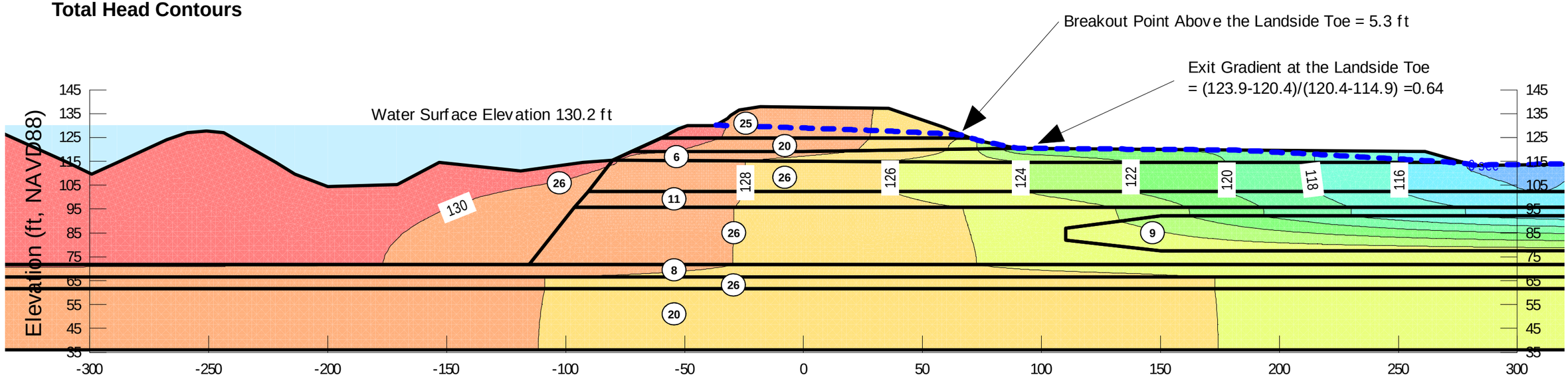
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 39, Section at Sta. 2314+91 Existing Conditions WSE at 200yr+3 ft
			TASK ORDER 1	ANALYZED GTH	FIGURE B39-E4
			DATE 02/09/2011	CHECKED NT	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



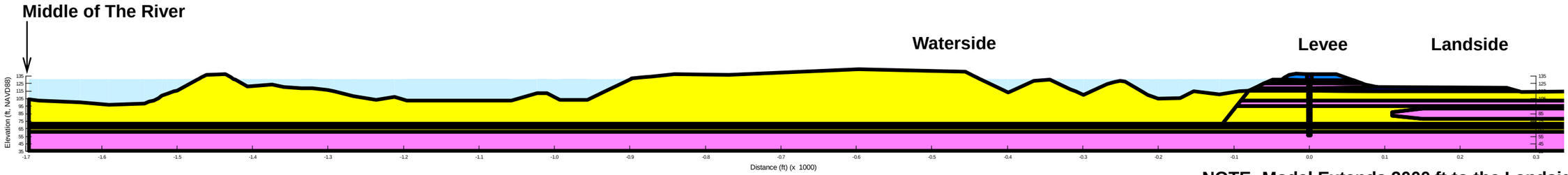
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

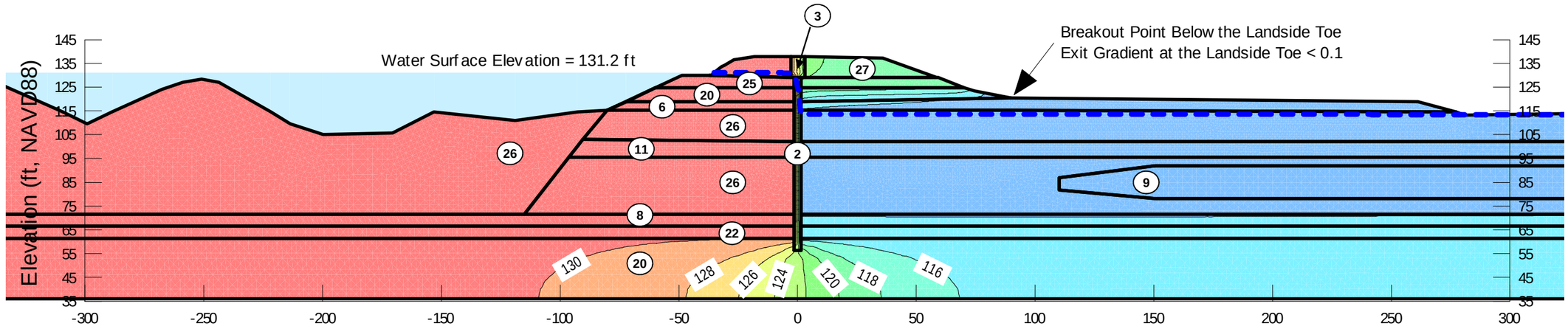
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/09/2011 / CHECKED MW	STEADY-STATE SEEPAGE ANALYSIS Reach 40, Section at Sta. 2332+91 Existing Conditions WSE at 200yr	FIGURE B40-E1

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



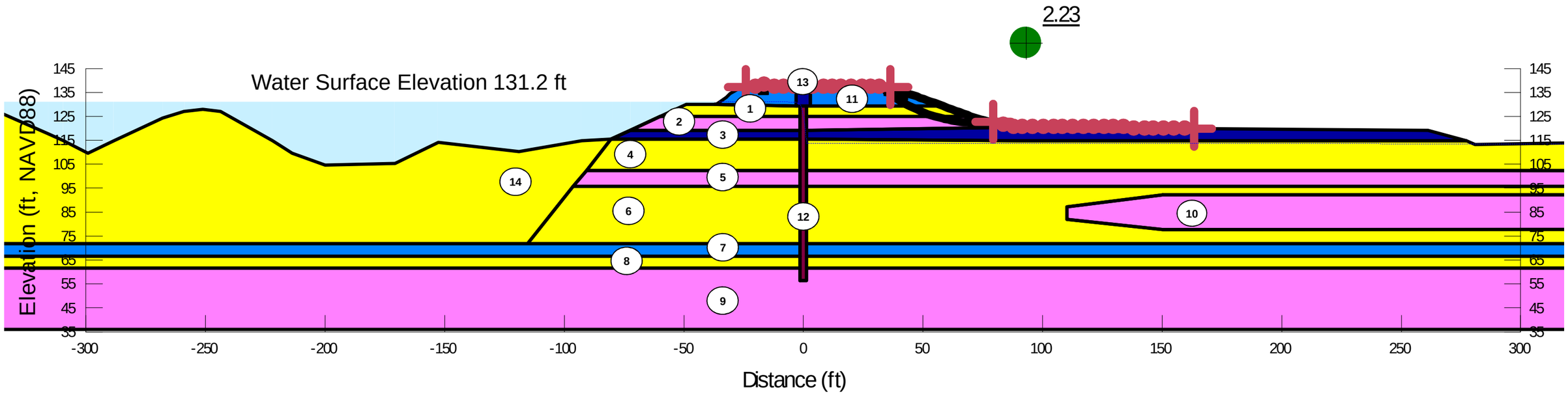
Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee, Clay Cap,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/09/2011 / CHECKED MW	**STEADY-STATE SEEPAGE ANALYSIS** **Reach 40, Section at Sta. 2332+91** **Alternative 1: Cutoff Wall** **WSE at 200yr+1 ft**	**FIGURE B40-A1**

Slope Stability Analysis Results,
Critical Slip Surface

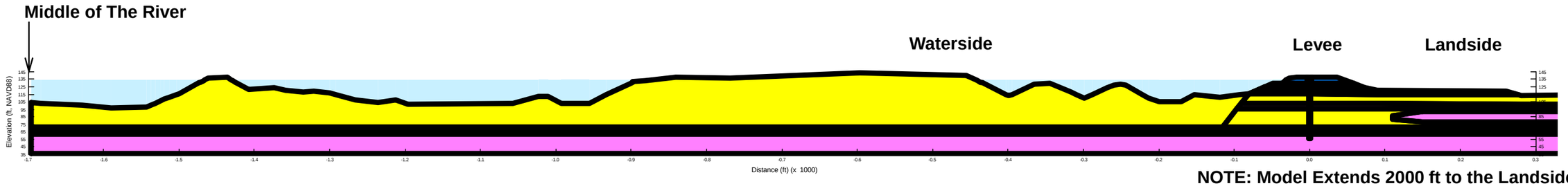


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 GP-GM 120 pcf C'=0, Phi'=35
2 GC 120 pcf C'=0, Phi'=35
3 CL 115 pcf C'=100 psf, Phi'=31
4 GW 125 pcf C'=0, Phi'=36
5 SW-SC 125 pcf C'=0, Phi'=36
6 GP 125 pcf C'=0, Phi'=36
7 ML 120 pcf C'=0, Phi'=32
8 GP-GC 125 pcf C'=0, Phi'=36
9 GC 125 pcf C'=0, Phi'=36
10 SC 120 pcf C'=0, Phi'=33
11 Regrade ML 120 pcf C'=50, Phi'=32
12 SB Wall 100 pcf C'=300, Phi'=0
13 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
14 GP 120 pcf C'=0, Phi'=32

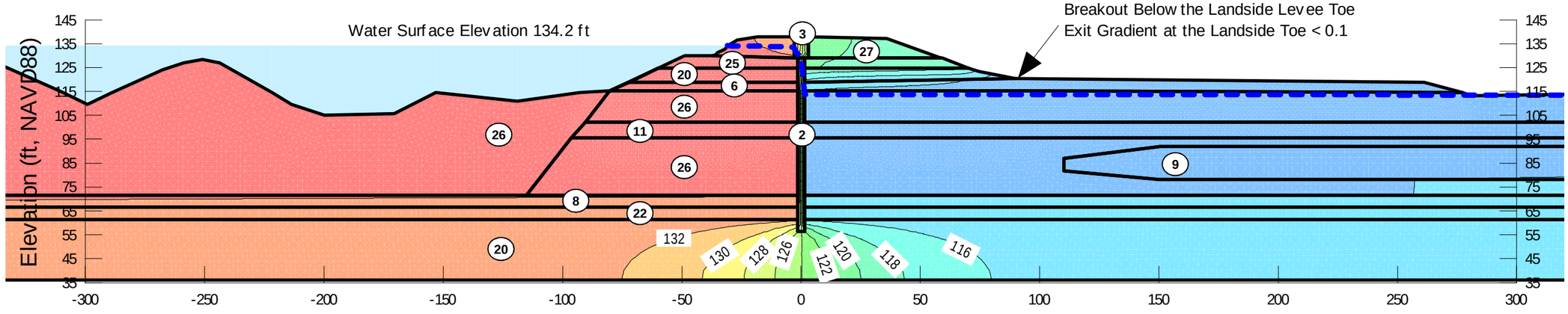
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 40, Section at Sta. 2332+91** **Alternative 1: Cutoff Wall** **WSE at 200yr+1 ft**
			TASK ORDER 1	ANALYZED GTH	**FIGURE B40-A2**
			DATE 02/09/2011	CHECKED MW	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



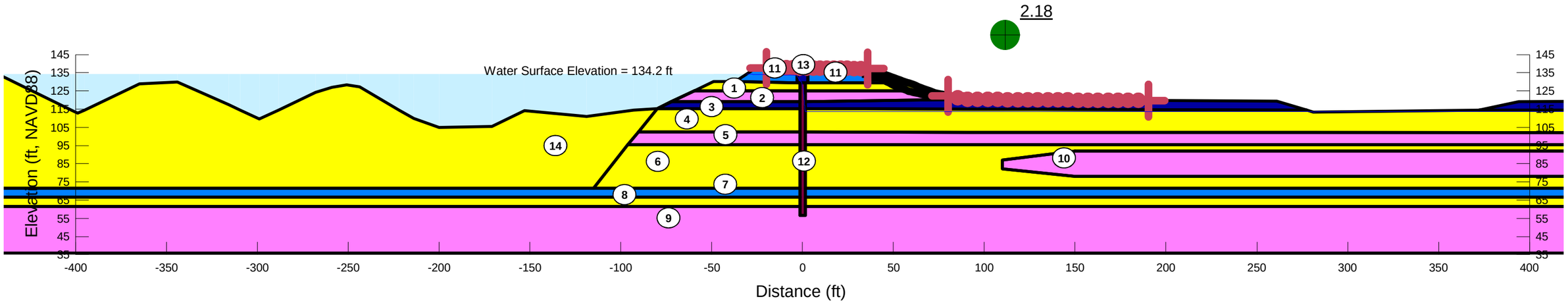
Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(2) Slurry Wall (SB),		Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee, Clay Cap,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade ML,		Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/09/2011 / CHECKED MW	STEADY-STATE SEEPAGE ANALYSIS Reach 40, Section at Sta. 2332+91 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B40-A3

Slope Stability Analysis Results, Critical Slip Surface

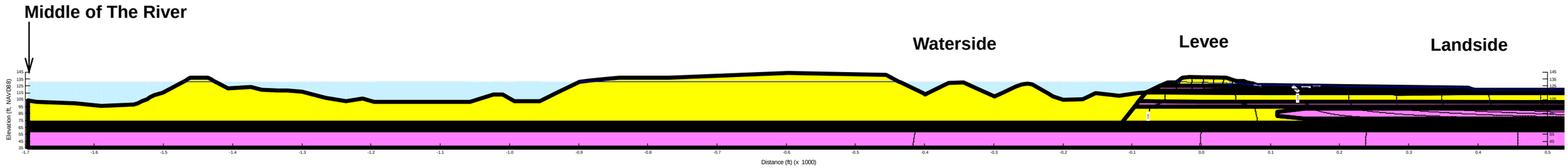


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 GP-GM 120 pcf C'=0, Phi'=35
2 GC 120 pcf C'=0, Phi'=35
3 CL 115 pcf C'=100 psf, Phi'=31
4 GW 125 pcf C'=0, Phi'=36
5 SW-SC 125 pcf C'=0, Phi'=36
6 GP 125 pcf C'=0, Phi'=36
7 ML 120 pcf C'=0, Phi'=32
8 GP-GC 125 pcf C'=0, Phi'=36
9 GC 125 pcf C'=0, Phi'=36
10 SC 120 pcf C'=0, Phi'=33
11 Regrade ML 120 pcf C'=50, Phi'=32
12 SB Wall 100 pcf C'=300, Phi'=0
13 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
14 GP 120 pcf C'=0, Phi'=32

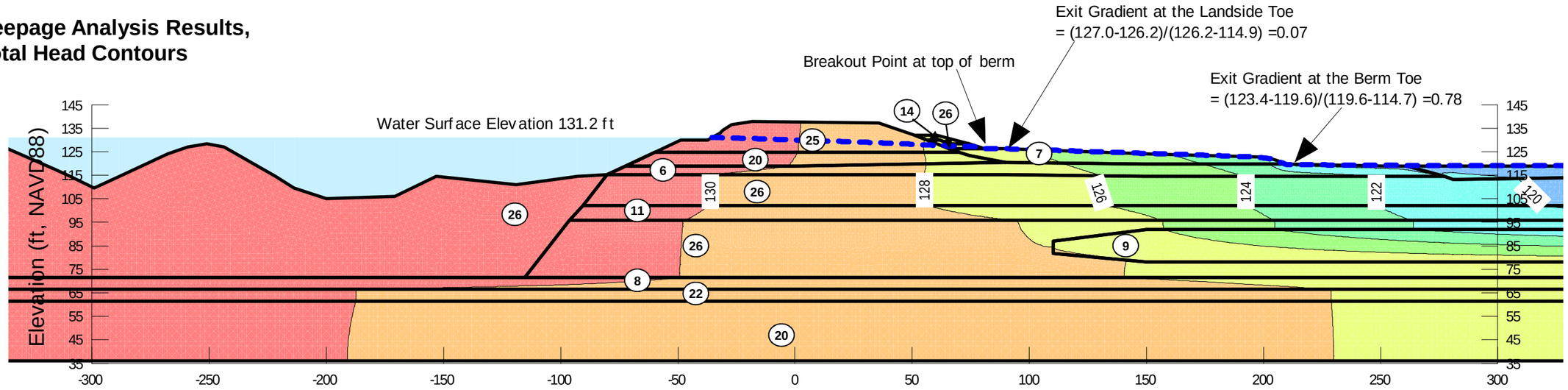
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN GTH	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 40, Section at Sta. 2332+91 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B40-A4
			TASK ORDER 1	ANALYZED GTH		
			DATE 02/09/2011	CHECKED MW		

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



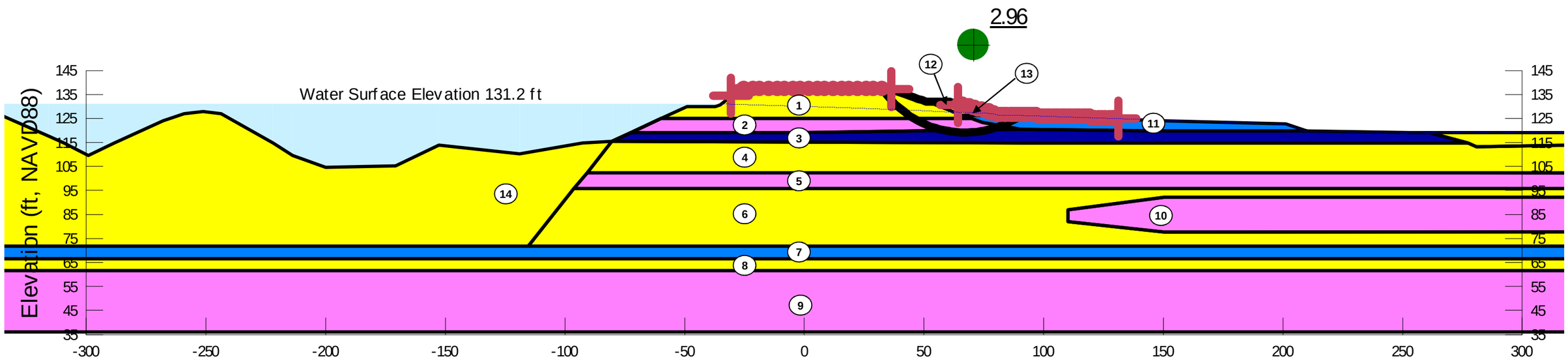
Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(24) Silty Gravel to Sandy Gravel,	13-29% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

NOTE: Head Contour Interval 2.0 ft

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/10/2011 / CHECKED MW	**STEADY-STATE SEEPAGE ANALYSIS** **Reach 40, Section at Sta. 2332+91** **Alternative 2 : Seepage and Stability Berm** **WSE at 200yr+1 ft**	**FIGURE B40-A5**

Slope Stability Analysis Results,
Critical Slip Surface

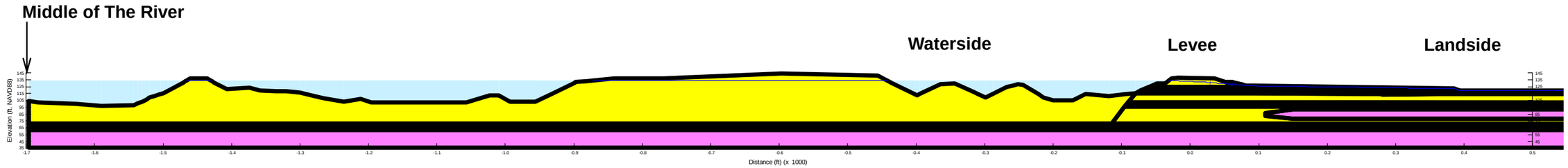


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 GP-GM 120 pcf C'=0, Phi'=35
2 GC 120 pcf C'=0, Phi'=35
3 CL 115 pcf C'=100, Phi'=31
4 GW 125 pcf C'=0, Phi'=36
5 SW-SC 125 pcf C'=0, Phi'=36
6 GP 125 pcf C'=0, Phi'=36
7 ML 120 pcf C'=0, Phi'=32
8 GP-GC 125 pcf C'=0, Phi'=36
9 GC 125 pcf C'=0, Phi'=36
10 SC 120 pcf C=0, Phi=33
12 Stability Berm, SM 120 pcf C'=0, Phi'=35
13. Drainage Material, GP 130 pcf C'=0, Phi'=36
11 New Compacted ML Berm 120 pcf C'=50 psf, Phi'=32
14 GP 120 pcf C'=0, Phi'=32

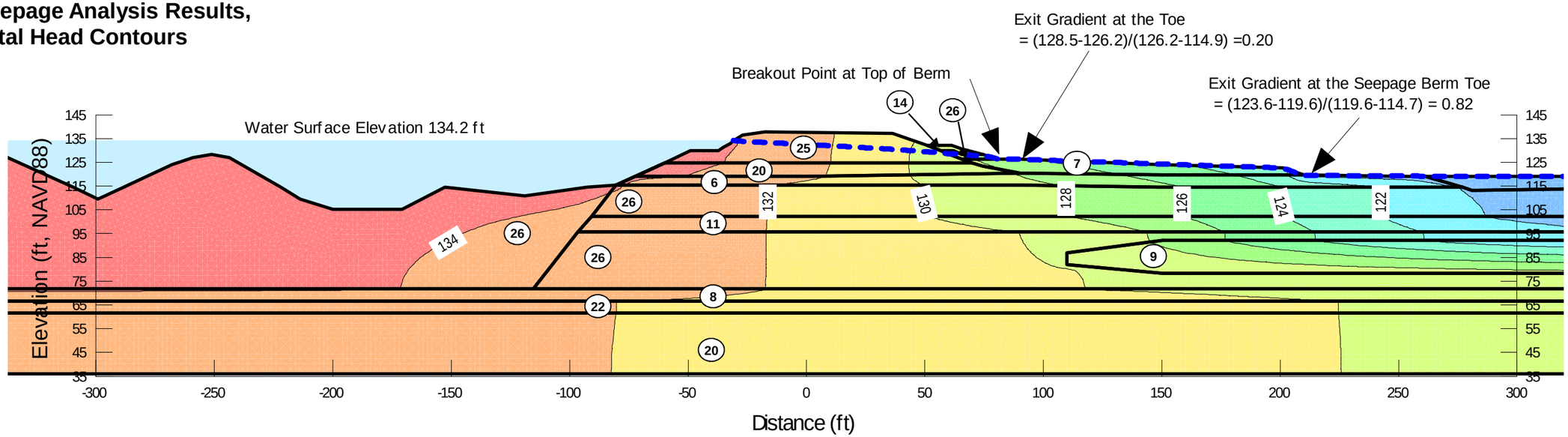
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/10/2011	DRAWN GTH ANALYZED GTH CHECKED MW	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 40, Section at Sta. 2332+91** **Alternative 2 : Seepage and Stability Berm** **WSE at 200yr+1 ft**	**FIGURE B40-A6**

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



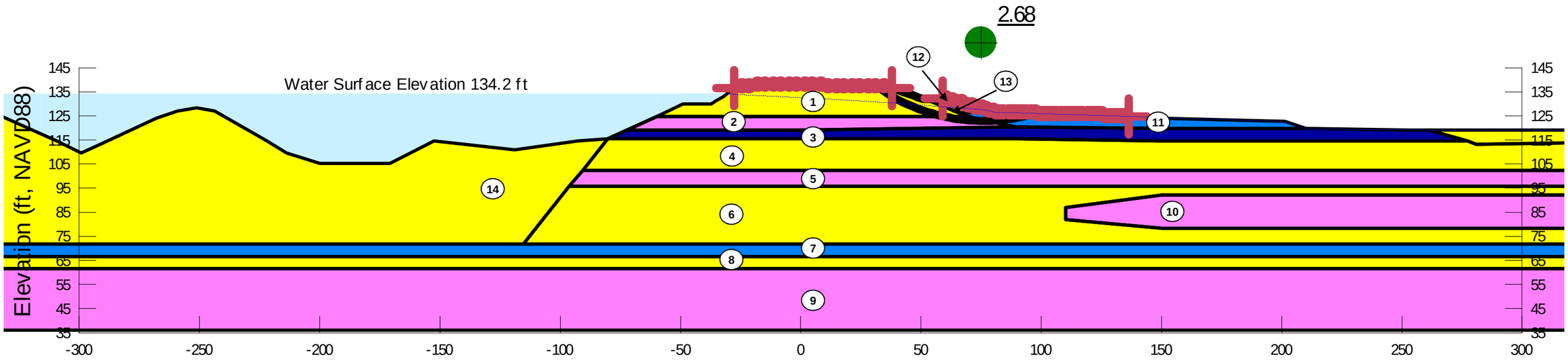
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (kh), Anisotropic Ratio (kv/kh)

(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(7) Silt or Plastic Silt .80-100% fines, or >50% fines and PI=4,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(9)* Clayey Sand to Sand,	30-49% fines,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(11) Clayey Sand to Sand,	8- 12% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(14) Silty Sand to Sand,	30-49% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(20) Clayey Gravel to Gravel,	13-29% fines,	Kh=0.28 ft/day	(=1x10-4 cm/s)	0.25
(22) Clayey Gravel to Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(25) Silty Gravel to Sandy Gravel,	8- 12% fines,	Kh=28 ft/day	(=1x10-2 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN GTH TASK ORDER 1 / ANALYZED GTH DATE 02/10/2011 / CHECKED MW	STEADY-STATE SEEPAGE ANALYSIS Reach 40, Section at Sta. 2332+91 Alternative 2 : Seepage and Stability Berm WSE at 200yr+4 ft	FIGURE B40-A7

Slope Stability Analysis Results,
Critical Slip Surface

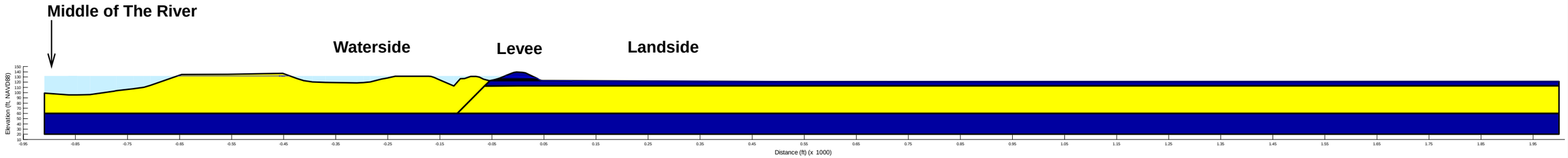


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 GP-GM 120 pcf C'=0, Phi'=35
2 GC 120 pcf C'=0, Phi'=35
3 CL 115 pcf C'=100, Phi'=31
4 GW 125 pcf C'=0, Phi'=36
5 SW-SC 125 pcf C'=0, Phi'=36
6 GP 125 pcf C'=0, Phi'=36
7 ML 120 pcf C'=0, Phi'=32
8 GP-GC 125 pcf C'=0, Phi'=36
9 GC 125 pcf C'=0, Phi'=36
10 SC 120 pcf C=0, Phi=33
12 Stability Berm, SM 120 pcf C'=0, Phi'=35
13. Drainage Material, GP 130 pcf C'=0, Phi'=36
11 New Compacted ML Berm 120 pcf C'=50 psf, Phi'=32
14 GP 120 pcf C'=0, Phi'=32

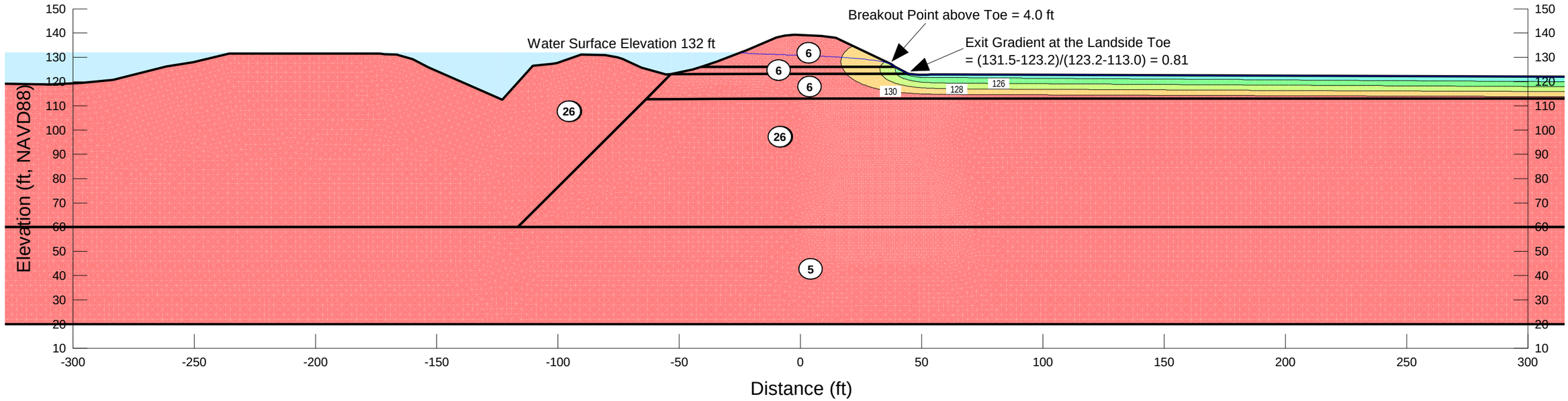
Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/10/2011	DRAWN GTH ANALYZED GTH CHECKED MW	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 40, Section at Sta. 2332+91** **Alternative 2 : Seepage and Stability Berm** **WSE at 200yr+4 ft**	**FIGURE B40-A8**

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



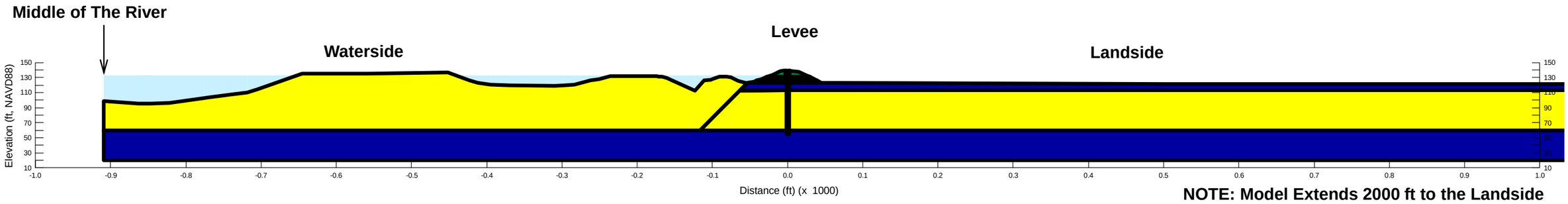
Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5) Clay Layer over 20 ft below Ground Surface, Kh=0.0028 ft/day (=1x10-6 cm/s) 0.25
(6) Clay Blanket, Kh=0.028 ft/day (=1x10-5 cm/s) 0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines, Kh=85 ft/day (=3x10-2 cm/s) 0.25

NOTE: Head Contour Interval 2.0 ft

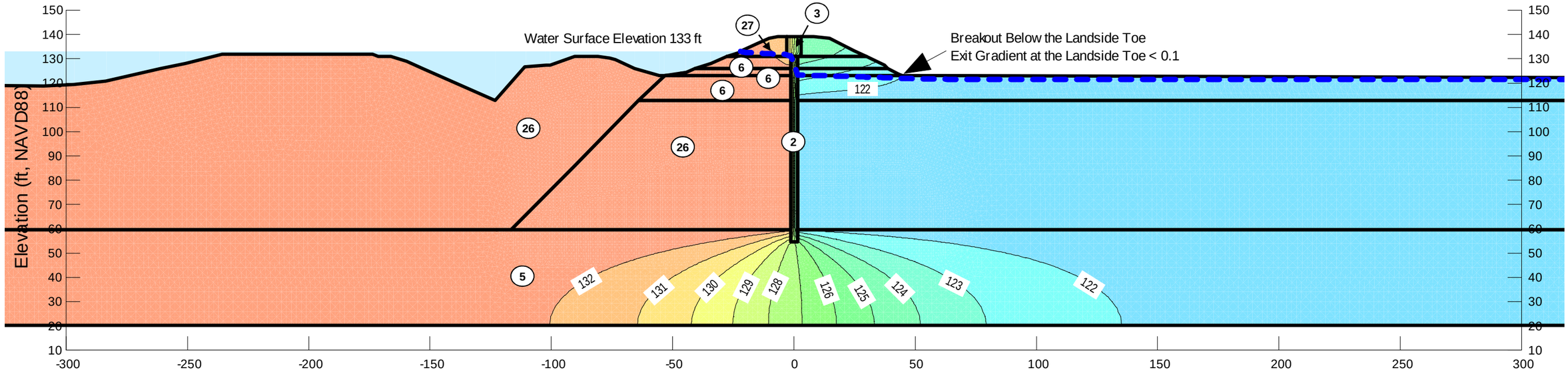
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 41, Section at Sta. 2362+70 Existing Conditions WSE at 200yr
			TASK ORDER 1	ANALYZED MW	FIGURE B41-E1
			DATE 02/10/2011	CHECKED NT	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



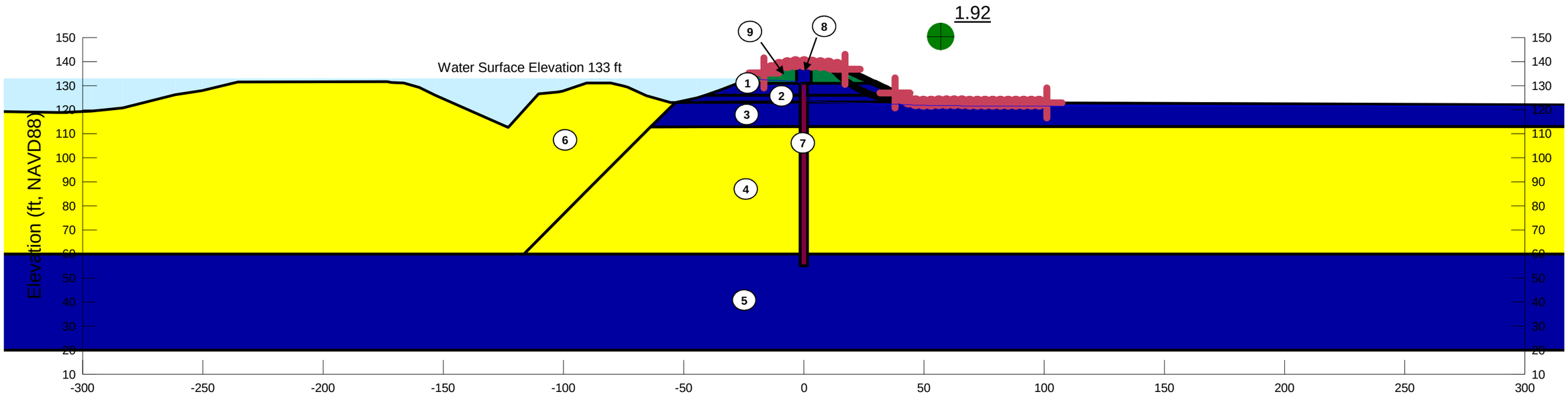
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),	Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade SM,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SEEPAGE ANALYSIS Reach 41, Section at Sta. 2362+70 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED MW	
			DATE 02/10/2011	CHECKED NT	FIGURE B41-A1

Slope Stability Analysis Results, Critical Slip Surface

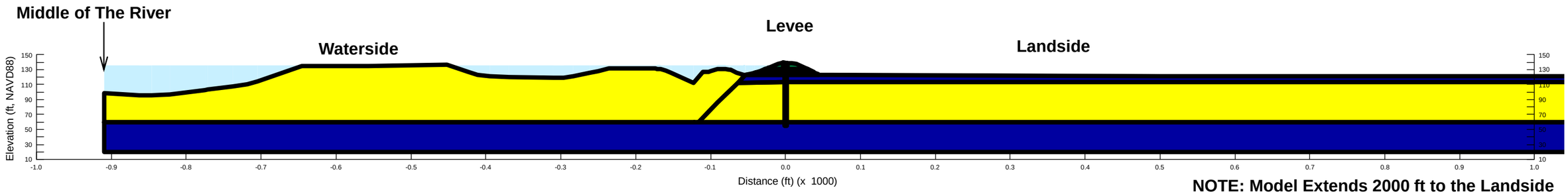


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100, Phi'=31
2 CL 115 pcf C'=100, Phi'=31
3 CL 115 pcf C'=100, Phi'=31
4 GP 130 pcf C'=0, Phi'=36
5 CL 115 pcf C'=100, Phi'=31
6 GP 120 pcf C'=0, Phi'=32
7 SB Wall 100 pcf C'=300, Phi'=0
8 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
9 Regrade SM 120 pcf C'=0, Phi'=35

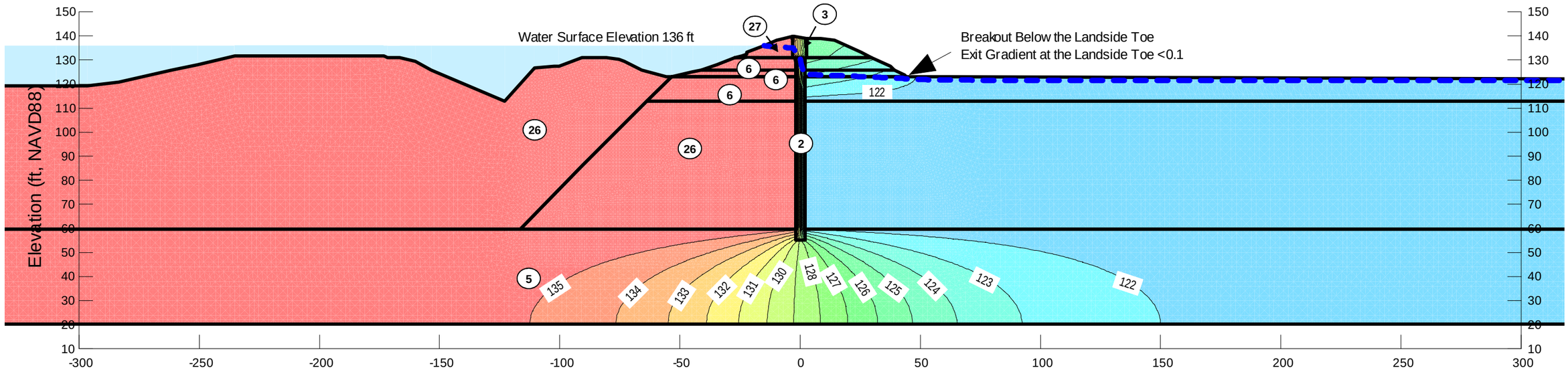
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463	DRAWN MW	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 41, Section at Sta. 2362+70 Alternative 1: Cutoff Wall WSE at 200yr+1 ft
			TASK ORDER 1	ANALYZED MW	FIGURE B41-A2
			DATE 02/10/2011	CHECKED NT	

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



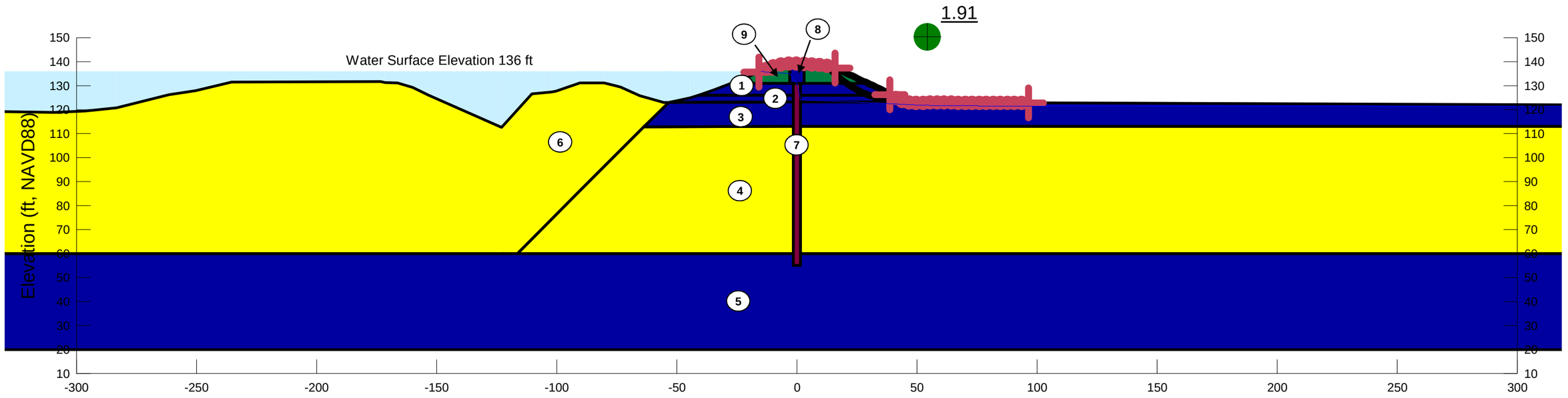
NOTE: Head Contour Interval 1.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(2) Slurry Wall (SB),	Kh=0.00028 ft/day	(=1x10-7 cm/s)	1
(3) New Compacted Clay Levee,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(5) Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel, 0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25
(27) Regrade SM,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/10/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 41, Section at Sta. 2362+70 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B41-A3

Slope Stability Analysis Results, Critical Slip Surface

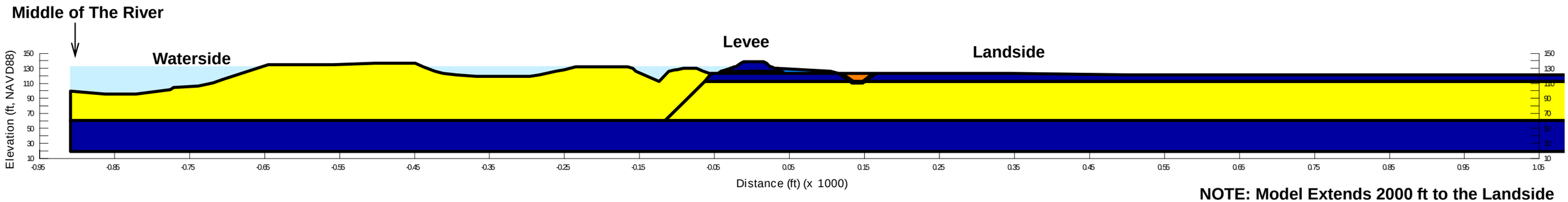


Material ID and Type, Unit Weight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

1 CL 115 pcf C'=100, Phi'=31
2 CL 115 pcf C'=100, Phi'=31
3 CL 115 pcf C'=100, Phi'=31
4 GP 130 pcf C'=0, Phi'=36
5 CL 115 pcf C'=100, Phi'=31
6 GP 120 pcf C'=0, Phi'=32
7 SB Wall 100 pcf C'=300, Phi'=0
8 New Compacted Clay Levee, Clay Cap 120 pcf C'=100, Phi'=32
9 Regrade SM 120 pcf C'=0, Phi'=35

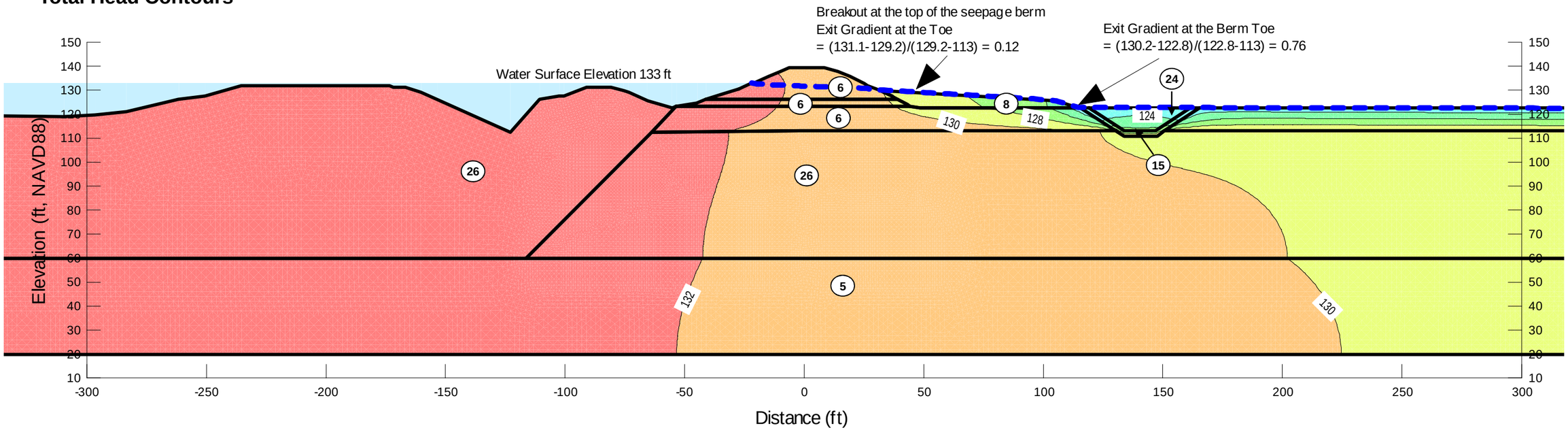
Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/10/2011	DRAWN MW ANALYZED MW CHECKED NT	STEADY-STATE SLOPE STABILITY ANALYSIS Reach 41, Section at Sta. 2362+70 Alternative 1: Cutoff Wall WSE at 200yr+4 ft	FIGURE B41-A4

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

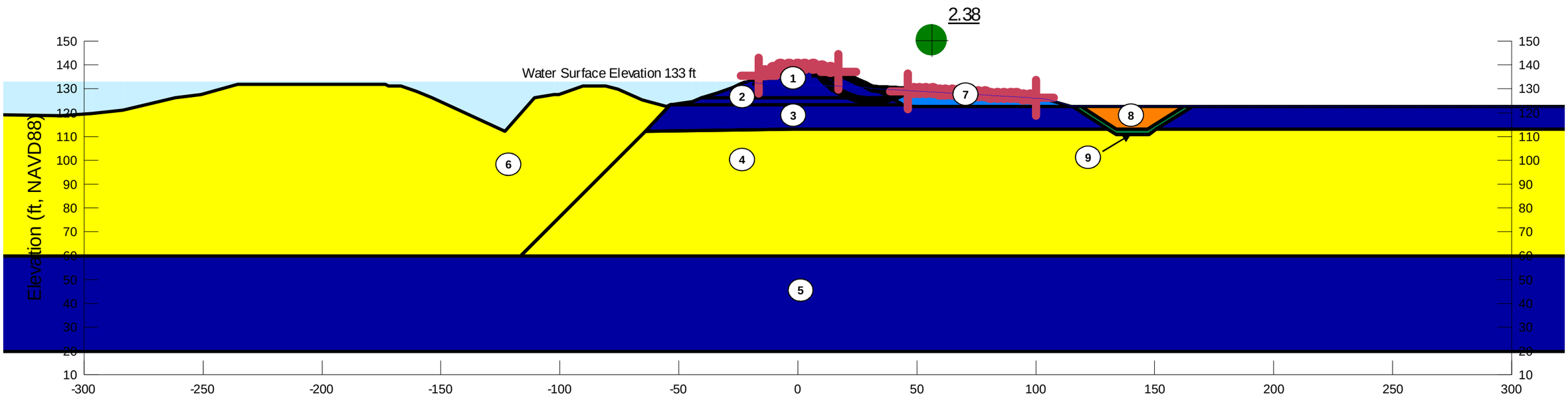
(5) Clay Layer over 20 ft below Ground Surface,		Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6) Clay Blanket,		Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8) Sandy Silt,	50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15) Silty Sand to Sand,	13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(24) Silty Gravel to Sandy Gravel,	13-29% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26) Silty Gravel to Sandy Gravel,	0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / TASK ORDER 1 / DATE 02/10/2011	DRAWN MW / ANALYZED MW / CHECKED NT

STEADY-STATE SEEPAGE ANALYSIS
Reach 41, Section at Sta. 2362+70
Alternative 2: Seepage Berm and Relief Trench
WSE at 200yr+1 ft

FIGURE B41-A5

Slope Stability Analysis Results, Critical Slip Surface



Material ID and Type, Unit W eight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

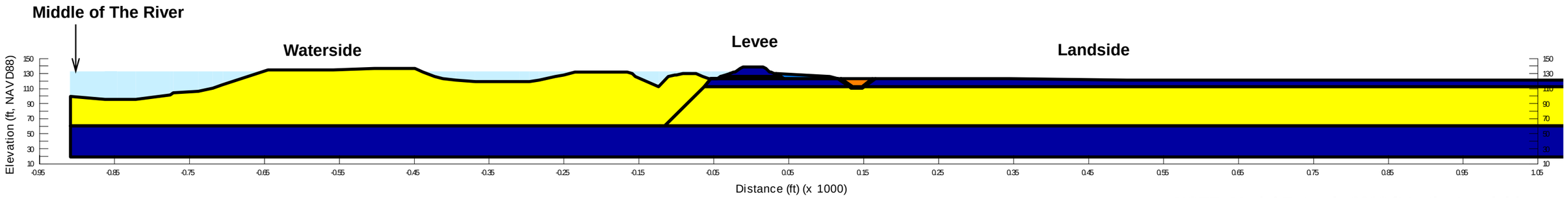
1	CL	115 pcf	C'=100, Phi'=31
2	CL	115 pcf	C'=100, Phi'=31
3	CL	115 pcf	C'=100, Phi'=31
4	GP	130 pcf	C'=0, Phi'=36
5	CL	115 pcf	C'=100, Phi'=31
6	GP	120 pcf	C'=0, Phi'=32
8	GM	130 pcf	C'=0, Phi'=36
9	SM	120 pcf	C'=0, Phi'=34
7	Compacted Berm, ML	120 pcf	C'=50 psf, Phi'=32

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / TASK ORDER 1 / DATE 02/10/2011	DRAWN MW / ANALYZED MW / CHECKED NT

STEADY-STATE SLOPE STABILITY ANALYSIS
Reach 41, Section at Sta. 2362+70
Alternative 2: Seepage Berm and Relief Trench
WSE at 200yr+1 ft

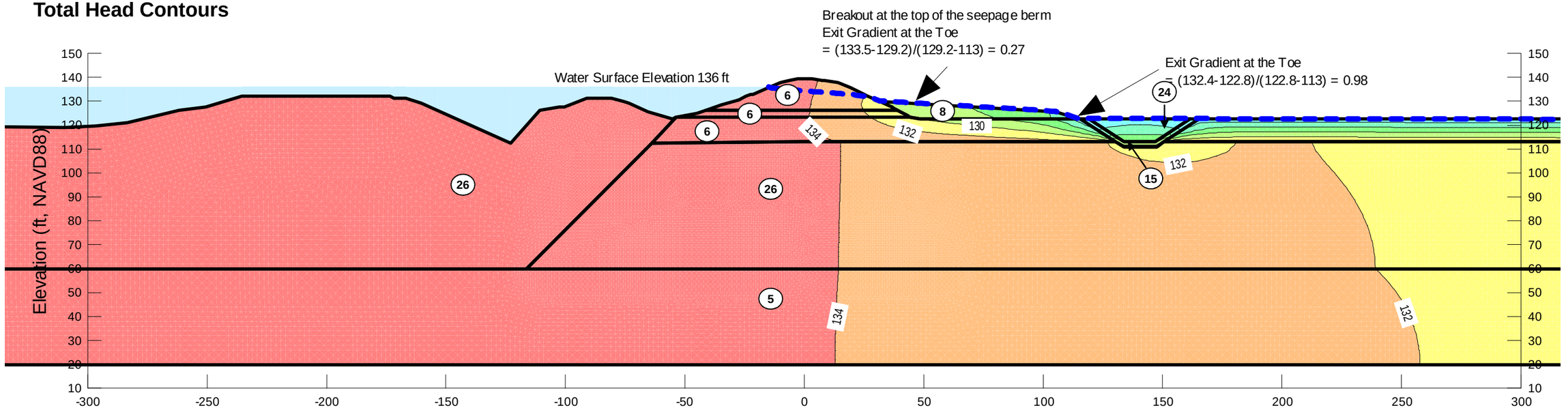
FIGURE B41-A6

Model Geometry



NOTE: Model Extends 2000 ft to the Landside

Seepage Analysis Results, Total Head Contours



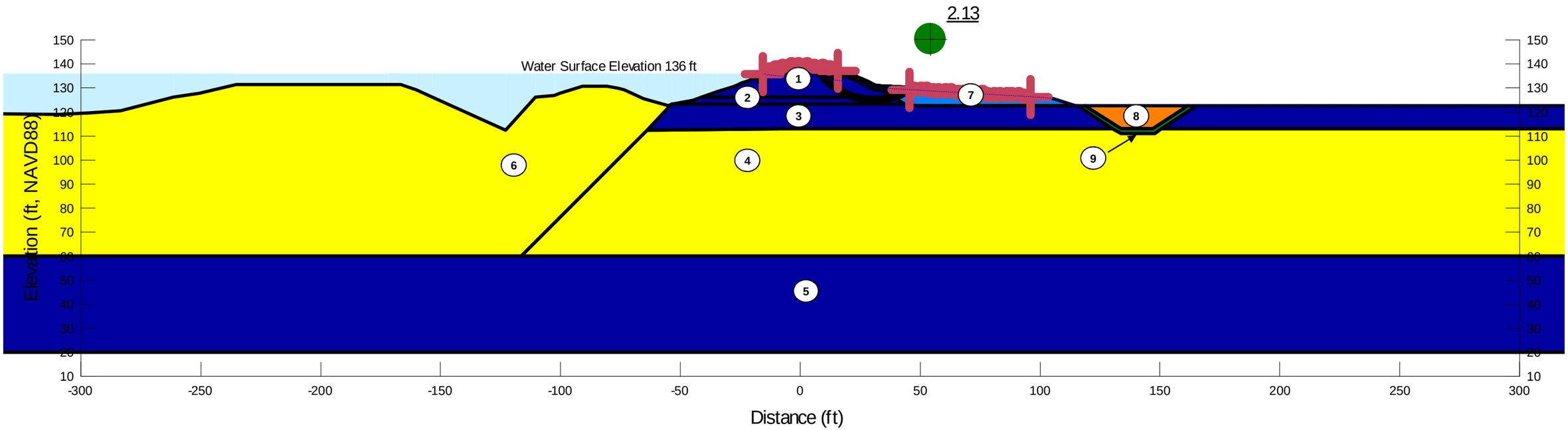
NOTE: Head Contour Interval 2.0 ft

Material ID and Type, Horizontal Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

(5)	Clay Layer over 20 ft below Ground Surface,	Kh=0.0028 ft/day	(=1x10-6 cm/s)	0.25
(6)	Clay Blanket,	Kh=0.028 ft/day	(=1x10-5 cm/s)	0.25
(8)	Sandy Silt, 50-79% fines,	Kh=0.085 ft/day	(=3x10-5 cm/s)	0.25
(15)	Silty Sand to Sand, 13-29% fines,	Kh=2.8 ft/day	(=1x10-3 cm/s)	0.25
(24)	Silty Gravel to Sandy Gravel, 13-29% fines,	Kh=14 ft/day	(=5x10-3 cm/s)	0.25
(26)	Silty Gravel to Sandy Gravel, 0- 7% fines,	Kh=85 ft/day	(=3x10-2 cm/s)	0.25

Sutter Butte Flood Control Agency	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 / DRAWN MW TASK ORDER 1 / ANALYZED MW DATE 02/10/2011 / CHECKED NT	STEADY-STATE SEEPAGE ANALYSIS Reach 41, Section at Sta. 2362+70 Alternative 2: Seepage Berm and Relief Trench WSE at 200yr+4 ft	FIGURE B41-A7

Slope Stability Analysis Results, Critical Slip Surface



Material ID and Type, Unit W eight, Effective Strength Parameters (Cohesion Intercept and Friction Angle)

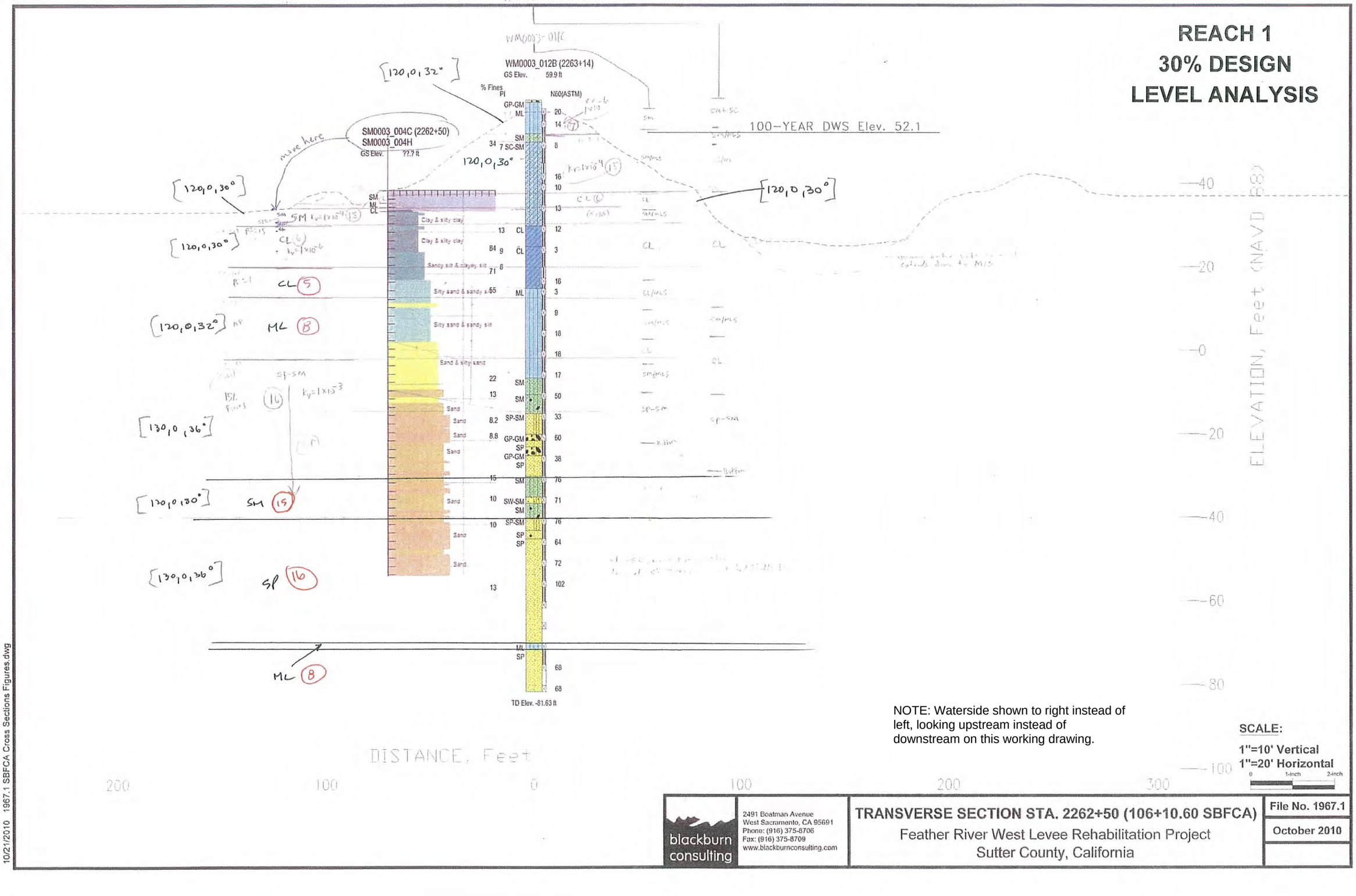
1 CL 115 pcf C'=100, Phi'=31
2 CL 115 pcf C'=100, Phi'=31
3 CL 115 pcf C'=100, Phi'=31
4 GP 130 pcf C'=0, Phi'=36
5 CL 115 pcf C'=100, Phi'=31
6 GP 120 pcf C'=0, Phi'=32
8 GM 130 pcf C'=0, Phi'=36
9 SM 120 pcf C'=0, Phi'=34
7 Compacted Berm, ML 120 pcf C'=50 psf, Phi'=32

Sutter Butte Flood Control Agency	**FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT** Geotechnical Analyses for Pre-Design Formulation Report	URS In association with: blackburn consulting	URS PROJECT NO. 17326463 TASK ORDER 1 DATE 02/100/2011	DRAWN MW ANALYZED MW CHECKED NT	**STEADY-STATE SLOPE STABILITY ANALYSIS** **Reach 41, Section at Sta. 2362+70** **Alternative 2: Seepage Berm and Relief Trench** **WSE at 200yr+4 ft**	**FIGURE B41-A8**

APPENDIX C

Working Sketches for Cross Section Development

REACH 1
30% DESIGN
LEVEL ANALYSIS



NOTE: Waterside shown to right instead of left, looking upstream instead of downstream on this working drawing.

SCALE:
1"=10' Vertical
1"=20' Horizontal

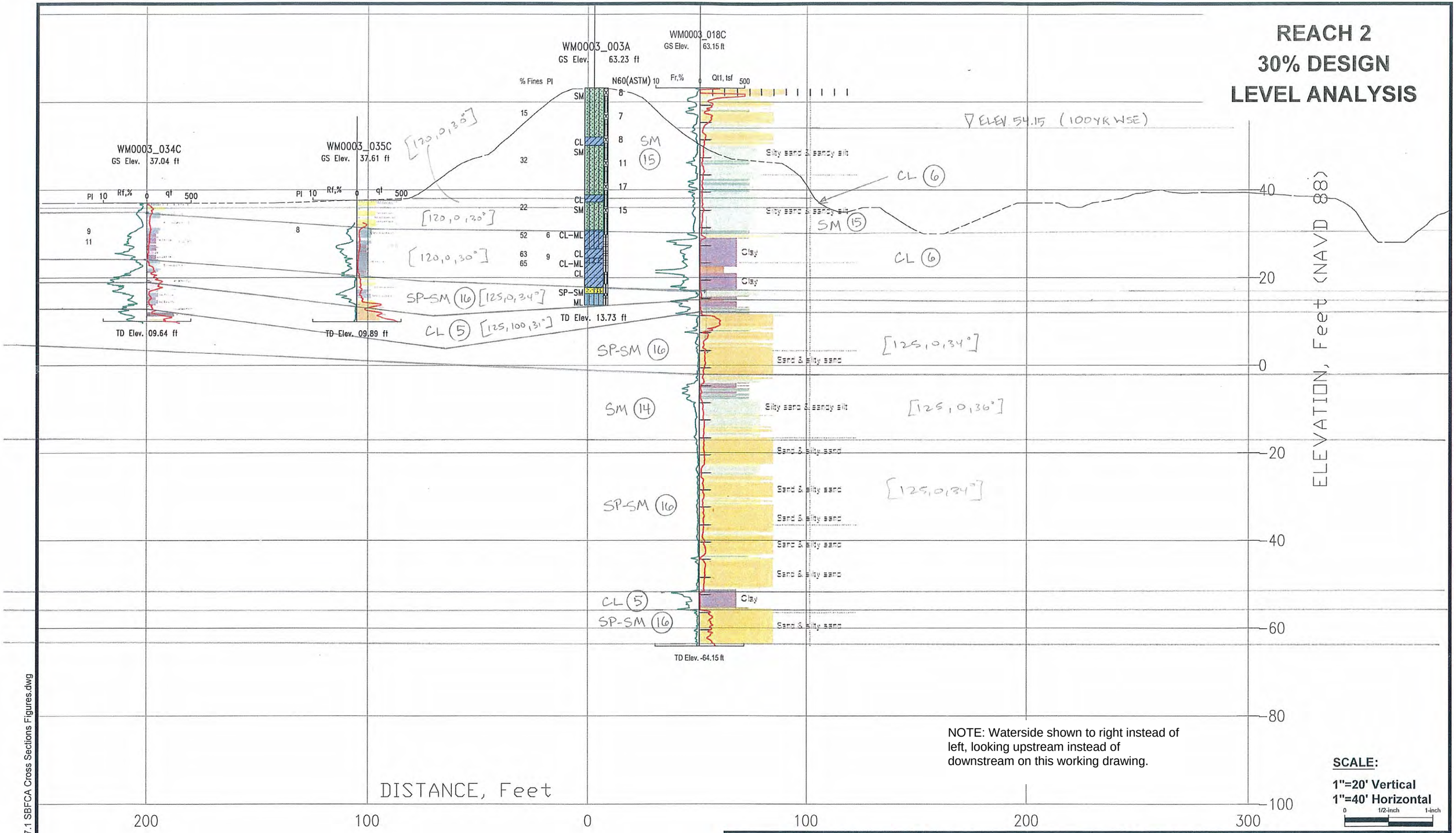
blackburn consulting
2491 Boatman Avenue
West Sacramento, CA 95691
Phone: (916) 375-8706
Fax: (916) 375-8709
www.blackburnconsulting.com

TRANSVERSE SECTION STA. 2262+50 (106+10.60 SBFCA)
Feather River West Levee Rehabilitation Project
Sutter County, California

File No. 1967.1
October 2010

10/21/2010 1967.1 SBFCA Cross Sections Figures.dwg

REACH 2
30% DESIGN
LEVEL ANALYSIS



NOTE: Waterside shown to right instead of left, looking upstream instead of downstream on this working drawing.

SCALE:

1"=20' Vertical
1"=40' Horizontal

0 1/2-inch 1-inch

10/21/2010 1967.1 SBFCA Cross Sections Figures.dwg

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West Sacramento, CA 95691
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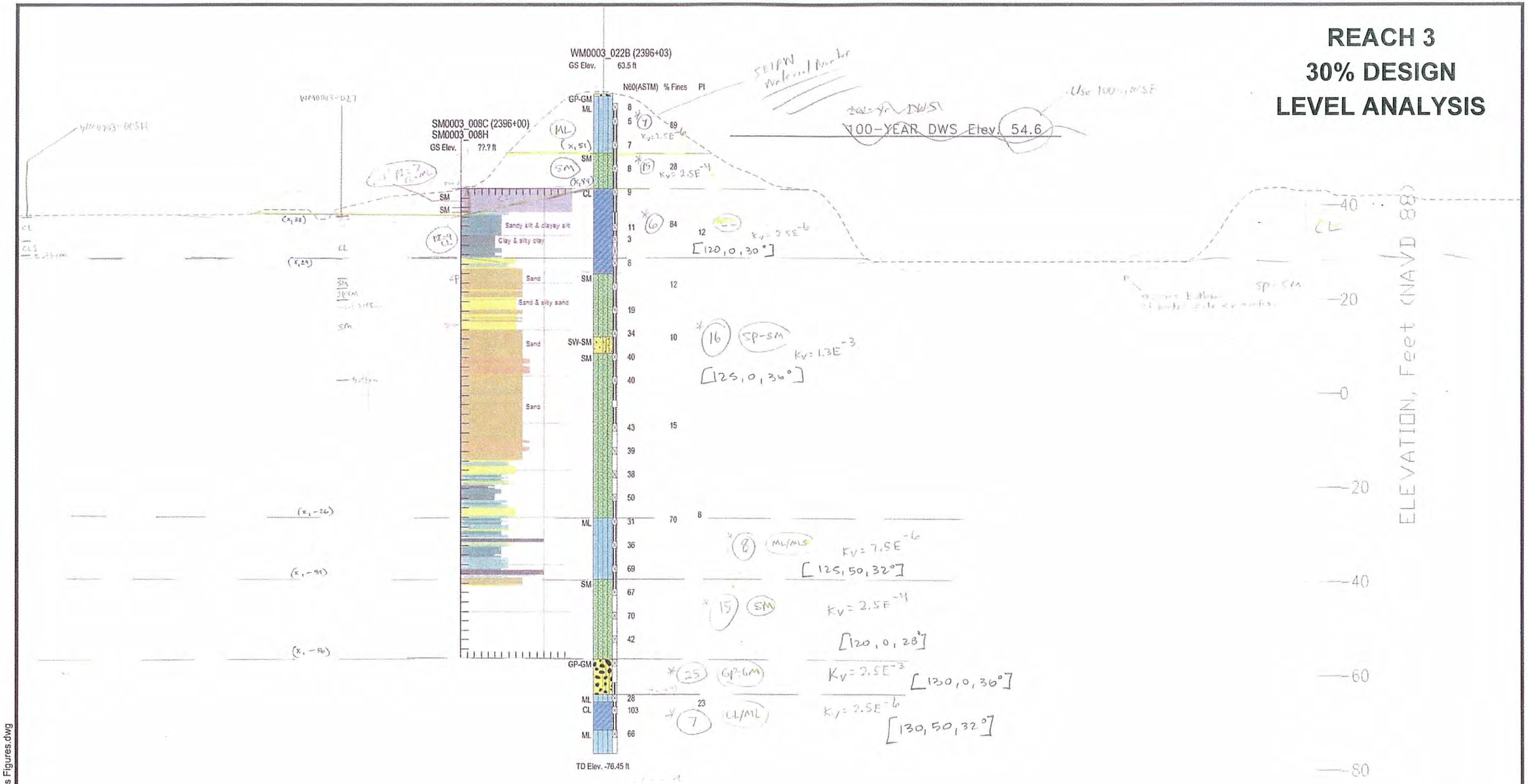
TRANSVERSE SECTION STA. 2337+50 (151+37.72 SBFCA)

Feather River West Levee Rehabilitation Project
Sutter County, California

File No. 1967.1

October 2010

REACH 3
30% DESIGN
LEVEL ANALYSIS



NOTE: Waterside shown to right instead of left, looking upstream instead of downstream on this working drawing.

SCALE:

1"=10' Vertical
1"=20' Horizontal

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TRANSVERSE SECTION STA. 2396+00 (239+78.20 SBFCA)

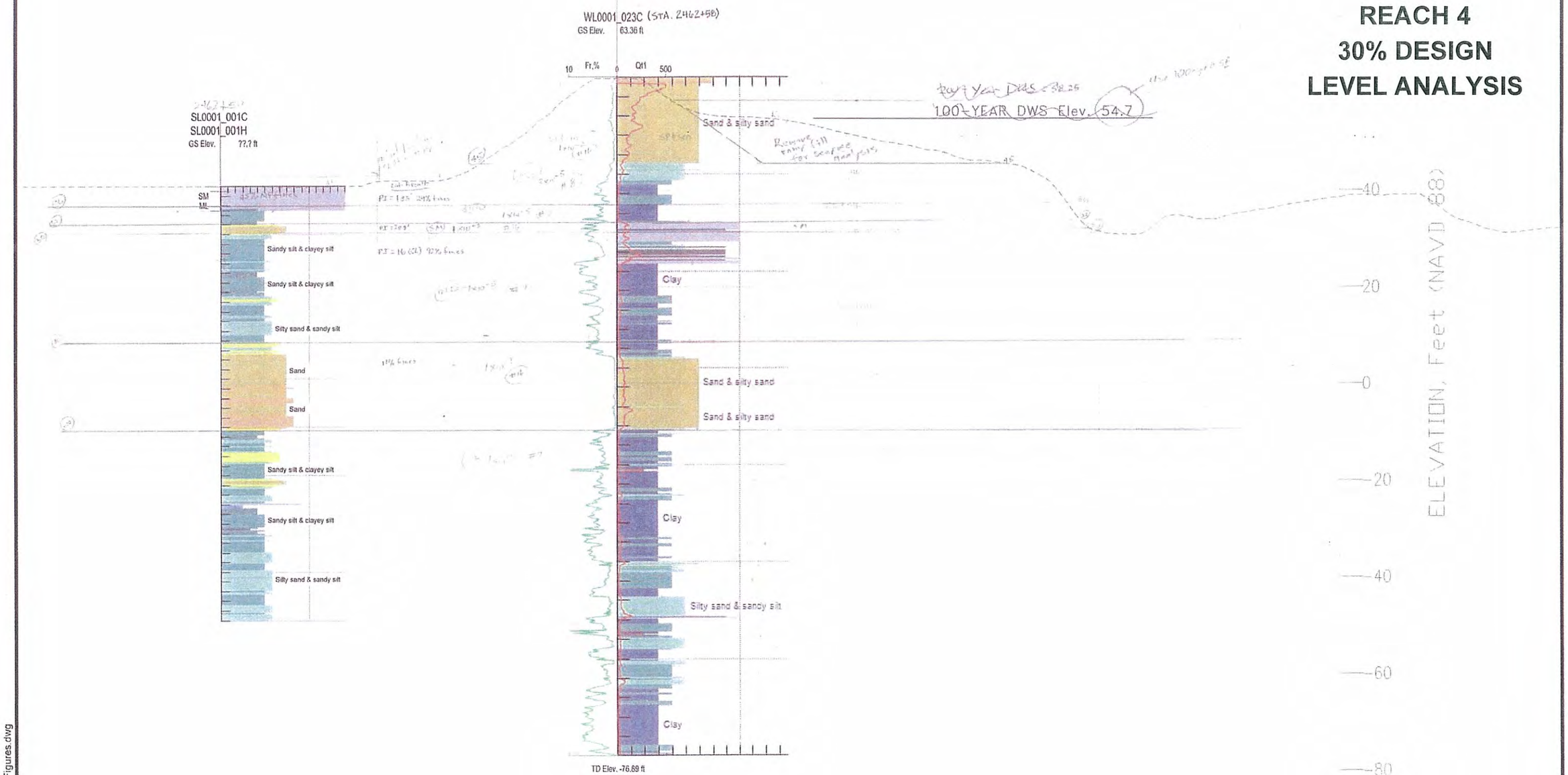
Feather River West Levee Rehabilitation Project
Sutter County, California

File No. 1967.1

October 2010

10/21/2010 1967.1 SBFCA Cross Sections Figures.dwg

REACH 4
30% DESIGN
LEVEL ANALYSIS



NOTE: Waterside shown to right instead of left, looking upstream instead of downstream on this working drawing.

SCALE:
1"=10' Vertical
1"=20' Horizontal
0 1-inch 2-inch

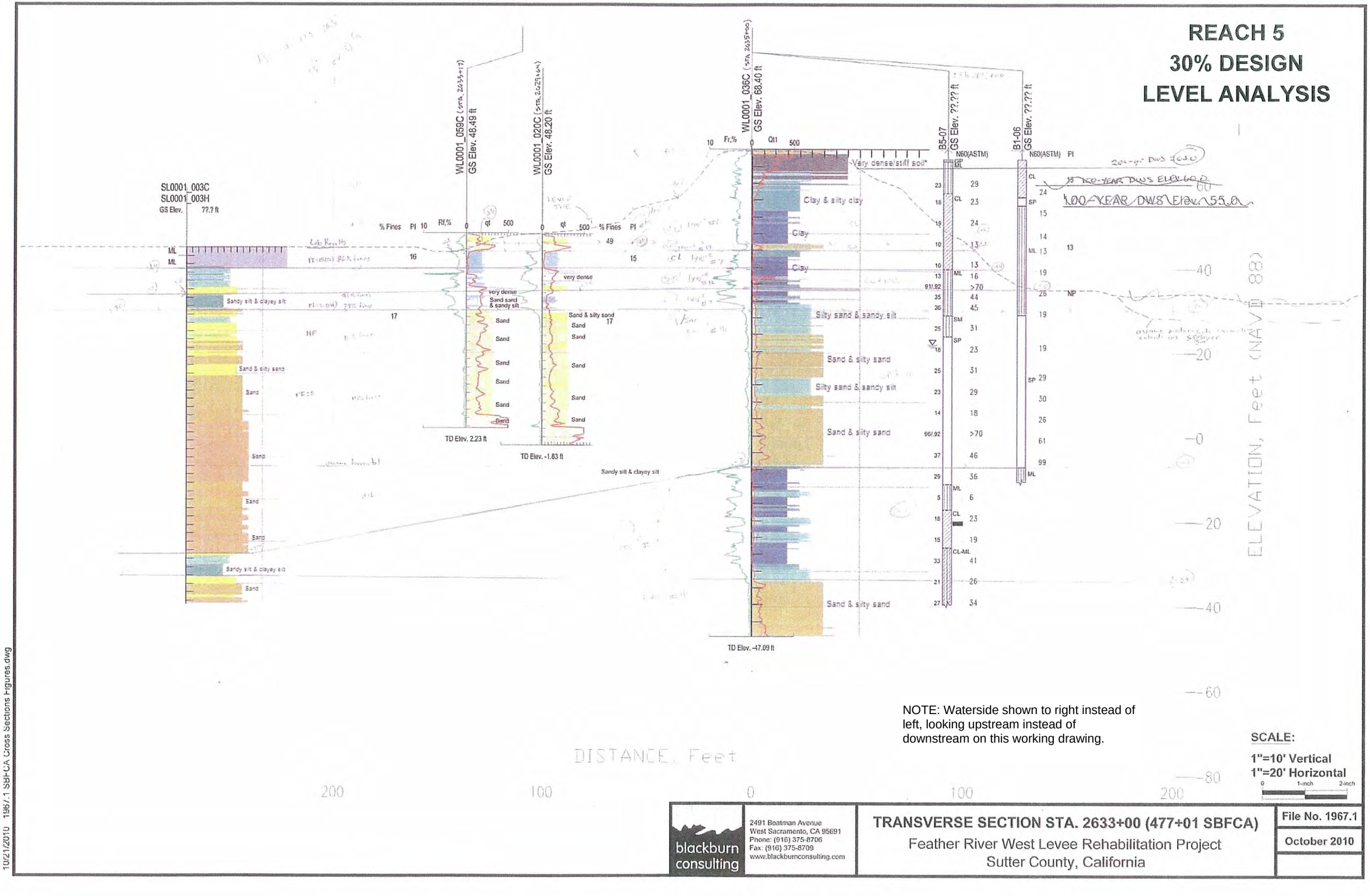
blackburn consulting
2491 Boatman Avenue
West Sacramento, CA 95691
Phone: (916) 375-8706
Fax: (916) 375-8709
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TRANSVERSE SECTION STA. 2462+50 (306+33.33 SBFCA)
Feather River West Levee Rehabilitation Project
Sutter County, California

File No. 1967.1
October 2010

10/21/2010 1967.1 SBFCA Cross Sections Figures.dwg

REACH 5
30% DESIGN
LEVEL ANALYSIS



NOTE: Waterside shown to right instead of left, looking upstream instead of downstream on this working drawing.

SCALE:
1"=10' Vertical
1"=20' Horizontal

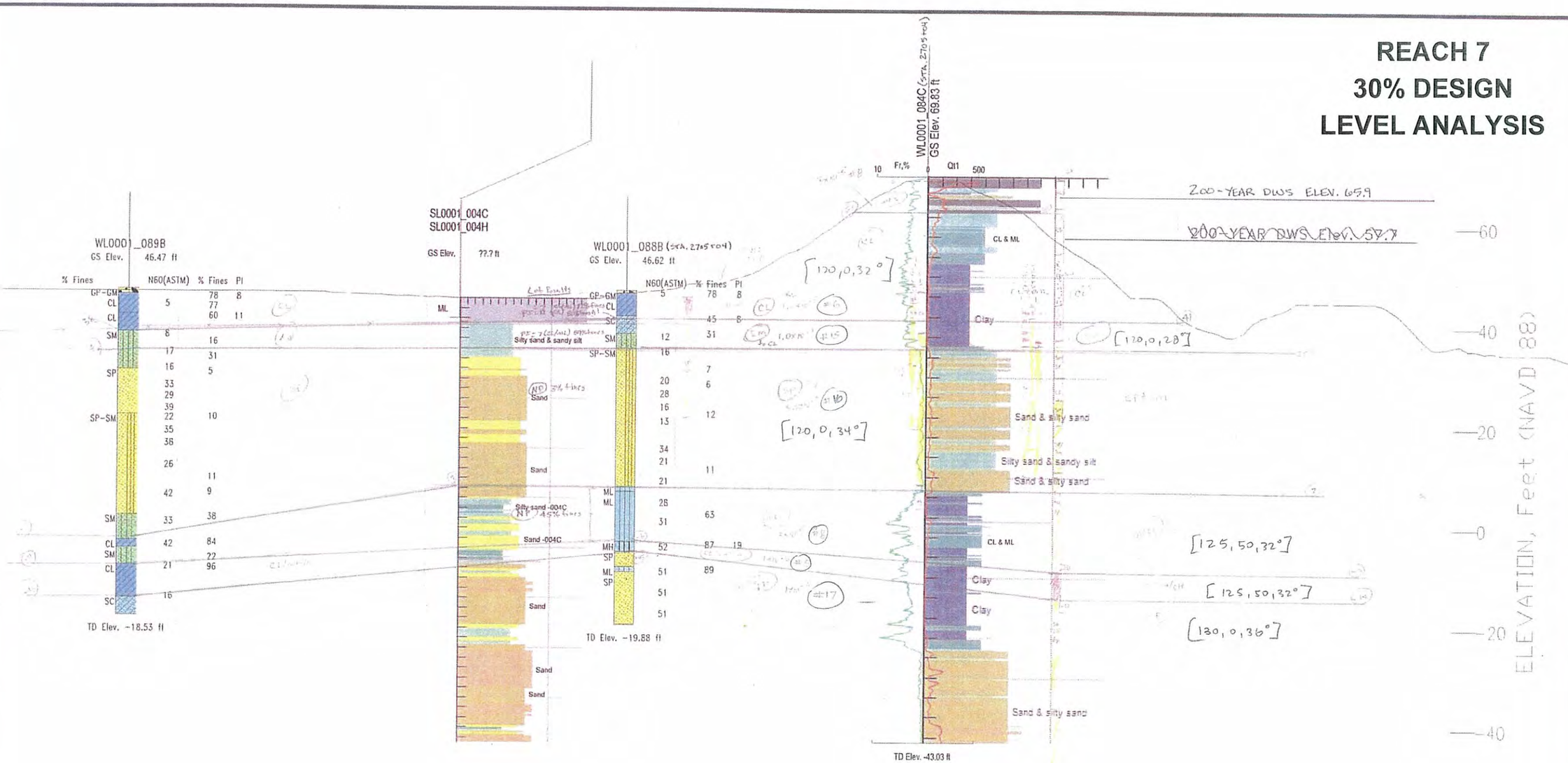
10/21/2010 1967.1 SBFCA Cross Sections Figures.dwg

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Fax: (916) 375-8709
www.blackburnconsulting.com

TRANSVERSE SECTION STA. 2633+00 (477+01 SBFCA)
Feather River West Levee Rehabilitation Project
Sutter County, California

File No. 1967.1
October 2010

REACH 7
30% DESIGN
LEVEL ANALYSIS



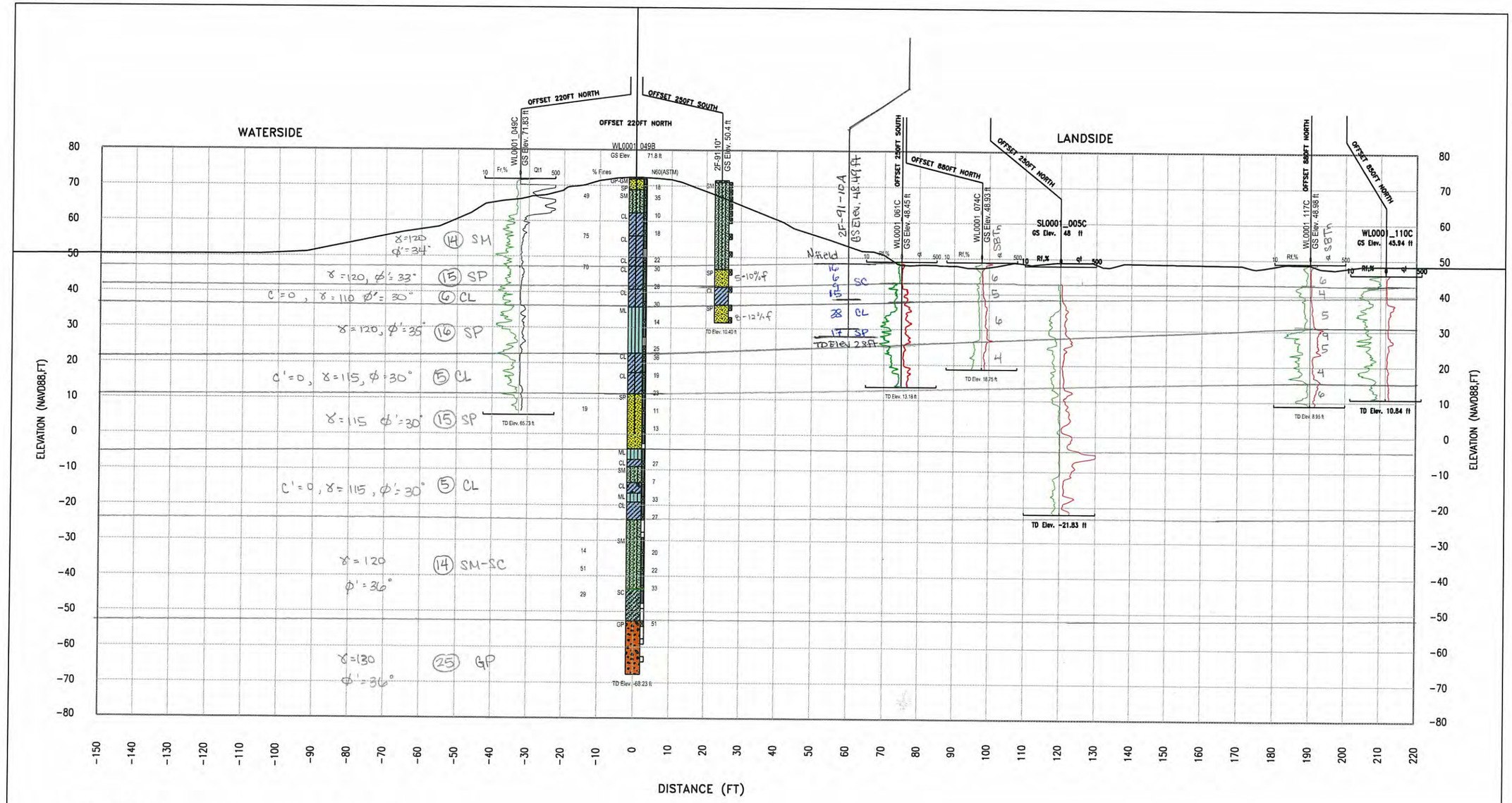
NOTE: Waterside shown to right instead of left, looking upstream instead of downstream on this working drawing.

SCALE:
1"=10' Vertical
1"=20' Horizontal
0 1-inch 2-inch

blackburn consulting
2491 Boatman Avenue
West Sacramento, CA 95691
Phone: (916) 375-8706
Fax: (916) 375-8709
www.blackburnconsulting.com

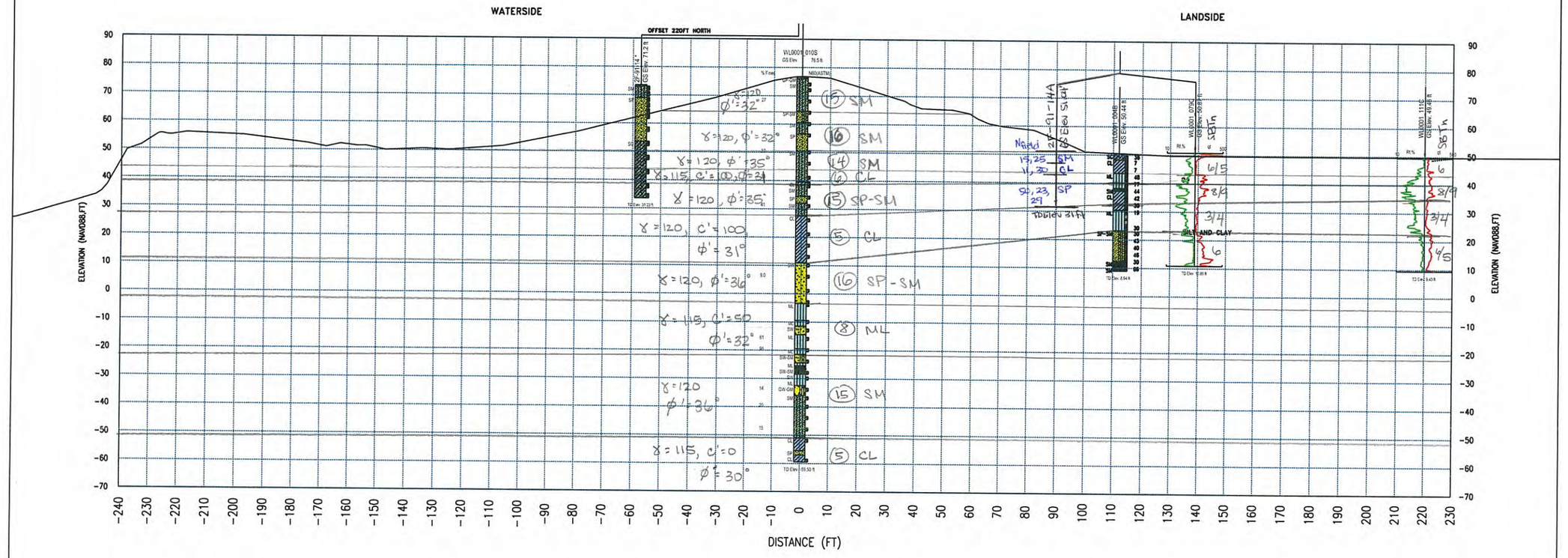
TRANSVERSE SECTION STA. 2705+00 (539+30.30 SBFCA)
Feather River West Levee Rehabilitation Project
Sutter County, California

File No. 1967.1
October 2010



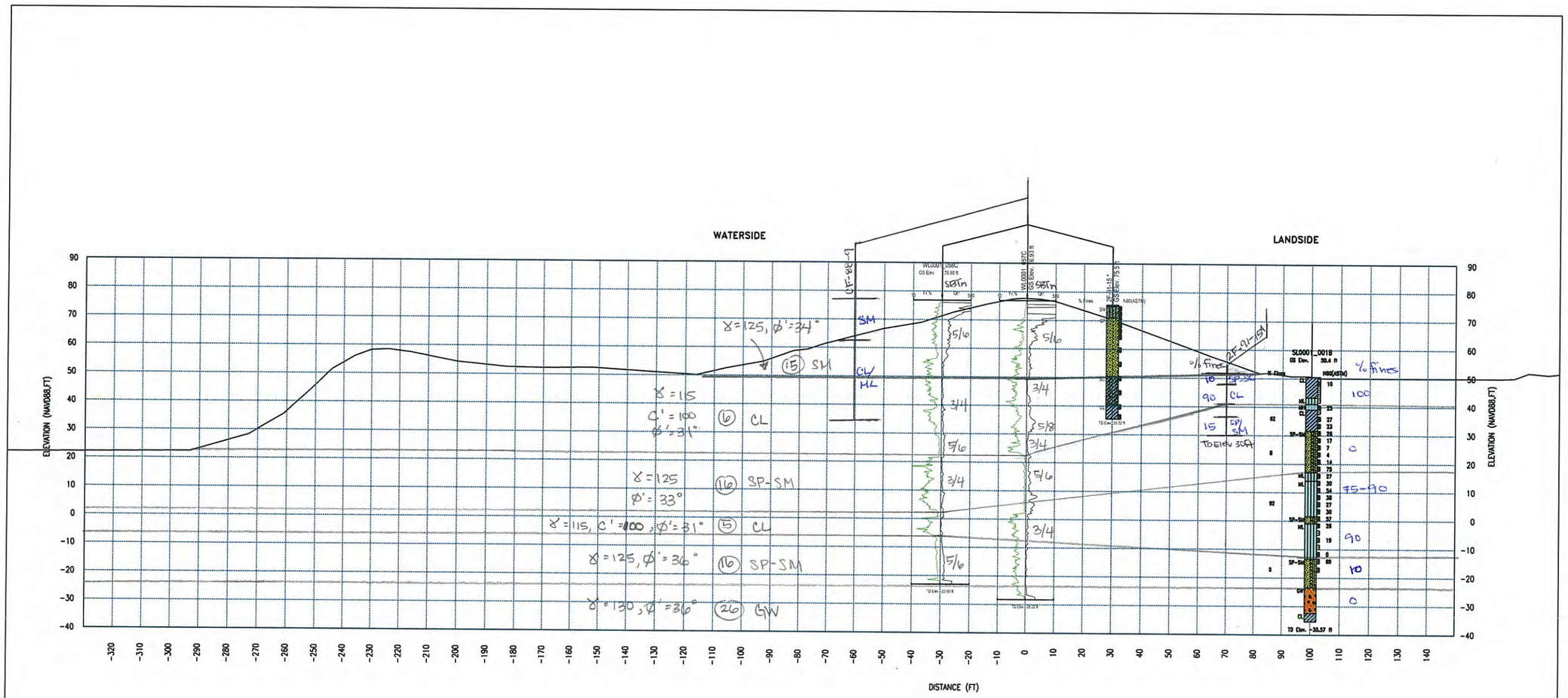
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2.

		FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 623+86 Reach 08	SCALE 1"=30'



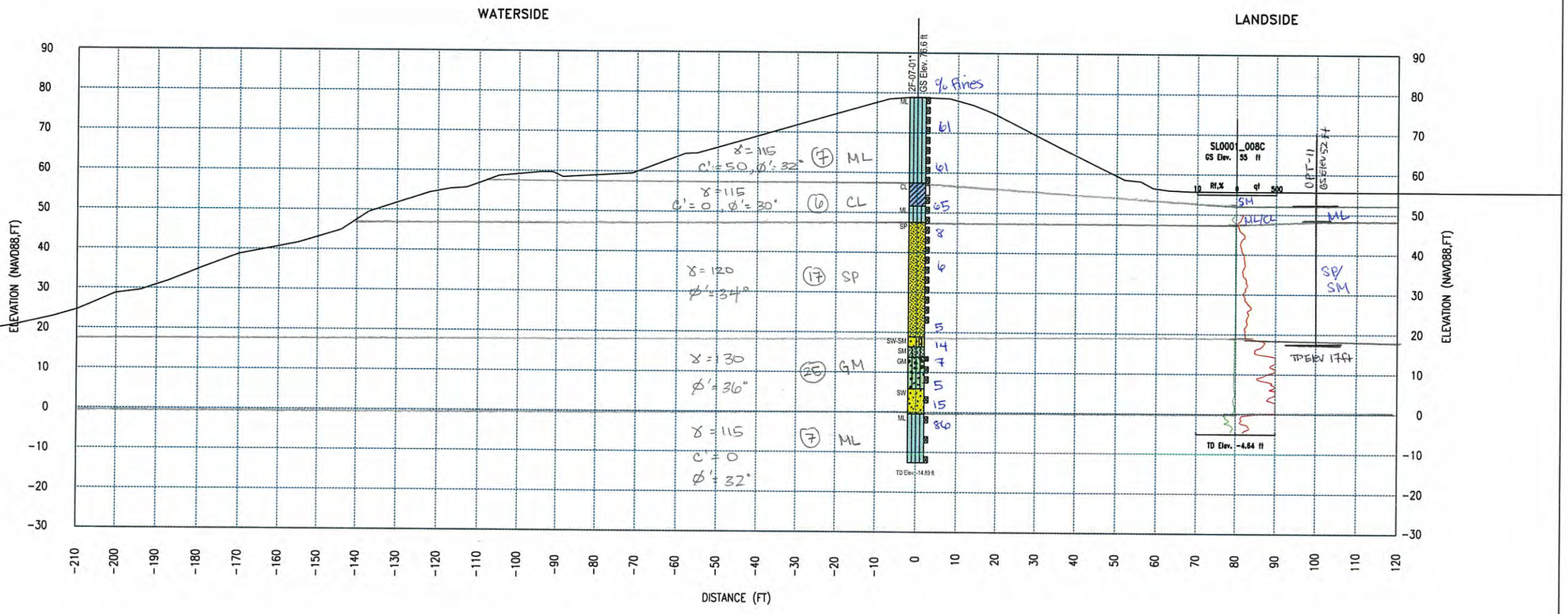
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 705+84 Reach 09	SCALE 1"=40'



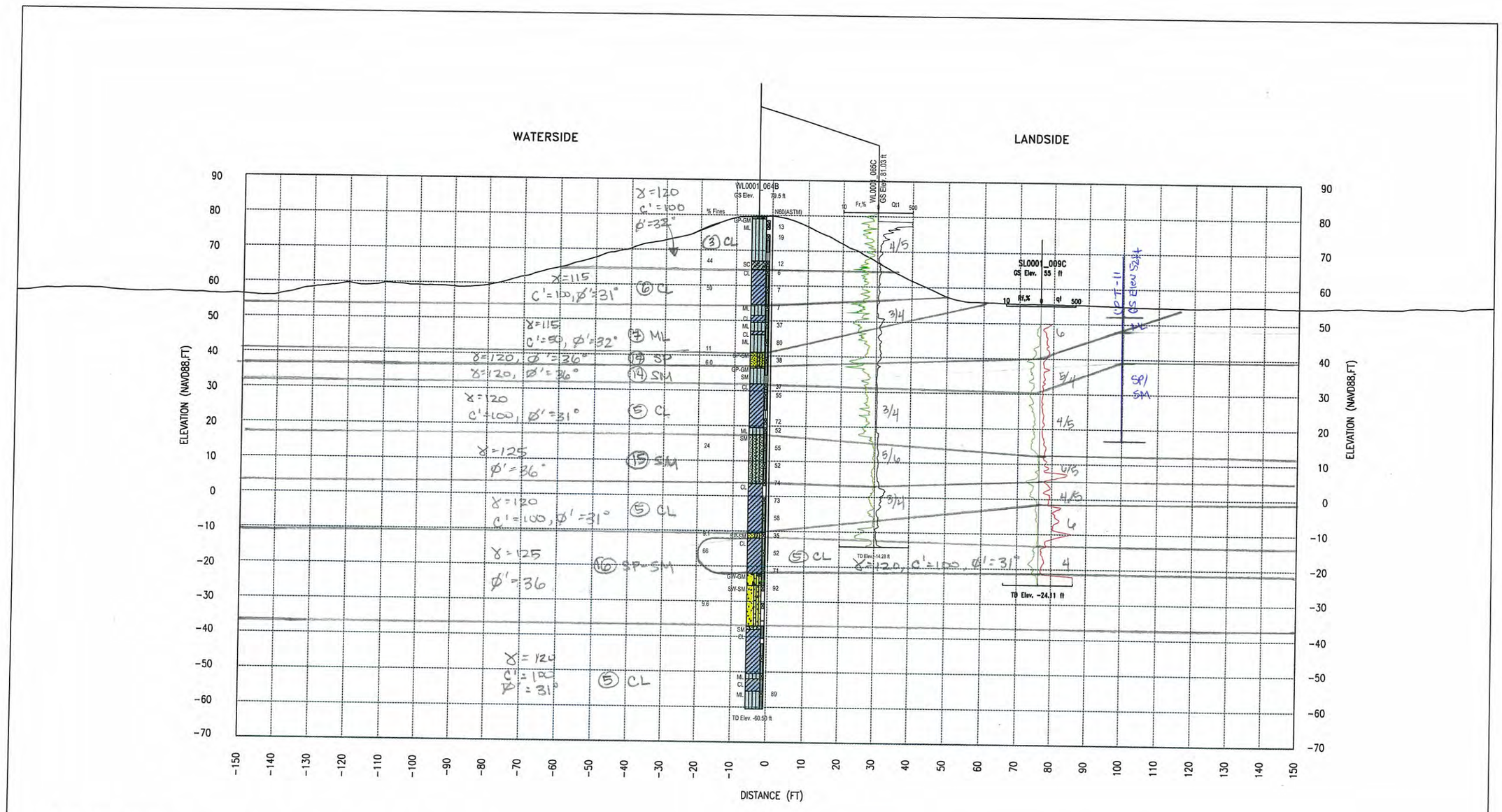
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 733+84 Reach 10	SCALE 1"=40'



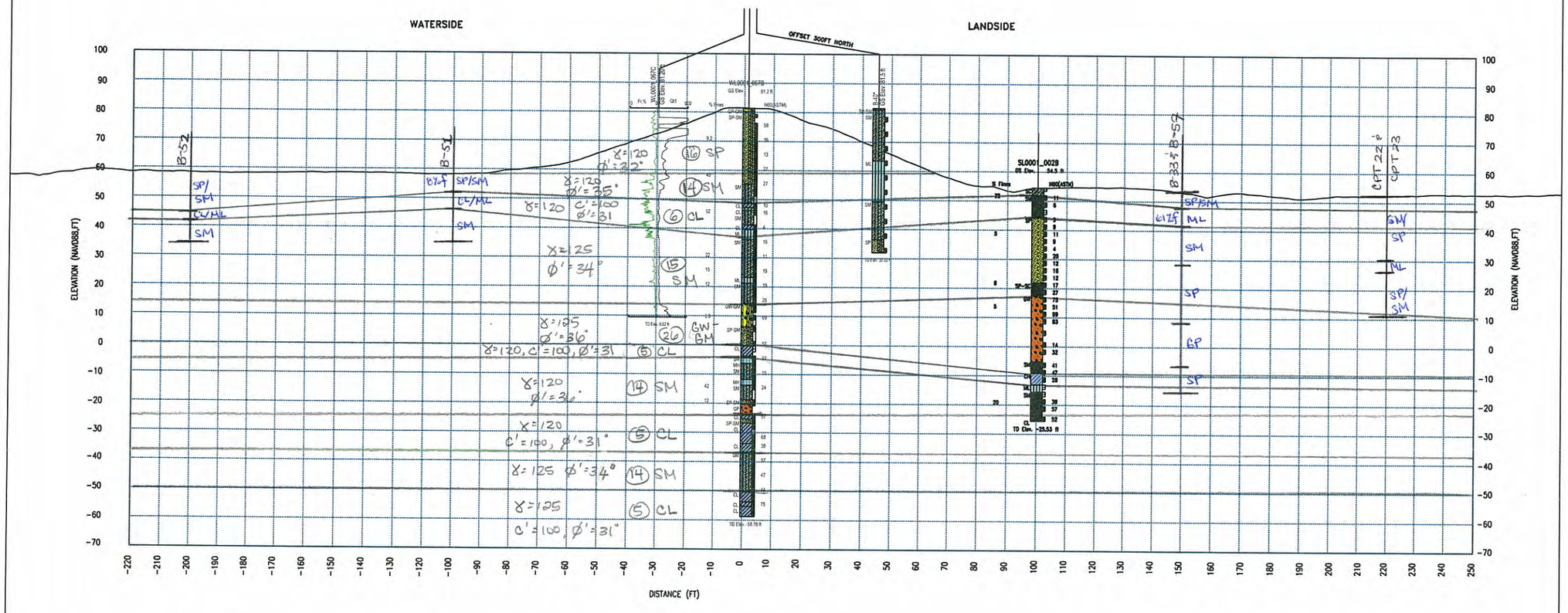
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 808+85 Reach 11	SCALE 1"=30'



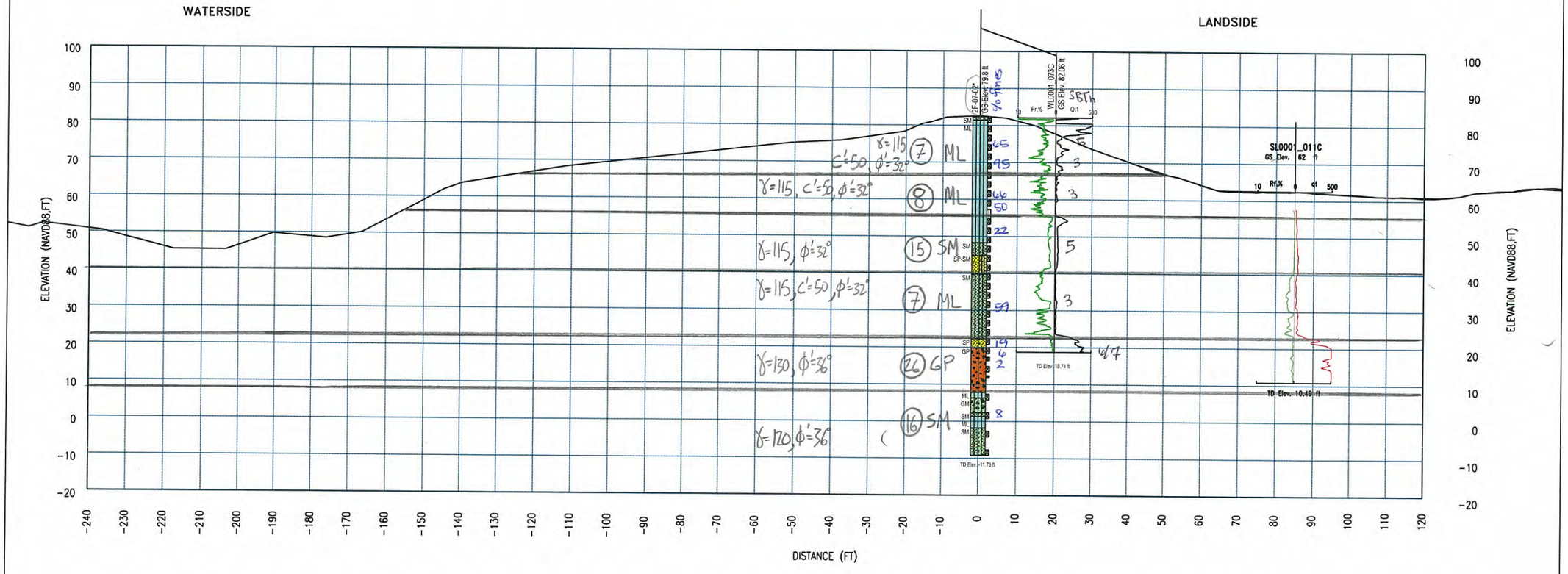
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 830+59 Reach 12	SCALE 1"=30'



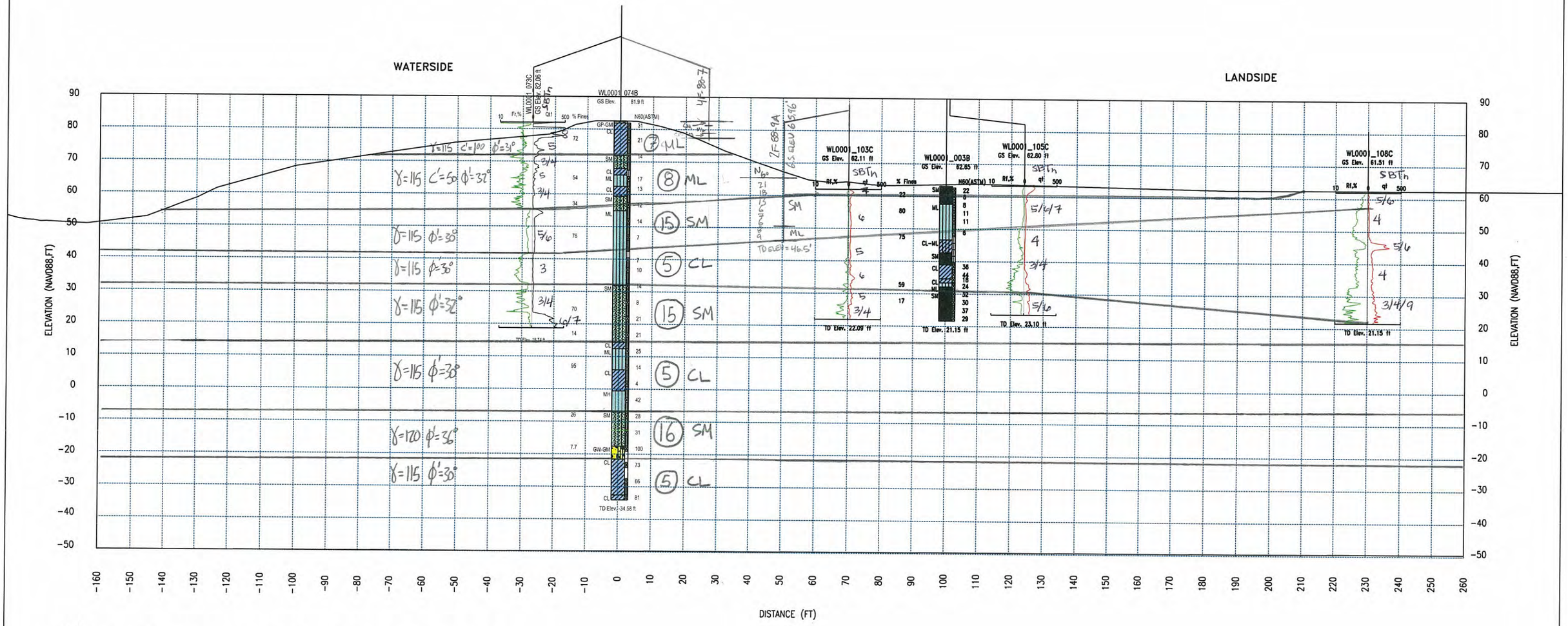
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

SUTTER BUTTE FLOOD CONTROL AGENCY	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 861+33 Reach 13	SCALE 1"=40'



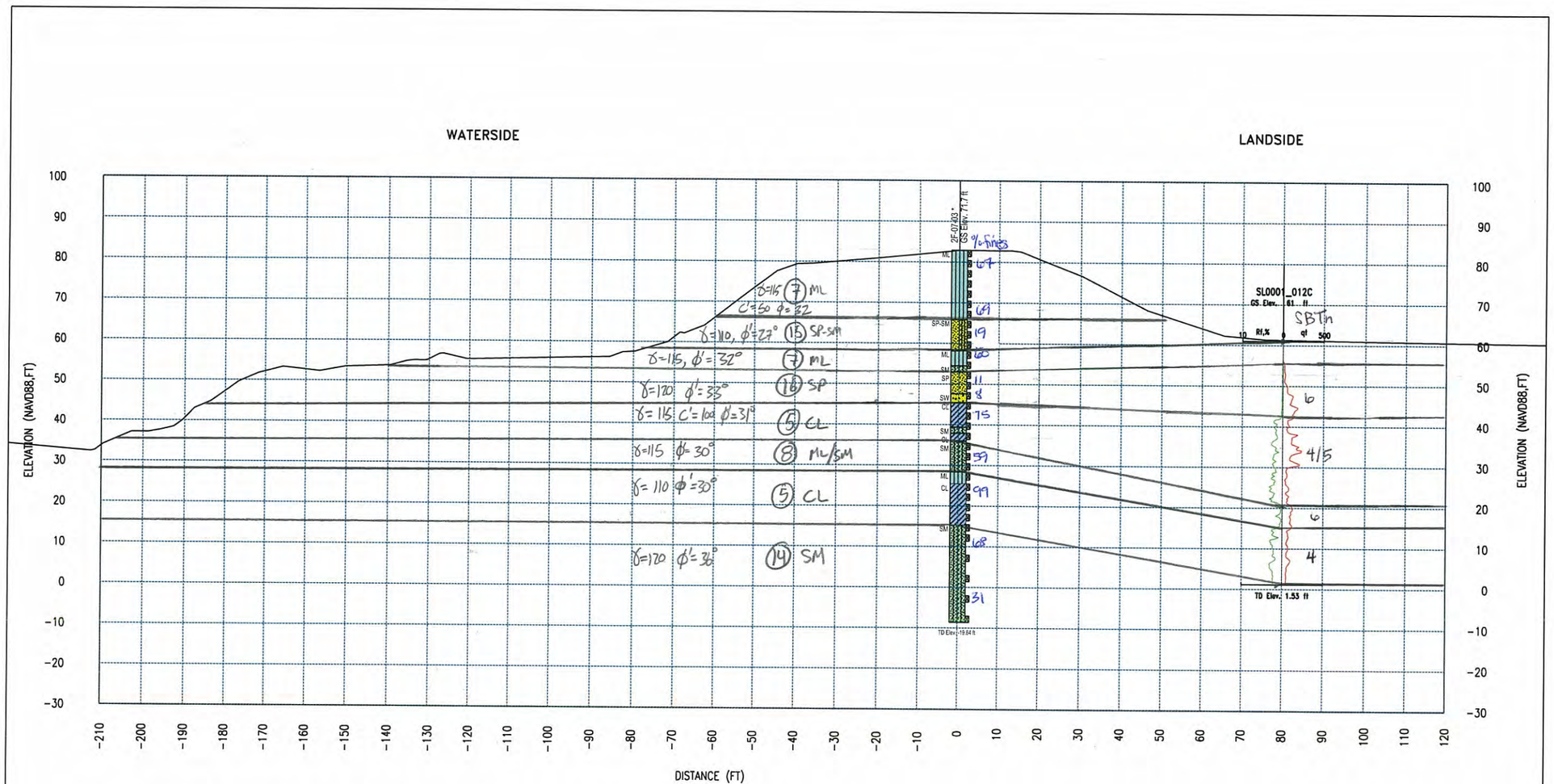
NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

SUTTER BUTTE FLOOD CONTROL AGENCY	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 939+33 Reach 14	SCALE 1"=30'



NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

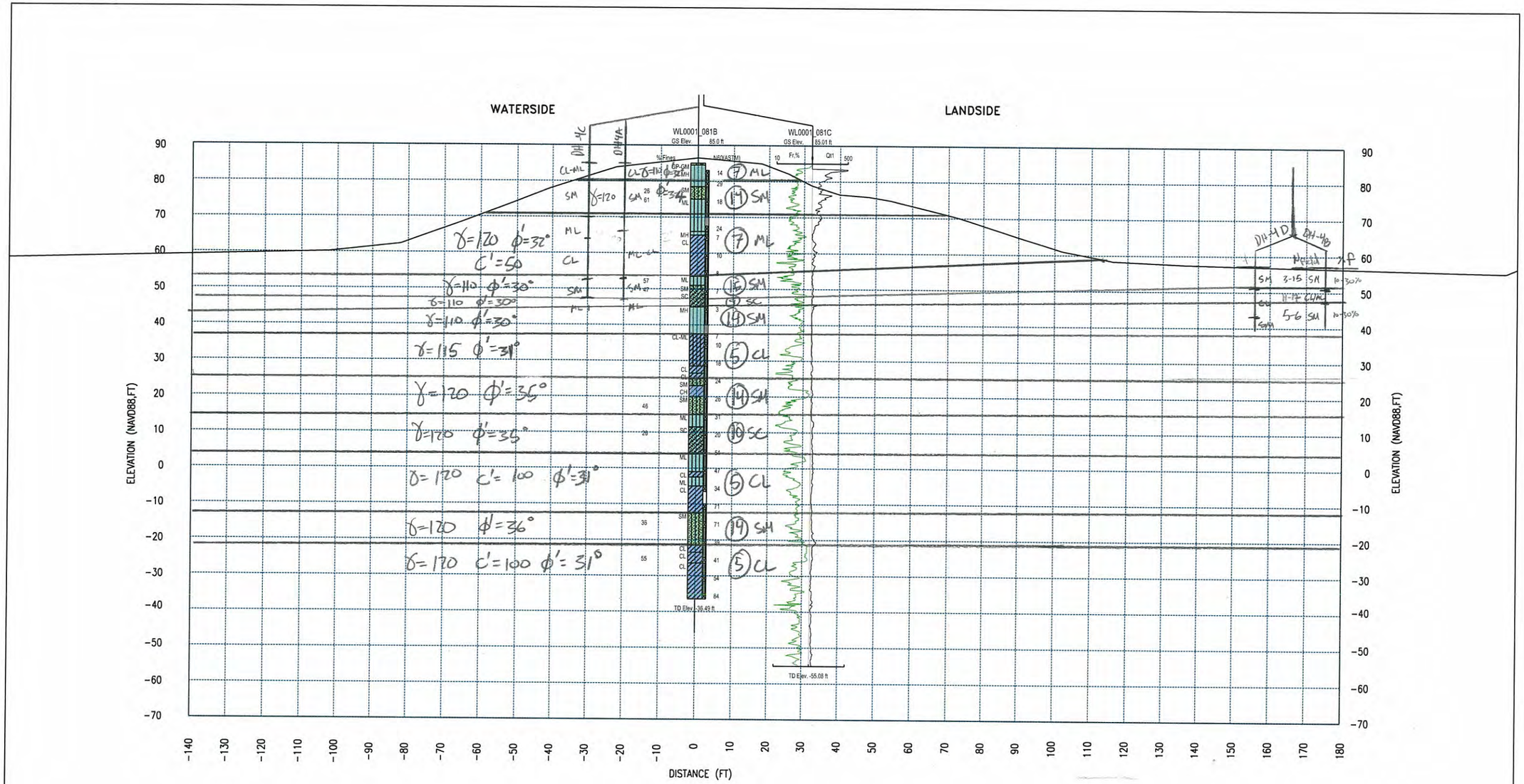
SUTTER BUTTE FLOOD CONTROL AGENCY	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 958+83 Reach 15	SCALE 1"=30'



Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

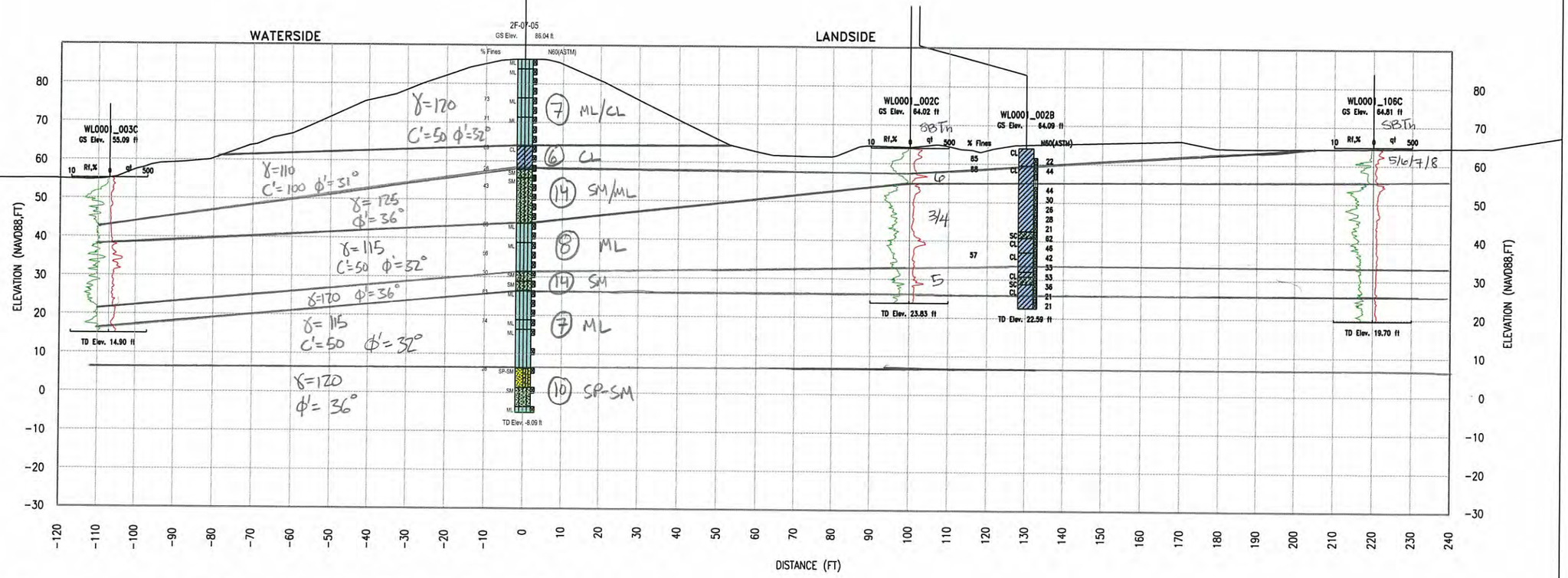
	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 993+80 Reach 16	SCALE 1"=30'

URS blackburn consulting



Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

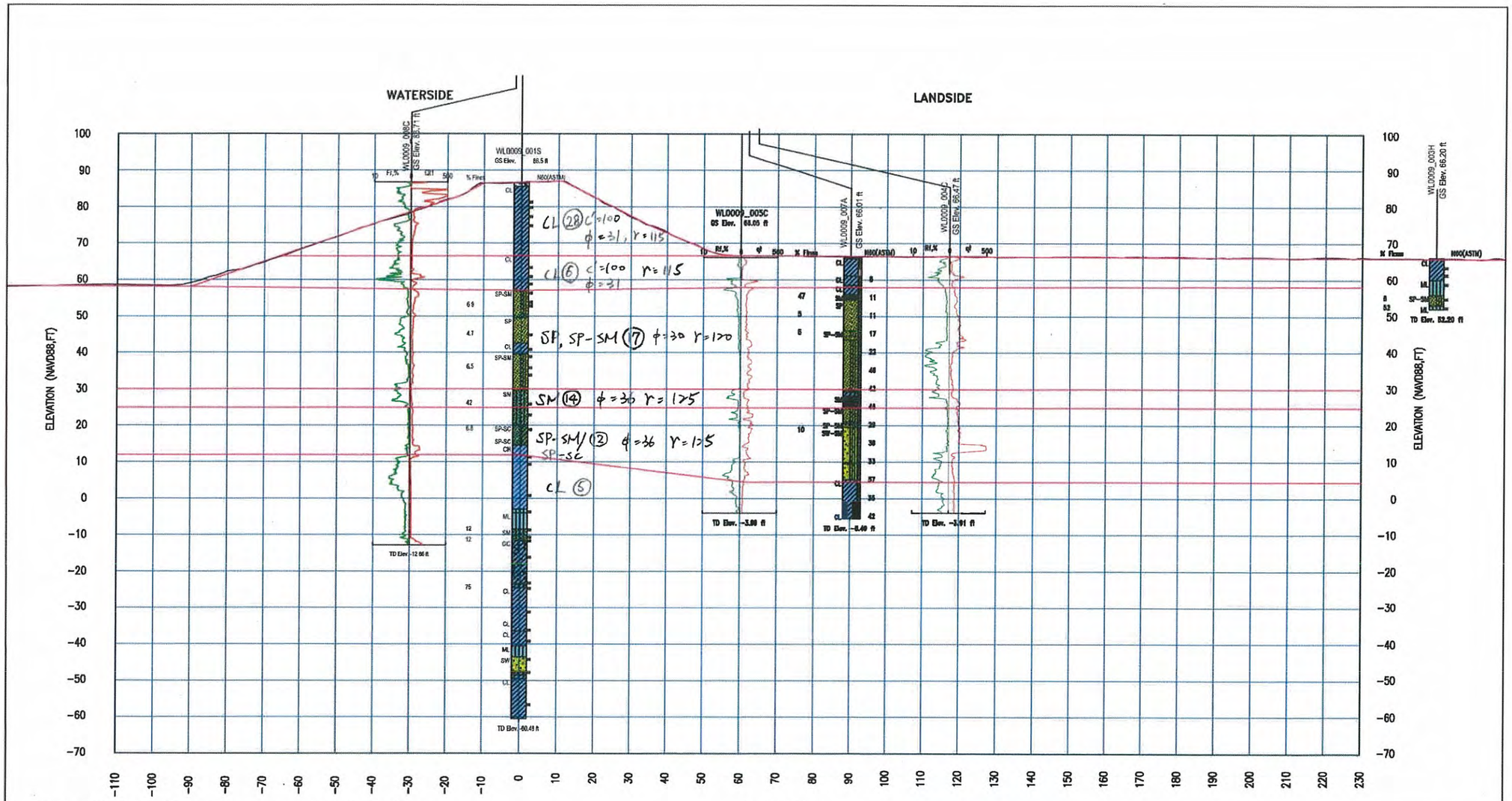
	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 1043+88 Reach 16	SCALE 1"=30'



NOTE! MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

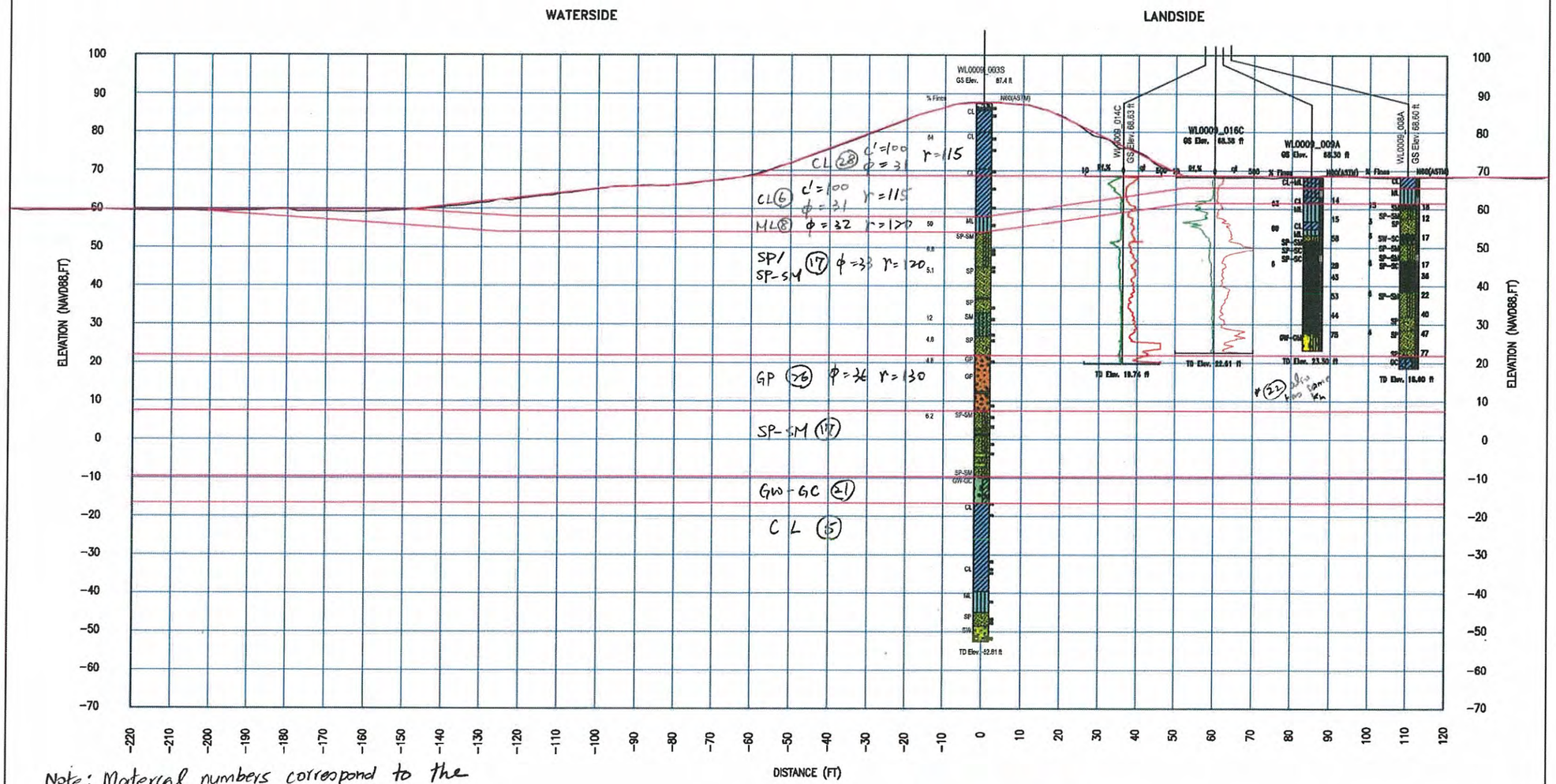
	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 1108+86 Reach 17	SCALE 1"=30'

URS blackburn consulting



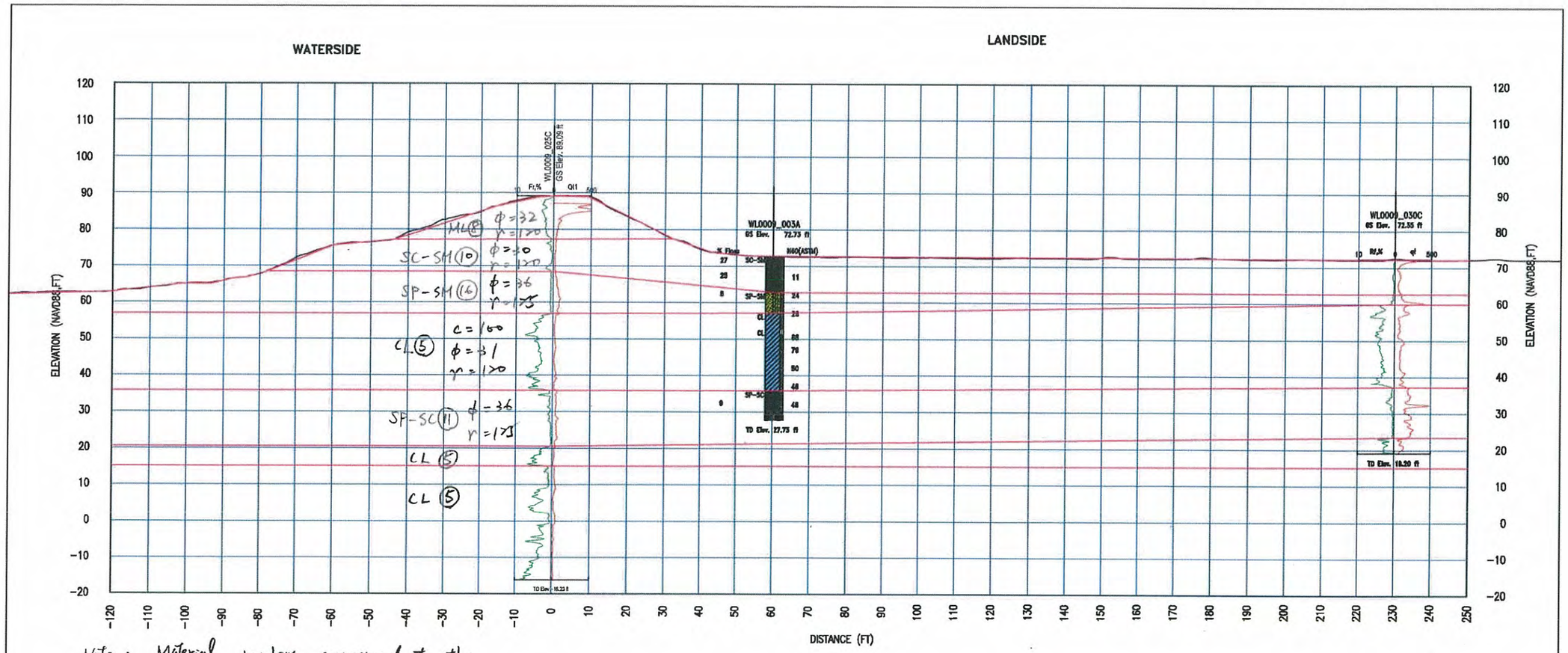
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 1138+86 Reach 18	SCALE 1"=30'



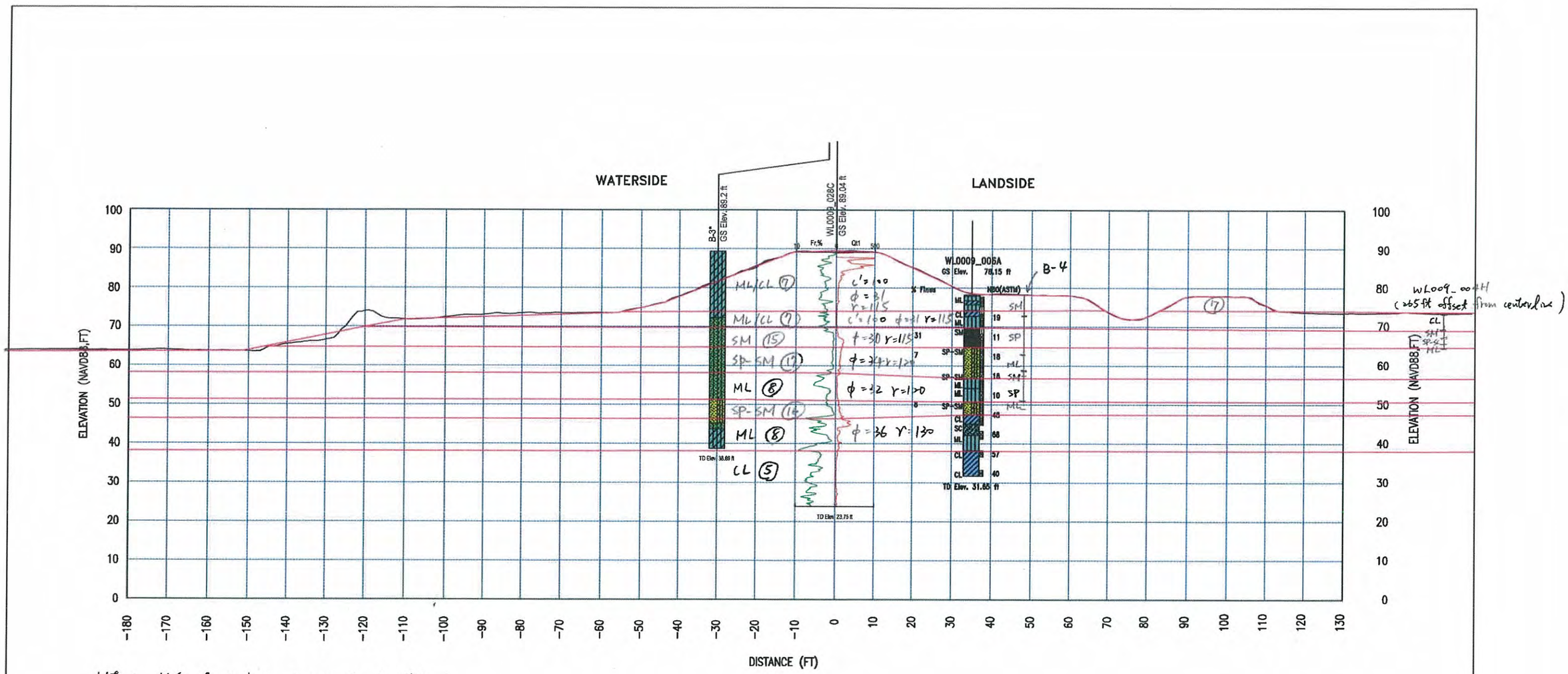
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17320463 Task Order 1	Transverse Section 1238+85 Reach 19	SCALE 1"=30'



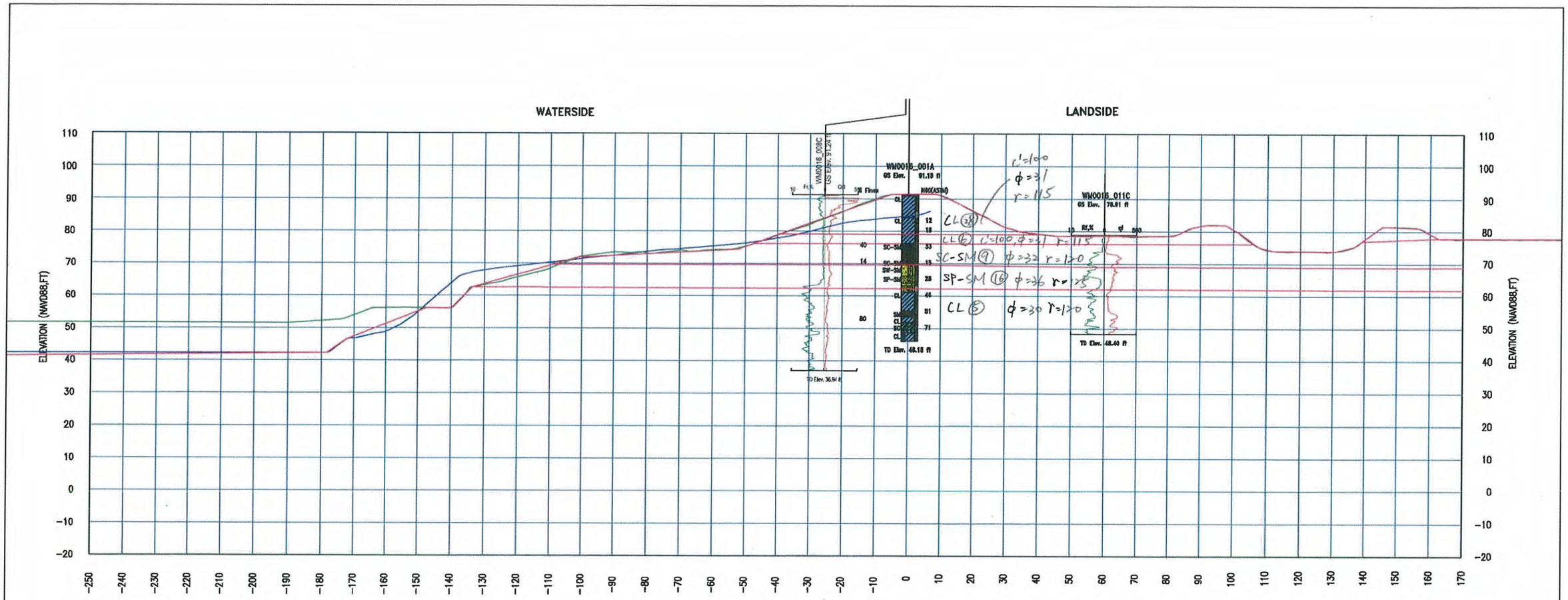
Note : Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1338+83 Reach 20	SCALE 1"=30'



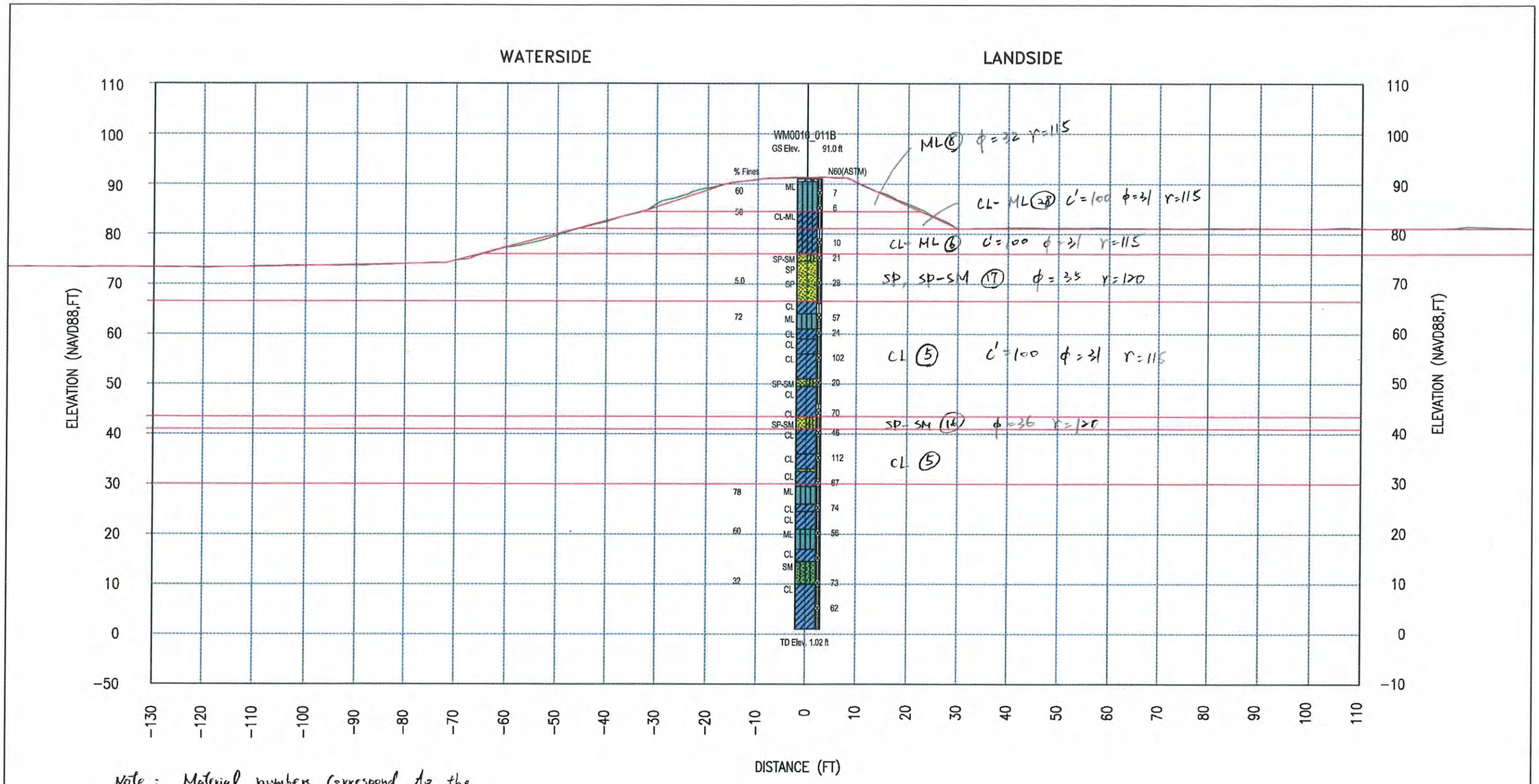
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1378+83 Reach 21	SCALE 1"=25'



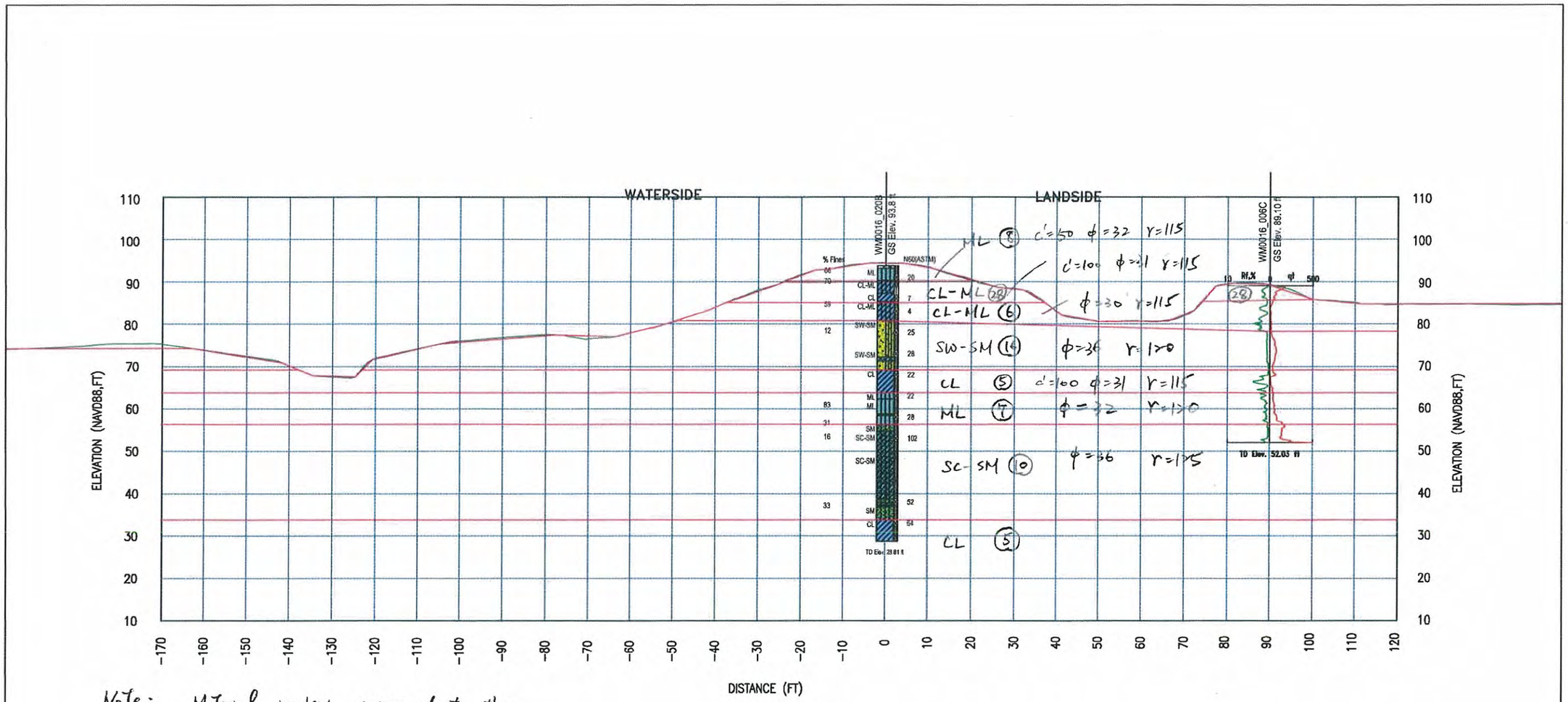
Note : Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1468+83 Reach 22	SCALE 1"=30'



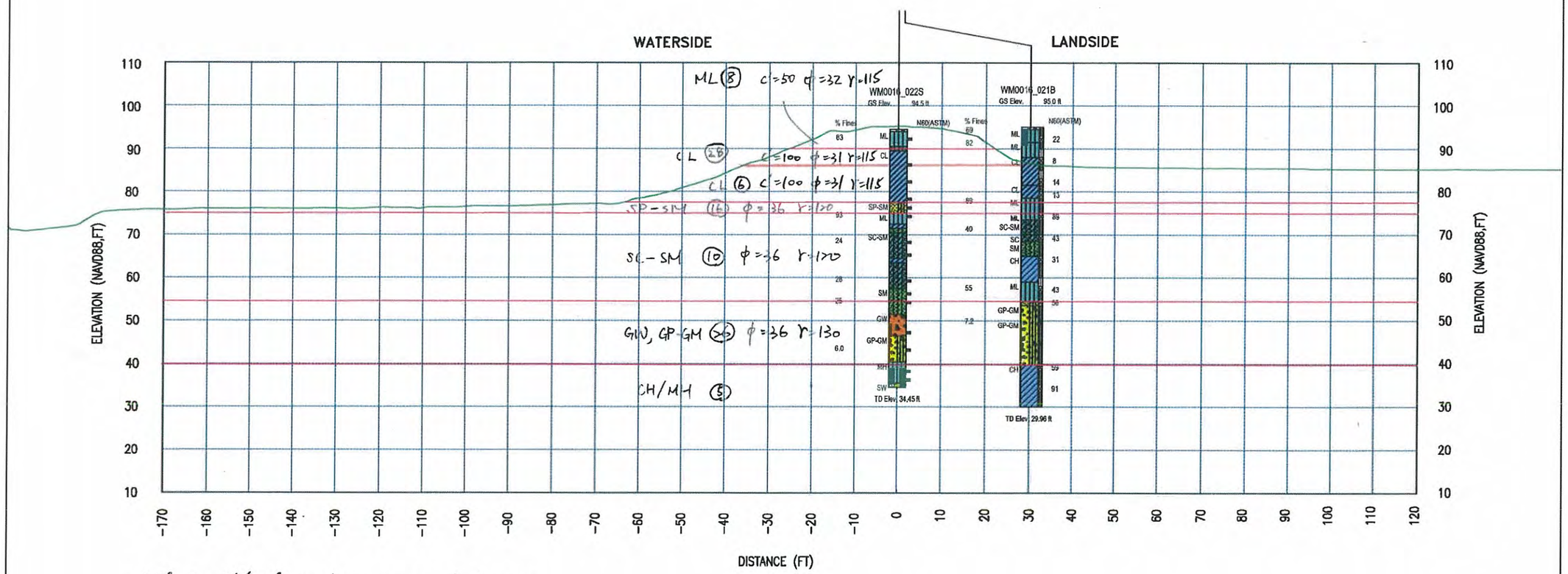
Note : Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1508+33 Reach 23	SCALE 1"=20'



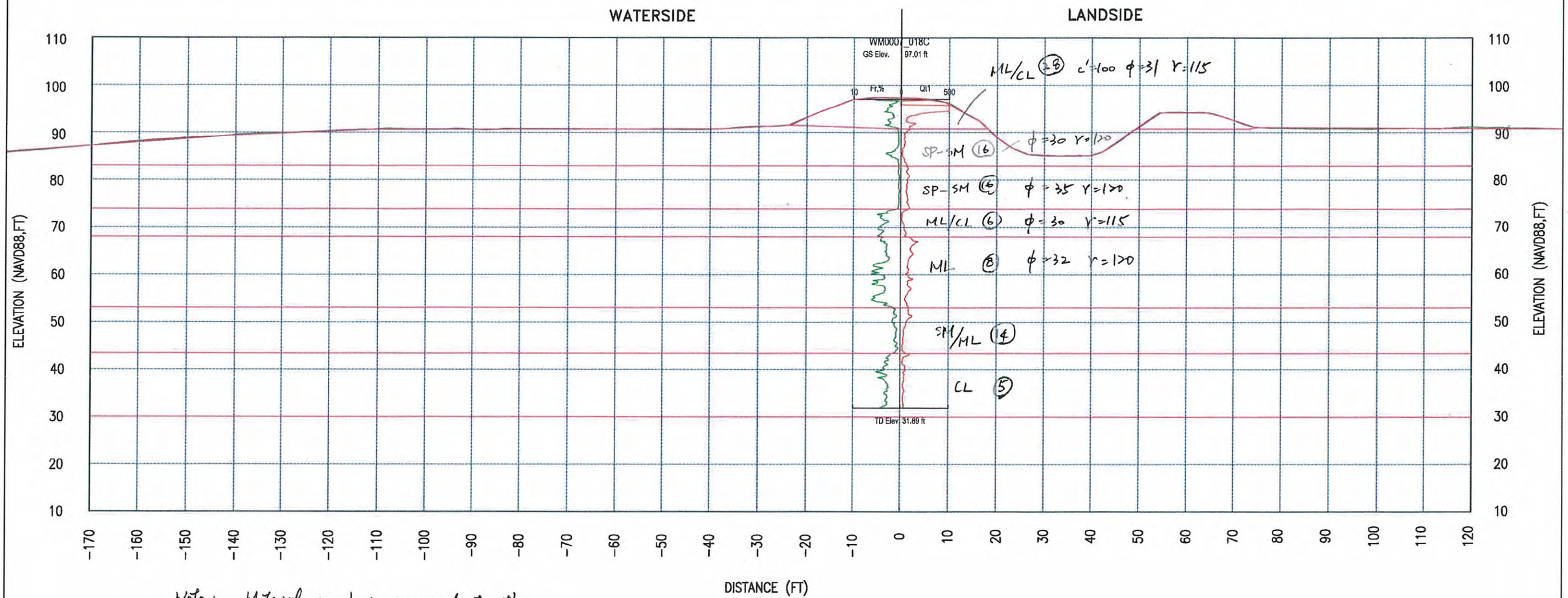
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1615+62 Reach 24	SCALE 1"=25'



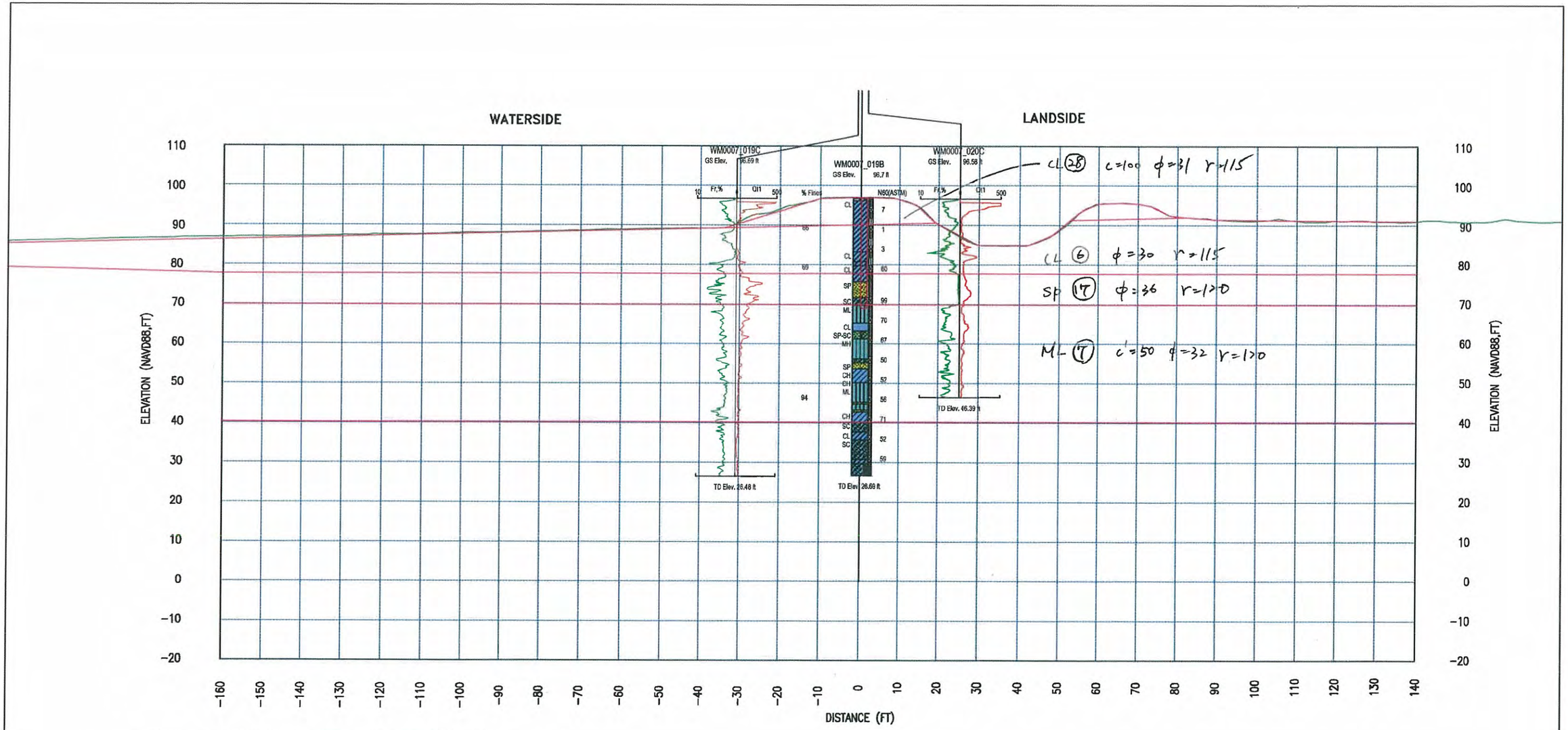
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

URS	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1645+86 Reach 25	SCALE 1"=25'



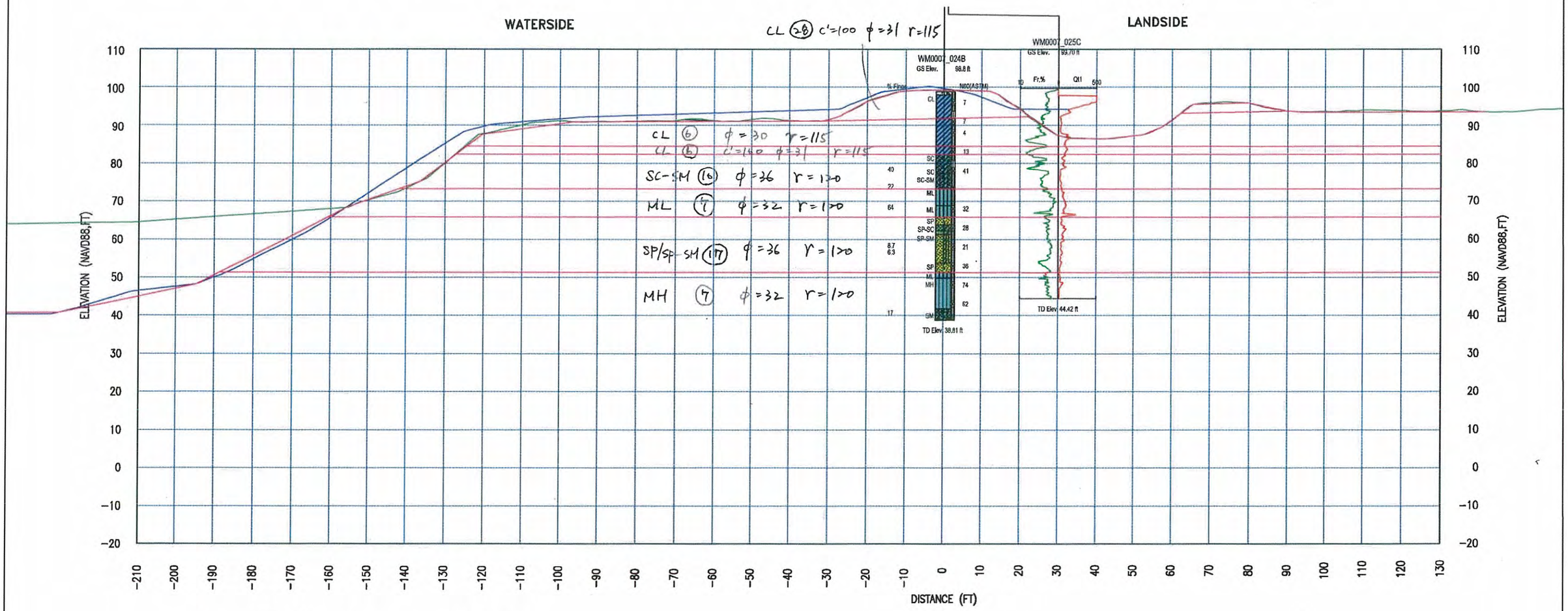
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1698+85 Reach 26	SCALE 1"=20'



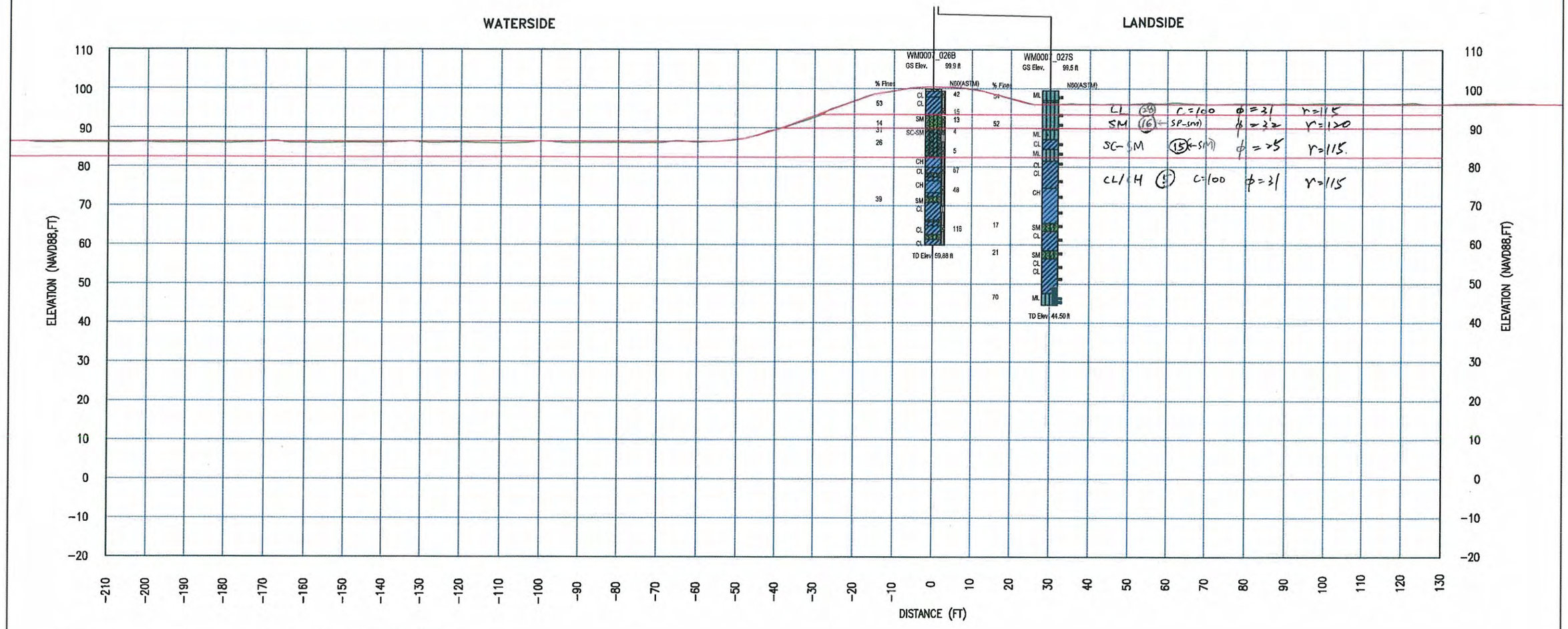
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17328483 Task Order 1	Transverse Section 1708+87 Reach 27	SCALE 1"=30'



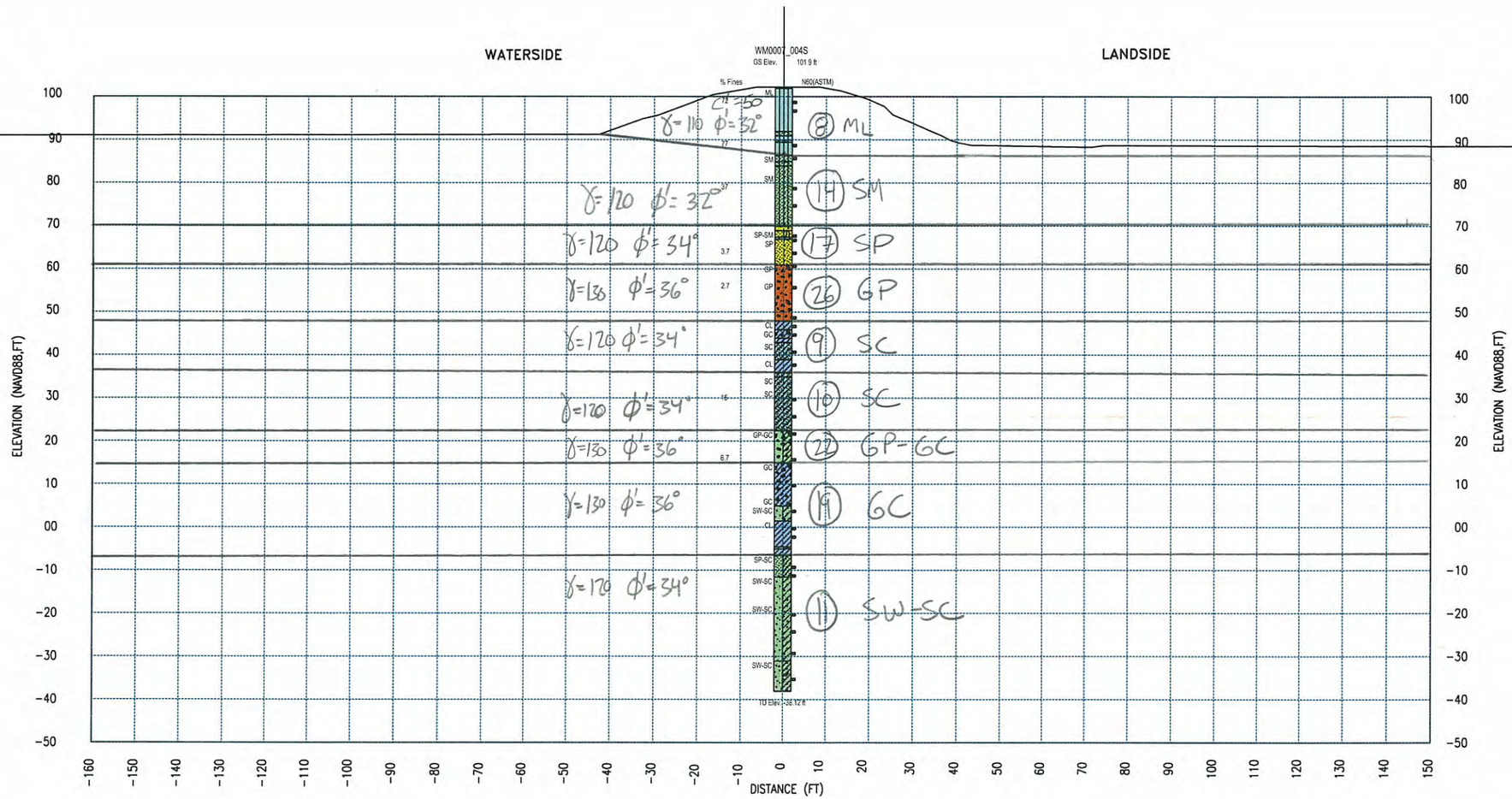
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	URS	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1760+87 Reach 28	SCALE 1"=25'



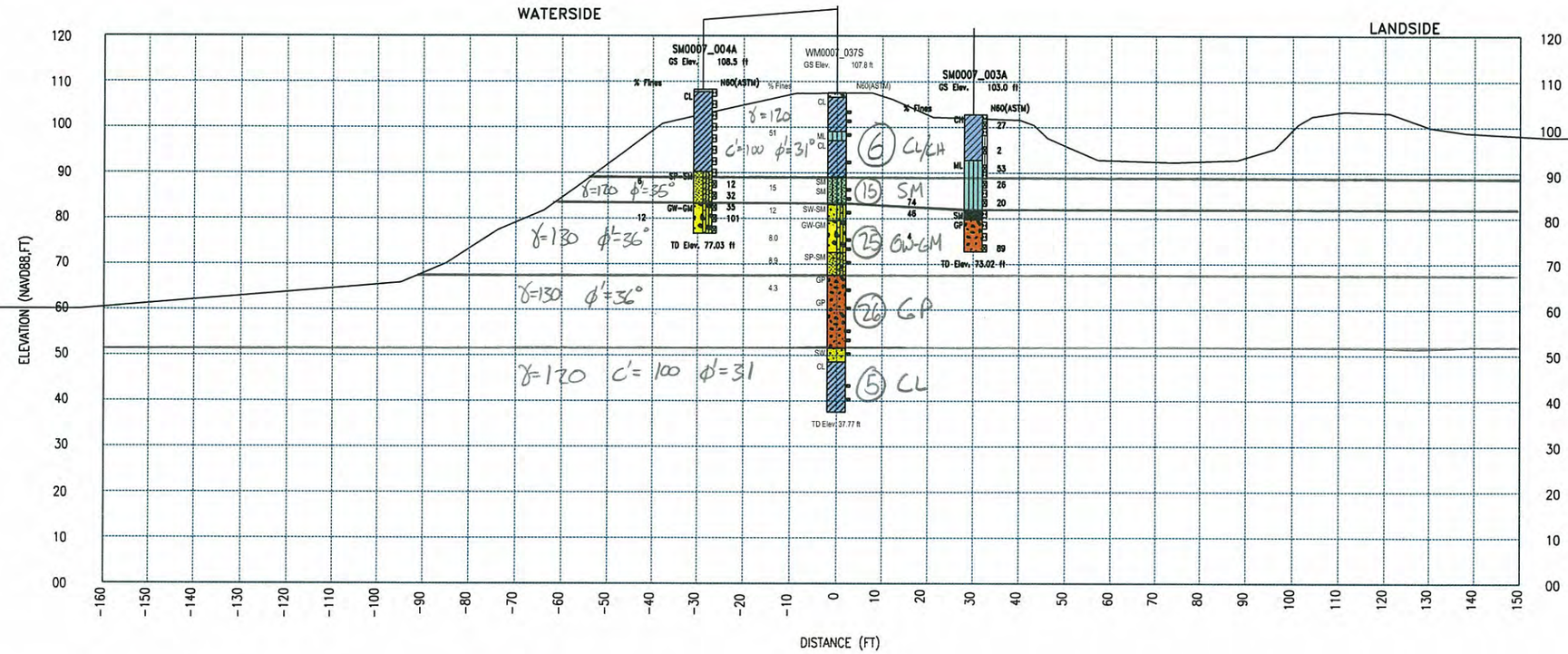
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1788+81 Reach 29	SCALE 1"=25'



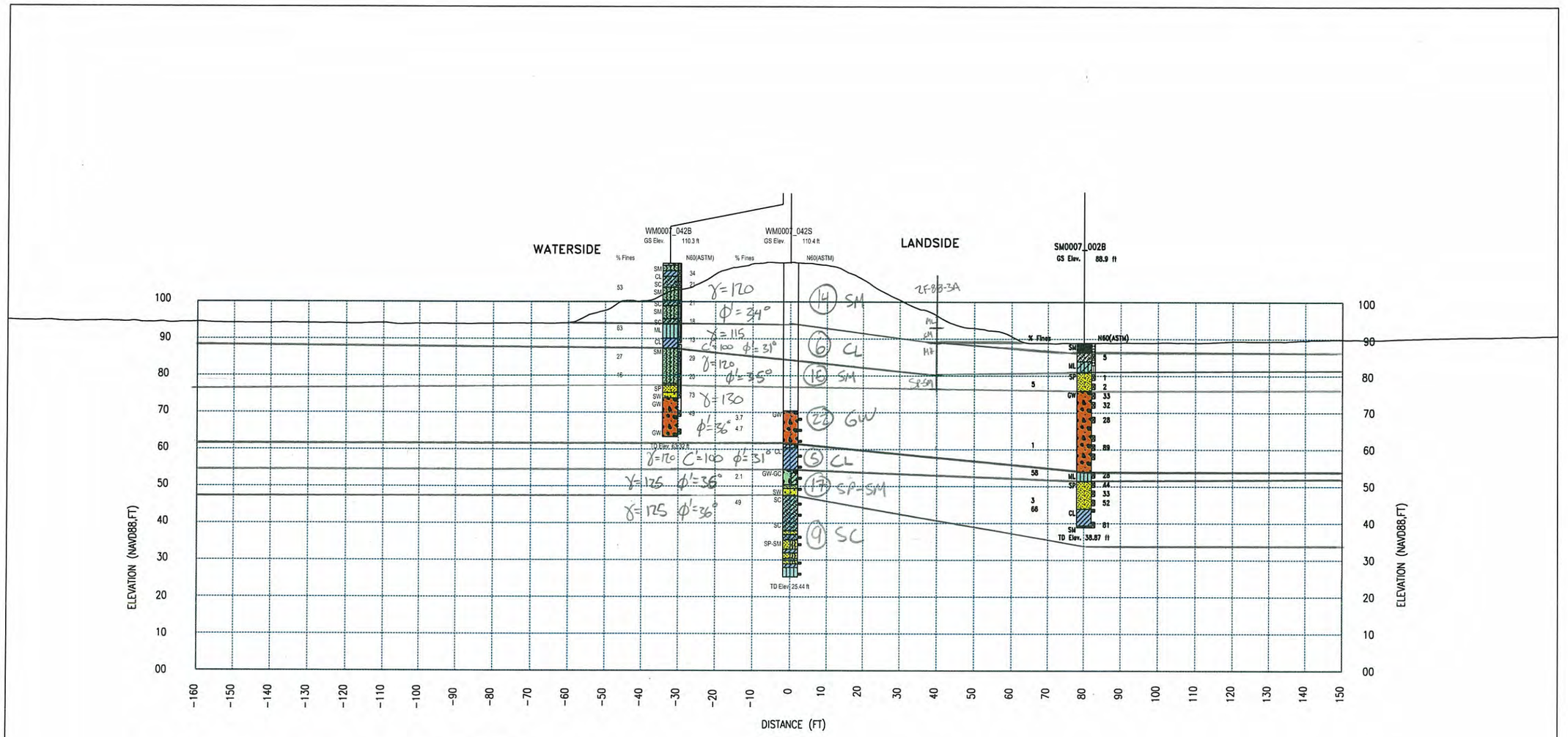
NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

		FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section Station 1826+94 Reach 30	SCALE 1"=30'



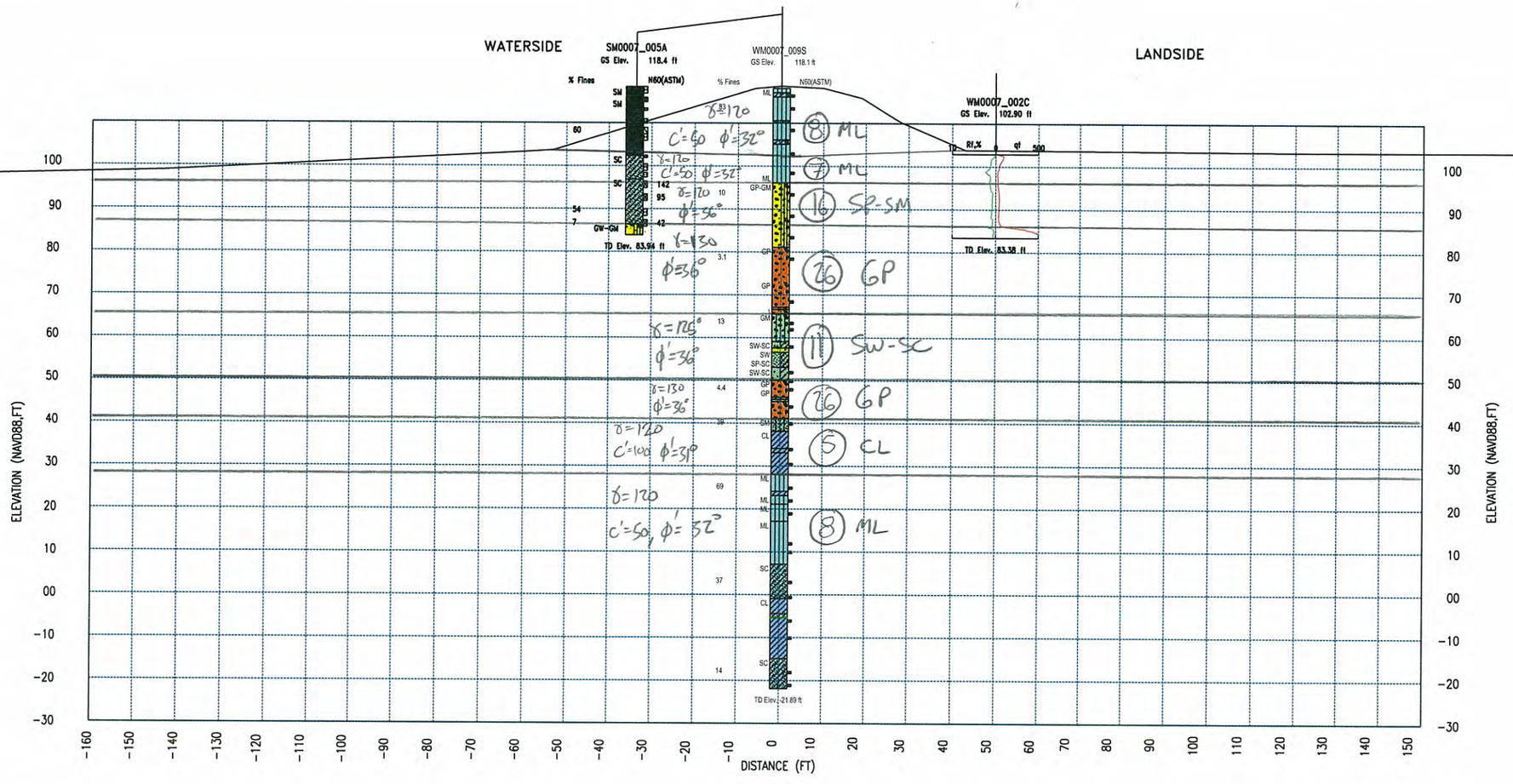
NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

SUTTER BUTTE FLOOD CONTROL AGENCY	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1907+91 Reach 31	SCALE 1"=30'



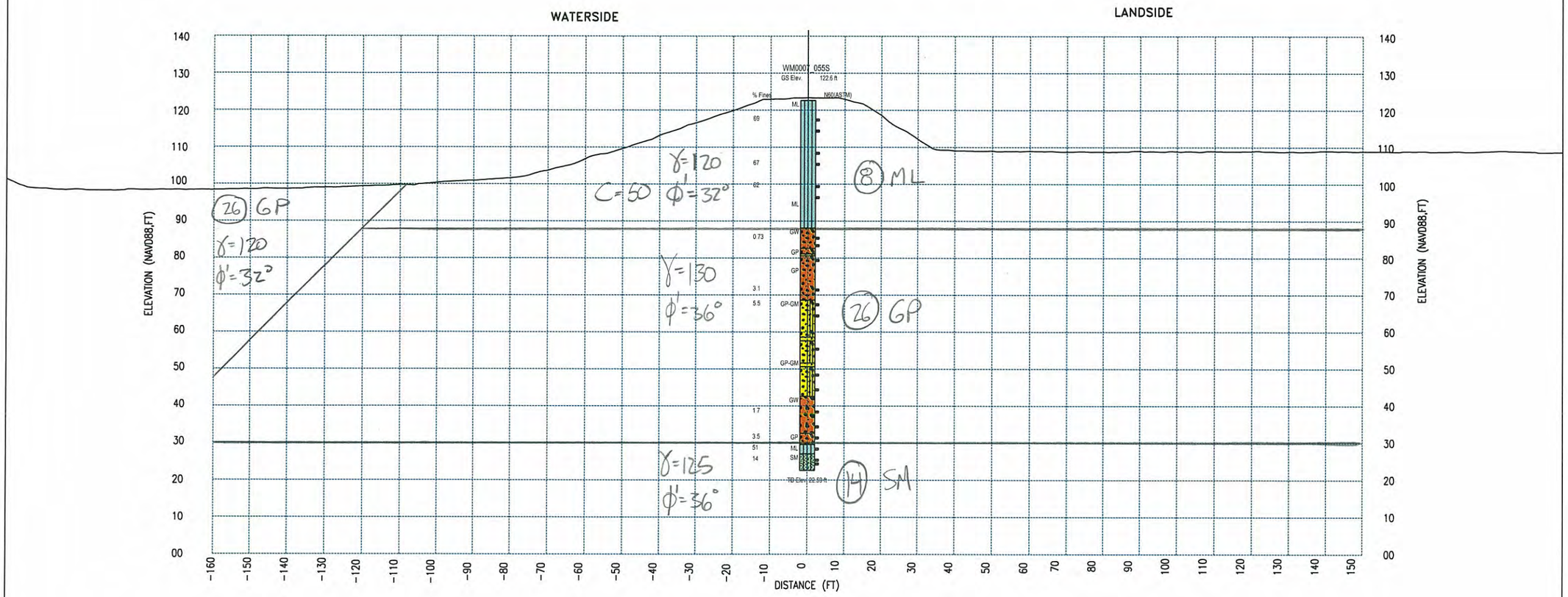
NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 1965+80 Reach 32	SCALE 1"=30'



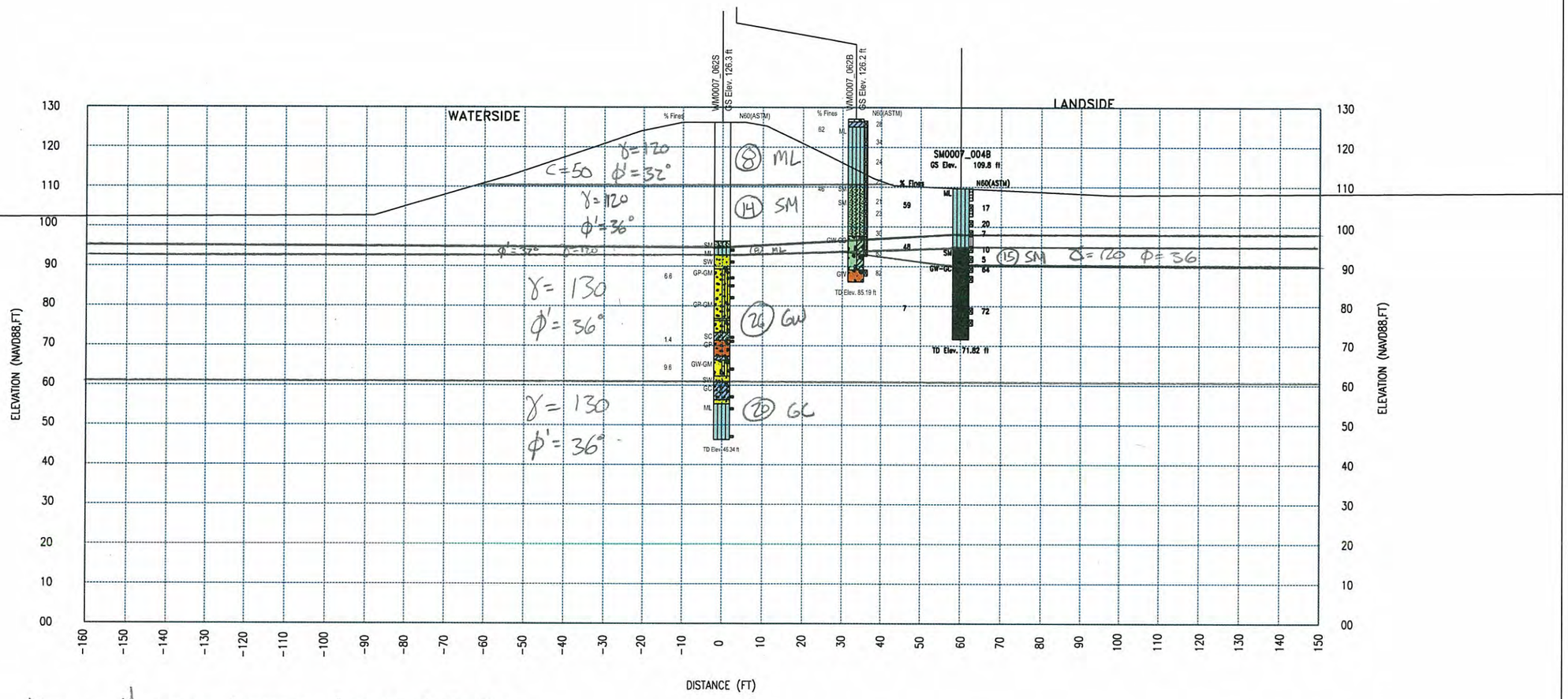
NOTE! MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 2076+90 Reach 33	SCALE 1"=30'



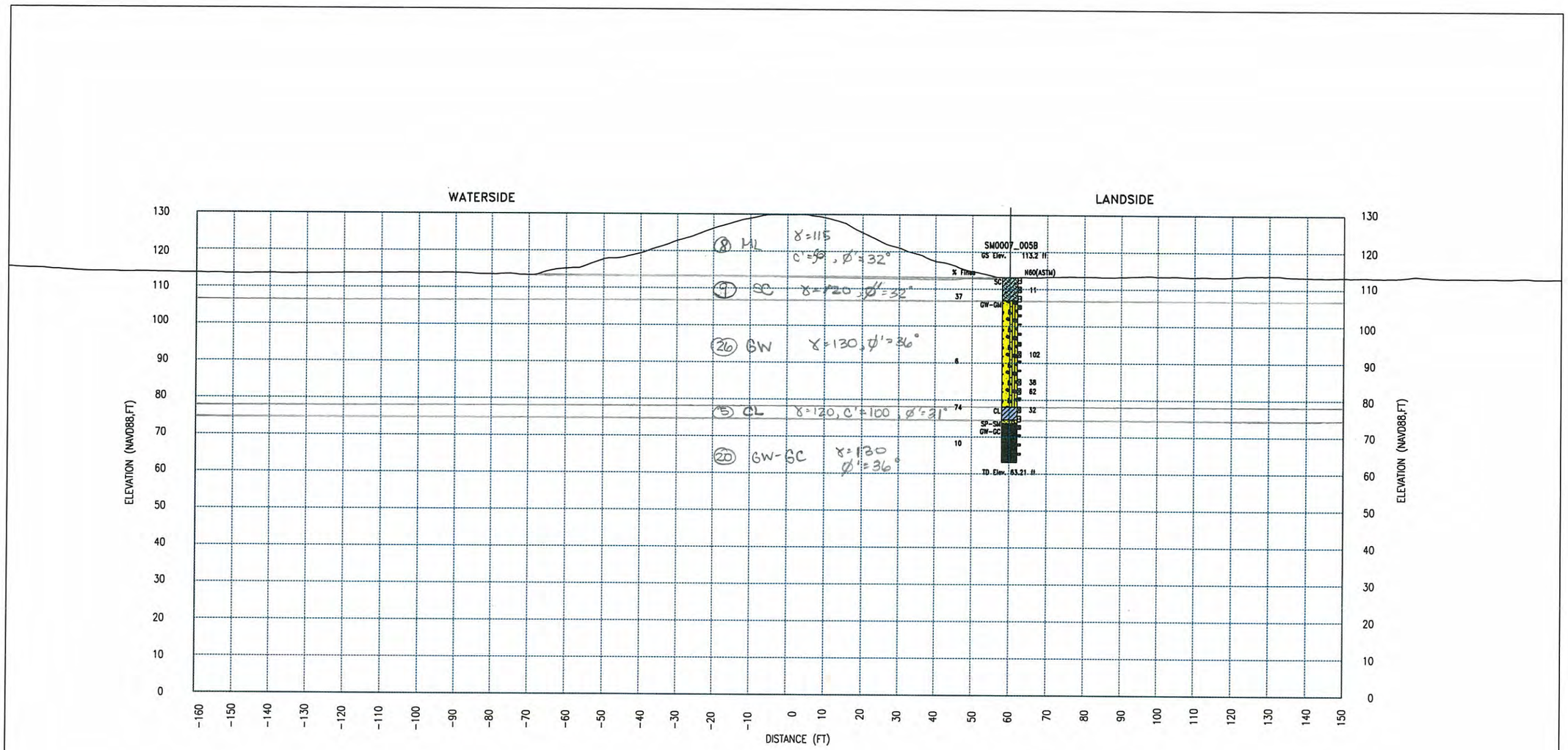
NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

SUTTER BUTTE FLOOD CONTROL AGENCY	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 2138+99 Reach 34	SCALE 1"=30'



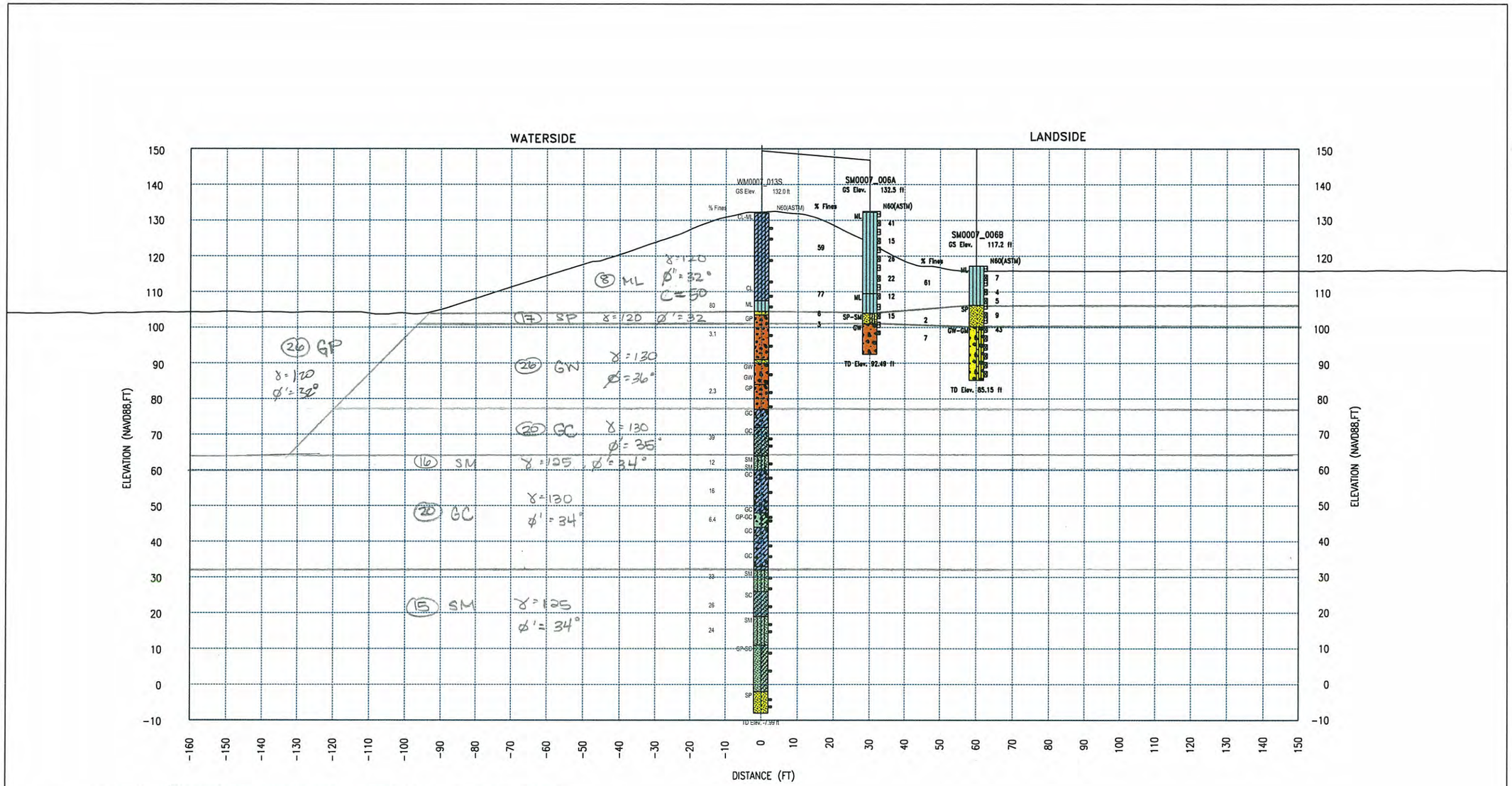
NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

SUTTER BUTTE FLOOD CONTROL AGENCY	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 2211+30 Reach 35	SCALE 1"=30'



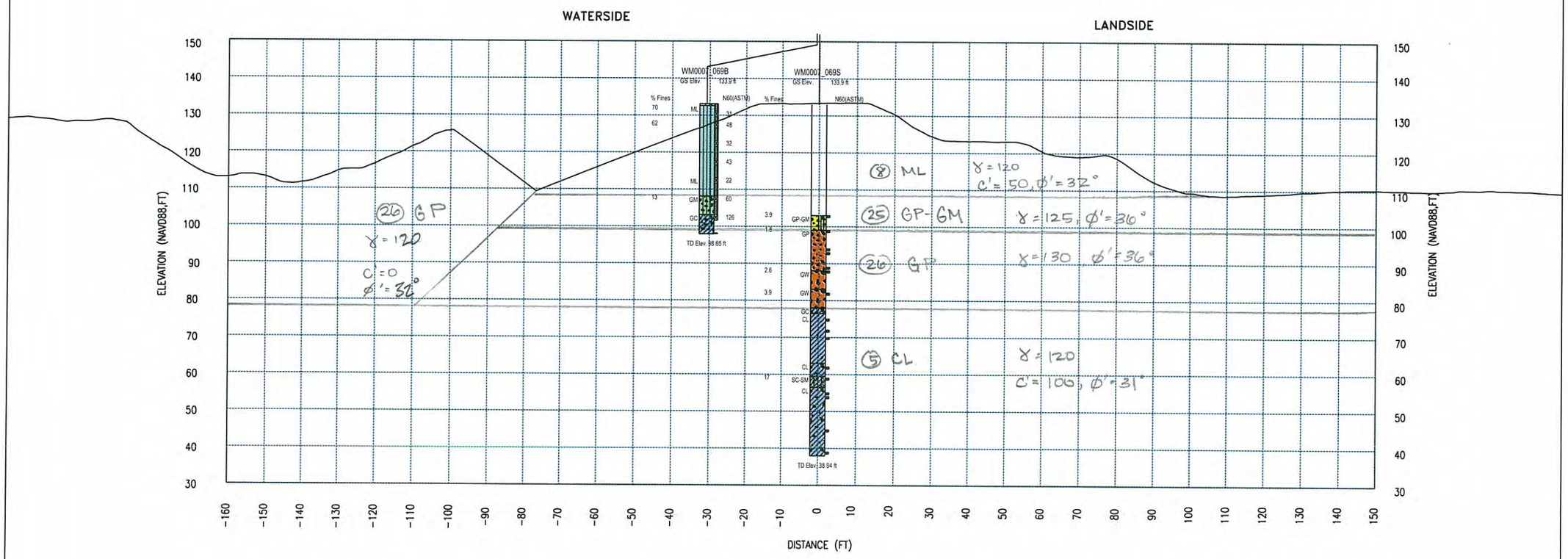
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2.

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 2250+78 Reach 36	SCALE 1"=30'



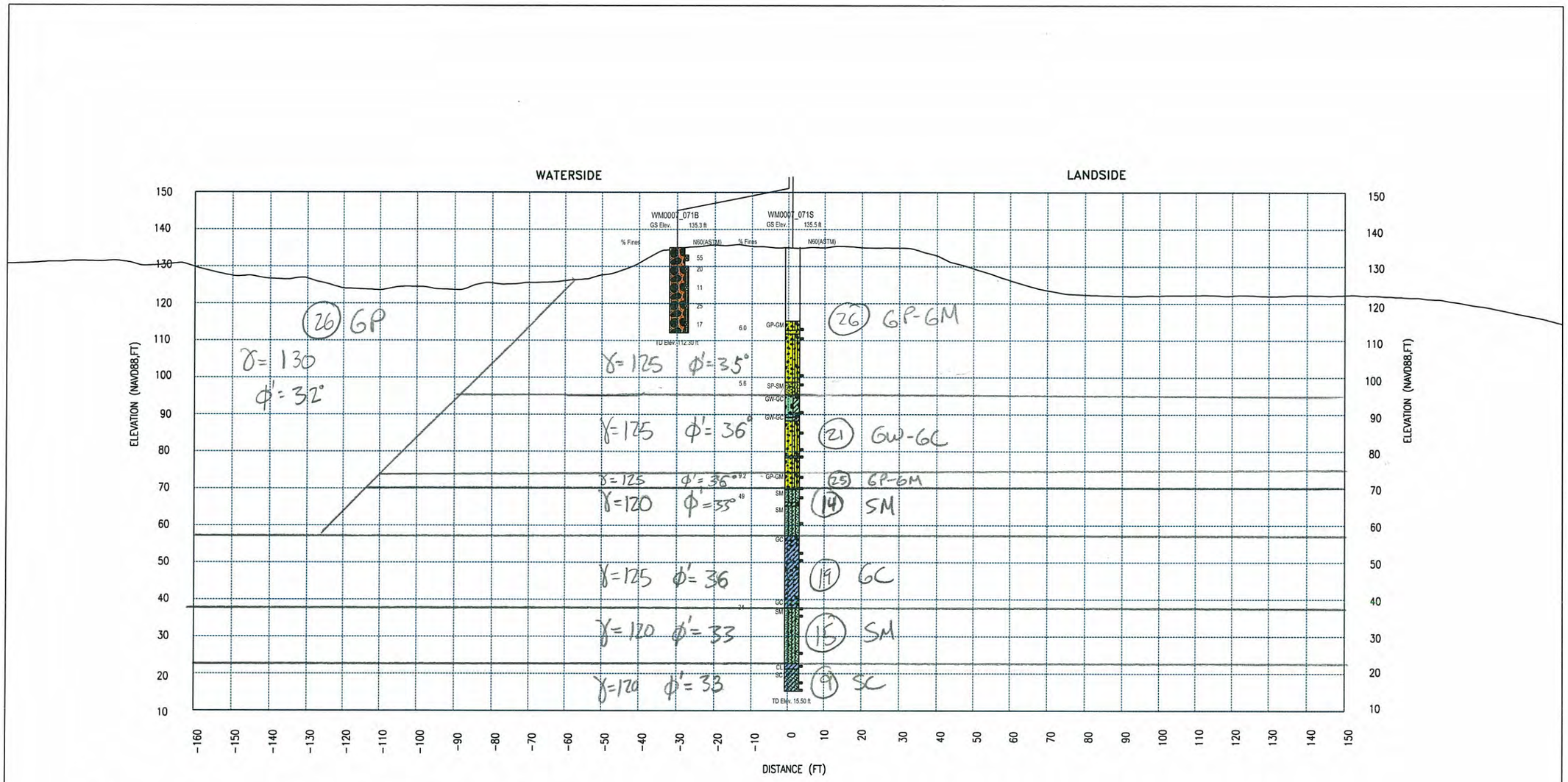
NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 2276+76 Reach 37	SCALE 1"=30'



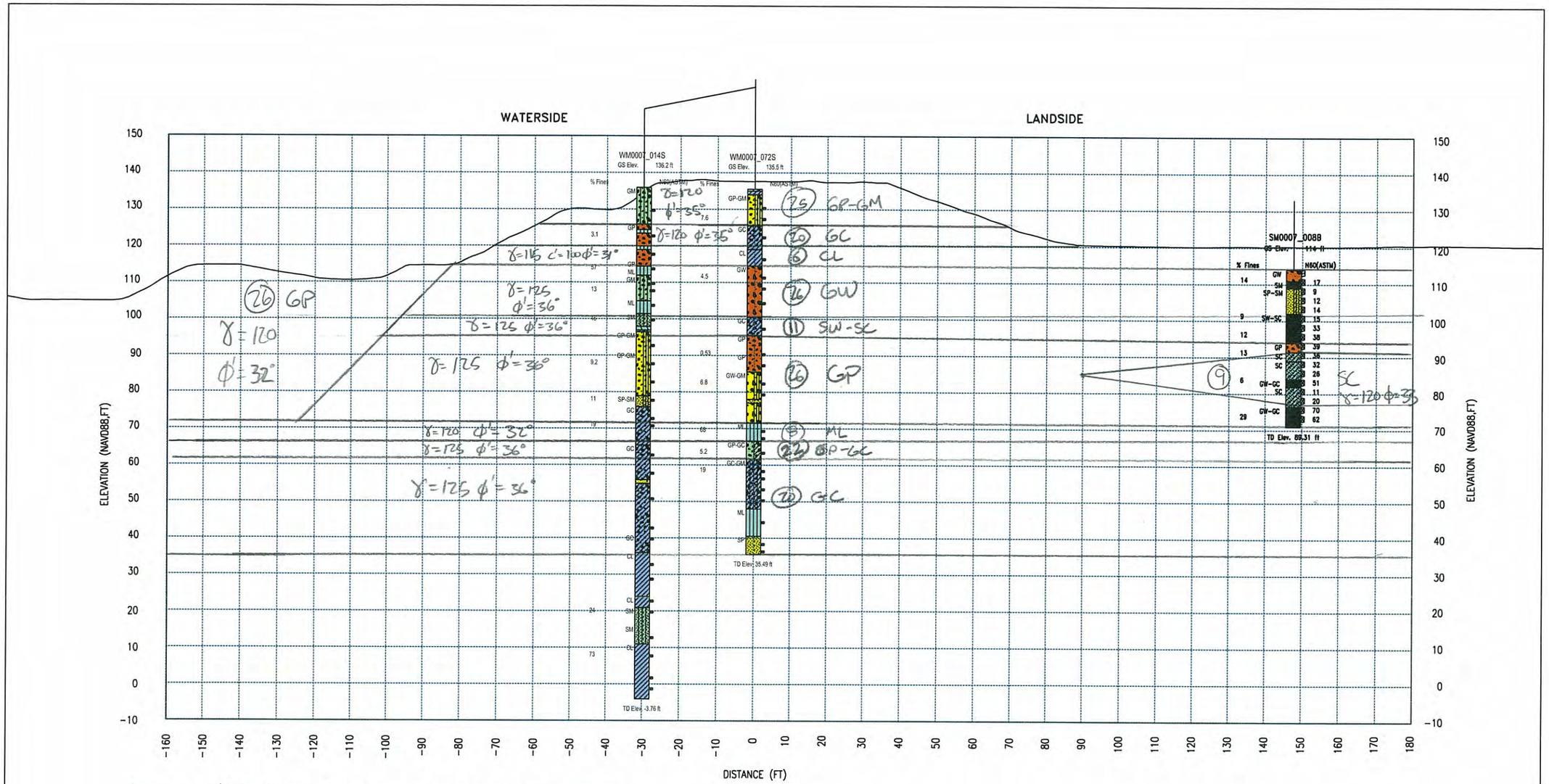
Note: Material numbers correspond to the hydraulic conductivity values shown on Table 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 2299+69 Reach 38	SCALE 1"=30'



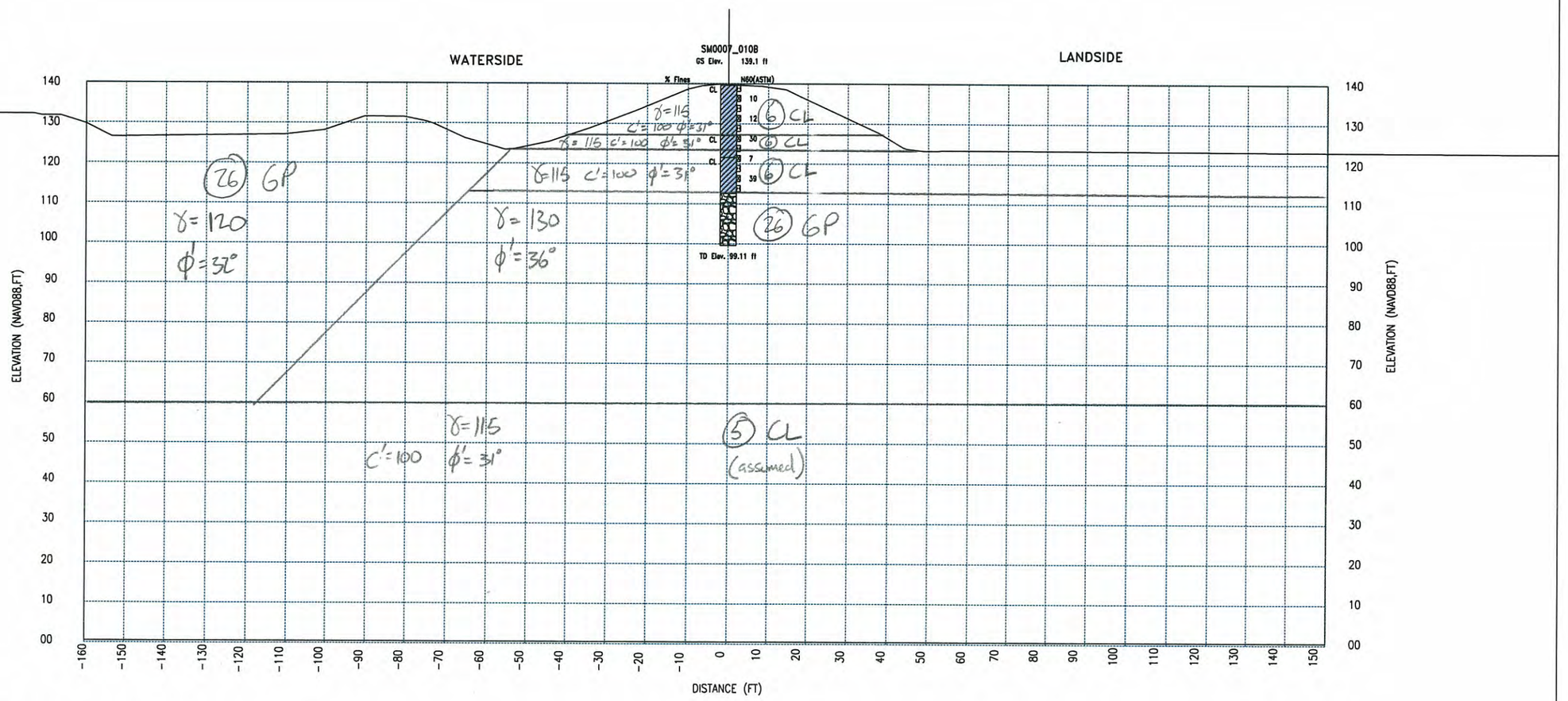
NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 2314+91 Reach 39	SCALE 1"=30'



NOTE : MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

	URS / blackburn consulting	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 2332+91 Reach 40	SCALE 1"=30'



NOTE: MATERIAL NUMBERS CORRESPOND TO THE HYDRAULIC CONDUCTIVITY VALUES SHOWN ON TABLE 4-2

	FEATHER RIVER WEST LEVEE REHABILITATION EARLY IMPLEMENTATION PROJECT Project No. 17326463 Task Order 1	Transverse Section 2362+70 Reach 41	SCALE 1"=30'

URS
blackburn consulting