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Final Addendum 1 to Geotechnical Design Recommendations Report Segments 1 through 6 Feather River West Levee Project

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Project	Feather River West Levee
Date	May 17 2013
Subject	Recommendations for Reach 13 of the Feather River West Levee Project
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Reviewed By	Francke Walberg, PE Robert Green, PE, GE Michael Hughes, PE

1.0 INTRODUCTION

The HDR team is providing design services to the Sutter Butte Flood Control Agency (SBFCA) for the Feather River West Levee (FRWL) Project. URS Corporation (URS), as a member of the HDR team, has been providing geotechnical engineering services for the FRWL Project.

This Addendum 1 to the Geotechnical Design Recommendations Report Segments 1 through 6, presents geotechnical considerations for remediation in Reach 13 of the FRWL Project.

2.0 REACH 13 BACKGROUND INFORMATION

Reach 13 is located to the north of Shanghai Bend and extends from Station 845+00 to Station 927+00. This approximately 8,200-foot-long reach has experienced levee breaches and seepage problems during past flood events. Major known past performance problems are summarized below.

- Levee breaks in 1909, 1911, and 1955. The 1955 levee break is a major levee break in California's history. A grand jury was formed subsequent to the 1955 flood. Based on the "Report of 1955 Sutter County Grand Jury", the following is a summary of the 1955 levee break in Reach 13,
    - The levee break occurred on the west bank of the Feather River at the Gum Tree portion, which is about 2-3/4 miles south of Yuba City (at that time) and approximately ¼ of a mile north of Shanghai Bend, as shown on Figures 1 and 2.

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- In one section of the report, it was reported that one boil had grown to six or seven feet in diameter and vertically spouting water three or four feet from the water line of the lake it had created. In another section of the report it was reported that a large lake around one of the boils which was reported to be shooting up in the air about six feet high; that there was one of these boils which appeared larger than the others and presumably is the one which finally caused the collapse of the levee.

- The eye-witness accounts put the distance of the boil 50 feet or 150 feet away from the levee toe. The break increased in size to approximately 2200 feet.

Figure 1: Photograph of 1955 Levee Break with 10th Street Bridge in the Foreground (Source: Sutter Butte Flood Control Agency Special Publication, Flood Aware/Flood Prepare)

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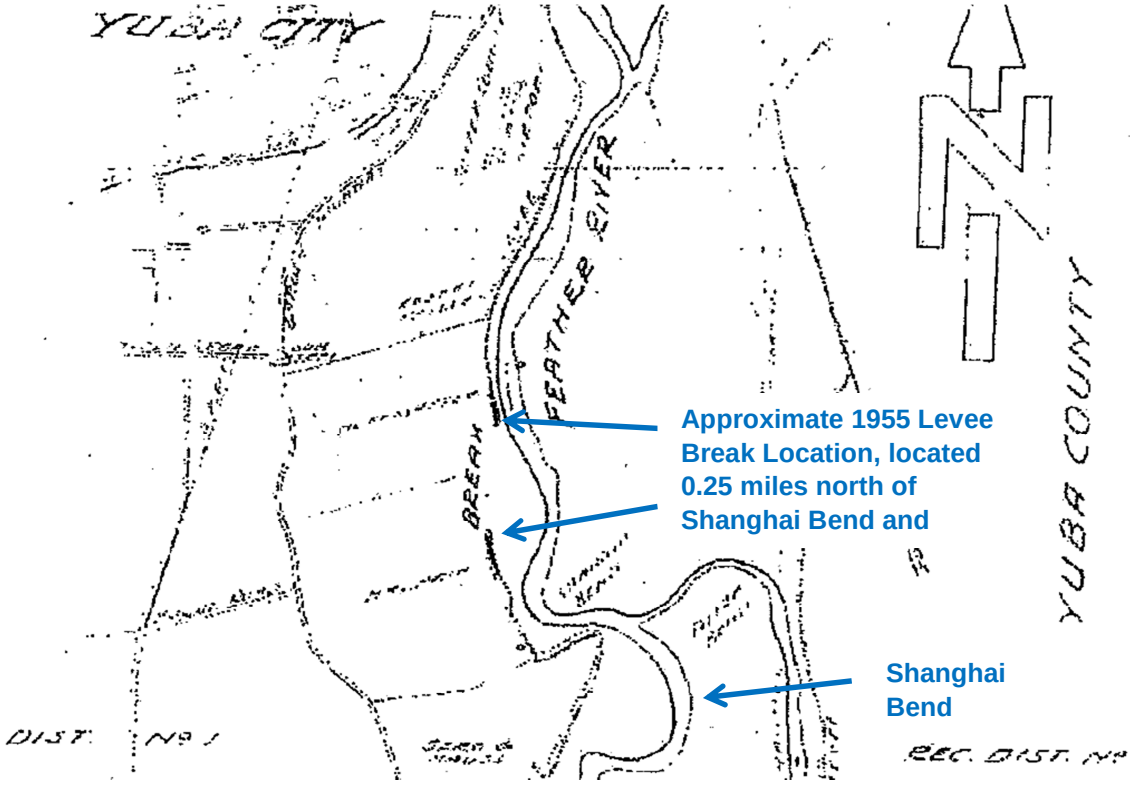

Figure 2: Approximate Location of 1955 Levee Break (Source: Report of 1955 Sutter County Grand Jury)

- Based on DWR's seepage area map for the FRWL, all of Reach 13 was mapped as a seepage area as indicated on aerial photographs taken on April 24, 1963 and February 10, 1965 and in conjunction with field observations.

- During the 1986 flood, volunteers sandbagged several boils between LM 11.0 and LM 12.75. This roughly corresponds to the limits of Reach 13, which extends between LM 11.1 and LM 12.8.

- During the 1986 flood, according to Levee District (LD) 1 Engineer Mr. Von Geldern, relief wells in Shanghai Bend area produced 3 gallons per minute. Additional seepage occurred in fields adjacent to the levee. Seepage appeared in this area up to several hundred feet away from the levee.

After the 1997 flood, LD 1 prepared a summary of repair and improvements required for the Feather River Levee. This summary report identified "heavy seepage and boils" from levee miles 12.13 to 12.30 (approximately between Stations 893+00 and 903+00). Notes on the letter state:

> "*Burns Drive is just north of the 1955 levee break and this area has also experienced boil and seepage problems in years of high water. Burns Drive is now associated with heavily developed industrial, as well as residential area. Another point of concern is that the City of Yuba City main sewage treatment plant is located in this area and could potentially cause severe contamination from sewage plant operation of a levee break should occur."*

A total of 81 relief wells are landside of the FRWL in Reach 13. These relief wells were installed by the U.S. Army Corps of Engineers (USACE) and the South Yuba City Improvement District in different phases between 1956 and 1998. In 2011, LD 1 prepared a relief well report on Feather River Levee Relief Wells from Shanghai Bend Road to Whiteaker Hall. Based on a description in the report, existing relief wells were installed in three phases, as described below.

- After the 1955 flood in Sutter County, 38 relief wells were installed in 1956 using an 8-inch corrugated metal casing at 200-foot spacing. These wells are on average less than 30 feet deep (Approximately Station 848+00 to Station 925+00).

- In 1991, the South Yuba City Improvement District added 20 new relief wells constructed from 6-inch PVC casing with an average depth of 60 feet interspaced between the original wells on the southern portion of Reach 13 (Approximately Station 848+00 to Station 881+00).

- In 1998, USACE installed 23 additional relief wells constructed of 8-inch stainless steel casing with an average depth around 60 feet interspaced between the original wells on the northern portion of Reach 13 (Approximately Station 881+00 to Station 925+00). The USACE also rehabilitated the original wells within this area and installed a concrete collection ditch back to the pump station.

A condition survey, including pump tests, of all relief wells in Reach 13 was completed in 2012 under the direction of LD1.

3.0 SURFICIAL GEOMORPHOLOGY OF REACH 13

According to the geomorphology map prepared by William Lettis & Associates for the California Department of Water Resources' (DWR's) Urban Levee Geotechnical Evaluations (ULE) Program, the surficial geologic unit of Reach 13 is historical channel meander scroll (Rms) deposits. Figure 3 is an excerpt of the ULE Programs geomorphology map in the area of Reach 13. Materials in a historical channel meander scroll geologic unit include sand, silt, and clay from lateral channel migration. An abandoned arm of Feather River is located west of the FRWL. Figure 4 shows the location of the existing channel and the abandoned arm of the Feather River. As the levee in Reach

13 lies between an abandoned arm of the Feather River and the existing river, it is likely Reach 13 has high underseepage potential. These geomorphological characteristics also match with underseepage related past performance problems in Reach 13.

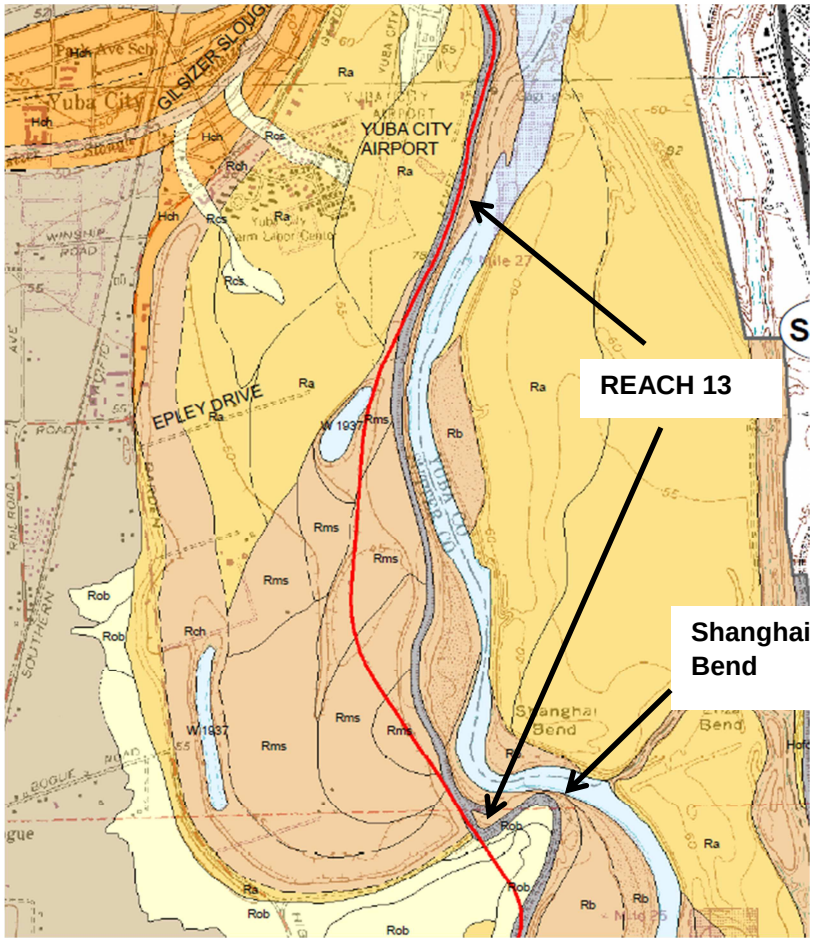

Figure 3: Geomorphology of Reach 13
(Source: DWR's ULE Sutter Area Geomorphology Map, 2009)

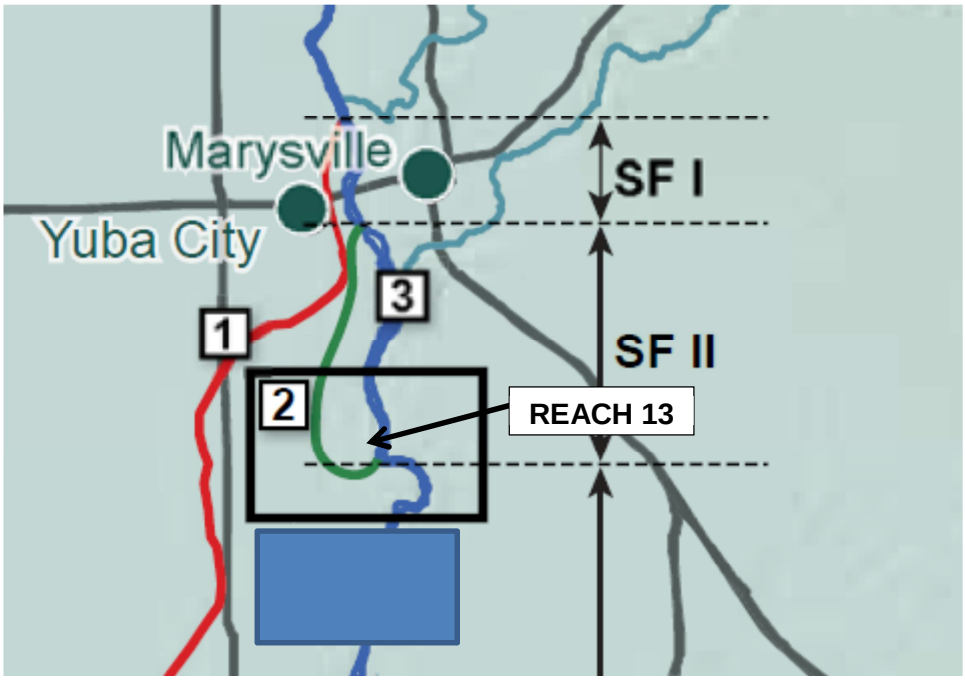

Figure 4: Map Showing Eastern Migration of Feather River (Source: DWR's ULE Sutter Area Geomorphology Map and Report, 2009)

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4.0 DISCUSSIONS ON REACH 13 REMEDIATION MEASURES WITH DWR, USACE, SBFCA, and HDR

As part of the geotechnical analysis for the Pre-Design Formulation Report, the URS team evaluated existing conditions in Reach 13 at the 200-year water surface elevation (WSE). The results of existing conditions analyses indicated a potential for through seepage and underseepage. The URS team, in consultation with HDR, developed two rehabilitation alternatives:

- Alternative A: Fully-penetrating cutoff wall.
- Alternative B: Combination of a shallow cutoff wall and relief well system comprising 65 feet deep wells at 100 feet spacing (i.e., installing new relief wells at a 200-foot spacing to augment existing wells, considering post-1990 existing relief wells effective).

Based on cost comparisons, Alternative B was considered the more cost effective option by the design team and was selected as the preferred option to move forward with to 65% design. During preparation of the draft Geotechnical Design Recommendations Report (GDRR), Reach 13 was further evaluated by performing additional explorations and geotechnical analyses. The draft 65 % GDRR proposed a cutoff wall with a tip elevation +35 feet (approximate wall depth of 20 feet to 25 feet below the base of the levee) in combination with new 65 feet deep relief wells at 200-foot spacing in between post 1990s relief wells. This would require rehabilitation and replacement of some of the existing relief wells.

In March 2012, the URS team held a workshop for the Independent Panel of Experts (IPE) and reviewing agencies. The workshop focused on geotechnical analyses for the FRWL Project to assist review of the draft GDRR.

During the workshop, DWR's reviewer Ray Costa suggested that, considering the history of distress and reliability of relief well system, a deep cutoff wall should be selected for Reach 13. As Ray Costa has been involved in some previous improvement work in Reach 13, and he is familiar with the performance of the system during the 1997 flood, the HDR team requested a meeting with Ray Costa.

In April 2012, Les Harder (HDR) and Khaled Chowdhury (URS) met with Ray Costa to discuss Ray Costa's understanding of the existing system and his suggestion of a deep cutoff wall in Reach 13. Following the meeting, Les Harder summarized the discussion notes in an e-mail to Ray Costa and received confirmation that the summary captured meeting discussions.

The following is a summary of the HDR team's understanding of Reach 13's performance history based on information provided by Ray Costa.

- *USACE initially constructed relief wells in this area around 1955/57. Counter to our previous understanding that these wells are relatively shallow, Ray has pointed out that some of the old drawings indicate that they may be as much as 60-65 feet deep (e.g. from Elevation ~50 feet down to Elevation -14 feet).*

- *In about 1990, a trench drain was installed about 100 feet landward of the landside levee toe, principally to control seepage for a new housing development. The trench was generally intended to be about 10 to 15 feet deep with a corrugated, black ABS drain pipe wrapped with sand near the bottom. The bottom few inches and the rest of the trench was backfilled with gravel. Where the bottom of the trench was found to be in a semi-pervious or impervious soil layer (e.g. silt or clay), the trench was deepened up to 8 feet to penetrate through these layers in an attempt relief seepage pressures in any pervious layers below. However, the ABS drain pipe was kept at the original design grade even if the trench was deepened. To construct this, the Contractor laid the slopes back and used a shield to place the pipe and backfill, and then slid the shield laterally as the trench was excavated and backfilled. Later, it was found that the ABS pipe had compressed vertically into an oval, probably due to the removal of the lateral support temporarily provided by the shield. After litigation, the City of Yuba City removed the drain pipe and replaced it with clay pipe (brittle and with joints) with diameters up to 18 to 24 inches that were drilled with small holes for drainage (~ 1/8 inch). There appears to not be a lot of information available about the pipe, the size of the holes or the filter around it. The clay drain pipe drains to a sump which is pumped out and back to the river during flood events. The upper portion of the drain trench is apparently filled or covered over with impervious material. To provide additional relief, risers with manholes are located at intervals along the drain trench (some of these risers/manholes were observed during the March 21st field trip). Ray believes that these are large drill holes a few feet in diameter that extend to the gravel in the trench drain and which were then backfilled with gravel. Ray did not know if there are riser pipes within these gravel risers.*

- *Also in 1990s (1994?), the City of Yuba City installed new relief wells between the 1955/57 relief wells installed by the Corps. Both the relief wells and the trench drain extend from about Station 845 to about 882. Since the older wells were constructed on a 200-foot spacing, the addition of the new wells provided an overall spacing of about 100 feet. There is an additional discharge pipe for the ~1990 wells located at a depth of about 5 feet below the surface. Therefore, while there is an above-ground discharge pipe, there apparently is also a subsurface pipe for these newer relief wells. The subsurface discharge pipes lead to a subsurface collection pipe that also discharges to the same sump that the trench drain flows to.*

- *Both Ray's recollection and most of the performance reports indicate that this reach performed generally well during the 1997 Flood. While a lot of seepage was noted, boils were not reported in this area.*

The HDR design team also summarized Ray Costa's concerns about performance in Reach 13:

While the system seemed to perform okay during the 1997 flood, it was later found that some of the subsurface discharge lines from the ~1990 relief wells had sand in them, presumably from relief flows from the wells. So, at least some of the wells appear to be pumping sand. In addition, some of the recent relief well tests indicate that at least some of these wells are pumping sand and/or have missing or damaged casing.

Ray Costa was also concerned about the following:

- Past levee failures near Shanghai Bend,
- Reach 13 is largely founded on top of an old river meander bend, and
- Condition and performance of existing relief wells

In June 2012, a meeting was held at URS office with USACE, DWR, DWR's consultants (GEI), SBFCA, and HDR design team members. HDR design team presented a summary of geomorphology, past performance, existing improvement measures, and results of sensitivity analysis for alternative design options for Reach 13. The following analyses were presented:

- Existing conditions analysis for 200 year + 1 foot WSE and 200 Year + 4 foot WSE. The existing relief wells were considered in the analysis.
- Alternative 1: Shallow cutoff wall and relief wells at 100 feet spacing, as presented in the draft GDRR.
- Alternative 2: Fully penetrating wall and abandonment of existing relief wells.
- Alternative 3: Full levee degrade with a deep cutoff wall up to 85 feet deep and rehabilitation of existing relief wells at 100 feet spacing.

Considering the positive contribution of the existing relief wells to the improved performance of the reach during the 1997 flood, the HDR design team contended the current design option utilizing a shallow cutoff wall in combination with relief wells was a valid option, provided relief wells were rehabilitated as needed and properly maintained thereafter. However, DWR and USACE raised the following concerns with these options:

1. The ability of the design to meet seepage criteria is dependent on the continued performance of the wells. However, to date there has only been a single round of pump testing in June 2011 since installation and this only accounted for 20% of the 81 wells installed. Therefore, there is not a high confidence that the wells will be regularly tested and properly maintained in the future.
2. Due to the complex stratigraphy within the reach and variable gradation within aquifer layers, a variable gravel pack should be used during installation of relief wells in this area. However,

based on available information this was not done for the existing relief wells, which brings into question the efficiency and long term performance of the existing wells. Furthermore, replacement/rehabilitation of existing wells will be difficult.

3. A seepage relief trench installed as part of the adjacent residential development lies at an offset of about 100 feet from the landside levee toe. Portions of this trench were extended to depths of around 30 feet below existing ground surface to penetrate through fine grained layers and provide connection to underlying aquifer layers. It is felt that the trench provides a potential path through which materials could be transported, thereby creating a potential piping failure mechanism for the levee, which would not be mitigated by the shallower wall option.

Based on the above, Mary Perlea and Steve Mahnke concluded that they were satisfied that both the fully penetrating wall and deep cutoff wall options would work, but expressed major doubts about the viability of the alternative utilizing a shallow wall in combination with relief wells .

Given the concerns raised with the draft 65% design option, the proposal was to move forward with the fully penetrating cutoff wall option as the preferred design. The analysis results for this option, which do not include any contribution due to the positive effects of the relief wells, show that seepage criteria meets at the levee toe and the relief well ditch at an offset of about 12 feet from the levee toe.

Based on the discussions with DWR and USACE, a total of eight supplemental explorations were suggested in Reach 13 to provide additional information regarding the depth and continuity of the deep aquiclude layer beneath the levee.

5.0 SUPPLEMENTAL EXPLORATIONS AND LABORATORY TESTING

A total of eight explorations, identified as SL001_002S through SL001 _009S were performed from October 2 to October 20, 2012. These explorations were advanced using sonic drilling technique considering presence of dense coarse-grained soil layers in Reach 13. Five of these explorations were advanced from crown locations and the remaining three explorations were advanced from landside toe locations. The depths of supplemental crown explorations varied between 120 and 135 feet and the depths of landside toe explorations varied between 90 and 97.5 feet. The locations of these explorations were selected at areas where there were perceived data gaps. National EWP was the drilling sub-contractor for these supplemental explorations.

A laboratory testing program was implemented on selected samples from these supplemental explorations. The laboratory testing program included water content tests, Atterberg limits tests, sieve analyses, and percent passing #200-sieve tests. The laboratory tests were performed at Geocon laboratory in Rancho Cordova, California.

The plans and stick log profiles for Reach 13 were updated with the eight supplemental explorations. These updated plans and stick log figures are included in Attachment A. The boring logs and laboratory test results for these supplemental explorations are included in Attachment D.

Based on results of the supplemental explorations, the two analysis cross-sections at Station 861+33 and 907+00 in Reach 13 were updated and a series of sensitivity analyses were performed. The results of the analyses were discussed with HDR's Senior Reviewer, Les Harder, in February 2013. The end around effect at the transitions to the deeper cutoff wall section at Station 844+50 and Station 896+00 was also considered. At the southern end of Reach 13, the explorations indicate that the geologic conditions from Reach 12, which has an existing shallow cutoff wall, extend through to approximately Station 848+00. However, a deeper section of the cutoff wall has been proposed between Station 844+50 and Station 848+00 to address potential end around effects. Similarly, at the northern transition location the deeper section of cutoff wall has been extended upstream approximately 300 feet to Station 896+00 to cover potential end-around effects.

Based on the analysis results and discussions, the URS team updated the recommendations for Reach 13 and presented these to the Independent Panel of Experts, DWR, USACE and the CVFPB in March 2013. All parties were in agreement with the proposed changes and agreed that the current transition locations are adequate to address potential end-around effects.

The discussion of analysis results and recommendations for remediation measures are presented in the following sections. The results of seepage and stability analyses are presented in Table 2. Geologic cross sections, parameter tables, and seepage and stability analyses figures for Station 861+33 and Station 907+00 are presented in Attachments C and D, respectively.

6.0 DISCUSSION OF ANALYSES AND RESULTS

Geotechnical analysis cross-sections at Station 861+33 and 907+00 were updated with the supplemental explorations and cutoff wall tip elevations and additional analyses performed.

At Station 861+33, URS proposed three remediation alternatives; shallow cutoff wall with relief well system, partially-penetrating hanging cutoff wall, and fully-penetrating cutoff wall. The shallow cutoff wall with relief well option was eliminated with the concern of questionable efficiency and long term performance of the existing wells and difficulty in replacement/rehabilitation of existing wells. Therefore, no further analysis with shallow cutoff wall with relief well option was performed. Analyses for the partially and fully-penetrating cutoff wall were performed using the updated geologic profiles.

Based on the new exploration data, fine-grained materials, comprising silts and clays interbedded with very dense silty sands and clayey gravels are encountered at a depth of around 85 feet. The primary analysis with full levee degrade and 85 feet deep cutoff wall resulted in average exit gradients less than 0.10 at toe and ditch. Sensitivity analyses with full levee degrade and partially penetrating cutoff wall did not meet criteria.

At Station 907+00, URS previously proposed a cutoff wall tip elevation of +35 feet. New exploration data included in the geologic cross section indicated a thicker aquifer layer and a need for a deeper cutoff wall tip elevation of +25 feet. The primary analysis with cutoff wall tip elevation +25 feet resulted in exit gradients of 0.42 at the landside toe and 0.52 at concrete lined relief well ditch for

200yr+1' WSE, with an associated seepage flow volume of 0.53 gallons per minute for a 100 foot length of levee within 100 feet from toe. This is considered to be relatively low and so the gradient of 0.52 at the ditch was considered acceptable. Sensitivity analysis with 50-79% fines instead of 80-100 % fines for Layer 3 ML was performed to evaluate the proposed cutoff wall design.

Based on evaluation of the updated plans and stick log figures for Reach 13, the cutoff wall depths for the central and southern portion of Reach 13 (Station 844+50 to 896+00) were revised to a deeper depth, elevation -38 feet (NAVD 88), where the cutoff wall is expected to be fully penetrating. This option will eliminate the need for relief wells in Reach 13, provided that construction records confirm complete penetration of the aquiclude layer. The proposed cutoff wall depth measured from landside toe is now approximately 90 feet from Station 848+00 to Station 896+00.

In the northern portion of Reach 13 (Station 896+00 to 923+75), the geologic conditions change from a thin blanket overlying a thick aquifer layer to a thicker blanket with interbedded shallow sandy layers. Therefore, the purpose of the cutoff wall in the northern portion is to tie in these layers such that the seepage through these leaking layers is reduced. The tip elevation of the proposed cutoff wall was revised to an elevation +25 feet, with an overall depth measured from landside toe of approximately 35 feet.

The updated cross-sections, parameter tables, and figures for seepage and stability analyses for Station 861+33 and 907+00 are included in Attachments B and C.

7.0 RECOMMENDATIONS

Based on discussion of analyses with supplemental explorations, the recommendations for remediation measures are summarized in Table 1. Table 2 presents a summary of the geotechnical analyses results. A number of sensitivity analyses were also performed to evaluate the performance of the recommended mitigation measures. The results of these sensitivity analyses are included in Table 2. The recommendations for remediation measures and existing relief wells in Reach 13 are summarized below:

Recommendations for Remediation Measures:

- Station 844+50 to 848+00: Full levee degrade and a cutoff wall tip elevation of -20 ft.
- Station 848+00 to 896+00: Full levee degrade and a cutoff wall tip elevation of -38 ft.
- Station 896+00 to 923+75: Partial levee degrade and a cutoff wall tip elevation of +25 ft.

Recommendations for Existing Relief Wells:

- Abandon the relief wells that pumped sand, appear non-functional, or have internal defects based on 2012 relief well testing.

- Convert the relief wells that appear functional based on 2012 relief well testing to observation wells.
- Buried collector pipes for existing relief wells should be abandoned and backfilled, and the release points of the collector pipes should be raised to the ground surface.
- During periods of high water in the river, monitor and record water levels in observation wells and any flow from them.

8.0 LIMITATIONS

This technical memorandum was prepared 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. The limitations section of the final GDRR for the FRWL is also applicable for this Addendum.

The construction of the cutoff wall should be monitored continuously by a representative of the geotechnical engineer of record to confirm that the soil conditions are consistent with those used in developing these recommendations. Variations in soil conditions found during construction may result in adjustments to these recommendations.

This Addendum 1 is for the use and benefit of the HDR design team and SBFCA. Use by any other party is at their own discretion and risk.

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TABLES

ATTACHMENTS

Attachment A

- Plans and Stick Log Figures of Reach 13 (updated with supplemental explorations)

Attachment B

- Geologic Cross Section, Parameter Table, Seepage and Stability Analyses Results for Station 861+33

Attachment C

- Geologic Cross Section, Parameter Table, Seepage and Stability Analyses Results for Station 907+00

Attachment D

- Boring Logs and Laboratory Test Results for Supplemental Explorations at Reach 13

Table 1 Recommendations for Rehabilitation Measures for Reach 13.

Reach	Stationing	Length (feet)	Rehabilitation Measure(s)	Approximate Dimensions of Primary Features	Comments
13	845+00 to 927+00	8,200	Cutoff Walls	844+50 to 848+00: cutoff wall tip elevation -20' 848+00 to 896+00: cutoff wall tip elevation -38' 896+00 to 923+75: cutoff wall tip elevation +25'	Abandon existing relief wells, if non-functional. Otherwise, convert the existing relief wells to observation wells.

Table 2. Seepage and Slope Stability Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Reach 13													
Station 861+33	Cutoff Wall Tip Elev. -38.0'	81.2	55	26.2	200yr + 4'	78.4	< 0.10 [Toe, blanket=12.2'] < 0.10 [Existing Relief Well Ditch 11' from toe, blanket=9.4']	0.0 (no breakout above toe) Seepage flux Q within 100 feet from toe across 100 feet distance of levee < 0.10 gpm	Existing relief wells are not modeled. Exit gradients are calculated at toe and existing relief well ditch. <u>Sensitivity analysis</u> with full levee degrade and approximately 1.7 feet gap between cutoff wall tip and 4.4 feet thick clay layer results in; <u>200yr+4'</u> i=0.42 [Toe, blanket=12.2'] i=0.72 [Existing Relief Well Ditch 11' from Levee Toe, blanket= 9.4'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee = 0.79 gpm FS =1.56 (Slope stability) <u>200yr+1'</u> i=0.33 [Toe, blanket=12.2'] i=0.61 [Existing Relief Well Ditch 11' from Levee Toe, blanket=9.4'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee = 0.66 gpm FS =1.63 (Slope stability) <u>Sensitivity analysis</u> with full levee degrade and approximately 22 feet gap between cutoff wall tip and aquiclude (based on WL0001_013S, WL0001_067B, SL0001_002S –new exploration, 2012) results in; <u>200yr+4'</u> i=0.60 [Toe, blanket=12.2'] i=0.95 [Existing Relief Well Ditch 11' from Levee Toe, blanket= 9.4'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee = 1.00 gpm FS =1.40 (Slope stability) <u>200yr+1'</u> i=0.49 [Toe, blanket=12.2'] i=0.82 [Existing Relief Well Ditch 11' from Levee Toe, blanket=9.4'] Seepage flux Q within 100 feet from toe across 100 feet distance of levee = 0.84 gpm FS =1.50 (Slope stability)	1.90 (for primary analysis)		-	

Table 2. Seepage and Slope Stability Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
					200yr + 1'	75.4	< 0.10 [Toe, blanket=12.2'] < 0.10 [Existing Relief Well Ditch 11' from toe, blanket=9.4']	0.0 (no breakout above toe) Seepage flux Q within 100 feet from toe across 100 feet distance of levee < 0.10 gpm	<u>Sensitivity analysis</u> with kh=5.0E-7 cm/s instead of kh=1.0E-7 cm/s for cutoff wall results in; <u>200yr+4'</u> i<0.10 [Toe, blanket=12.2'] i=0.13 [Existing Relief Well Ditch 11' from Levee Toe, blanket= 9.4'] FS =1.86 (Slope stability) <u>200yr+1'</u> i<0.10 [Toe, blanket=12.2'] i<0.10 [Existing Relief Well Ditch 11' from Levee Toe, blanket=9.4'] FS =1.90 (Slope stability)	1.90 (for primary analysis)		-	

Table 2. Seepage and Slope Stability Analysis Results.

Reach and Station for Analysis Section	Rehabilitation Measure at Analysis Section	Top of Levee Elevation (NAVD88, approx. feet)	Landside Toe Elevation (NAVD88, approx. feet)	Levee Height[1] (feet)	Flood Level Analyzed	Water Surface Elevation (NAVD88, feet)	Steady State Seepage Analysis Results			Landside Slope Stability Analysis Results		Rapid Drawdown Analysis Results	
							Average Vertical Exit Gradient, i [Location, Blanket Thickness]	Breakout Above Landside Toe (feet)	Comments	Minimum Factor of Safety	Comments	Minimum Factor of Safety[2]	Comments
Station 907+00	Cutoff Wall Tip Elev. +25.0'	81.4	57.3	24.1	200yr + 4'	79.3	0.48 [Toe, blanket=35.3'] 0.59 [Existing Relief Well Concrete Lined Ditch 14' from toe, blanket=33.7'] 0.71 [Low point 95.5' from toe, blanket=31.9']	0.0 (no breakout above toe) Seepage flux Q within 100 feet from toe across 100 feet distance of levee = 0.60 gpm	Existing relief wells are not modeled. Exit gradient is calculated at toe, relief well ditch, landside low point. Seepage analyses meet criteria at toe of levee, relief well ditch (criteria 0.53 for 200+1 year WSE), and in field. Gradients are high at relief well ditch, however, flow at this location is 0.60 gpm at 200yr + 4 ft and 0.53 gpm at 200yr + 1 ft. <u>Sensitivity analysis</u> with a sandy silt (50-79% fines) for layer 3 which increases the horizontal hydraulic conductivity from 1.0E-5 cm/sec to 3.0E-5 cm/sec. Results are shown below: <u>200yr+4'</u> 0.40 [Toe, blanket=35.3'] 0.50 [Ditch 14' from toe, blanket=33.7'] 0.59 [Low point 95.5' from toe, blanket=31.9'] FS=1.59 (Slope stability) <u>200yr+1'</u> 0.34 [Toe, blanket=35.3'] 0.44 [Ditch 14' from toe, blanket=33.7'] 0.53 [Low point 95.5' from toe, blanket=31.9'] FS=1.64 (Slope stability) <u>Sensitivity analysis</u> with kh=5.0E-7 cm/s instead of kh=1.0E-7 cm/s for cutoff wall results in; <u>200yr+4'</u> 0.48 [Toe, blanket=35.3'] 0.59 [Ditch 14' from toe, blanket=33.7'] 0.71 [Low point 95.5' from toe, blanket=31.9'] FS=1.66 (Slope stability) <u>200yr+1'</u> 0.42 [Toe, blanket=35.3'] 0.52 [Ditch 14' from toe, blanket=33.7'] 0.64 [Low point 95.5' from toe, blanket=31.9'] FS=1.71 (Slope stability)	1.71 (Primary analysis)			
					200yr + 1'	76.3	0.42 [Toe, blanket=35.3'] 0.52 [Existing Relief Well Concrete Lined Ditch 14' from toe, blanket=33.7'] 0.64 [Low point 95.5' from toe, blanket=31.9']	0.0 (no breakout above toe) Seepage flux Q within 100 feet from toe across 100 feet distance of levee = 0.53 gpm		1.76 (Primary analysis)			

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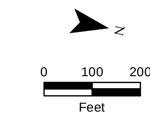
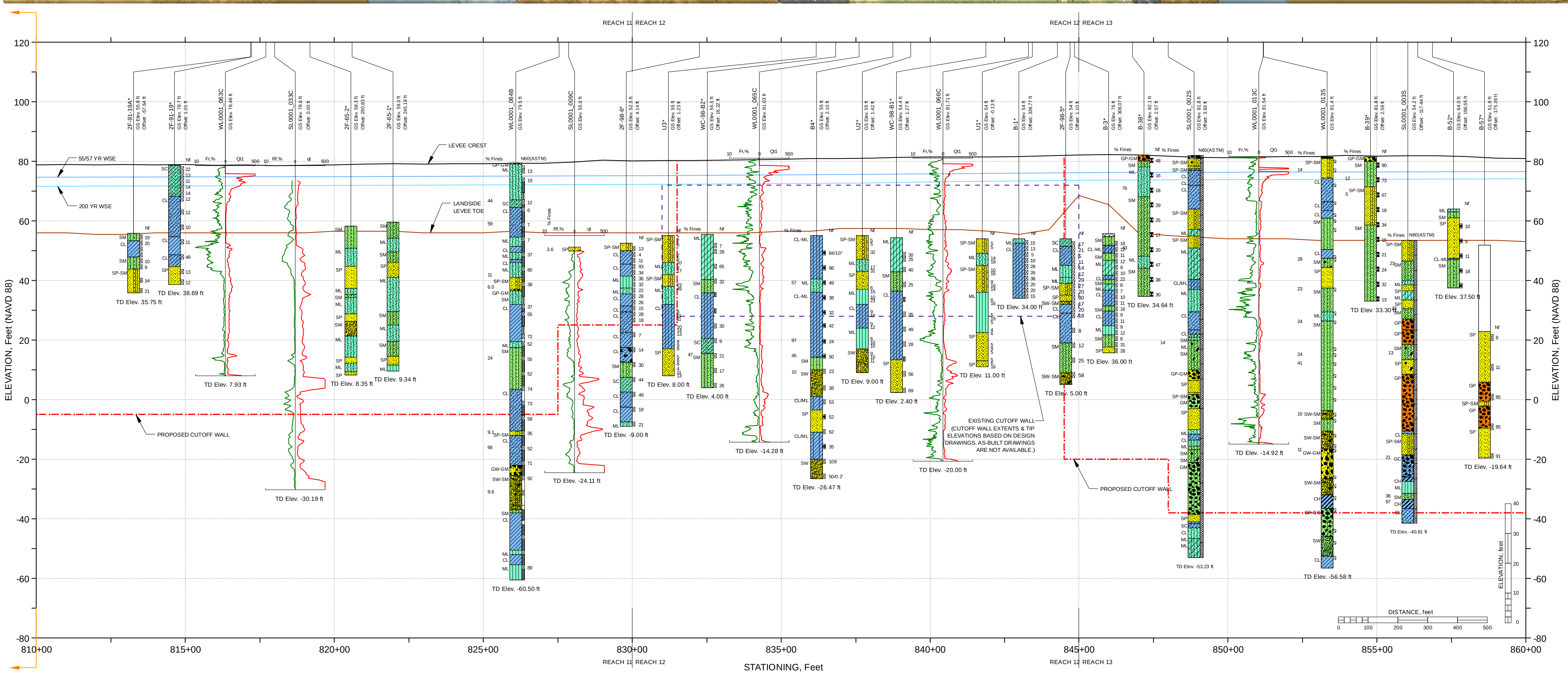
Addendum 1 to Geotechnical Design Recommendations Report Segments 1 through 6 Feather River West Levee Project

Attachment A



NOTES:

1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LiDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, N_{60}(ASTM), refers to N_{60}(ASTM) = N_{field} * Hammer Efficiency (%). See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS,2010).
10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
11. These plans and stick-log plates are 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. These figures should not to be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures

FRWL Project: Station 810+00 to Station 860+00

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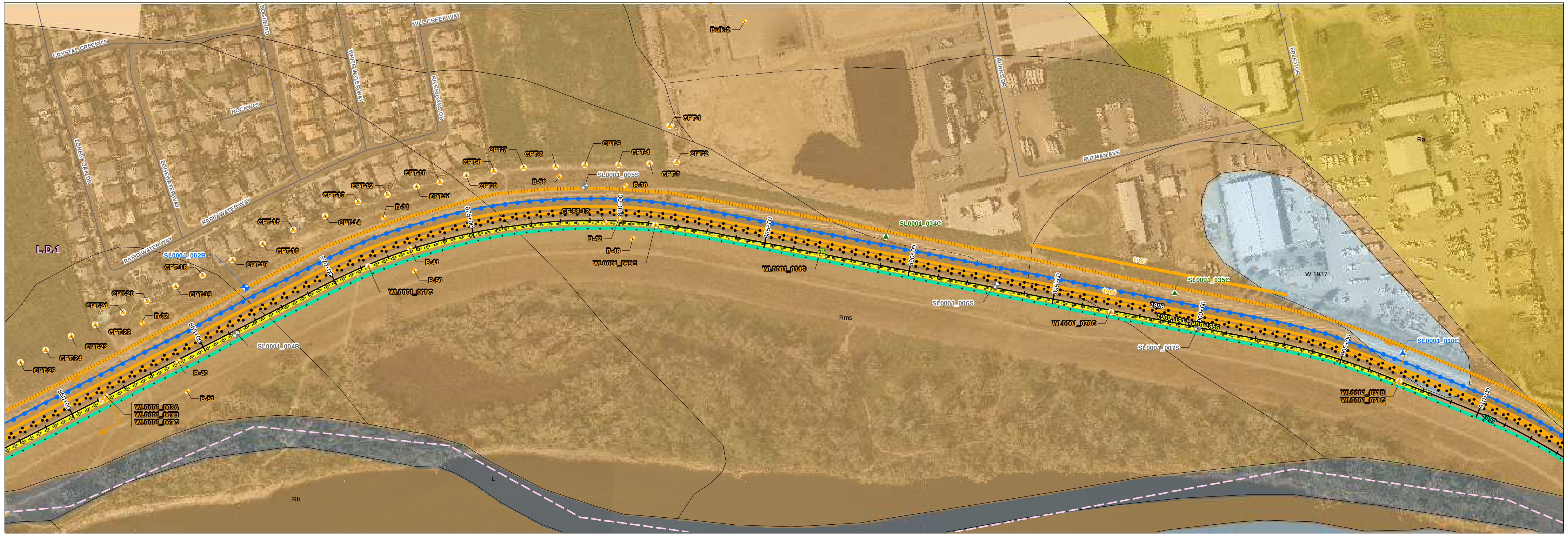
Geotechnical Design Recommendations Report

Sutter Butte Flood Control Agency

FEATHER RIVER WEST LEVEE PROJECT

Appendix A19



N

0 100 200

Feet

NOTES:

1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LiDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
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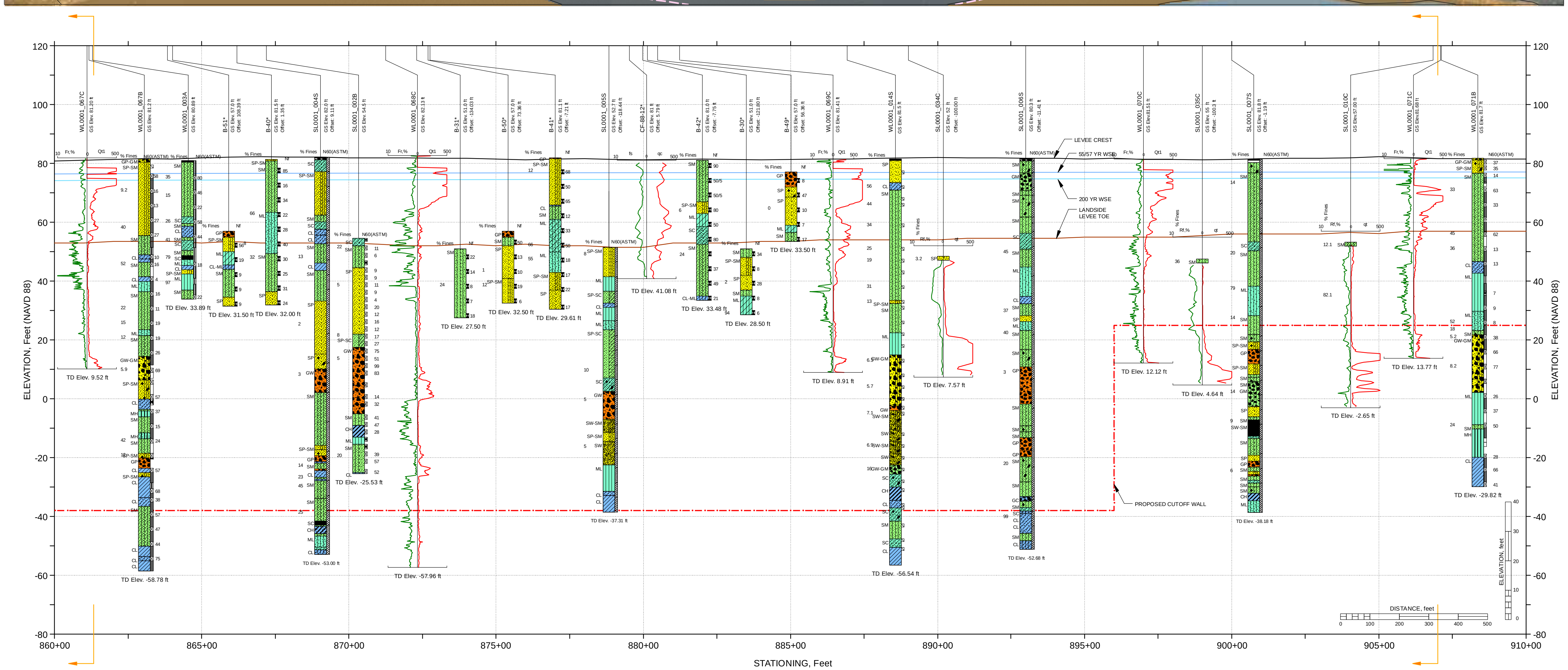
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



L:\Projects\SBFCA\ArcMaps\Reach13_New_Borings.mxd TNC 12.05.2012 SAC

FRWL Project Plan Views and Stick Log Figures

FRWL Project: Station 860+00 to Station 910+00

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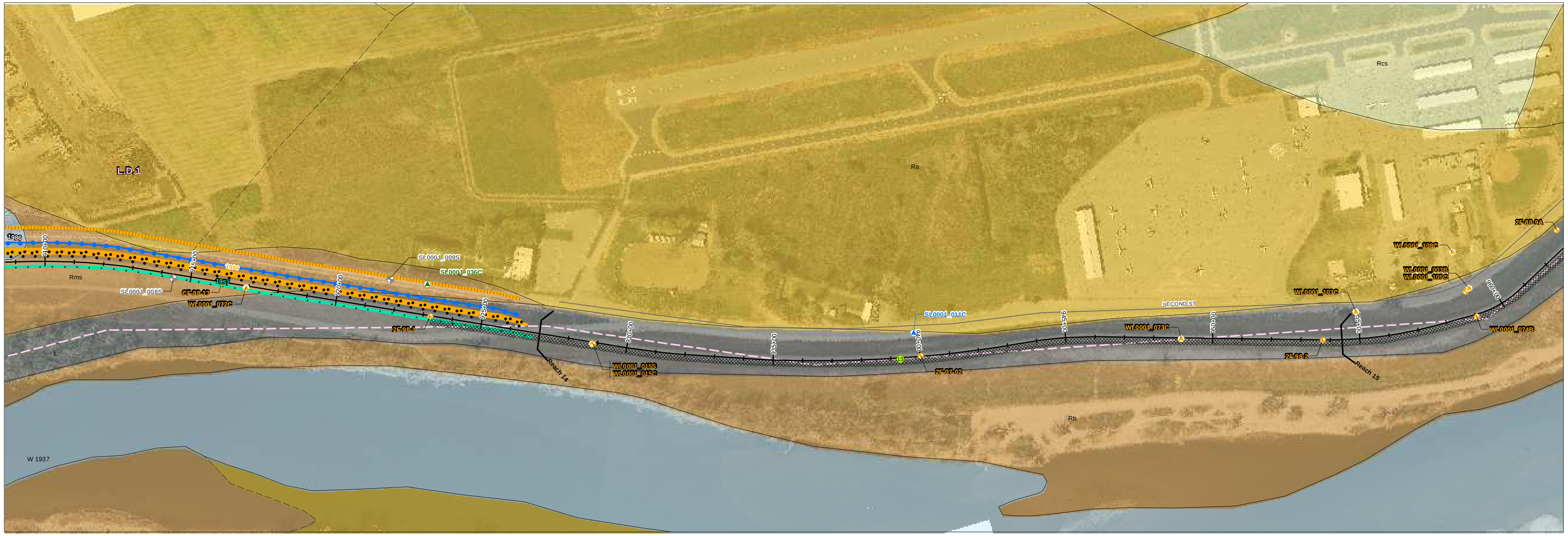
Geotechnical Design Recommendations Report

Sutter Butte Flood Control Agency

FEATHER RIVER WEST LEVEE PROJECT

Appendix A20



0 100 200
Feet

NOTES:

1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LiDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
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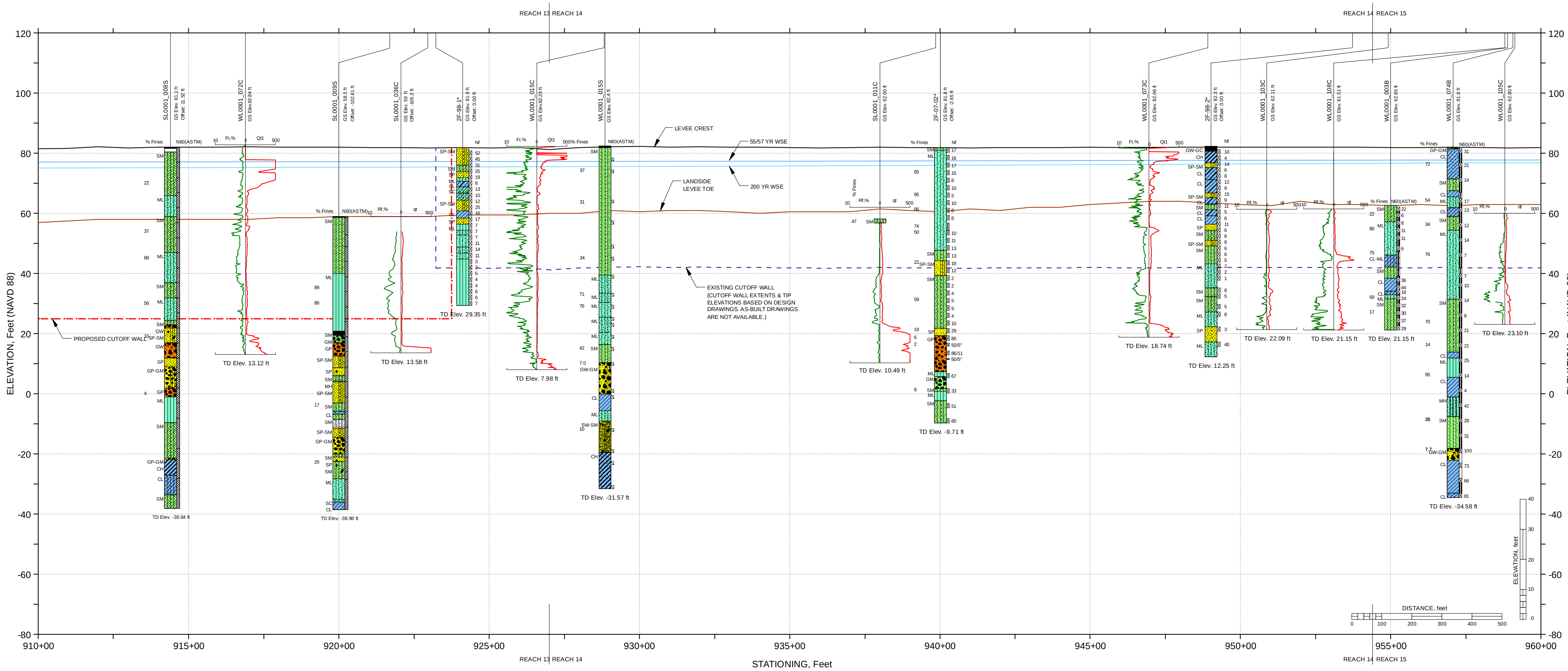

FRWL Project Plan Views and Stick Log Figures

FRWL Project: Station 910+00 to Station 960+00

URS — Geotechnical Design Recommendations Report

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix A21

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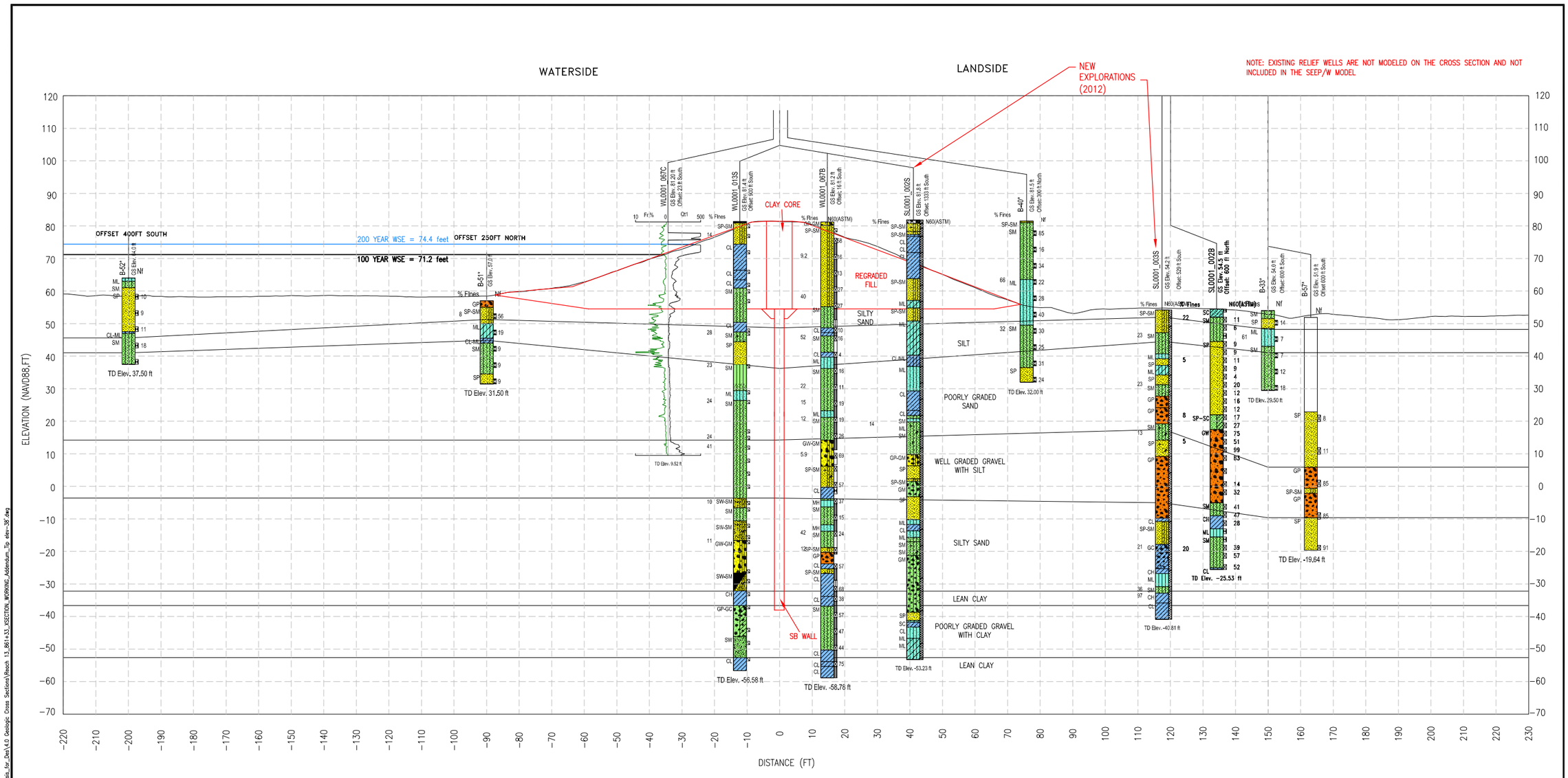
Attachment B



Sutter Butte Flood Control Agency	URS in association with: blackburn consulting	PROJECT NUMBER 17326712 TASK ORDER TO4 DATE October 2012	FEATHER RIVER WEST LEVEE PROJECT GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT	Transverse Cross Section with Mitigation Station 861+33 Reach 13	FIGURE B-1

PLOT BY: OYEONG-TAEK_HONG - Apr 15, 2013 - 10:46:39am
DRAWING: \\SACDATA01\Projects\SBFCA_FRWLV4_Analyses\V4-4_TO4\V4-4-2_Geotech_Analysis_for_Desk\V4.0 Geologic Cross Sections\Reach 13_861+33_XSECTION_MPWING_Addendum_Tip elev.-38' dwg

URS

Feather River West Levee Project
Hydraulic Conductivity Parameters for Seepage Analyses - Reach 13

PROJECT: SBFCA-FRWL
PROJECT NUMBER: 17326712
REACH: 13
STATION: 861+33
EXPLORATION ID: SL0001_002B (LS Toe), WL0001_067B (crown)

By: N. Malyala **Date:** 12/8/2011
Chk'd By: S. Orgill **Date:** 12/20/2011

Reference Explorations	Station	Elevation of Levee Crest (feet)	Layer ID	USCS Description	SBT_n Number - (If CPT is used)	Zone	Depth to Top of Layer (feet)	Depth to Bottom of Layer (feet)	Elevation of Top of Layer (NAVD 88)	Elevation of Bottom of Layer (NAVD 88)	Layer Thickness (feet)	% Fines (- Sieve #200)		Estimated Hydraulic Conductivity from FRWL Table					Rationale
												From Lab	From Field Classification	Horizontal kh (kx) cm/sec	kv/kh	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	
SL0001_002B (LS Toe), WL0001_067B (crown)	861+33	81.2	1	Poorly Graded Sand with Silt (SP-SM)		Embankment	0	26.7	81.2	54.5	26.7	9		**4.00E-03**	**1.00**	**4.00E-03**	11.3	11.3	(3-7% fines regraded material),Layer 1 has not been used in the analysis due to full levee degrade condition.
			2	Silty Sand (SM)		Foundation	26.7	32.741	54.5	48.5	6.041	40		**2.00E-04**	**0.25**	**5.00E-05**	0.57	0.14	(30-49% fines)
			3	Silt (ML)			32.741	45	48.5	36.2	12.259	52 (52-61)		**1.00E-05**	**0.25**	**2.50E-06**	0.028	0.0071	Silt or Plastic Silt 80-100% fines or >50% fines and PI>4
			4	Poorly Graded Sand (SP)			45	66.9	36.2	14.3	21.9	5 (5-24)		**4.00E-03**	**1.00**	**4.00E-03**	11.3	11.3	(3-7% fines)
			5	Well Graded Gravel with Silt (GW-GM)			66.9	84.804	14.3	-3.6	17.904	5 (5-6)		**1.00E-02**	**1.00**	**1.00E-02**	28.3	28.3	(3-7% fines)
			6	Silty Sand (SM)			84.804	133.3	-3.6	-52.1	48.496	12 (12-42)		**3.00E-03**	**0.50**	**1.50E-03**	8.5	4.3	(8-12% fines)
			7	Lean Clay (CL)			133.3	117.8	-52.1	-36.6	-15.5		(60-95)	**1.00E-06**	**0.25**	**2.50E-07**	0.0028	0.0007	Clay Layer over 20 ft below ground surface
			8	Poorly Graded Gravel with Clay (GP-GC)			117.8	133.80	-36.6	-52.6	16	(11-12)		**1.20E-03**	**0.50**	**6.00E-04**	3.4	1.7	(8-12% fines)
			9	Lean Clay (CL)			133.8	140	-52.6	-58.8	6.2		(60-90)	**1.00E-06**	**0.25**	**2.50E-07**	0.0028	0.0007	Clay Layer over 20 ft below ground surface
			10	Regraded Fill (SP-SM)		Embankment								**4.00E-03**	**0.25**	**1.00E-03**	11.3	2.8	
			11	Clay Core										**1.00E-06**	**0.25**	**2.50E-07**	0.0028	0.00071	
			12	SB Cutoff Wall		Cutoff Wall								**1.00E-07**	**1.00**	**1.00E-07**	0.00028	0.00028	

Total Depth (ft) 140.0

Landside Toe El: **54.5** **(NAVD 88)**
Levee Height: **35.6** **(feet)**

PROJECT: SBFCA-FRWL
PROJECT NO. 17326712
REACH: 13
STATION: 861+33
EXPLORATION: SL0001_002B (LS Toe), WL0001_067B (crown)

Feather River West Levee Project

Strength Parameters for Stability Analysis - Reach 13

By: N. Malyala Date: 12/8/2011
Checked By: S. Orgill Date: 12/20/2011

URS

Material Description (Layer Number)	Zone	Soil Layer Details					SPT and Laboratory Test Data														SPT Interpretation						CPT Interpretation						Strength Parameters for Analysis								COMMENTS
		Depth to Top of Layer (feet)	Depth to Bottom of Layer (feet)	Elevation of Top of Layer (NAVD 88)	Elevation of Bottom of Layer (NAVD 88)	Layer Thickness (feet)	N_{60}	$(N_1)_{60}$	Water Content (%)	Total Density (pcf)	LL	PI	LI	% Passing #200 Sieve	Maximum Past Pressure from Consolidation Test, σ'_{vmax} (ksf)	OCR from Consolidation Test	Vane Shear [su(psf), su/σv']	Direct Shear [c'(psf), φ'(degrees)]	Direct Shear [c(psf), φ(degrees)]	ICU triaxial [c'(psf), φ'(degrees)]	ICU triaxial [c(psf), φ(degrees)]	ϕ' from $(N_1)_{60}$ (deg)	ϕ' from PI (deg)	OCR from N	OCR from LI	S_u/σ'_{v0} from N_{60}	S_u from N_{60} (psf)	ϕ' from CPT (deg)	OCR from CPT	Max past pressure from CPT, Correlation (psf)	Max past pressure from CPT, SHANSEP (psf)	Undrained shear strength from CPT, s_u (psf)	S_u/σ'_{v0} from CPT	Soil Group Categorization(see Soil Group Categorization Notes)	Drained Cohesion, c' (psf)	Drained Friction Angle, ϕ' (deg)	OCR	Maximum past pressure (psf)	Undrained Cohesion, c (psf)	Undrained Friction Angle, ϕ (deg)	Total unit weight (pcf)	
SP-SM (1)	Embankment	0	26.7	81.2	54.5	26.7	13 (13-27)	13 (13-23)						9 (9-40)								34 (34-39)												6	0	35	-	-	-	-	125	From SPT interpretation, capped at phi'=35 deg. Layer 1 has not been used in the analysis due to full levee degrade condition.
SM (2)	Foundation	26.7	32.74	54.5	48.5	6.041	27	21														38												6	0	36	-	-	-	-	125	From SPT interpretation, capped at phi'=36 deg.
ML (3)	Foundation	32.74	45	48.5	36.2	12.26	4 (4-16)	2 (2-14)	23		29	8	0.25	52								26 (26-35)	35	2.9	2.6	0.1	500							4	0	30	1.0	-	75	15	115	From FRWL Project - Strength Parameter Table
SP (4)	Foundation	45	66.9	36.2	14.3	21.9	9 (4-27)	7 (3-22)						12 (5-20)								27 (27-38)												6	0	31	-	-	-	-	125	Based on SPT interpretation. One low blow count (N60=4) was an outlier.
GW-GM (5)	Foundation	66.9	84.8	14.3	-3.6	17.9	14 (14-123)	9 (9-58)						5 (5-6)								32 (32-44)												6	0	32	-	-	-	-	130	Based on SPT Interpretation
SM (6)	Foundation	84.8	133.3	-3.6	-52.1	48.5	15 (15-106)	7 (7-24)						9 (12-42)								31 (31-41)												6	0	31	-	-	-	-	130	Based on SPT Interpretation
CL (7)	Foundation	133.3	117.8	-52.1	-36.6	-15.5	38	17	34		36	10	0.8										35	4.6	1	0.5	3600							1	100	31	6.0	-	150	17	125	From FRWL Project - Strength Summary Table.
GP-GC (8)	Foundation	117.8	133.80	-36.6	-52.6	16	44 (44-57)	19 (19-26)														37 (37-40)												6	0	36	-	-	-	-	130	From SPT interpretation, capped at phi'=36 deg.
CL (9)	Foundation	133.8	140	-52.6	-58.8	6.2	75	32																8.1		0.8	9600							1	100	31	>2	-	150	17	125	From FRWL Project - Strength Summary Table.
Regraded Fill - SP-SM (10)	Embankment (Regraded)	-	-	-	-	-																												5	0	35		-	-	-	125	From FRWL Project - Strength Summary Table.
Clay Core (11)	Embankment (Regraded)	-	-	-	-	-																												5	100	31		-	150	17	125	From FRWL Project - Strength Summary Table.
Cutoff Wall (12)	New Cutoff Wall	-	-	-	-	-																												5	300	0	-	-	300	0	100	From FRWL Project - Strength Summary Table.

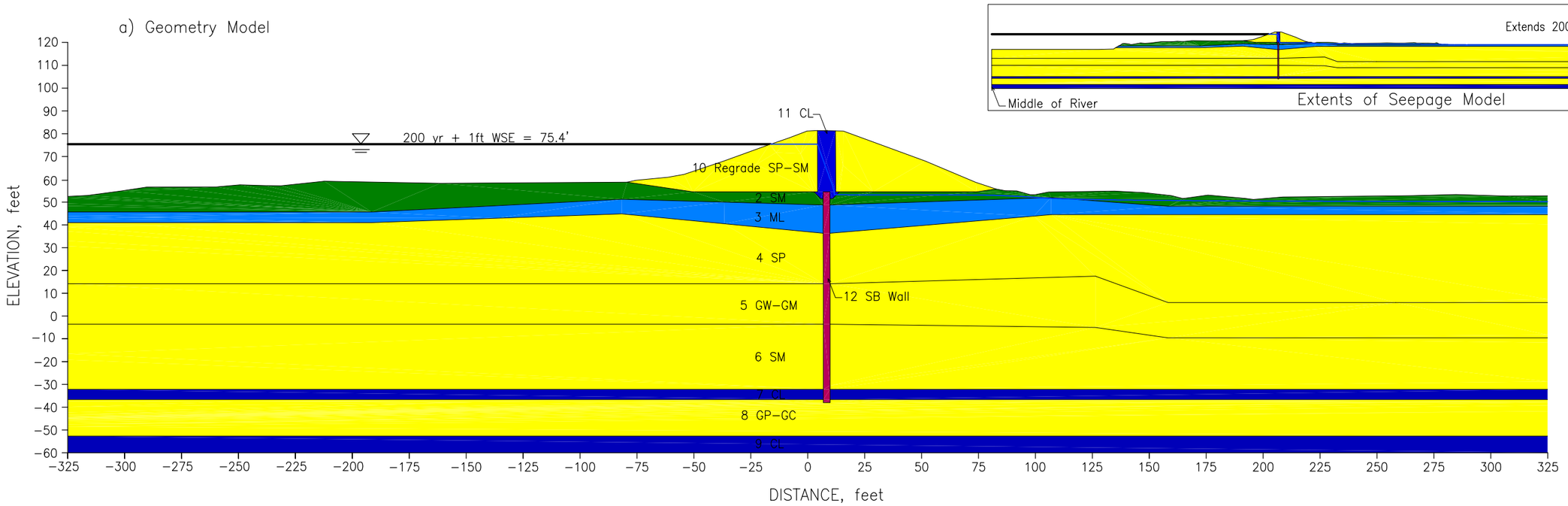
Levee Crest Elevation	**81.2**	**(NAVD 88)**
Landside Toe Elevation	**54.5**	**(NAVD 88)**
Levee Height	**26.7**	**(feet)**
WSE During Exploration	**35.6**	**(feet)** (From WL0001_067B)

General Notes: - Ranges and outliers shown where appropriate.

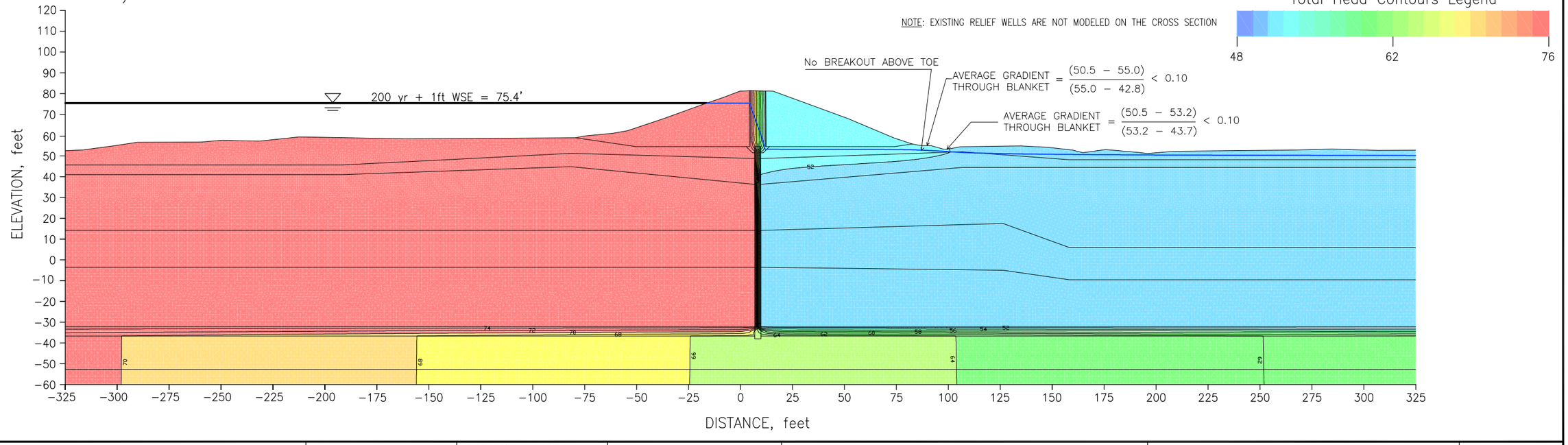
Soil Group Categorization Notes:

1. **Non-free-draining Group 1**
2. **Non-free-draining Group 2**
3. **Non-free-draining Group 3**
4. **Non-free-draining Group 4**
5. **Regraded fill**
6. **Free-draining**

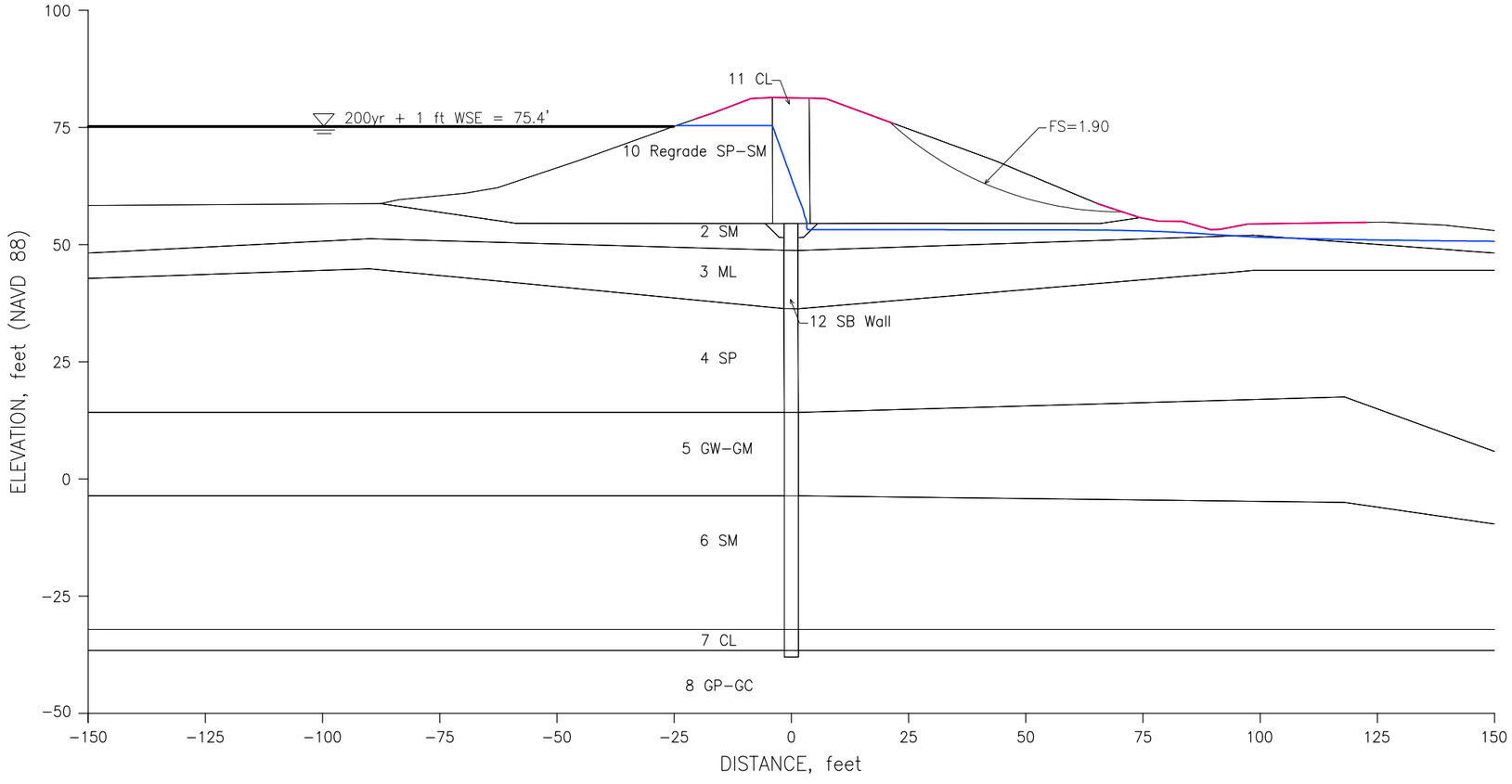
a) Geometry Model



b) Total Head Contours

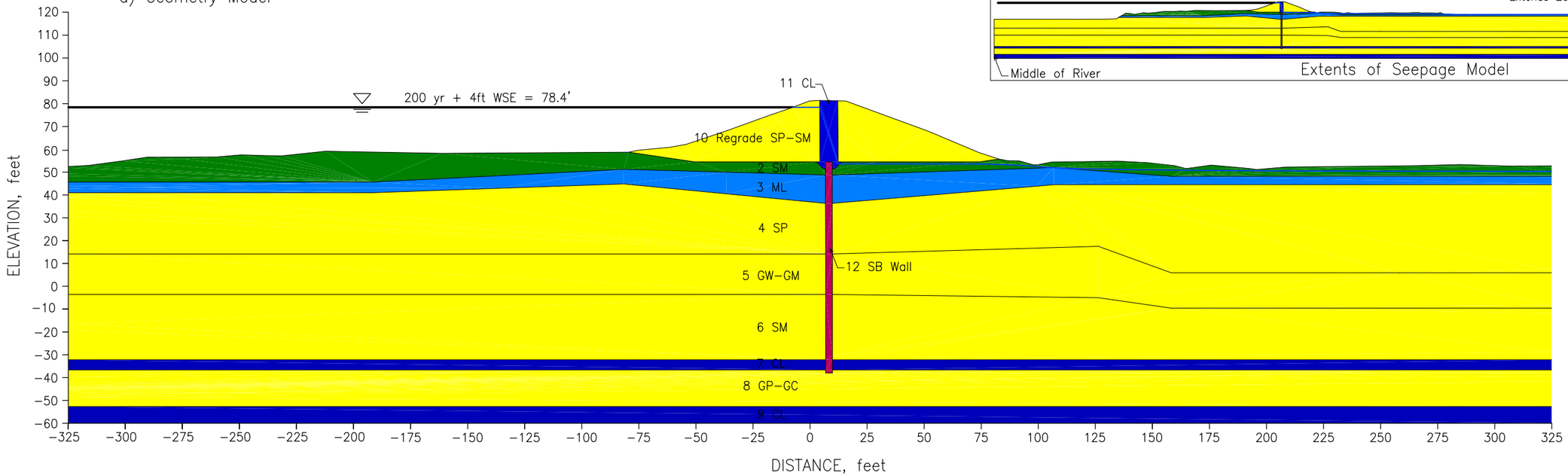


Sutter Butte Flood Control Agency	URS in association with: blackburn consulting	PROJECT NUMBER 17326712 TASK ORDER TO4 DATE October 2012	PREPARED BY GT Hong CHECKED BY Khaled Chowdhury	FEATHER RIVER WEST LEVEE PROJECT GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT	Seepage Analysis Results with Mitigation 200yr+1' Flood Event Steady State Seepage Condition 861+33 Reach 13	FIGURE B-2

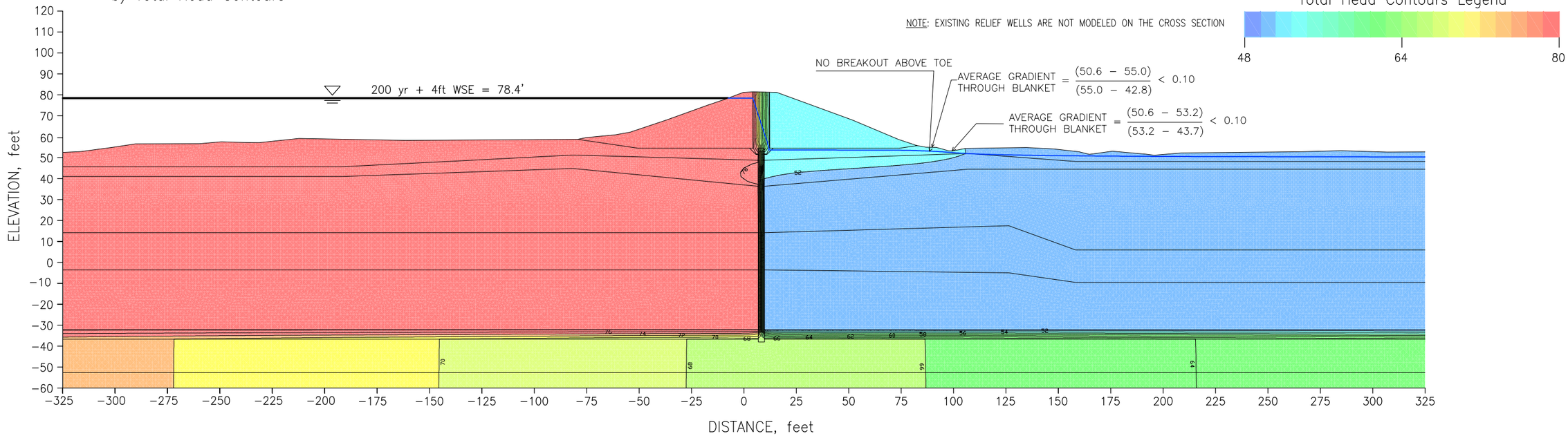


Sutter Butte Flood Control Agency	in association with: URS / blackburn consulting	PROJECT NUMBER 17326712 TASK ORDER TO4 DATE October 2012	PREPARED BY GT Hong CHECKED BY Khaled Chowdhury	FEATHER RIVER WEST LEVEE PROJECT GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT	Slope Stability Analysis Results with Mitigation 200yr+1' Flood Event Steady State Seepage Condition Station 861+33 Reach 13	FIGURE B−3

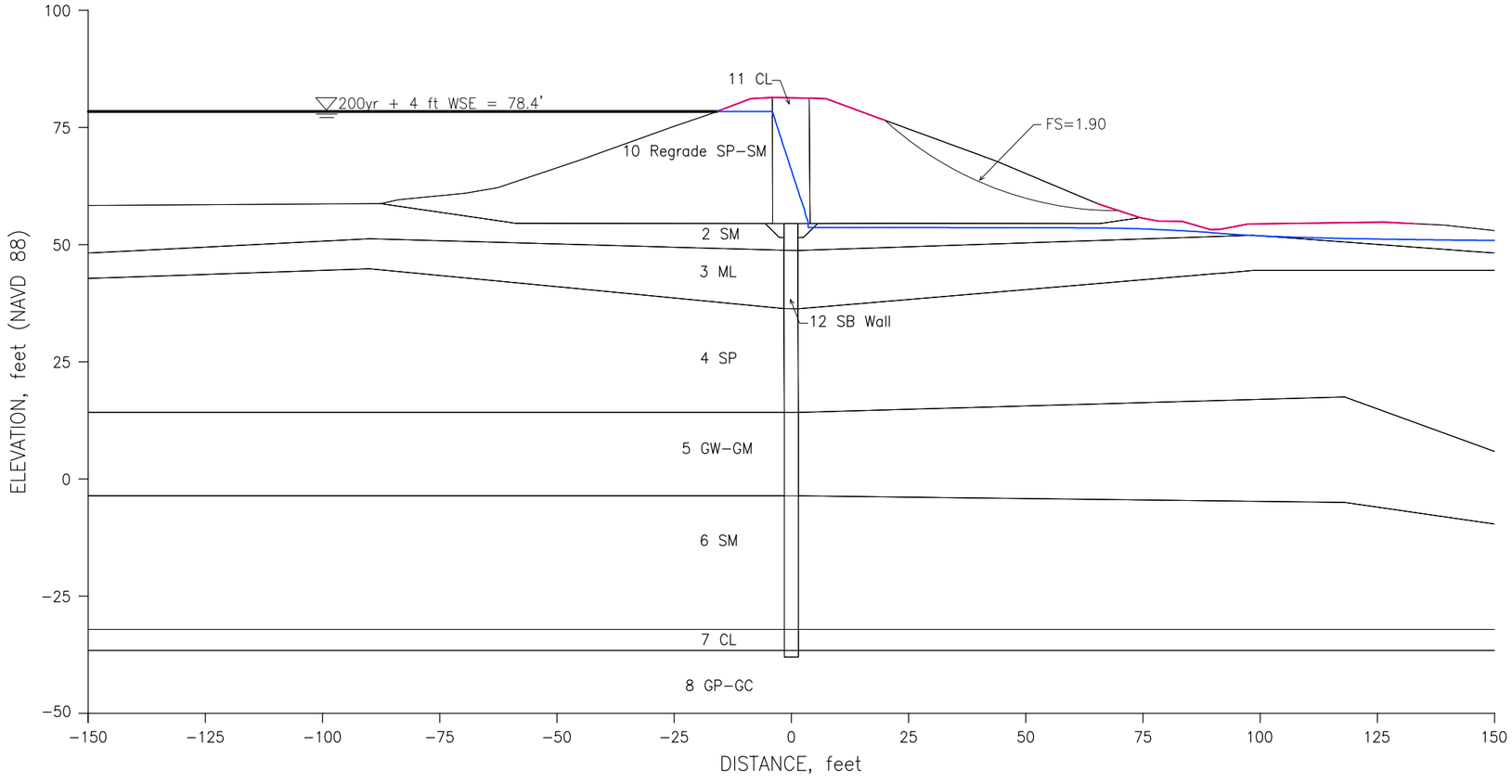
a) Geometry Model



b) Total Head Contours



Sutter Butte Flood Control Agency	URS in association with: blackburn consulting	PROJECT NUMBER 17326712 TASK ORDER TO4 DATE October 2012	PREPARED BY GT Hong CHECKED BY Khaled Chowdhury	FEATHER RIVER WEST LEVEE PROJECT GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT	Seepage Analysis Results with Mitigation 200yr+4' Flood Event Steady State Seepage Condition 861+33 Reach 13	FIGURE B-4



Sutter Butte Flood Control Agency	URS in association with: blackburn consulting	PROJECT NUMBER 17326712 TASK ORDER TO4 DATE October 2012	PREPARED BY GT Hong CHECKED BY Khaled Chowdhury	FEATHER RIVER WEST LEVEE PROJECT GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT	Slope Stability Analysis Results with Mitigation 200yr+4' Flood Event Steady State Seepage Condition Station 861+33 Reach 13	FIGURE B−5

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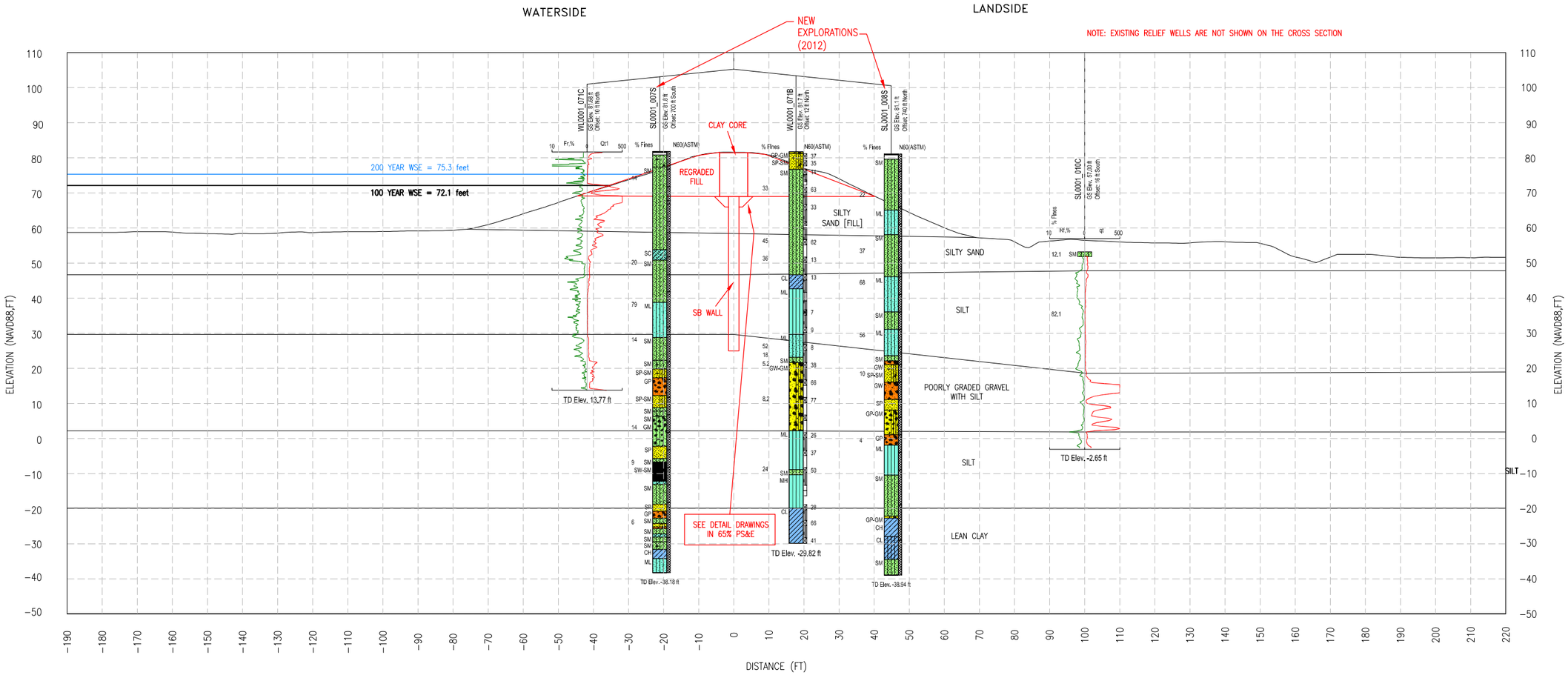
Attachment C



PLOT BY: GYEONG-TAEK_HONG – Dec 06, 2012 – 9:22:57am
DRAWING: \\SACSVR01\Projects\SBFCA_FRWL\2_Analyses\4-4_TO4\4-4-2_Geotech_Analysis_for_Dev\4.0 Geologic Cross Sections\Reach 13_907+00_XSECTION_MORNING-Addendum.dwg

Sutter Butte Flood Control Agency	URS in association with: blackburn consulting	PROJECT NUMBER 17326712 TASK ORDER TO4 DATE October 2012	FEATHER RIVER WEST LEVEE PROJECT GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT	Transverse Cross Section with Mitigation Station 907+00 Reach 13	FIGURE C–1

URS

Feather River West Levee Project
Hydraulic Conductivity Parameters for Seepage Analyses - Reach 13

PROJECT: SBFA-FRWL
PROJECT NUMBER: 17326712
REACH: 13
STATION: 907+00
EXPLORATION ID: WL0001_071C (crown), SL0001_010C (LS toe), WL0001_071B (crown)

By: E. Sinco Date: 12/14/2011
Chk'd By: S. Orgil Date: 12/20/2011

Reference Explorations	Station	Elevation of Levee Crest (feet)	Layer ID	USCS Description	SBT_n - Description (If CPT is used)	Zone	Depth to Top of Layer (feet)	Depth to Bottom of Layer (feet)	Elevation of Top of Layer (NAVD 88)	Elevation of Bottom of Layer (NAVD 88)	Layer Thickness (feet)	% Fines (- Sieve #200)		Estimated Hydraulic Conductivity from FRWL Table					Rationale
												From Lab	From Field Classification	Horizontal kh (kx) cm/sec	kv/kh	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	
WL0001_071C (crown), SL0001_010C (LS toe), WL0001_071B (crown)	907+00	81.7	1	Silty Sand (SM)	Silty sands & sandy silts	Embankment	0.0	23.3	81.7	58.4	23.3	33		**2.0E-04**	**0.25**	**5.00E-05**	0.57	0.14	
			2	Silty Sand (SM)	Silty sands & sandy silts	Foundation	23.3	35.0	58.4	46.7	11.7	36 (36-45)		**2.0E-04**	**0.25**	**5.00E-05**	0.57	0.14	
			3	Silt (ML)	Clays & silty clays		35.0	52.0	46.7	29.7	17.0	85		**1.0E-05**	**0.25**	**2.50E-06**	0.028	0.0071	
			4	Poorly Graded Gravel with Silt (GP-GM)	Sands & silty sands		58.5	79.5	29.7	27.5	2.2	5 (5-8)		**1.0E-02**	**1.00**	**1.00E-02**	28.3	28.3	
			5	Silt (ML)	Clays & silty clays		79.5	101.5	27.5	5.5	22.0			**1.0E-05**	**0.25**	**2.50E-06**	0.028	0.0071	
			6	Lean Clay (CL)			101.5	111.5	5.5	-4.5	10.0			**1.0E-06**	**0.25**	**2.50E-07**	0.0028	0.00071	Clay layer over 20 feet BGS
			7	Regraded Embankment SP-SM		Embankment								**4.0E-03**	**0.25**	**1.00E-03**	11.3	2.8	
			8	New Clay Core										**1.0E-06**	**0.25**	**2.50E-07**	0.0028	0.00071	
			9	SB Cutoff Wall		Cutoff Wall								**1.0E-07**	**1.00**	**1.00E-07**	0.00028	0.00028	
										Total Depth (ft)	86.2								

Landside Toe El: **57.0** **(NAVD 88)** from SL0001_010A (31ft from LS toe)
Levee Height: **24.7** **(feet)**

PROJECT: SBFCA-FRWL
PROJECT NO. 17326712
REACH: 13
STATION: 907+00
EXPLORATION: WL0001_071C (crown), SL0001_010C (LS toe), WL0001_071B (crown)

Feather River West Levee Project

Strength Parameters for Stability Analysis - Reach 13

By: E. Sinco Date: 12/14/2011
Checked By: S. Orgil Date: 12/20/2011

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Material Description (Layer Number)	Zone	Soil Layer Details					SPT and Laboratory Test Data														SPT Interpretation						CPT Interpretation						Strength Parameters for Analysis								COMMENTS
		Depth to Top of Layer (feet)	Depth to Bottom of Layer (feet)	Elevation of Top of Layer (NAVD 88)	Elevation of Bottom of Layer (NAVD 88)	Layer Thickness (feet)	N_{60}	$(N_1)_{60}$	Water Content (%)	Total Density (pcf)	LL	PI	LI	% Passing #200 Sieve	Maximum Past Pressure from Consolidation Test, σ'_{vmax} (ksf)	OCR from Consolidation Test	Vane Shear [su(psf), su/σ'v]	Direct Shear [c'(psf), ϕ'(degrees)]	Direct Shear [c(psf), ϕ(degrees)]	ICU triaxial [c'(psf), ϕ'(degrees)]	ICU triaxial [c(psf), ϕ(degrees)]	ϕ' from $(N_1)_{60}$ (deg)	ϕ' from PI (deg)	OCR from N	OCR from LI	S_u/σ'_{vo} from N_{60}	S_u from N_{60} (psf)	ϕ' from CPT (deg)	OCR from CPT	Max past pressure from CPT, Correlation (psf)	Max past pressure from CPT, SHANSEP (psf)	Undrained shear strength from CPT, S_u (psf)	S_u/σ'_{vo} from CPT	Soil Group Categorization(see Soil Group Categorization Notes)	Drained Cohesion, c' (psf)	Drained Friction Angle, ϕ' (deg)	OCR	Maximum past pressure (psf)	Undrained Cohesion, c (psf)	Undrained Friction Angle, ϕ (deg)	Total unit weight (pcf)	
SM (1)	Embankment	0.0	23.3	81.7	58.4	23.3	14 (14-63)	20 (20-69)	(21-35)					33								37						35						6	0	35	-	-	-	-	125	From CPT Interpretation
SM (2)	Foundation	23.3	35.0	58.4	46.7	11.7	13 (13-62)	10 (10-47)						(36-45)								32						32						6	0	32	-	-	-	-	125	From CPT Interpretation
ML (3)	Foundation	35.0	52.0	46.7	29.7	17.0	7 (7-13)	4 (4-9)	21 35	113	30 37	9 12	0 0.83	85	5400	1.0						28	35	1.4	1.0	0.2	800	27	1	5000	4800	800	0.2	4	0	30	1.0	5400	75	15	115	From FRWL Project - Strength Parameter Table; CPT data suggests OCR<2
GW-GM (4)	Foundation	58.5	79.5	29.7	2.2	21.0	38 (38-77)	20 (20-60)						(5-8)								38						32						6	0	32	-	-	-	-	130	From CPT Interpretation
ML (5)	Foundation	79.5	101.5	2.2	-19.8	22.0	26 (26-50)	13 (13-24)	31		35	10	0.6	24										3	1	0.4	3300	32	2.5	>10000	>10000	2700	0.5	4	0	30	1	-	75	15	125\	From FRWL Project - Strength Parameter Table; CPT data suggests OCR<2
CL (6)	Foundation	101.5	111.5	-19.8	-29.8	10.0	26 (26-66)	12 (12-28)															35	4.7		0.5	5200							1	100	31	2.5	-	150	17	125	From FRWL Project - Strength Parameter Table; OCR from SPT data
Regraded Fill (7)	Regraded Embankment	-	-	-	-	-																												5	0	35	-	-	-	-	125	From FRWL Project - Strength Parameter Table.
Clay Core (8)	Regraded Embankment	-	-	-	-	-																												5	100	31	-	-	150	17	125	From FRWL Project - Strength Parameter Table
Cutoff Wall (9)	New Cutoff Wall	-	-	-	-	-																												5	300	0	-	-	300	0	100	From FRWL Project - Strength Parameter Table

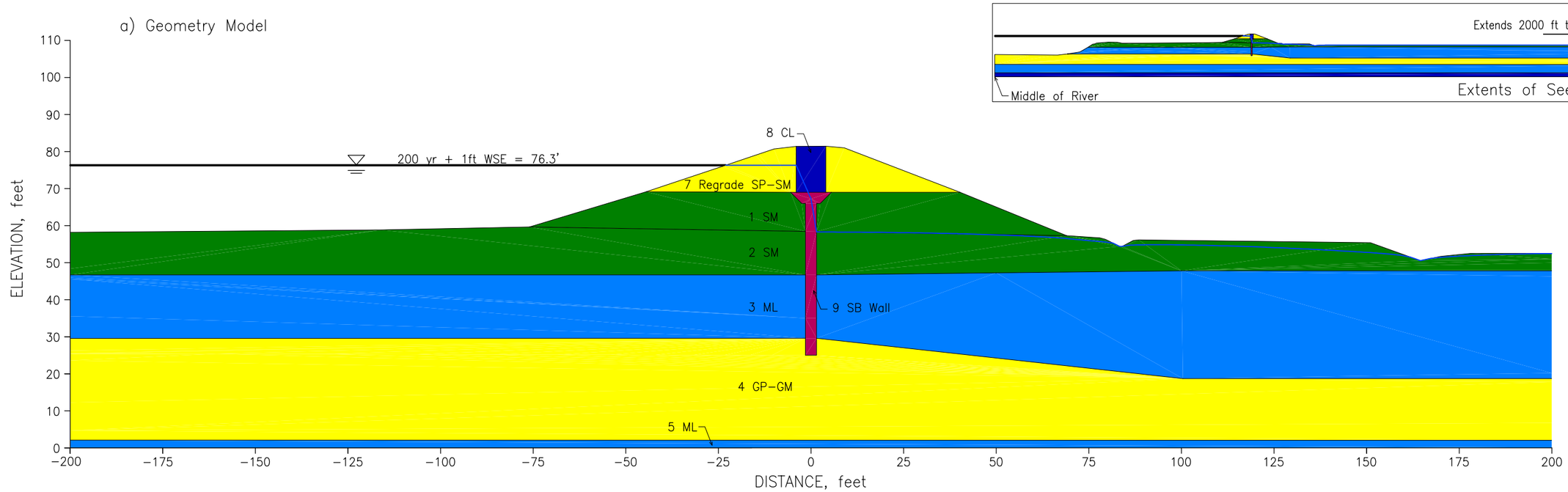
Levee Crest Elevation	**81.7**	**(NAVD 88)**	From WL0001_071B (crown)
Landside Toe Elevation	**57.0**	**(NAVD 88)**	From SL0001_010A (31ft from LS toe)
Levee Height	**24.7**	**(feet)**	
WSE During Exploration	**24.5**	**(feet)**	From SL0001_010A (31ft from LS toe)

General Notes: - Ranges and outliers shown where appropriate.

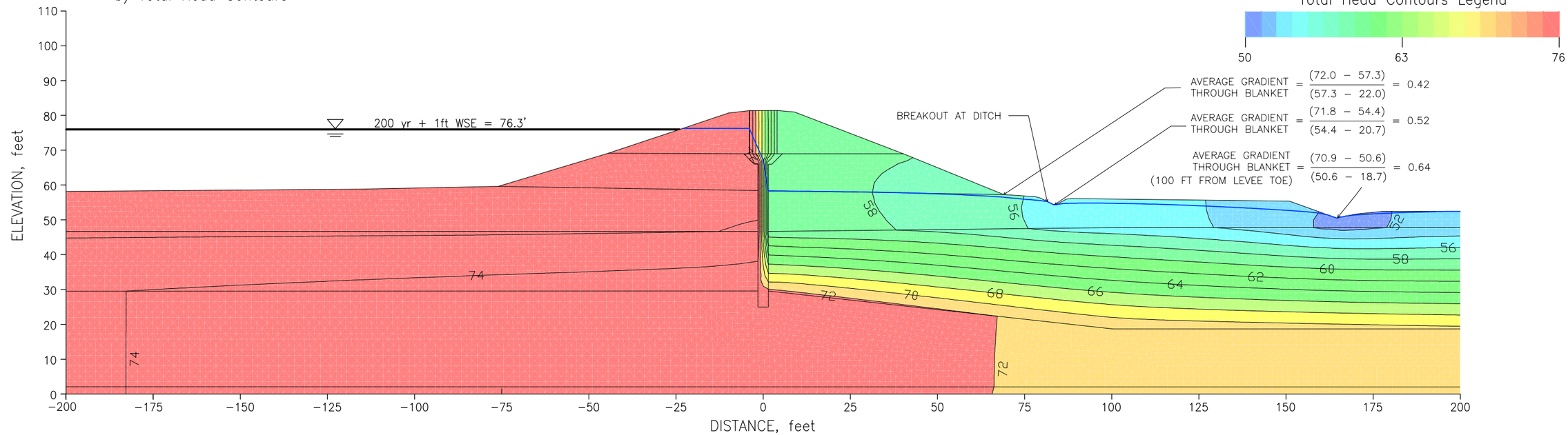
Soil Group Categorization Notes:

1. **Non-free-draining Group 1**
2. **Non-free-draining Group 2**
3. **Non-free-draining Group 3**
4. **Non-free-draining Group 4**
5. **Regraded fill**
6. **Free-draining**

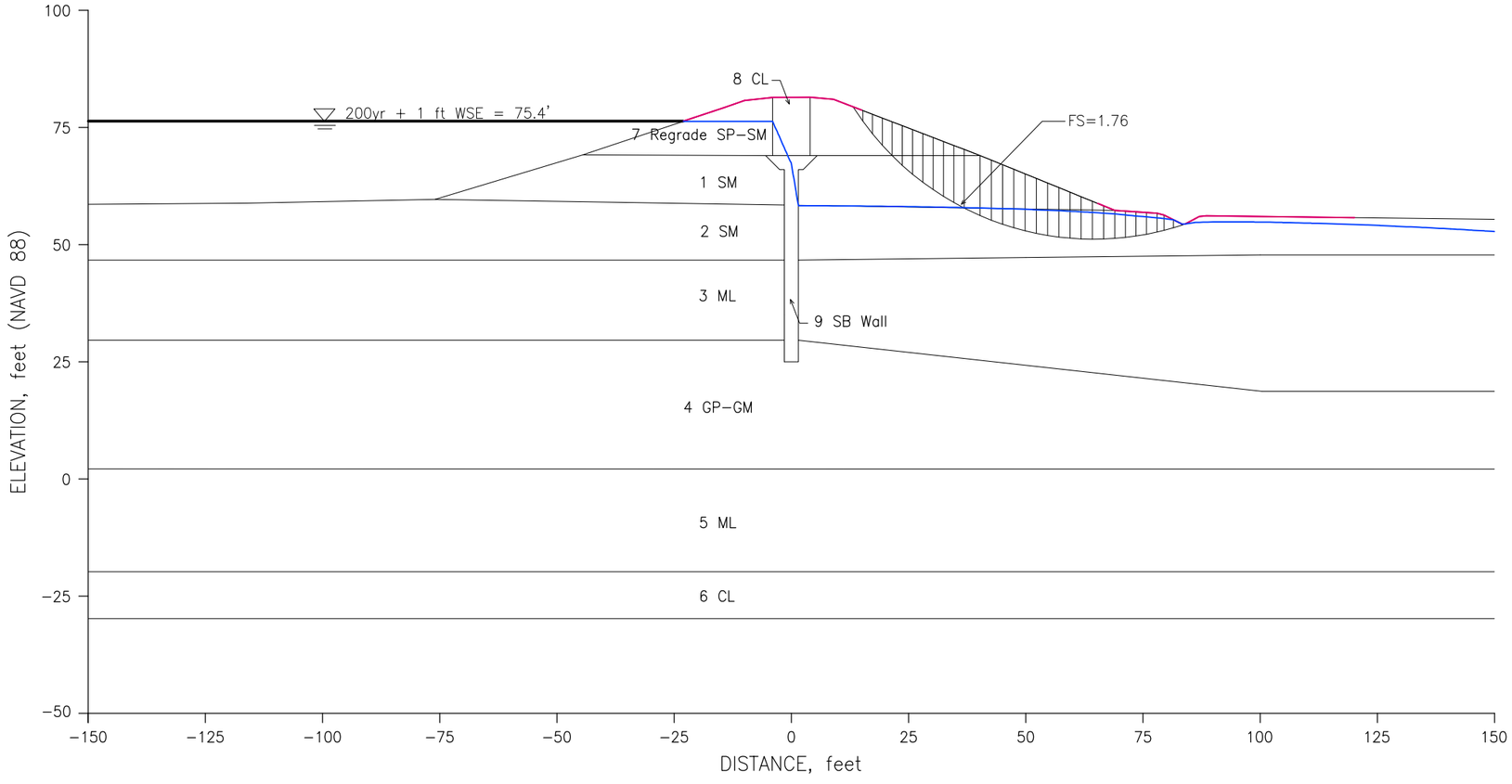
a) Geometry Model



b) Total Head Contours

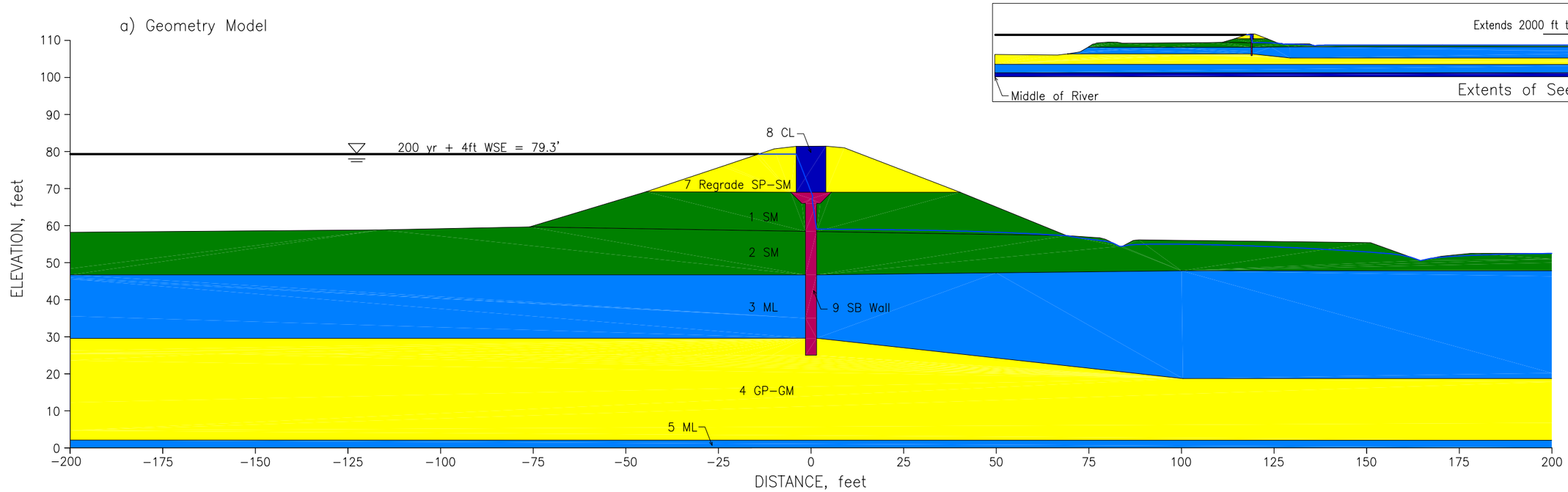


Sutter Butte Flood Control Agency	URS in association with: blackburn consulting	PROJECT NUMBER 17326712 TASK ORDER TO4 DATE October 2012	PREPARED BY GT Hong CHECKED BY Khaled Chowdhury	FEATHER RIVER WEST LEVEE PROJECT GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT	Seepage Analysis Results with Mitigation 200yr+1' Flood Event Steady State Seepage Condition 907+00 Reach 13	FIGURE C−2

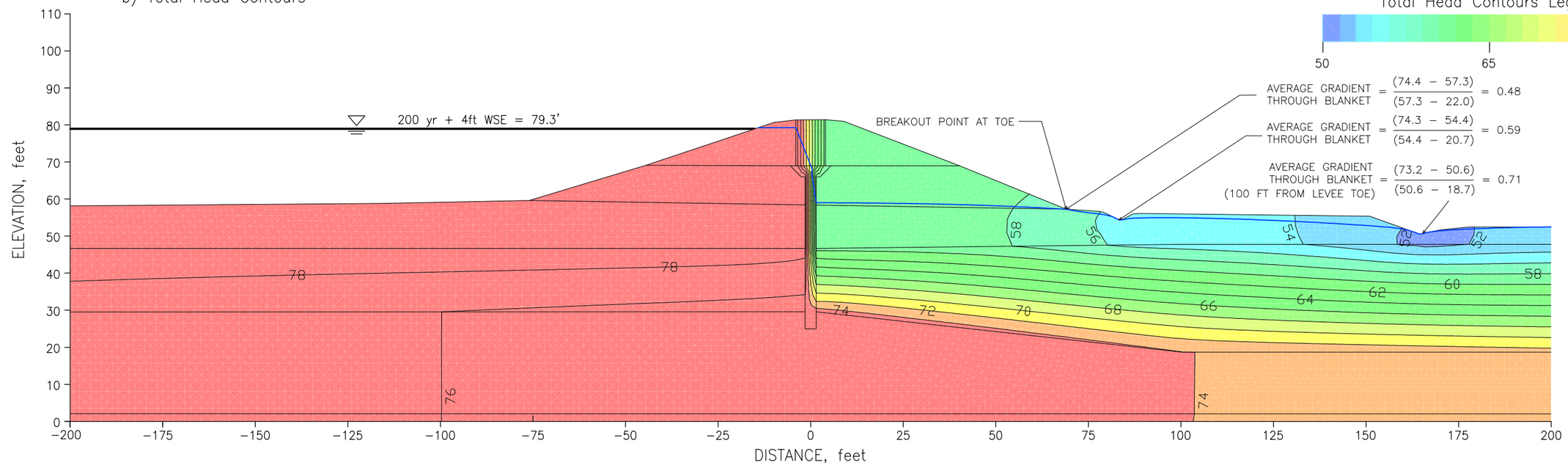


Sutter Butte Flood Control Agency	URS in association with: blackburn consulting	PROJECT NUMBER 17326712 TASK ORDER TO4 DATE October 2012	PREPARED BY GT Hong CHECKED BY Khaled Chowdhury	FEATHER RIVER WEST LEVEE PROJECT GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT	Slope Stability Analysis Results with Mitigation 200yr+1' Flood Event Steady State Seepage Condition Station 907+00 Reach 13	FIGURE C-3

a) Geometry Model



b) Total Head Contours



Sutter Butte Flood Control Agency

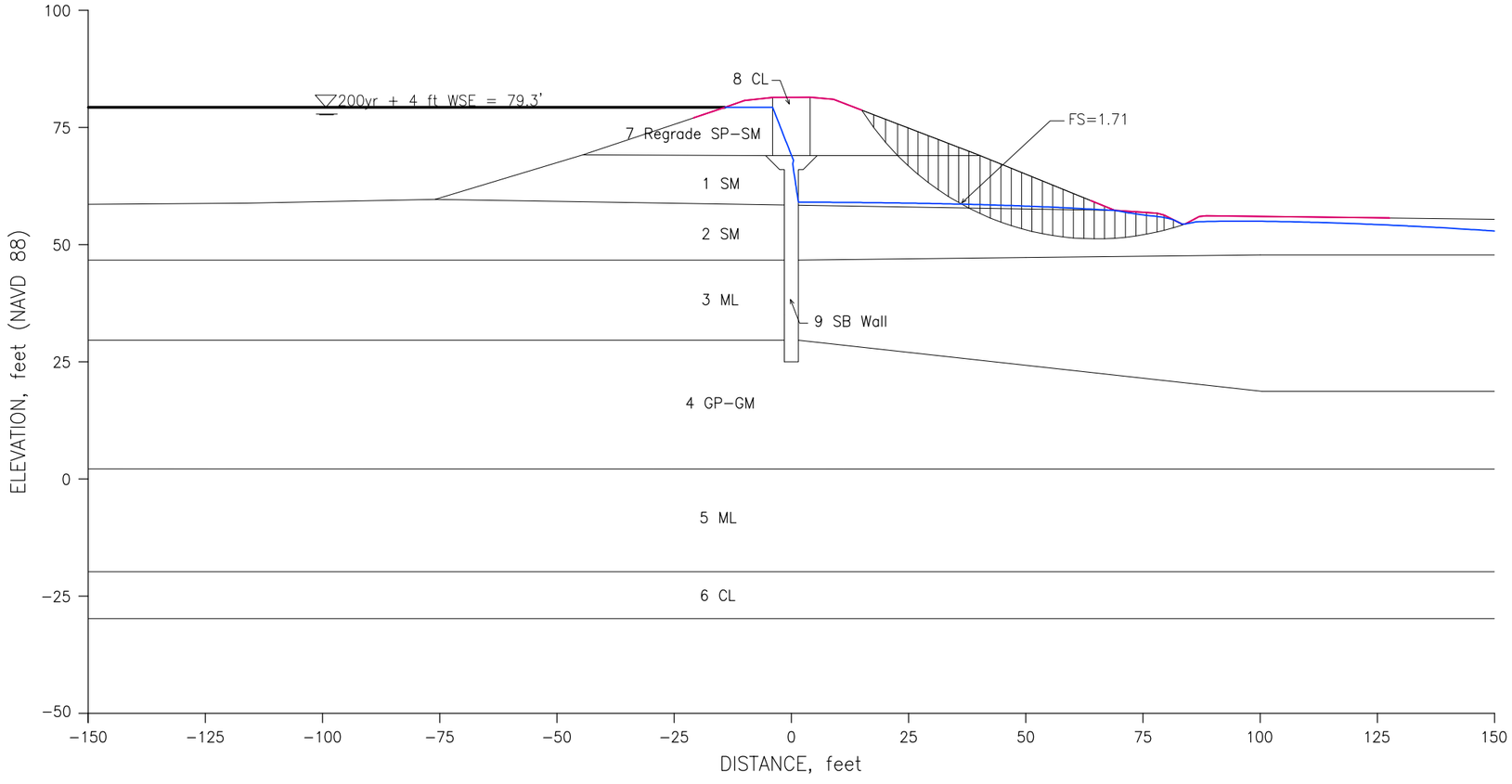
URS in association with: blackburn consulting

PROJECT NUMBER	17326712
TASK ORDER	TO4
DATE	October 2012
PREPARED BY	GT Hong
CHECKED BY	Khaled Chowdhury

FEATHER RIVER WEST LEVEE PROJECT
GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT

Seepage Analysis Results with Mitigation
200yr+4' Flood Event Steady State Seepage Condition
907+00
Reach 13

FIGURE C-4



Sutter Butte Flood Control Agency	URS in association with: blackburn consulting	PROJECT NUMBER 17326712 TASK ORDER TO4 DATE October 2012	PREPARED BY GT Hong CHECKED BY Khaled Chowdhury	FEATHER RIVER WEST LEVEE PROJECT GEOTECHNICAL DESIGN RECOMMENDATIONS REPORT	Slope Stability Analysis Results with Mitigation 200yr+4' Flood Event Steady State Seepage Condition Station 907+00 Reach 13	FIGURE C-5

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Attachment D

DATE STARTED 10/18/12 **DATE COMPLETED** 10/19/12	**GROUND ELEVATION** 81.77 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 135.0 ft
DRILLING CONTRACTOR National	**DRILLER'S NAME** J. Marok **HELPER'S NAME** N. Castro/M. Woolcott	**TOTAL DEPTH OF FILL** 24.7 ft
DRILLING METHOD Sonic	**DRILL RIG MAKE AND MODEL** Geoprobe 8140 LC #34	**CONSULTANT COMPANY** URS Corporation
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 4-1/2" Sonic Corebarrel/6-1/4 csg bit	**DRILLING ROD TYPE AND DIAMETER** 3-1/2" Sonic	**FIELD LOGGER** M. Palmer
X VERTICAL ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** 5-7/8 x 5-1/8 Steel	**FIELD LOG REVIEWER** G.T. HONG
SAMPLER TYPE(S) 4-1/2 x 3-1/2 Core Barrel	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** NA	**HAMMER EFFICIENCY**
BOREHOLE BACKFILL OR COMPLETION Neat cement grout	**GROUNDWATER READING: DURING DRILLING** NA **AFTER DRILLING (DATE-TIME)**	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		AB Roadbase.			0									0-1' Sonic
	1		[LEVEE FILL] Poorly Graded SAND with Silt and Gravel (SP-SM); light olive brown; dry; 60% fine to coarse sand; 30% fine to coarse gravel, max. 3 in.; 10% no plasticity fines; presence of mica.												1-2.5' Hand Auger, refusal at 2.5'.
80	2					100									
	3														Run 1
	4		[LEVEE FILL] Poorly Graded SAND with Silt (SP-SM); light yellowish brown; dry; 90% fine to medium sand; 10% no plasticity fines; trace mica.			100									
	5		[LEVEE FILL] LEAN CLAY with Sand (CL); yellowish brown; moist; 80% low to medium plasticity, no dilatancy fines; 20% fine sand; trace mica; trace fine organics.												At 5' set casing to 5'. Run 2
	6														
75	7		[LEVEE FILL] SANDY LEAN CLAY (CL); yellowish brown; moist; 55% low plasticity, no to slow dilatancy fines; 45% fine sand; trace mica.			50									
	8														
	9														
	10		[LEVEE FILL] LEAN CLAY with Sand (CL); yellowish brown; moist; 80% fine sand; 20% low to medium plasticity, no to slow dilatancy fines; presence of mica.												Run 3
	11														
70	12					60									
	13														
	14														
	15														At 15' set casing to 10'. Run 4
	16														
65	17					80									
	18		[LEVEE FILL] Poorly Graded SAND with Silt (SP-SM); light yellowish brown; dry; 90% fine to medium sand; 10% no plasticity fines; presence of mica.												
	19														
	20														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,162,010.38 **Easting:** 6,674,532.17
Latitude: 39.09819 **Longitude:** -121.60229
Levee Station or Milepost: 848+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_002S
Sheet 1 of 6

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/6/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
	20														Run 5
60	21														
	22					70									
	23														
←FILL	24														
	25		CLAYEY SILT with Sand (ML/CL); dark gray; moist; 85% low to medium plasticity, no to slow dilatancy fines; 15% fine sand; presence of mica; presence of roots.												Run 6
	26		At 26 feet yellowish brown; trace organics.							29	39	12			Sample fell out, went back in and recovered.
55	27		Poorly Graded SAND with Silt (SP-SM); light yellowish brown; dry; 90% fine to medium sand; 10% no plasticity fines; presence of mica.			70									
	28														
	29														
	30														At 30' set casing to 25'. Run 7 No recovery 30-32'
	31		CLAYEY SILT with Sand (ML/CL); yellowish brown; 85% low plasticity, slow to rapid dilatancy fines; 15% fine sand; orange-red iron oxide staining throughout.												
50	32					60									
	33														
	34														
	35														Run 8
	36														Use flapper bit. Upper 2.5' of 3.5 recovered totally disturbed and not saved.
45	37					20									
	38														
	39														
	40														At 40' set casing to 35'. Run 9 No recovery 40-43' Completely disturbed and soupy.
	41														
40	42		SILTY CLAY with Sand (CL/ML); very soft; dark gray; moist; 80% low plasticity, slow dilatancy fines; 20% fine sand; moderate organic odor; some organic fragments.			34									
	43														
	44														
	45														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,162,010.38 **Easting:** 6,674,532.17
Latitude: 39.09819 **Longitude:** -121.60229
Levee Station or Milepost: 848+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_002S
Sheet 2 of 6

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45		SANDY SILT (ML); very dark gray; wet; 55% no to low plasticity, rapid dilatancy fines; 45% fine sand; slight organic odor; presence of woody organic fragments;presence of mica.												Run 10 Use open bit.
35	46														
	47					60				40	33	3			
	48														
	49														
	50														At 50' set casing to 45'. Run 11 No recovery Core barrel fell off three times during extraction from borehole, sample lost out of sampler.
30	51														
	52					0									
	53		LEAN CLAY with Sand (CL); olive brown; moist; 55% low plasticity, no to slow dilatancy fines; 45% fine sand; presence of mica; trace organic fragments.												
	54														
	55														At 55' set casing to 50'. Run 12
25	56														
	57					100									
	58														
	59		SANDY LEAN CLAY (CL/SC); olive brown; moist; 50% fine sand; 50% low plasticity, no to slow dilatancy fines; presence of mica and organics.												
	60		SILTY SAND (SM); very dark greenish gray; wet; 70% fine to medium sand; 30% no to low plasticity, rapid dilatancy fines.												At 60' set casing to 55'. Run 13
	61		SANDY SILT (ML/SM); very dark greenish gray; wet; 50% fine sand; 50% low plasticity, rapid dilatancy fines; micaceous.												
20	62		SILTY SAND with Gravel (SM); very dark greenish gray; moist; 46% fine to coarse sand; 40% fine to coarse, rounded, hard gravel, max. 1.5 in.; 14% low plasticity, no to slow dilatancy fines; micaceous.			90				14	27	3	14		
	63														
	64														
	65														At 65' set casing to 60'. Run 14
15	66														
	67					90									
	68														
	69		At 68.5 feet 65% fine to coarse sand; 20% fines; 15% gravel.												
	70		At 69.5 feet 0.8' interbed of Clayey Sand (SC); 70% fine												

Final Report Version 12/5/2012

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,162,010.38 **Easting:** 6,674,532.17
Latitude: 39.09819 **Longitude:** -121.60229
Levee Station or Milepost: 848+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_002S
Sheet 3 of 6

SBFCA Feather River West Levee

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
	70		to coarse sand; 30% low plasticity fines; trace fine gravel.												At 70' set casing to 65'. Run 15 No recovery 70-72'
10	71														
	72		Poorly Graded GRAVEL with Silt and Sand (GP-GM); very dark greenish gray; wet; 60% fine to coarse, rounded gravel; 30% fine to coarse sand; 10% no to low plasticity fines.			60									
	73														
	74														
	75														At 75' set casing to 70'. Run 16
	76		Poorly Graded SAND (SP); very dark greenish gray; wet; 95% fine to coarse sand; 5% no plasticity fines; trace gravel, max. 1.5 in.												
5	77														
	78														
	79														
	80		Poorly Graded SAND with Silt (SP-SM); very dark greenish gray; wet; 90% fine to coarse sand; 10% no plasticity fines; trace fine to coarse gravel, max. 1.5 in.			95									
	81		SILTY GRAVEL (GM); very dark greenish gray; moist; 40% fine to coarse gravel, max. 1.25 in.; 30% fine to coarse sand; 30% no plasticity fines; well consolidated; blocky to friable texture.												
0	82														
	83		At 82.5 feet 0.3-0.5' thick interbeds; micaceous; Silty Sand (SM); 75% fine to medium sand; 25% no plasticity fines; Sandy Silt (ML); 70% no to low plasticity fines; 30% fine sand; Poorly graded Sand with Silt (SP-SM); 90% fine to medium sand; 10% no plasticity fines.											
	84														
	85		Poorly Graded SAND (SP); greenish black; wet; 95% fine to medium sand; 5% no plasticity fines; presence of mica.												At 85' set casing to 80'. Run 17
-5	86														
	87														
	88														
	89														
	90					100									
	91														
-10	92		SILT with Sand (ML); very dark greenish gray; moist; 75% low plasticity, rapid dilatancy fines; 25% fine sand; micaceous.												
	93														
	94		SANDY LEAN CLAY (CL); very dark greenish gray; moist; 70% low to medium plasticity, slow dilatancy fines; 30% fine sand; micaceous. At 94.5 feet poorly-well indurated to 95.7'.												
	95														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,162,010.38 **Easting:** 6,674,532.17
Latitude: 39.09819 **Longitude:** -121.60229
Levee Station or Milepost: 848+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_002S
Sheet 4 of 6

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
	95														Run 18
	96		SANDY SILT (ML); very dark greenish gray; moist; 65% low plasticity, rapid dilatancy fines; 35% fine sand.												
-15	97														
	98		SILTY SAND (SM); very dark greenish gray; moist; 60% fine sand; 40% no to low plasticity fines; presence of mica; fine grained organic fragments.			90									Gradational content.
	99		SILTY SAND with Gravel (SM); very dark greenish gray; moist; 50% fine to coarse sand; 30% fine to coarse, rounded, hard gravel, max. 1 in.; 20% no to low plasticity, slow dilatancy fines; poorly indurated; friable to crumbly texture.												
	100														At 100' set casing to 95'. Run 19
	101														
-20	102														
	103		SILTY GRAVEL with Sand (GM); very dark greenish gray; moist; 50% fine to coarse, rounded, hard gravel, max. 3 in.; 35% fine to coarse sand; 15% no plasticity fines.												
	104														
	105					95									
	106														
-25	107														
	108														
	109		At 109 feet 0.5' lens of (SM) as in 98.8 to 103 feet; friable texture.												
	110														At 110' set casing to 100'. Run 20
	111														
-30	112														
	113														
	114														
	115					80									
	116														
-35	117														
	118														
	119														
	120														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,162,010.38 **Easting:** 6,674,532.17
Latitude: 39.09819 **Longitude:** -121.60229
Levee Station or Milepost: 848+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_002S
Sheet 5 of 6

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
	120														At 120' set casing to 110'. Run 21
	121		Poorly Graded SAND (SP); greenish black; wet; 100% fine to coarse sand; trace fine gravel, max. 1/8 in.; presence of mica.												
-40	122														
	123		CLAYEY SAND (SC); dark greenish gray; moist; 80% fine to coarse sand; 20% low plasticity, no dilatancy fines; micaceous; poorly indurated; friable texture.												
	124		SANDY LEAN CLAY (CL/SC); very dark greenish gray; moist; 55% low to medium plasticity, no dilatancy fines; 45% fine sand; very hard; blocky texture; poorly indurated; micaceous.												
	125					100									
	126		SILT with Sand (ML); very dark greenish gray; moist; 80% medium plasticity, no dilatancy fines; 20% fine sand; very hard; blocky texture variably crumbly; poorly indurated; micaceous.												
-45	127									30	46	12			
	128														
	129		SANDY CLAYEY SILT (ML/CL); very dark greenish gray; moist; 50% fine sand; 50% low plasticity, slow to rapid dilatancy fines; blocky texture; poorly indurated; micaceous.												
	130														Run 22
	131														
-50	132		At 131.5 feet to 134 feet well indurated; blocky texture; too hard to manually work to soil (similar to mudstone).			74									Upper 1.3 disturbed and mixed with slough and tossed out.
	133														
	134														
	135														
	136		Borehole terminated at 135 feet. Backfilled boring with 250 gallons of neat grout consisting of 185 gallons water, 25 pounds of bentonite powder, 40-47 lb sacks of portland cement.												
-55	137														
	138														
	139														
	140														
	141														
-60	142														
	143														
	144														
	145														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,162,010.38 **Easting:** 6,674,532.17
Latitude: 39.09819 **Longitude:** -121.60229
Levee Station or Milepost: 848+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_002S
Sheet 6 of 6

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

DATE STARTED	DATE COMPLETED	GROUND ELEVATION	ELEVATION DATUM	TOTAL DEPTH OF BORING
10/2/12	10/4/12	54.19 ft	NAVD 88	95.0 ft

DRILLING CONTRACTOR	DRILLER'S NAME	HELPER'S NAME	TOTAL DEPTH OF FILL
National	J. Marok	R. Estrado/E. Jasso	0 ft

DRILLING METHOD	DRILL RIG MAKE AND MODEL	CONSULTANT COMPANY
Sonic	Geoprobe 8140 LC #34	URS Corporation

DRILL BIT SIZE AND TYPE (HOLE DIAMETER)	DRILLING ROD TYPE AND DIAMETER	FIELD LOGGER
4" Sonic Corebarrel/6-1/4 csg bit	3-1/2" Sonic	GT Hong

	CASING TYPE, DIAMETER, INSTALLATION DEPTH	FIELD LOG REVIEWER
[X] VERTICAL [ ] INCLINED	5-7/8 x 5-1/8 Steel	M. PALMER

SAMPLER TYPE(S)	HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP	HAMMER EFFICIENCY
4-1/2 x 3-7/8 Core Barrel	NA	

BOREHOLE BACKFILL OR COMPLETION	GROUNDWATER READING: DURING DRILLING	AFTER DRILLING (DATE-TIME)
Cement with 5% Bentonite	NA	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Poorly Graded SAND with Silt (SP-SM); loose; dark yellowish brown; dry; 90% fine sand; 10% no plasticity fines.												Run 1
50	5														Run 2
	7		SILTY SAND (SM); dark yellowish brown; dry; 77% fine sand; 23% no plasticity fines.										23		
45	10														Run 3
40	14		SANDY SILT (ML); yellowish brown; moist; 60% medium plasticity, slow dilatancy fines; 40% fine sand.												
	15		Poorly Graded SAND (SP); yellowish brown; moist; 95% fine sand; 5% no plasticity fines.												Run 4
	17		CLAYEY SILT (ML/CL); dark yellowish brown; moist; 90% medium plasticity, slow dilatancy fines; 10% fine sand.							42	44	15			
35	20														

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Borehole Location: Landside Toe **County:** Sutter

Coordinates: Northing: 2,162,621.88 **Easting:** 6,673,997.64

Latitude: 39.09988 **Longitude:** -121.60416

Levee Station or Milepost: 856+04 **Levee Mile:**

Levee Segment Reach 13

Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II

Channel / River Name / Feature: Feather River

LOG OF BORING

SL0001_003S

Sheet 1 of 5

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20		Poorly Graded SAND (SP); dark yellowish brown; wet; 95% medium sand; 5% no plasticity fines.												Run 5
	21														
	22														
	23		SILTY SAND (SM); dark yellowish brown; wet; 77% medium sand; 23% no plasticity fines.										23		
30	24														
	25														Run 6
	26														
	27		Poorly Graded GRAVEL with Sand (GP); very dark greenish gray; wet; 65% gravel; 32% sand; 3% no plasticity fines.												
	28		At 28 feet tree trunk to 30'; 40% of decomposition.												
25	29														
	30		Poorly Graded GRAVEL with Sand (GP); very dark greenish gray; wet; 60% gravel; 35% sand; 5% no plasticity fines.												Run 7
	31														
	32														
	33		At 33.5 feet three core samples; 40% of decomposition.												
20	34														
	35		SILTY SAND with Gravel (SM); dark greenish gray; wet; 59% sand; 28% gravel; 13% no plasticity fines.												Run 8
	36														
	37														
	38												13		
15	39														
	40		Poorly Graded SAND with Gravel (SP); dark greenish gray; wet; 80% sand; 15% gravel; 5% no plasticity fines.												Run 9
	41														
	42														
	43														
10	44														
	45														

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SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Borehole Location: Landside Toe **County:** Sutter
Coordinates: Northing: 2,162,621.88 **Easting:** 6,673,997.64
Latitude: 39.09988 **Longitude:** -121.60416
Levee Station or Milepost: 856+04 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_003S
Sheet 2 of 5

SBFCA Feather River West Levee

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45		Poorly Graded GRAVEL with Sand (GP); dark greenish gray; wet; 55% gravel; 40% sand; 5% no plasticity fines.												Run 10
	46														
	47														
	48														
5	49														
	50		At 50 feet 70% gravel; 25% sand; 5% no plasticity fines.												Run 11 No recovery 50-51'
	51														
	52														
	53					80									
0	54														
	55														Run 12 No recovery 55-56'
	56														
	57														
	58					20									
-5	59														
	60		At 60 feet 70% gravel; 27% coarse sand; 3% no plasticity fines.												Run 13
	61														
	62														
	63					100									
-10	64														
	65		LEAN CLAY with Sand (CL); dark greenish gray; moist; 85% medium plasticity, no dilatancy fines; 15% fine sand.												Run 14 No recovery 65-66'
	66		Poorly Graded SAND with Silt (SP-SM); dark greenish gray; wet; 90% medium sand; 10% no plasticity fines.												
	67														
	68					80									
-15	69														
	70														

Final Report Version 12/5/2012

Borehole Location: Landside Toe **County:** Sutter
Coordinates: Northing: 2,162,621.88 **Easting:** 6,673,997.64
Latitude: 39.09988 **Longitude:** -121.60416
Levee Station or Milepost: 856+04 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_003S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	70													Run 15
	71													
	72	CLAYEY GRAVEL with Sand (GC); dark greenish gray; wet; 40% fine to coarse gravel; 39% fine sand; 21% fines.			100							21		
-20	73													
	74													
	75													Run 16 No recovery 75-76'
	76													
	77				80									
	78													
-25	79													
	80	FAT CLAY (CH); greenish gray; moist; 97% high plasticity, no dilatancy fines; 3% fine sand.												Run 17
	81	SILT (ML); greenish gray; moist; 95% medium plasticity, no to slow dilatancy fines; 5% fine sand.												
	82				100				31	41	9			
	83													
-30	84													
	85	SILTY SAND (SM); greenish gray; wet; 64% fine sand; 36% no plasticity fines.												Run 18
	86											36		
	87	FAT CLAY (CH); greenish gray; moist; 97% high plasticity, no dilatancy fines; 3% fine sand.			100									
	88											97		
-35	89													
	90	LEAN CLAY with Sand (CL); greenish gray; moist; 75% low plasticity fines; 25% fine sand.												Run 19
	91													
	92				100			4.5+P						
	93													
-40	94													
	95													

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Borehole Location: Landside Toe **County:** Sutter
Coordinates: Northing: 2,162,621.88 **Easting:** 6,673,997.64
Latitude: 39.09988 **Longitude:** -121.60416
Levee Station or Milepost: 856+04 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_003S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, % / Liquid Limit / Plasticity Index / Fines, % < #200 / Other Lab Tests	REMARKS
	95		Borehole terminated at 95 feet. Backfilled boring with neat grout consisting of 70 gallons water and 18-47 lb sacks of portland cement.								
	96										
	97										
	98										
-45	99										
	100										
	101										
	102										
	103										
-50	104										
	105										
	106										
	107										
	108										
-55	109										
	110										
	111										
	112										
	113										
-60	114										
	115										
	116										
	117										
	118										
-65	119										
	120										

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SUTTER BUTTE FLOOD CONTROL AGENCY

Borehole Location: Landside Toe **County:** Sutter
Coordinates: **Northing:** 2,162,621.88 **Easting:** 6,673,997.64
Latitude: 39.09988 **Longitude:** -121.60416
Levee Station or Milepost: 856+04 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_003S
Sheet 5 of 5

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

DATE STARTED 10/19/12	**DATE COMPLETED** 10/20/12	**GROUND ELEVATION** 82.00 ft	**ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 135.0 ft	
DRILLING CONTRACTOR National		**DRILLER'S NAME** J. Marok	**HELPER'S NAME** N. Castro/J. Woolcott	**TOTAL DEPTH OF FILL** 24.5 ft	
DRILLING METHOD Sonic		**DRILL RIG MAKE AND MODEL** Geoprobe 8140 LC #34		**CONSULTANT COMPANY** URS Corporation	
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 4-1/2" Sonic Corebarrel/6-1/4 csg bit		**DRILLING ROD TYPE AND DIAMETER** 3-1/2" Sonic		**FIELD LOGGER** M. Palmer	
X VERTICAL ☐ **INCLINED**		**CASING TYPE, DIAMETER, INSTALLATION DEPTH** 5-7/8 x 5-1/8 Steel		**FIELD LOG REVIEWER** G.T. HONG	
SAMPLER TYPE(S) 4-1/2 x 3-1/2 Core Barrel		**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** NA		**HAMMER EFFICIENCY**	
BOREHOLE BACKFILL OR COMPLETION Neat cement grout		**GROUNDWATER READING:**	**DURING DRILLING** NA	**AFTER DRILLING (DATE-TIME)**	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		0.3' AC.												
	1		0.7' AB.												
80	2		[LEVEE FILL] CLAYEY SAND (SC); olive brown; dry; 75% fine to medium sand; 25% low plasticity, slow dilatancy fines; micaceous.			50									Advance boring to 1' with casing bit. Run 1 Blocked with 4" cobble at 2'. No recovery 2-5'
	3														
	4														
	5		[LEVEE FILL] Poorly Graded SAND with Silt (SP-SM); yellowish brown; dry; 90% fine to medium sand; 10% no plasticity fines; micaceous.												Run 2 No recovery 5-8' 5-8' disturbed by slough from above.
75	6					40									
	7														
	8														
	9														
	10														At 10' set casing to 5'. Run 3
70	11					76									
	12														
	13														
	14														
	15														At 15' set casing to 10'. Run 4 No recovery 15-19'
65	16					60									
	17														
	18														
	19														
	20														

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Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,163,543.05 **Easting:** 6,673,552.11
Latitude: 39.10241 **Longitude:** -121.60572
Levee Station or Milepost: 866+19 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_004S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
	20		[LEVEE FILL] SILTY SAND (SM); olive brown; moist; 70% fine to medium sand; 30% no to low plasticity, slow dilatancy fines; presence of mica and fine organic fragments.												
60	21														
	22		[LEVEE FILL] CLAYEY SAND (SC); hard; olive brown; moist; 60% fine to medium sand; 40% low plasticity, slow dilatancy fines; presence of mica and organic fragments.			60									
	23														
← FILL	24														
	25		[LEVEE FILL] SANDY LEAN CLAY (CL); hard; light olive brown; moist; 55% low plasticity, no to slow dilatancy fines; 45% fine to medium sand; micaceous and fine organic fragments.												At 25' set casing to 15'. Run 5
	26														
55	27		SANDY LEAN CLAY (CL); hard; light olive brown; moist; 55% low plasticity, no to slow dilatancy fines; 45% fine to medium sand; trace of mica; presence of roots.			100				23	33	11			
	28														
	29														
	30		SILTY SAND (SM); dark yellowish brown; dry; 87% fine to medium sand; 13% no plasticity fines; micaceous.												At 30' set casing to 25'. Run 6 No recovery 30-32.2' washed
	31														
50	32					56									
	33														
	34												13		
	35														
	36		LEAN CLAY (CL); yellowish brown; 90% low plasticity, slow dilatancy fines; 10% fine sand; orange-red iron oxide staining.												At 35' set casing to 30'. Run 7 No recovery 35-36' washed
45	37					80									
	38														
	39		SILTY SAND (SM); light yellowish brown; moist; 75% fine sand; 25% no plasticity fines; micaceous.												
	40														At 40' set casing to 35'. Run 8 No recovery 40-40.8' washed
	41														
40	42					84									
	43		At 43 feet 85% fine to medium sand; 15% no plasticity fines.												
	44														
	45														

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Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,163,543.05 **Easting:** 6,673,552.11
Latitude: 39.10241 **Longitude:** -121.60572
Levee Station or Milepost: 866+19 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SL0001_004S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45														At 45' set casing to 40'. Run 9 No recovery 45-47' washed
	46														
35	47		At 47 feet 80% fine to medium sand; 20% no plasticity fines; predominantly fine sand.			60									
	48														
	49		At 48.5 feet 0.5' lens of Sandy Silt (ML); light olive brown.												
			Poorly Graded SAND (SP); olive gray; wet; 95% fine to medium sand; 5% no plasticity fines; presence of mica.												
	50														Run 10 No recovery 50-55' washed
	51														
30	52														
	53														
	54														
	55					50									
	56														
25	57		At 57 feet 98% sand; 2% fines.										2		Hard drilling 57-59'.
	58														
	59														
	60														At 60' set casing to 55'. Run 11 No recovery 60-61' washed 61-63' highly disturbed.
	61		At 61 feet wet; dark gray.												
20	62														
	63														
	64														
	65					90									
	66														
15	67		Poorly Graded SAND with Gravel (SP); dark gray; wet; 55% fine to coarse sand; 40% fine to coarse, subrounded to rounded, hard gravel, max. 1.25 in.; 5% no plasticity fines; presence of mica.												
	68														
	69														
	70														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,163,543.05 **Easting:** 6,673,552.11
Latitude: 39.10241 **Longitude:** -121.60572
Levee Station or Milepost: 866+19 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_004S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	70														At 70' set casing to 65'. Run 12
	71														
10	72		Well-Graded GRAVEL with Sand (GW); dark bluish gray; wet; 67% fine to coarse, subrounded to rounded gravel, max. 2.5 in.; 30% fine to coarse sand; 3% no plasticity fines; presence of mica.												
	73														
	74												3		
	75					100									
	76														
5	77														
	78														
	79														
	80		SILTY SAND (SM); gray; wet; 85% fine to medium sand; 15% no to low plasticity, rapid dilatancy fines; micaceous.												At 80' set casing to 75'. Run 13 No recovery 80-89.5' washed sample. No gravel just sand in shoe.
	81														
0	82														
	83														
	84														
	85					5									
	86														
-5	87														
	88														
	89														
	90														Run 14 No recovery 90-98.5' washed sample
	91														
-10	92					15									
	93														
	94														
	95														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,163,543.05 **Easting:** 6,673,552.11
Latitude: 39.10241 **Longitude:** -121.60572
Levee Station or Milepost: 866+19 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_004S
Sheet 4 of 6

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	95														
	96														
-15	97					15									
	98		Poorly Graded SAND with Silt (SP-SM); dark gray; wet; 90% fine to coarse sand; 10% no plasticity fines; micaceous.												
	99														
	100		Poorly Graded SAND with Gravel (SP); dark gray; wet; 55% fine to coarse sand; 40% fine gravel; 5% no plasticity fines.												At 100' set casing to 95'. Run 15 No recovery 100-101.5'. Washed away; 101.5-104' highly disturbed.
	101														
-20	102		Poorly Graded GRAVEL with Sand (GP); dark gray; 80% fine to coarse, subrounded to rounded, hard gravel, max. 3 in.; 15% fine to coarse sand; 5% no plasticity fines.												
	103														
	104		LEAN CLAY with Sand (CL); medium stiff; dark gray.												
	105		SILTY SAND (SM); dark gray; wet; 78% fine to medium sand; 14% no plasticity fines; 8% fine to coarse gravel; micaceous.			85							14		
	106		Poorly Graded GRAVEL (GP); 100% fine to coarse gravel, max. 2.5 in..												
-25	107		LEAN CLAY with Sand (CL); very stiff; dark gray; moist; 75% medium plasticity, no dilatancy fines; 25% fine sand.												
	108														
	109		SILTY SAND (SM); dark gray; wet; 77% fine to coarse sand; 23% no to low plasticity, slow dilatancy fines; micaceous; top and bottom of layer is boarded by 0.1' lenses of fine to coarse gravel, max. 1 in.										23		
	110		LEAN CLAY with Sand (CL); very stiff to hard; greenish gray; moist; 85% medium plasticity, no dilatancy fines; 15% fine sand.												Run 16 No recovery. Upper 1.5' disturbed and destroyed by gravelly slough.
	111														
-30	112		SILTY SAND (SM/ML); hard; very dark greenish gray; moist; 55% fine sand; 45% low plasticity, slow dilatancy fines; micaceous; over consolidated friable texture.			70				24	29	3	45		
	113		At 113 feet 0.3-0.5' interbeds of Silty Sand (SM); very dense; 85% fine sand; 15% no plasticity fines.												
	114														
	115														Run 17 No recovery. 115-118' destroyed by slough; 118-119 highly disturbed. Did not save 118-118.5'.
	116		SILTY SAND (SM); very dense; very dark greenish gray; moist; 85% fine sand; 15% no plasticity fines; micaceous.												
-35	117					30									
	118														
	119														
	120														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,163,543.05 **Easting:** 6,673,552.11
Latitude: 39.10241 **Longitude:** -121.60572
Levee Station or Milepost: 866+19 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SL0001_004S
Sheet 5 of 6

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
	120														Run 18
	121												25		
-40	122														
	123					100									
	124		CLAYEY SAND (SC); hard; very dark greenish gray; moist; 70% fine sand; 30% low plasticity, no to slow dilatancy fines; micaceous.												
	125		SILTY SAND (SM); very dark greenish gray; moist; 85% fine to medium sand; 15% no plasticity fines; micaceous; crumbly texture.												Run 19
	126		SANDY FAT CLAY (CH); very dark greenish gray; moist; 50% low to medium plasticity, no dilatancy fines; 50% fine sand and very hard; fine to coarse sand size indurated (CL) fragments; poorly indurated; blocky texture.							37	71	37			
-45	127														
	128		SILTY SAND (SM); very dark greenish gray; moist; 80% fine sand; 20% no plasticity fines; micaceous; crumbly-friable texture.												
	129		SANDY SILT (ML); dark greenish gray; moist; 70% fine sand and fine to coarse sand size indurated (ML/CL) fragments; 30% low plasticity, no dilatancy fines; micaceous; poorly to well indurated; blocky texture; induration increases with depth. Sand fraction (70%) breaks down to 30% fine sand and 40% very hard, indurated lean clay (ML/CL) fragments.											
	130					100				30	40	9			
-50	131														
	132														
	133		CLAYEY SAND (SC); dark greenish gray; moist; 65% fine sand; 35% low plasticity, slow dilatancy fines; presence of mica; friable to crumbly texture; poorly indurated.												
	134		SANDY SILTY CLAY (CL/ML); dark greenish gray; moist; 65% low plasticity, no dilatancy fines; 35% fine sand and very hard, fine to medium sand size indurated (CL) fragments; poorly indurated to trace well indurated.												
	135		Borehole terminated at 135 feet. Backfilled boring with 250 gallons of neat grout consisting of 185 gallons water, 30 pounds of bentonite powder, 37-47 lb sacks of portland cement.												
-55	136														
	137														
	138														
	139														
	140														
	141														
-60	142														
	143														
	144														
	145														

Final Report Version 12/5/2012

SUTTER BUTTE FLOOD CONTROL AGENCY

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,163,543.05 **Easting:** 6,673,552.11
Latitude: 39.10241 **Longitude:** -121.60572
Levee Station or Milepost: 866+19 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SL0001_004S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

DATE STARTED	DATE COMPLETED	GROUND ELEVATION	ELEVATION DATUM	TOTAL DEPTH OF BORING
10/4/12	10/5/12	52.69 ft	NAVD 88	90.0 ft

DRILLING CONTRACTOR	DRILLER'S NAME	HELPER'S NAME	TOTAL DEPTH OF FILL
National	J. Marok	R. Estrado/E. Jasso	

DRILLING METHOD	DRILL RIG MAKE AND MODEL	CONSULTANT COMPANY
Sonic	Geoprobe 8140 LC #34	URS Corporation

DRILL BIT SIZE AND TYPE (HOLE DIAMETER)	DRILLING ROD TYPE AND DIAMETER	FIELD LOGGER
4-1/2" Sonic Corebarrel/6-1/4 csg bit	3-1/2" Sonic	M. Weil

	CASING TYPE, DIAMETER, INSTALLATION DEPTH	FIELD LOG REVIEWER
[X] VERTICAL [ ] INCLINED	5-7/8 x 5-1/8 Steel	M. PALMER

SAMPLER TYPE(S)	HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP	HAMMER EFFICIENCY
3-7/8 Core Barrel	NA	

BOREHOLE BACKFILL OR COMPLETION	GROUNDWATER READING: DURING DRILLING	AFTER DRILLING (DATE-TIME)
Cement with 5% Bentonite	NA	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Poorly Graded SAND with Silt (SP-SM); loose; dark yellowish brown; moist; 92% fine sand; 8% no plasticity fines.												Run 1 Hand auger
	1														
	2														
50	3					100							8		
	4														
	5														Run 2
	6														
	7														
45	8					100									
	9														
	10		SILT (ML); soft; olive gray; moist; 95% low plasticity, no dilatancy fines; 5% medium sand.												Run 3
	11									33	42	14			
	12														
40	13					100			<0.5P						
	14														
	15		Poorly Graded SAND with Clay (SP-SC).												Run 4 No recovery 15-19', driller indicated sand lost due to water used to advance casing.
	16														
	17														
35	18					100									
	19		SANDY LEAN CLAY (CL); soft; dark olive gray; moist; 55% low plasticity fines; 45% fine to medium sand.												
	20														

Final Report Version 12/5/2012

Borehole Location: Landside Toe **County:** Sutter
Coordinates: Northing: 2,164,673.03 **Easting:** 6,672,931.45
Latitude: 39.10552 **Longitude:** -121.60789
Levee Station or Milepost: 878+83 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_005S
Sheet 1 of 4

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20														Run 5
	21		SILT (ML); soft; olive gray; moist; 98% low plasticity fines; 2% fine sand.												
	22									49	47	14			
30	23					100									
	24		At 24 feet tree core (decomposing).												
	25														Run 6
	26		SANDY SILT (ML); soft; olive gray; moist; 55% low plasticity fines; 45% fine sand.												
	27									40	32	4			
25	28		Tree core section.			100									
	29		Poorly Graded SAND with Clay (SP-SC); loose; very dark greenish gray; moist; 90% fine to coarse sand; 10% low plasticity fines.												
	30														Run 7
	31														
	32					100									
20	33														
	34														
	35														Run 8
	36														
	37					100									
15	38														
	39														
	40														Run 9 No recovery 40-42.5'. Loose sand, loss of sample in hole.
	41														
	42												10		
10	43					100									
	44														
	45		CLAYEY SAND with Gravel (SC); medium dense; very												

Final Report Version 12/5/2012

Borehole Location: Landside Toe **County:** Sutter
Coordinates: Northing: 2,164,673.03 **Easting:** 6,672,931.45
Latitude: 39.10552 **Longitude:** -121.60789
Levee Station or Milepost: 878+83 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_005S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
	45		dark greenish gray; moist; 60% fine to coarse sand; 20% gravel; 20% low plasticity fines.												Run 10 1st attempt to recovery (rock in bit) 2nd attempt full recovery.
5	46														
	47														
	48					100									
	49		Well-Graded GRAVEL with Sand (GW); very dark gray; moist; 59% gravel and cobbles; 36% coarse sand; 5% low plasticity fines.												
	50														Run 11
	51														
	52												5		
0	53					100									
	54														
	55														Run 12
	56														
	57														
-5	58					100									
	59		Well-Graded SAND with Silt (SW-SM); very dark gray; moist; 90% fine to coarse sand; 10% no plasticity fines.												
	60														Run 13
	61														
	62														
-10	63		Poorly Graded SAND with Silt (SP-SM); very dark gray; moist; 90% fine to medium sand; 10% no plasticity fines.												
	64														
	65														Run 14
	66		Well-Graded SAND (SW); very dark gray; moist; 95% fine to coarse sand; 5% no plasticity fines.												
	67														
-15	68												5		
	69														
	70														

Final Report Version 12/5/2012

Borehole Location: Landside Toe **County:** Sutter
Coordinates: Northing: 2,164,673.03 **Easting:** 6,672,931.45
Latitude: 39.10552 **Longitude:** -121.60789
Levee Station or Milepost: 878+83 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_005S
Sheet 3 of 4

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	70														Run 15
	71														
	72														
-20	73														
	74		SILT (ML); stiff; dark greenish gray; moist; 95% low plasticity fines; 5% fine sand.												
	75														Run 16
	76														
	77									44	46	14			
-25	78														
	79														
	80														Run 17
	81														
	82														
-30	83		SANDY LEAN CLAY (CL); dark greenish gray; moist; 55% low plasticity, no dilatancy fines; 45% medium sand.												
	84														
	85		LEAN CLAY (CL); stiff; dark greenish gray; moist; 95% low plasticity, no dilatancy fines; 5% fine sand.												Run 18
	86														
	87														
-35	88														
	89														
	90		Borehole terminated at 90 feet. Backfilled boring with _____ gallons of neat grout consisting of 85 gallons water, 25 pounds of bentonite powder, 24-47 lb sacks of portland cement.												
	91														
	92														
-40	93														
	94														
	95														

Final Report Version 12/5/2012

Borehole Location: Landside Toe **County:** Sutter
Coordinates: **Northing:** 2,164,673.03 **Easting:** 6,672,931.45
Latitude: 39.10552 **Longitude:** -121.60789
Levee Station or Milepost: 878+83 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_005S
Sheet 4 of 4

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

DATE STARTED 10/12/12 **DATE COMPLETED** 10/17/12	**GROUND ELEVATION** 80.32 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 133.0 ft
DRILLING CONTRACTOR National	**DRILLER'S NAME** J. Marok **HELPER'S NAME** N. Castro/M. Walker	**TOTAL DEPTH OF FILL** 25.5 ft
DRILLING METHOD Sonic	**DRILL RIG MAKE AND MODEL** Geoprobe 8140 LC #34	**CONSULTANT COMPANY** URS Corporation
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 4-1/2" Sonic Corebarrel/6-1/4 csg bit	**DRILLING ROD TYPE AND DIAMETER** 3-1/2" Sonic	**FIELD LOGGER** M. Palmer
[X] **VERTICAL** [ ] **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** 5-7/8 x 5-1/8 Steel to 115'	**FIELD LOG REVIEWER** G.T. HONG
SAMPLER TYPE(S) 4-1/2 x 3-1/2 Core Barrel	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** NA	**HAMMER EFFICIENCY**
BOREHOLE BACKFILL OR COMPLETION Neat cement grout	**GROUNDWATER READING: DURING DRILLING** NA **AFTER DRILLING (DATE-TIME)**	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
80	0		3" AC.												Sonic 0-0.5'
	1		AB road base.			0									0.5-3.5 Hand auger
			[LEVEE FILL] SILTY SAND with Gravel (SM); yellowish brown; moist; 50% fine to coarse sand; 30% fine to coarse, subangular gravel; 20% no plasticity fines; presence of mica.												
	3					100									
	5														
75			[LEVEE FILL] SILTY GRAVEL with Sand (GM); yellowish brown; moist; 50% fine to coarse, subangular to subrounded, hard gravel; 35% fine to coarse sand; 15% no to low plasticity, slow to rapid dilatancy fines.												Run 1
	7					100									
	10														At 10' set casing to 10'. Run 2 Hard advancing core barrel to 12/5'.
70	11		[LEVEE FILL] SILTY SAND (SM); olive brown; moist; 55% fine to medium sand; 45% no to low plasticity, slow to rapid dilatancy fines; presence of mica.			100									
	13		[LEVEE FILL] SILTY SAND with Gravel (SM); dark yellowish brown; moist; 65% fine to coarse sand; 20% no plasticity fines; 15% fine to coarse, subangular to rounded, hard gravel, max. 1.25 in.; presence of mica.												Run 3
						100									
	15														Run 4
65															
	17					100									
	20														

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Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,166,097.89 **Easting:** 6,673,123.92
Latitude: 39.10943 **Longitude:** -121.60719
Levee Station or Milepost: 893+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_006S
Sheet 1 of 6

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
60	20		[LEVEE FILL] SILTY SAND (SM); olive gray; moist; 80% fine to coarse sand; 20% no plasticity fines; presence of mica.			100									Run 5 No recovery 20.5-22'
	21														
	22														Difficult drilling, sands very compact. Run 6
	23		At 23 feet 70% fine to coarse sand; 30% no plasticity fines.			100									
	24														
FILL	25														At 25' set casing to 25'. Run 7
55															
	26		CLAYEY SAND (SC); dark gray; moist; 70% fine sand; 30% low plasticity, no to slow dilatancy fines; organic odor; presence of mica and fine grained size organic fragments.			100									
	27														
	28														
	29														
50	30														Run 8 30-32 disturbed and soupy; 32-34 fines washed away; core variably disturbed.
	31		SILTY SAND (SM); light olive brown; moist; 50% fine to coarse sand; 45% no to low plasticity, slow dilatancy fines; 5% fine, rounded, hard gravel.										45		
	32														
	33														
	34														
45	35					60									
	36														
	37		SILT with Sand (ML); dark yellowish brown; moist; 85% low plasticity, rapid dilatancy fines; 15% fine sand; micaceous.							27	26	NP			
	38														
	39														
40	40														At 40 set casing to 30'. Run 9 No recovery 40-45' completely disturbed (liquid).
	41														
	42														
	43					50									
	44														
	45														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,166,097.89 **Easting:** 6,673,123.92
Latitude: 39.10943 **Longitude:** -121.60719
Levee Station or Milepost: 893+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_006S
Sheet 2 of 6

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
35	45														
	46														
	47		LEAN CLAY with Sand (CL); dark yellowish brown; moist; 80% low to medium plasticity, no dilatancy fines; 20% fine to coarse sand; micaceous.			50									
	48														
	49														
30	50		SILTY SAND (SM/SC); dark yellowish brown; moist; 63% fine to coarse sand; 37% low plasticity, slow to rapid dilatancy fines.												Run 10 At 50' set casing to 45'.
	51														
	52												37		
	53														
	54		Poorly Graded SAND (SP); very dark greenish gray; wet; 95% fine to medium sand; 5% no plasticity fines; micaceous.												
25	55					88									
	56		SANDY SILT (ML/SM); dark yellowish brown; wet; 50% fine sand; 50% low plasticity, slow to rapid dilatancy fines; micaceous.												
	57									30	27	1			
	58														
	59		SILTY SAND (SM); olive; moist; 60% fine to medium sand; 40% no plasticity fines; micaceous.										40		
20	60														At 60' set casing to 55'. Run 11 No recovery 60-65'
	61														
	62														
	63														
	64														
	65		SILTY SAND with Gravel (SM); very dark greenish gray; 55% fine to coarse sand; 30% fine to coarse gravel, max. 1.5 in.; 15% no plasticity fines; presence of mica.			50									
15	66														
	67														
	68														
	69														
	70														

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Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,166,097.89 **Easting:** 6,673,123.92
Latitude: 39.10943 **Longitude:** -121.60719
Levee Station or Milepost: 893+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
10	70														At 70' set casing to 65'. Run 12
	71		Poorly Graded GRAVEL with Sand (GP); dark greenish gray; wet; 80% fine to coarse, subrounded to rounded gravel, max. 2 in.; 17% fine to coarse sand; 3% no plasticity fines.												
	72					86							3		
	73														
	74														
5	75														At 75' set casing to 70'. Run 13
	76														
	77														
	78														
	79														
0	80					89									
	81														
	82														
	83														
	84		SILTY SAND (SM); greenish black; moist; 80% fine to medium sand; 20% no plasticity fines; micaceous; friable texture.												
-5	85														Run 14 No recovery 85-88.5'
	86														
	87														
	88														
	89														
-10	90					65									
	91		SILTY SAND with Gravel (SM); greenish black; moist; 60% fine to coarse sand; 20% fine to coarse, rounded, hard gravel, max. 1.5 in.; 20% no plasticity fines.												
	92														
	93		SILTY SAND (SM); greenish black; moist; 65% fine to medium sand; 30% no plasticity fines; 5% fine gravel; poorly indurated; friable texture.												
	94														
	95														

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Borehole Location: Levee Crest **County:** Sutter
Coordinates: **Northing:** 2,166,097.89 **Easting:** 6,673,123.92
Latitude: 39.10943 **Longitude:** -121.60719
Levee Station or Milepost: 893+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
-15	95		Poorly Graded GRAVEL with Sand (GP); very dark greenish gray; wet; 65% fine to coarse, subrounded to rounded, hard gravel, max. 1 in.; 30% fine to coarse sand; 5% no plasticity fines.												At 95' set casing to 85'. Run 15
	96														
	97														
	98														
	99														
-20	100		Poorly Graded GRAVEL (GP); very dark greenish gray; wet; 85% fine to coarse, subrounded to rounded, hard gravel, max. 2 in.; 10% fine to coarse sand; 5% no plasticity fines.			100									
	101														
	102		SILTY SAND with Gravel (SM); very dark greenish gray; wet; 42% fine to coarse sand; 38% fine, subangular to subrounded, hard gravel, max. .75 in.; 20% no plasticity fines; poorly indurated; friable texture.												
	103														
	104												20		
-25	105														At 105' set casing to 95'. Run 16 No recovery 105-107' Rig broke, core barrel in hole at 115'.
	106														
	107														
	108														
	109														
-30	110		SILTY SAND (SM/ML); very dark greenish gray; moist; 55% fine sand; 45% no to low plasticity, low dry strength, slow to rapid dilatancy fines; micaceous; variably thin bedded to massive bedding; no to weakly indurated.			80									
	111														
	112														
	113														
	114														
-35	115		At 114.5 feet 75% fine to medium sand; 25% no to low plasticity, slow to rapid dilatancy fines; micaceous; friable texture.			100									Recover core barrel continue coring. Run 17 Clean out and advance to 116. Run 18
	116		CLAYEY GRAVEL with Sand (GC); very dark greenish gray; moist; 50% fine to coarse, rounded, hard gravel, max. 1.25 in.; 35% fine to coarse sand; 15% low plasticity, medium to high dry strength, no dilatancy fines; blocky texture; poorly indurated.												
	117														
	118		SILTY SAND with Gravel (SM); very dark greenish gray; moist; 40% fine to medium sand; 35% fine to coarse gravel, max. 1.5 in.; 25% low plasticity, no to slow dilatancy fines; micaceous.			100				12	30	6			
	119		CLAYEY SAND (SC); very dark greenish gray; moist; 75% fine to coarse sand; 25% low plasticity, no to slow dilatancy fines; micaceous.												
	120														

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Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,166,097.89 **Easting:** 6,673,123.92
Latitude: 39.10943 **Longitude:** -121.60719
Levee Station or Milepost: 893+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
-40	120		SANDY SILTY CLAY (CL/ML); very dark greenish gray; moist; 65% low plasticity, no to slow dilatancy fines; 35% fine sand; micaceous.												At 120' set casing to 115'. Run 19
	121		SANDY LEAN CLAY (CL); very hard; very dark greenish gray; moist; 50% fine sand and sand size indurated soil fragments; 50% low plasticity, no dilatancy fines; micaceous; blocky; weakly indurated.												
	122												99		
	123					100									
	124														
-45	125		At 125 feet poorly indurated to well indurated (similar to a mudstone).												Run 20
	126														
	127														
	128		SILTY SAND (SM); very dense; very dark greenish gray; moist; 70% fine sand and fine to coarse sand size indurated fragments of (SM); 30% low plasticity, slow dilatancy fines; micaceous; poorly indurated; friable texture.												
	129					100									
-50	130		SANDY SILTY CLAY (CL/ML); very hard; very dark greenish gray; moist; 50% fine sand and fine to coarse sand size indurated soil fragments; 50% low plasticity, no to slow dilatancy fines; well indurated (similar to a mudstone).												
	131														
	132														Driller over drilled by 3'.
	133														
	134		Borehole terminated at 133 feet. Backfilled boring with 225 gallons of neat grout consisting of 170 gallons water, 25 pounds of bentonite powder, 38-47 lb sacks of portland cement.												
-55	135														
	136														
	137														
	138														
	139														
-60	140														
	141														
	142														
	143														
	144														
	145														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,166,097.89 **Easting:** 6,673,123.92
Latitude: 39.10943 **Longitude:** -121.60719
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Levee Segment Reach 13
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

DATE STARTED	DATE COMPLETED	GROUND ELEVATION	ELEVATION DATUM	TOTAL DEPTH OF BORING
10/11/12	10/12/12	81.82 ft	NAVD 88	120.0 ft
DRILLING CONTRACTOR		**DRILLER'S NAME**	**HELPER'S NAME**	**TOTAL DEPTH OF FILL**
National		J. Marok	N. Castro/G. Becker	28 ft
DRILLING METHOD		**DRILL RIG MAKE AND MODEL**		**CONSULTANT COMPANY**
Sonic		Geoprobe 8140 LC #34		URS Corporation
DRILL BIT SIZE AND TYPE (HOLE DIAMETER)		**DRILLING ROD TYPE AND DIAMETER**		**FIELD LOGGER**
4-1/2" Sonic Corebarrel/6-1/4 csg bit		3-1/2" Sonic		M. Palmer
[X] VERTICAL [ ] INCLINED		**CASING TYPE, DIAMETER, INSTALLATION DEPTH**		**FIELD LOG REVIEWER**
		5-7/8 x 5-1/8 Steel to 100'		G.T. HONG
SAMPLER TYPE(S)		**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP**		**HAMMER EFFICIENCY**
4-1/2 x 3-1/2 Core Barrel		NA		
BOREHOLE BACKFILL OR COMPLETION		**GROUNDWATER READING:**	**DURING DRILLING**	**AFTER DRILLING (DATE-TIME)**
Neat cement grout			NA	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Asphalt-pavement.												0-0.5 sonic casing bit.
	1		Gravel roadbase.												Hand auger to 5'
80	2		[LEVEE FILL] SILTY SAND with Gravel yellowish brown; moist; 60% fine to coarse sand; 25% fine to coarse, subrounded to rounded, hard gravel; 15% no plasticity fines; presence of mica.												
	3														
	4														
	5		[LEVEE FILL] SILTY SAND (SM); yellowish brown; moist; 81% fine to coarse sand; 14% no plasticity fines; 5% fine, subrounded to rounded, hard gravel, max. 3/8 in.; presence of mica.												Run 1
75	6														
	7					92									
	8												14		
	9		At 9 feet olive gray; 80% fine to coarse sand; 20% no plasticity fines.												
	10														Run 2
	11														
70	12		At 12 feet 70% fine to coarse sand; 20% no plasticity fines; 10% fine to coarse gravel, max. 1 in.			88									
	13														
	14		At 14 feet 80% fine to coarse sand; 20% no plasticity fines.			100									Run 3
	15		At 15 feet dark olive gray; 60% fine to medium sand; 40% no to low plasticity, rapid dilatancy fines; micaceous; trace fine organic fragments with 3.5" lifts of Silt with Sand (ML); 75% no plasticity fines; 25% fine sand; trace fine organic fragments and Silty Sand (SM); 85% fine to medium sand; 15% no plasticity fines.												At 15' set casing to 10'. Run 4
65	16														
	17					65									
	18														
	19														
	20														

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SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,166,793.84 **Easting:** 6,673,197.52
Latitude: 39.11134 **Longitude:** -121.60692
Levee Station or Milepost: 900+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SBFCA Feather River West Levee

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20														Run 5
	21														
60	22														
	23					80									
	24														
	25														Run 6
	26														
FILL 55	27														
	28		CLAYEY SAND (SC); hard; olive gray; 60% fine to coarse sand; 40% low to medium plasticity, no to slow dilatancy fines; micaceous.			90									Original ground at 28'.
	29														
	30														Run 7
	31		SILTY SAND (SM); light olive brown; moist; 80% fine to medium sand; 20% no plasticity fines; micaceous.												
50	32												20		Hard drilling to 34.
	33														No recovery 33-40'
	34														
	35					30									At 35-36 soft/quick advance.
	36														
45	37														
	38														
	39														
	40														At 40' set casing to 30'.
	41		At 41 feet interbeds of Silty Sand as in 31-41 feet and Silt (ML) as in 43-44 feet..												Run 8 40-50' no vibration used, sample advanced to depth under weight of rods.
40	42					80									
	43														
	44		SILT with Sand (ML); black; moist; 79% low plasticity, slow to rapid dilatancy fines; 21% fine sand; micaceous; presence of fine organic matter; slight organic odor. At 44 feet very dark grayish brown; no organics or							37	35	7	79	
	45														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,166,793.84 **Easting:** 6,673,197.52
Latitude: 39.11134 **Longitude:** -121.60692
Levee Station or Milepost: 900+00 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SL0001_007S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45		organic odor.												
	46														
35	47														
	48					80									
	49														
	50														At 50' set casing to 50'. Run 9 Initial recovery 3'/10' some sample fell out of core barrel. Re-cored interval to 60' and recovered 5'/10', however, 2' were disturbed appears as slough.
	51														
30	52														
	53		SILTY SAND (SM); dark olive gray; wet; 86% fine to medium sand; 14% no plasticity fines; trace coarse sand; micaceous.												
	54												14		
	55					50									No recovery 55-59.5'
	56														
25	57														
	58														
	59														
	60		SILTY SAND with Gravel (SM); olive gray; wet; 65% fine to coarse sand; 25% no to low plasticity fines; 15% fine to coarse, rounded, hard gravel; presence of mica.												At 60' set casing to 60'. Run 10
	61														
20	62		Poorly Graded SAND with Silt and Gravel (SP-SM); dark greenish gray; wet; 60% fine to coarse sand; 30% fine to coarse, rounded, hard gravel, max. 1 in.; 10% no plasticity fines.			70									Flapper bit is disturbing sample, request to use open bit. No recovery 63.5-65'
	63														
	64														
	65		Poorly Graded GRAVEL with Sand (GP); very dark greenish gray; wet; 80% fine to coarse, rounded, hard gravel; 15% fine to coarse sand; 5% no plasticity fines.												Run 11
	66														
15	67					90									
	68														
	69														
	70		Poorly Graded SAND with Silt (SP-SM); very dark												

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Borehole Location: Levee Crest **County:** Sutter
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	70		greenish gray; wet; 90% fine to medium sand; 10% no plasticity fines.												Run 12
	71														
10	72		At 72 feet 90% fine to coarse sand; 10% no plasticity fines; trace fine gravel.			98									
	73		SILTY SAND (SM); greenish gray; wet; 70% fine to coarse sand; 30% no to low plasticity, slow dilatancy fines; presence of mica.												
	74														
	75		SILTY SAND with Gravel (SM); greenish gray; wet; 55% fine to coarse sand; 30% fine to coarse gravel, max. 1 in.; 15% no to low plasticity, slow dilatancy fines.												At 75' set casing to 70'. Run 13
	76		SILTY GRAVEL with Sand (GM); dark greenish gray; moist; 65% fine to coarse, rounded gravel, max. 2.25 in.; 26% fine to coarse sand; 14% no to low plasticity fines; consolidated, gravels leave pluck marks (casts) in matrix when removed.												
5	77					86									
	78														
	79												14		
	80														At 80' set casing to 75'. Run 14
	81														
0	82					90									
	83														
	84		Poorly Graded SAND (SP); dark greenish gray; moist; 95% fine to medium sand; 5% no plasticity fines.												
	85														At 85' set casing to 80'. Run 15
	86														
-5	87					92									
	88		SILTY SAND (SM); dark greenish gray; moist; 80% fine to medium sand; 20% no plasticity fines; friable texture.												
	89		Well-Graded SAND with Silt and Gravel (SW-SM); dark greenish gray; moist; 66% fine to coarse sand; 25% fine to coarse gravel, max. 1.5 in.; 9% no plasticity fines.										9		
	90														At 90' set casing to 85'. Run 16
	91														
-10	92					100									
	93														
	94		CLAYEY SILT with Sand (ML/CL); dark gray; moist; 85% low plasticity, slow to rapid dilatancy fines; 15%												
	95														

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Borehole Location: Levee Crest **County:** Sutter
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Latitude: 39.11134 **Longitude:** -121.60692
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Channel / River Name / Feature: Feather River

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	95		fine sand; micaceous; slight organic odor; trace organic fragments. At 94.5 feet one 1/4 in. diameter root.												At 95' set casing to 90'. Run 17
	96		SILTY SAND (SM); dark gray; moist; 30% no plasticity fines; micaceous; presence of finely desseminated organics; friable texture; interbedded (0.3'-1.0' thick) with Poorly graded Sand (SP): dark gray; moist; 95% fine to medium sand; 5% no plasticity fines.												
-15	97					96									
	98														
	99														
	100														
	101		Poorly Graded SAND (SP); dark gray; moist; 95% fine to medium sand; 5% no plasticity fines; micaceous.												At 100' set casing to 95'. Run 18
-20	102														
	103		Poorly Graded GRAVEL with Sand (GP); dark gray; moist; 60% fine to coarse, subrounded to rounded gravel, max. 1.5 in.; 35% fine to coarse sand; 5% no plasticity fines.			100									
	104														
	105		SILTY SAND (SM); dark gray; moist; 80% fine sand; 20% no plasticity fines; micaceous; poorly indurated; friable. At 105 feet 85% fine to medium sand; 15% no plasticity fines; non-indurated.										6		Run 19 Upper 3' disturbed.
	106		Poorly Graded SAND with Silt (SP-SM); dark gray; moist; 93% fine sand; 6% no plasticity fines; 1% fine, rounded, hard gravel.												
-25	107		Poorly Graded GRAVEL with Sand (GP); dark gray; wet; 60% fine to coarse, subrounded to rounded, hard gravel, max. 1.25 in.; 35% fine to coarse sand; 5% no plasticity fines.			100									
	108														
	109		SILTY SAND (SM); dark gray; wet; 85% fine to medium sand; 15% no plasticity fines. At 108.9 feet lens of fine to coarse gravel, max. 1.25 in.												
	110		CLAYEY SAND (SC); very dark greenish gray; moist; 75% fine to coarse sand; 25% low plasticity, no dilatancy fines; micaceous; over consolidated texture.												At 110' set casing to 100'. Run 20
	111		SILTY SAND (SM); dark gray; moist; 80% fine to medium sand; 20% no plasticity fines; micaceous.												
-30	112		SILTY SAND with Gravel (SM); dark gray; moist; 70% fine to coarse sand; 15% fine to coarse, rounded, hard gravel, max. 3 in.; 15% no plasticity fines.												
	113														
	114		FAT CLAY (CH); hard; dark greenish gray; 90% high plasticity, no dilatancy fines; 10% fine sand; micaceous; blocky texture.												
	115					100									
	116		SANDY SILT (ML); hard; dark greenish gray; 60% low to medium plasticity, slow dilatancy fines; 40% fine sand; micaceous.												
-35	117														
	118									29	37	7			
	119														
	120														

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Borehole Location: Levee Crest **County:** Sutter
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Levee Station or Milepost: 900+00 **Levee Mile:**
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Channel / River Name / Feature: Feather River

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, % / Liquid Limit / Plasticity Index / Fines, % < #200 / Other Lab Tests	REMARKS
	120		Borehole terminated at 120 feet. Backfilled boring with 230 gallons of neat grout consisting of 170 gallons water, 0 pounds of bentonite powder, 28-47 lb sacks of portland cement.								
	121										
-40	122										
	123										
	124										
	125										
	126										
-45	127										
	128										
	129										
	130										
	131										
-50	132										
	133										
	134										
	135										
	136										
-55	137										
	138										
	139										
	140										
	141										
-60	142										
	143										
	144										
	145										

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Borehole Location: Levee Crest **County:** Sutter
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SL0001_007S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

DATE STARTED	DATE COMPLETED	GROUND ELEVATION	ELEVATION DATUM	TOTAL DEPTH OF BORING
10/5/12	10/9/12	81.06 ft	NAVD 88	120.0 ft
DRILLING CONTRACTOR		**DRILLER'S NAME**	**HELPER'S NAME**	**TOTAL DEPTH OF FILL**
National		J. Marok	R. Estrado/E. Jasso	
DRILLING METHOD		**DRILL RIG MAKE AND MODEL**		**CONSULTANT COMPANY**
Sonic		Geoprobe 8140 LC #34		URS Corporation
DRILL BIT SIZE AND TYPE (HOLE DIAMETER)		**DRILLING ROD TYPE AND DIAMETER**		**FIELD LOGGER**
4-1/2" Sonic Corebarrel/6-1/4 csg bit		3-1/2" Sonic		M. Weil/G. Hong
☒ VERTICAL ☐ INCLINED		**CASING TYPE, DIAMETER, INSTALLATION DEPTH**		**FIELD LOG REVIEWER**
		5-7/8 x 5-1/8 Steel		M. PALMER
SAMPLER TYPE(S)		**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP**		**HAMMER EFFICIENCY**
4-1/2 x 3-1/2 Core Barrel		NA		
BOREHOLE BACKFILL OR COMPLETION		**GROUNDWATER READING:**	**DURING DRILLING**	**AFTER DRILLING (DATE-TIME)**
Cement with Bentonite			NA	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
80	0		Asphalt pavement.												Run 1
	1		Gravel road base.												
	2		SILTY SAND (SM); dense; brown; moist; 70% fine to medium sand; 30% no plasticity fines.			100									
	3														
	4														
	5														Run 2 Difficult drilling, very stiff soil, low recovery, 2nd attempt additional 20" recovered.
75	6														
	7					67									
	8														
	9														
	10														Run 3
70	11														
	12		At 12 feet 78% sand; 22% fines.			100							22		
	13														
	14														
	15														Run 4
65	16		SANDY SILT (ML); very dark gray; moist; 55% low plasticity, slow dilatancy fines; 45% fine sand.												
	17					100									
	18														
	19														
	20														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
Coordinates: Northing: 2,168,172.15 **Easting:** 6,673,571.75
Latitude: 39.11512 **Longitude:** -121.60558
Levee Station or Milepost: 914+40 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SL0001_008S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20														Run 5
60	21														
	22														
	23		SILTY SAND (SM); olive brown; wet; 70% medium sand; 30% low plasticity fines.			60									
	24														
	25														Run 6
55	26		At 26 feet moist; very dark gray; 80% medium sand; 20% low plasticity fines.												
	27					100									
	28		At 28 feet 62% sand; 37% fines; 1% fine gravel.										37		
	29														
	30														No Recovery
50	31														
	32														
	33														
	34														
	35		SANDY SILT (ML); very dark gray; wet; 68% low plasticity, slow dilatancy fines; 32% fine sand.												Run 7
45	36														
	37					40				30	25	3	68		
	38														
	39														
	40														No Recovery
40	41														
	42														
	43														
	44														
	45														

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45		SILTY SAND (SM); brown; wet; 70% medium sand; 30% low plasticity fines.												Run 8
35	46														
	47														
	48					100									
	49														
	50		SANDY SILT (ML); brown; wet; 56% low plasticity fines; 44% fine to medium sand.												Run 9
30	51														
	52										20	2	56		
	53					60									
	54														
	55														Run 10
25	56														
	57														
	58		SILTY SAND (SM); very dark greenish gray; wet; 85% medium sand; 15% low plasticity fines.			40									
	59		Well-Graded GRAVEL with Sand (GW); very dark greenish gray; wet; 80% gravel; 17% coarse sand; 3% no plasticity fines.												
	60		Poorly Graded SAND with Silt and Gravel (SP-SM); very dark greenish gray; wet; 53% medium to coarse sand; 37% gravel; 10% no plasticity fines.												Run 11
20	61														
	62														
	63					50							10		
	64														
	65														
	66		Well-Graded GRAVEL with Sand (GW); very dark gray; wet; 70% gravel; 25% coarse sand; 5% no plasticity fines.												Run 12 Low recovery due to large cobble at tip (not good for sieve analysis).
15	67														
	68					30									
	69														
	70														

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
	70		Poorly Graded SAND (SP); very dark greenish gray; wet; 90% medium to coarse sand; 5% gravel; 5% no plasticity fines.												Run 13
10	71														
	72					100									
	73		Poorly Graded GRAVEL with Silt and Sand (GP-GM); dark gray; wet; 65% gravel; 25% coarse sand; 10% low plasticity fines.												
	74														
	75														Run 14
5	76														
	77														
	78														
	79														
	80		Poorly Graded GRAVEL with Sand (GP); dark greenish gray; wet; 65% gravel; 31% coarse sand; 4% no plasticity fines.												Run 15
0	81														
	82												4		
	83		SILT (ML); dark greenish gray; moist; 95% no dilatancy fines; 5% fine sand.			100									
	84														
	85														Run 16
-5	86														
	87									32	43	12			
	88					42									
	89														
	90														Run 17 At 90' add casing from 75' to 90'.
-10	91														
	92		SILTY SAND (SM); very dark gray; moist; 80% fine to medium sand; 20% no plasticity fines; micaceous; with a few 1" thick interbeds of Sandy Silt (ML); 60% no plasticity fines; 40% sand.			80									
	93														
	94		At 93.5 feet a 2" lens of fine to coarse, round, hard gravel, max. 1.5 in.												
	95														

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	95														
-15	96														
	97														
	98					80									
	99														
	100														Run 18
-20	101		At 101 feet 75% fine to medium sand; 15% no plasticity fines 10% fine, round, hard gravel.												
	102														
	103														
	104		Poorly Graded GRAVEL with Silt and Sand (GP-GM); very dark gray; moist; 50% fine to coarse, rounded, hard gravel; 40% fine to coarse sand; 10% no plasticity fines.												
	105		FAT CLAY (CH); stiff; grayish green; moist; 90% slow dilatancy fines; 10% fine sand.			58				33	59	31			
-25	106														105.75' bit block off, no recovery to 110'.
	107														
	108														
	109		SANDY SILTY CLAY (CL/ML); stiff; grayish green; moist; 70% low plasticity, medium to high dry strength, slow dilatancy fines; 30% fine sand.												
	110														Run 19 Upper 18" (110-111.5') lost due to mixing with slough.
-30	111														
	112														
	113														
	114														
	115					85									
-35	116		SILTY SAND (SM); grayish green; moist; 65% fine sand; 35% no to low plasticity, medium dry strength, slow to rapid dilatancy fines.												
	117														
	118		At 118 feet a 6" lens of (SM) 75% fine to coarse sand; 25% no plasticity fines; SM as in 115.5 with 1-3" interbeds of SM as in 118 to 118.5.												
	119														
	120		At 119.5 feet Sand Lean Clay (CL); very stiff; 78% low												

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, % / Liquid Limit / Plasticity Index / Fines, % < #200 / Other Lab Tests	REMARKS
	120		to medium plasticity, no to slow dilatancy fines; 30% fine sand.								
-40	121										
	122		Borehole terminated at 120 feet. Backfilled boring with 250 gallons of neat grout consisting of 200 gallons water, 45 pounds of bentonite powder, 40-47 lb sacks of portland cement..								
	123										
	124										
	125										
-45	126										
	127										
	128										
	129										
	130										
-50	131										
	132										
	133										
	134										
	135										
-55	136										
	137										
	138										
	139										
	140										
-60	141										
	142										
	143										
	144										
	145										

Final Report Version 12/5/2012

Borehole Location: Levee Crest **County:** Sutter
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

DATE STARTED	DATE COMPLETED	GROUND ELEVATION	ELEVATION DATUM	TOTAL DEPTH OF BORING
10/9/12	10/10/12	58.52 ft	NAVD 88	97.5 ft

DRILLING CONTRACTOR	DRILLER'S NAME	HELPER'S NAME	TOTAL DEPTH OF FILL
National	J. Marok	N. Castro/G. Becker	0 ft

DRILLING METHOD	DRILL RIG MAKE AND MODEL	CONSULTANT COMPANY
Sonic	Geoprobe 8140 LC #34	URS Corporation

DRILL BIT SIZE AND TYPE (HOLE DIAMETER)	DRILLING ROD TYPE AND DIAMETER	FIELD LOGGER
4-1/2" Sonic Corebarrel/6-1/4 csg bit	3-1/2" Sonic	M. Palmer

	CASING TYPE, DIAMETER, INSTALLATION DEPTH	FIELD LOG REVIEWER
[X] VERTICAL [ ] INCLINED	5-7/8 x 5-1/8 Steel to 80'	G.T. HONG

SAMPLER TYPE(S)	HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP	HAMMER EFFICIENCY
4-1/2 x 3-1/2 Core Barrel	NA	

BOREHOLE BACKFILL OR COMPLETION	GROUNDWATER READING: DURING DRILLING	AFTER DRILLING (DATE-TIME)
Neat cement Bentonite grout	NA	

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		3: AC.												0-0.5 sonic core
	1		SILTY SAND (SM/ML); dark yellowish brown; moist; 55% fine sand; 45% no to low plasticity, rapid dilatancy fines; micaceous.												0.5-6 hand auger, bagged
	2														
	3														
55	4					100									
	5														
	6														Run 1
	7														
	8					50									
50	9														
	10														At 10' set casing to 10'.
	11														Run 2
	12					90									
	13		At 13 feet moist to wet.												
45	14		At 14.5 feet low plasticity, slow to rapid dilatancy fines.												
	15		At 15 feet wet.												Run 3
	16														
	17									31	28	3			
	18					20									
40	19		SILT (ML); dark yellowish brown; wet; 89% no plasticity fines; 11% fine to medium sand; micaceous.												
	20														

Final Report Version 12/5/2012

Borehole Location: Landside Toe **County:** Sutter
Coordinates: Northing: 2,168,876.02 **Easting:** 6,673,792.83
Latitude: 39.11705 **Longitude:** -121.60479
Levee Station or Milepost: 921+69 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20														Run 4
	21														
	22					95									
35	23														
	24												89		
	25														Run 5
	26														
	27					100									
30	28														
	29		At 28.5 feet wet; 86% no plasticity fines; 14% fine to medium sand; micaceous.							35	32	2	86		
	30														Run 6
	31														
	32					90									
25	33														
	34														
	35														Run 7
	36														
	37					100									
	38														
20	39		SILTY SAND (SM); very dark greenish gray; moist; 80% fine sand; 20% low plasticity, rapid dilatancy fines; organic odor; micaceous.												
	40		SILTY GRAVEL with Sand (GM); very dark greenish gray; wet; 65% fine to coarse, rounded, hard gravel, max. 1.5 in.; 20% fine to coarse sand; 15% no plasticity fines; micaceous.												At 40' set casing to 35'. Run 8
	41														
	42		Poorly Graded GRAVEL with Sand (GP); wet; 75% fine to coarse gravel; 20% fine to coarse sand; 5% no plasticity fines; micaceous; slight organic odor.			60									
15	43														
	44														
	45														

Final Report Version 12/5/2012

Borehole Location: Landside Toe **County:** Sutter
Coordinates: Northing: 2,168,876.02 **Easting:** 6,673,792.83
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Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45														At 45' set casing to 45'. Run 9 Upper 18-24" disturbed and contaminated with slough from casing advancement.
	46														
	47		Poorly Graded SAND with Silt (SP-SM); olive brown; moist; 90% fine to medium sand; 10% no plasticity fines; few thin (1") interbeds of Sandy Silt (ML); presence of mica.			100									
10	48														
	49														
	50														Run 10
	51		Poorly Graded SAND with Gravel (SP); greenish gray; wet; 60% fine to coarse, rounded to subangular, hard sand; 35% fine to coarse, rounded to subangular gravel, max. 1 in.; 5% no plasticity fines.												
	52					84									
	53		SILTY SAND (SM); greenish gray; wet; 70% fine to medium sand; 30% no plasticity fines; micaceous; several 0.1' lenses of coarse sand with gravels, max. 3/4 in.												
5	54														
	55		ELASTIC SILT (MH); gray; wet; 95% low to medium plasticity, medium dry strength, slow dilatancy fines; 5% fine sand; slight organic odor.												At 55' set casing to 50'. Run 11
	56		Poorly Graded SAND with Silt (SP-SM); very dark greenish gray; wet; 90% fine to medium sand; 10% no plasticity fines; micaceous; scattered thin (0.1-0.2') lenses of Silty Sand (SM); 85% fine to medium sand; 15% no plasticity fines; and Sandy Silt (ML); 60% no to low plasticity fines; 40% sand.			100									
	57														
	58														
0	59														
	60														At 60' set casing to 55'. Run 11
	61														
	62		At 61.99 feet one hard, subangular 3" cobble. SILTY SAND (SM); very dark greenish gray; wet; 83% fine to medium sand; 17% no plasticity fines; micaceous; slight organic odor.			92							17		
-5	63														
	64														
	65		At 64.8 feet one hard, rounded 2 in. gravel. LEAN CLAY with Sand (CL); soft; dark greenish gray; wet; 85% low to medium plasticity, no to slow dilatancy fines; 15% fine sand; slight organic odor.												At 65' set casing to 60'. Run 12
	66														
	67		SILTY SAND (SM); very dark greenish gray; wet; 60% fine sand; 40% no plasticity fines; micaceous.												
	68		Interbedded (SM) and (SP); 6"-12" beds; very dark greenish gray; wet; micaceous; Silty Sand (SM); 80% fine to medium sand; 20% no plasticity fines and Poorly Graded Sand with Silt (SP-SM); 90% fine to medium sand; 10% no plasticity fines.			100								
-10	69														
	70														

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Latitude: 39.11705 **Longitude:** -121.60479
Levee Station or Milepost: 921+69 **Levee Mile:**
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Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

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SL0001_009S
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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	70														At 70' set casing to 65'. Run 13
	71		Poorly Graded SAND with Silt (SP-SM); very dark greenish gray; wet; 90% fine to medium sand; 10% no plasticity fines; micaceous.												
	72					100									
	73														
-15	74		Poorly Graded GRAVEL with Silt and Sand (GP-GM); very dark greenish gray; 70% fine to coarse, subangular to subrounded gravel, max. 1.25 in.; 20% fine to coarse sand; 10% no to low plasticity fines; presence of mica.												
	75														At 75' set casing to 70'. Run 14
	76														
	77					94									
	78														
-20	79		SILTY SAND with Gravel (SM); very dark greenish gray; moist; 50% fine to coarse sand; 30% no to low plasticity fines; 20% fine to coarse, subangular to subrounded gravel; micaceous.												
	80		Poorly Graded SAND with Gravel (SP); very dark greenish gray; moist; 80% fine to medium sand; 15% fine to coarse gravel, max. 1.25 in.; 5% no plasticity fines; presence of mica.												Run 15
	81														
	82		SILTY SAND with Gravel (SM/SC); very dark greenish gray; 58% fine to medium sand; 22% gravel; 20% low plasticity, slow dilatancy fines; micaceous; friable.										20		
	83		0.1-0.2' interbeds grayish green; moist; micaceous; Silty Sand (SM/SC); friable; 60% fine to medium sand; 40% low plasticity, slow dilatancy fines and Sandy Lean Clay (CL); hard 65% low plasticity fines; 35% fine sand.			90									
-25	84														
	85														At 85' set casing to 80'. Run 16
	86					100									
	87														Stopped coring, driller thought core barrel was full, just hard ground. Run 17
	88		SILT with Sand (ML); very stiff to hard; grayish green; moist; 75% low to medium plasticity, no to slow dilatancy fines; 25% fine sand; over consolidated; blocky texture.												
-30	89														
	90									27	39	9			
	91					85									
	92														
	93														
-35	94		CLAYEY SAND (SC/CL); very stiff to hard; grayish green; moist; 55% fine to coarse sand; 45% low to												
	95														

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SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60} (ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	LABORATORY DATA: Liquid Limit	LABORATORY DATA: Plasticity Index	LABORATORY DATA: Fines, % < #200	LABORATORY DATA: Other Lab Tests	REMARKS
	95		medium plasticity, no to slow dilatancy fines; presence of mica; blocky texture; over consolidated.												
	96		LEAN CLAY with Sand (CL); very stiff to hard; grayish green; moist; 75% low to medium plasticity, no to slow dilatancy fines; 25% fine sand; over consolidated; blocky texture.			85									
	97														
	98		Borehole terminated at 97.5 feet. Backfilled boring with 185 gallons of neat grout consisting of 148 gallons water, 30 pounds of bentonite powder, 30-47 lb sacks of portland cement.												
-40	99														
	100														
	101														
	102														
	103														
-45	104														
	105														
	106														
	107														
	108														
-50	109														
	110														
	111														
	112														
	113														
-55	114														
	115														
	116														
	117														
	118														
-60	119														
	120														

Final Report Version 12/5/2012

Borehole Location: Landside Toe **County:** Sutter
Coordinates: **Northing:** 2,168,876.02 **Easting:** 6,673,792.83
Latitude: 39.11705 **Longitude:** -121.60479
Levee Station or Milepost: 921+69 **Levee Mile:**
Levee Segment Reach 13
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: Feather River

LOG OF BORING
SL0001_009S
Sheet 5 of 5

SBFCA Feather River West Levee

SUTTERBUTTETEMPORARYBORINGLOG; GINTSBFCA; SUTTERBUTTELIBRARY10012012.GLB; 12/5/12

Specimen ID	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Specific Gravity	%<#200 Sieve	Water Content (%)	Dry Density (pcf)
848+00_06_25-30	26	39	27	12			29.2	
848+00_10_45-50	47	33	30	3			39.5	
848+00_13_60-65	63	27	24	3		13.8	13.7	
848+00_21_120-130	127	46	34	12			30.2	
856+00_02_05-10	8					22.5		
856+00_04_15-20	18	44	29	15			41.5	
856+00_05_20-25	23					23.0		
856+00_08_35-40	38					12.5		
856+00_15_70-75	73					20.6		
856+00_17_80-85	82	41	32	9			31.3	
856+00_18_85-90	86					36.1		
856+00_18_85-90	88					97.0		
866+00_05_25-30	27	33	22	11			22.7	
866+00_06_30-35	34					12.9		
866+00_10_50-60	57					2.1		
866+00_12_70-80	74					3.1		
866+00_15_100-110	105					14.3		
866+00_15_100-110	109					22.8		
866+00_16_110-115	112	29	26	3		45.0	24.4	
866+00_18_120-125	121					25.2		
866+00_19_125-135	126.5	71	34	37			36.6	
866+00_19_125-135	130	40	31	9			29.5	
879+00_01_00-05	2.5					8.2		
879+00_03_10-15	11.5	42	28	14			33.0	
879+00_05_20-25	22	47	33	14			48.5	
879+00_06_25-30	27	32	28	4			40.4	
879+00_09_40-45	42					9.5		
879+00_11_50-55	52					4.8		
879+00_14_65-70	68					4.5		
879+00_16_75-80	77	46	32	14			43.8	
893+00_08_30-40	32					44.9		
893+00_08_30-40	38	26	27	NP			26.8	
893+00_10_50-60	52					36.9		
893+00_10_50-60	57	27	26	1			29.9	
893+00_10_50-60	59.5					40.3		
893+00_12_70-75	73					3.2		
893+00_15_95-105	104					19.5		
893+00_18_116-120	117.5	30	24	6			11.7	
893+00_19_120-125	122					98.8		
900+00_01_05-10	8					13.5		
900+00_07_30-40	32					20.2		
900+00_08_40-50	44	35	28	7		78.7	37.0	

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Summary of Laboratory Results

Project: Feather River West Levee Reach 13
Location:
Project Number: Project No. S9197-06-26
URS Project No. 17326868

Specimen ID	Depth (ft)	Liquid Limit	Plastic Limit	Plasticity Index	Specific Gravity	%<#200 Sieve	Water Content (%)	Dry Density (pcf)
900+00_09_50-60	54					13.9		
900+00_13_75-80	79					13.9		
900+00_15_85-90	89					9.3		
900+00_19_105-110	106					6.2		
900+00_20_110-120	118	37	30	7			29.4	
914+50_03_10-15	12					22.2		
914+50_06_25-30	28					36.8		
914+50_07_35-40	37	25	22	3		67.6	30.2	
914+50_09_50-55	52	20	18	2		55.8		
914+50_11_60-65	63					9.6		
914+50_15_80-85	82					4.0		
914+50_16_85-90	87	43	31	12			31.6	
914+50_17_90-100	97					18.7		
914+50_18_100-110	105	59	28	31			33.2	
922+00_03_15-20	17	28	25	3			30.5	
922+00_04_20-25	24					89.3		
922+00_05_25-30	29	32	30	2		86.4	35.4	
922+00_11_60-65	63					17.2		
922+00_15_80-85	82					20.2		
922+00_17_87.5-97.5	90	39	30	9			27.0	

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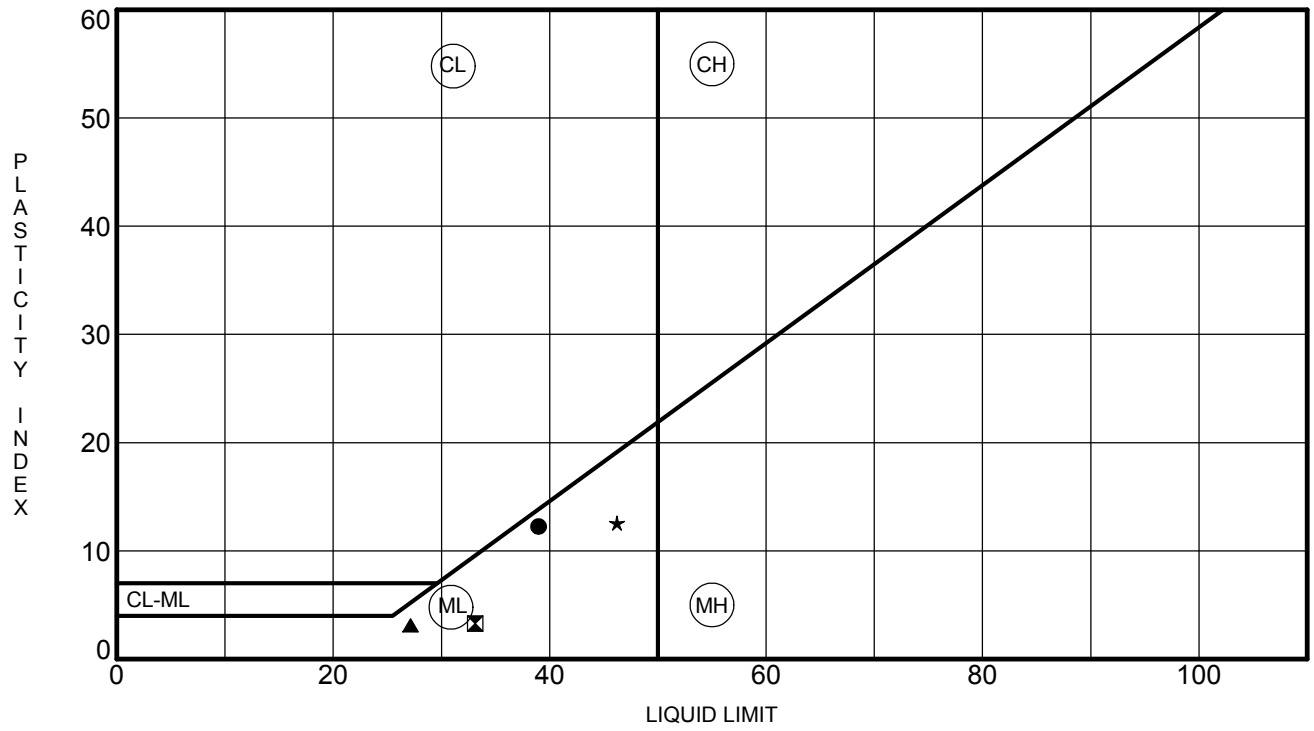

	Sample No. & Depth (ft.)	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Unified Soil Classification Description
●	848+00_06_25-30 26	39	27	12		
⊠	848+00_10_45-50 47	33	30	3		
▲	848+00_13_60-65 63	27	24	3	13.8	SILTY SAND(SM)
★	848+00_21_120-130 127	46	34	12		

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ATTERBERG LIMITS

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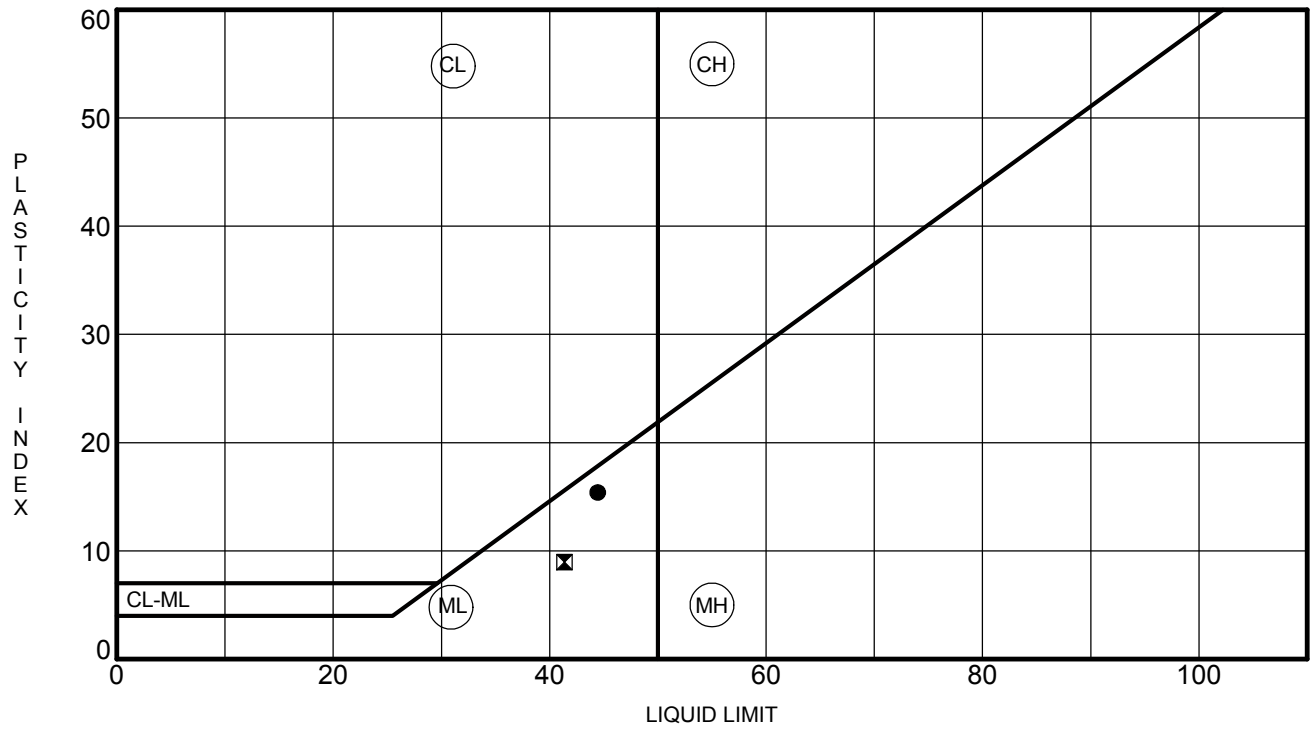

	Sample No. & Depth (ft.)	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Unified Soil Classification Description
●	856+00_04_15-20 18	44	29	15		
⊠	856+00_17_80-85 82	41	32	9		

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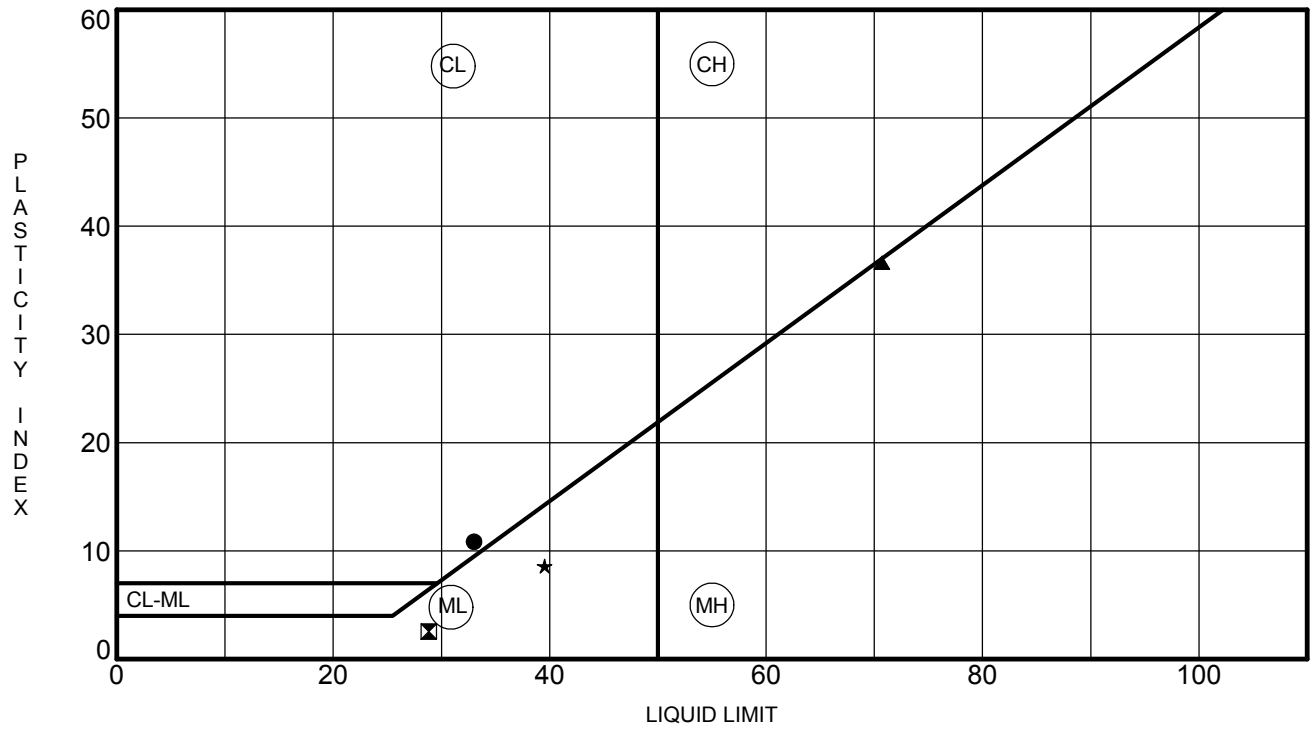

	Sample No. & Depth (ft.)	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Unified Soil Classification Description
●	866+00_05_25-30 27	33	22	11		
⊠	866+00_16_110-115 112	29	26	3	45.0	SILTY SAND(SM)
▲	866+00_19_125-135 126.5	71	34	37		
★	866+00_19_125-135 130	40	31	9		

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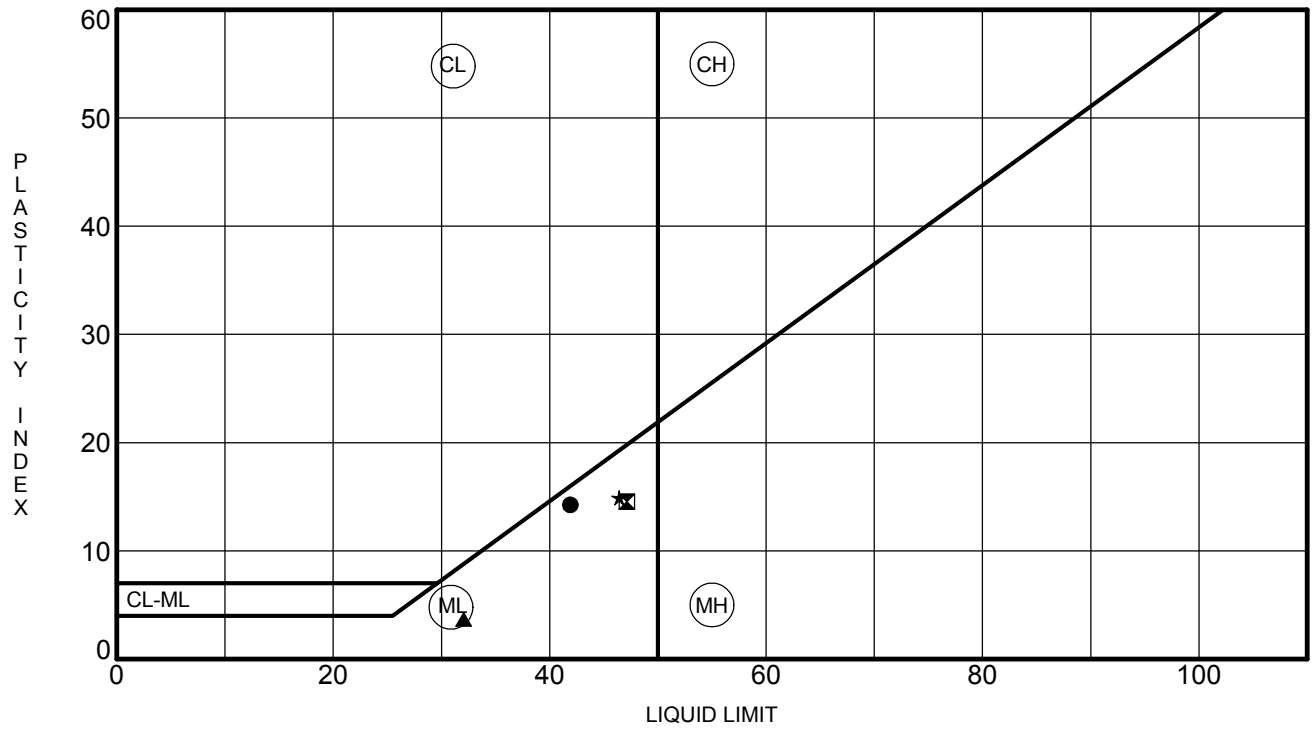

	Sample No. & Depth (ft.)	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Unified Soil Classification Description
●	879+00_03_10-15 11.5	42	28	14		
⊠	879+00_05_20-25 22	47	33	14		
▲	879+00_06_25-30 27	32	28	4		
★	879+00_16_75-80 77	46	32	14		

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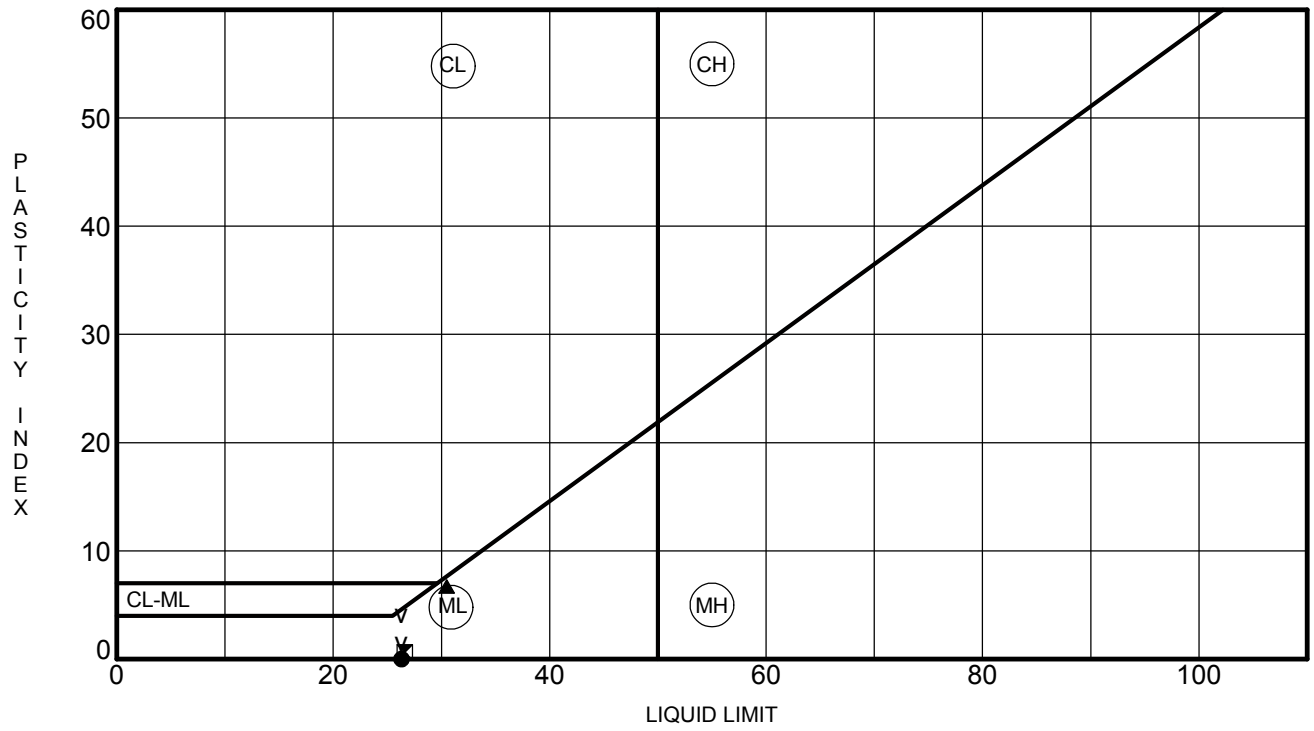

	Sample No. & Depth (ft.)	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Unified Soil Classification Description
●	893+00_08_30-40 38	26	27	NP		
⊠	893+00_10_50-60 57	27	26	1		
▲	893+00_18_116-120 117.5	30	24	6		

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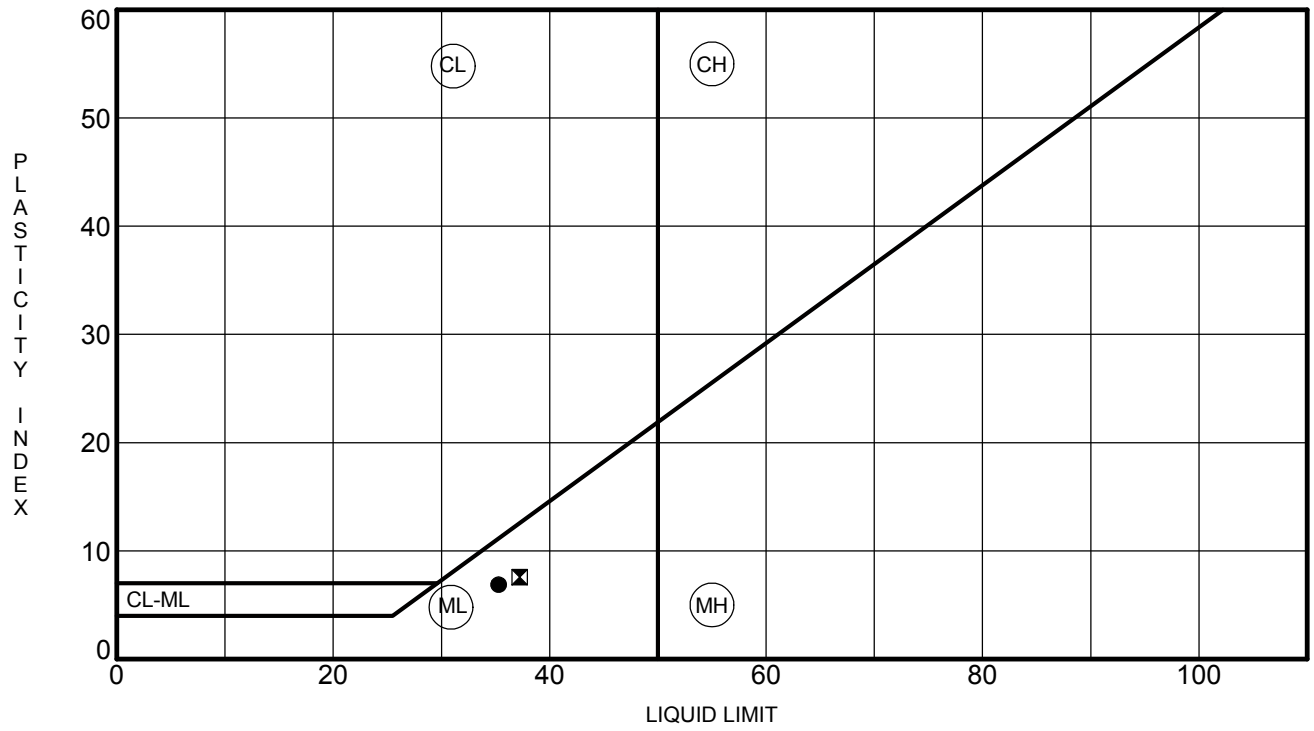

	Sample No. & Depth (ft.)	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Unified Soil Classification Description
●	900+00_08_40-50 44	35	28	7	78.7	**SILT with SAND(ML)**
⊠	900+00_20_110-120 118	37	30	7		

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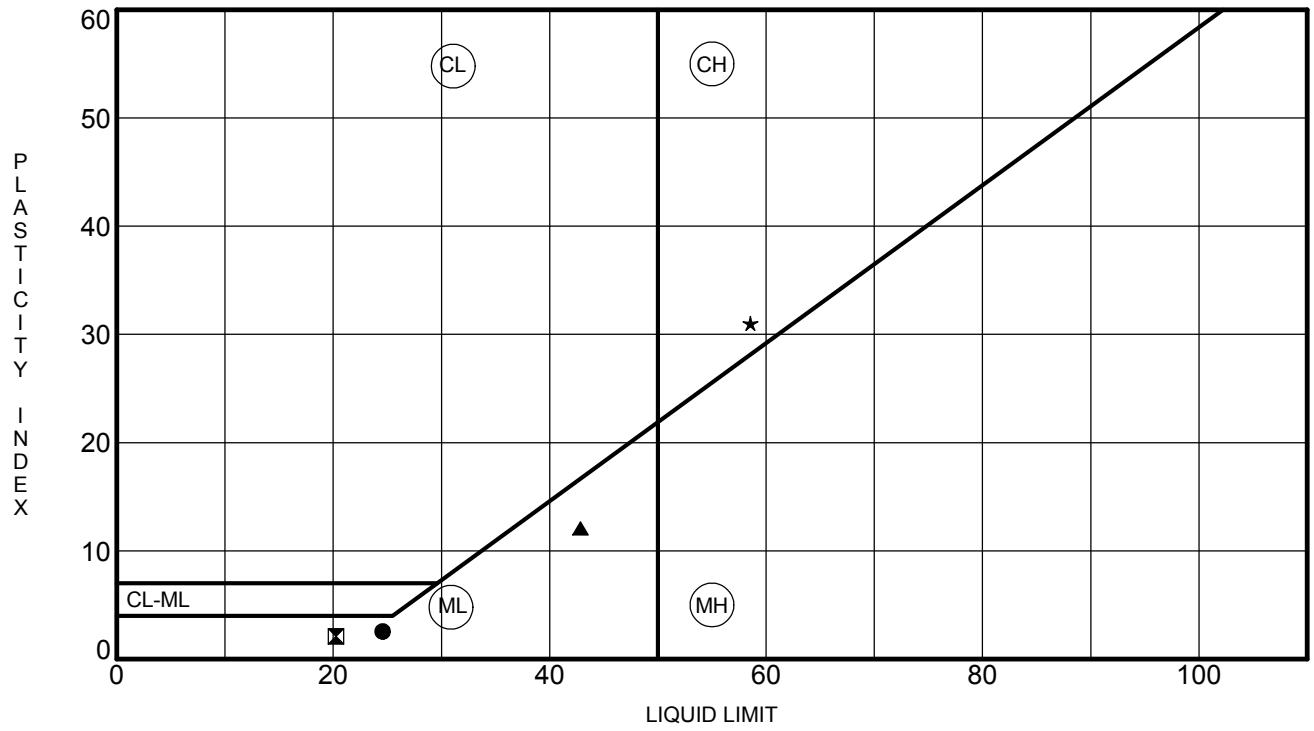

	Sample No. & Depth (ft.)	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Unified Soil Classification Description
●	914+50_07_35-40 37	25	22	3	67.6	SANDY SILT(ML)
⊠	914+50_09_50-55 52	20	18	2	55.8	SANDY SILT(ML)
▲	914+50_16_85-90 87	43	31	12		
★	914+50_18_100-110 105	59	28	31		

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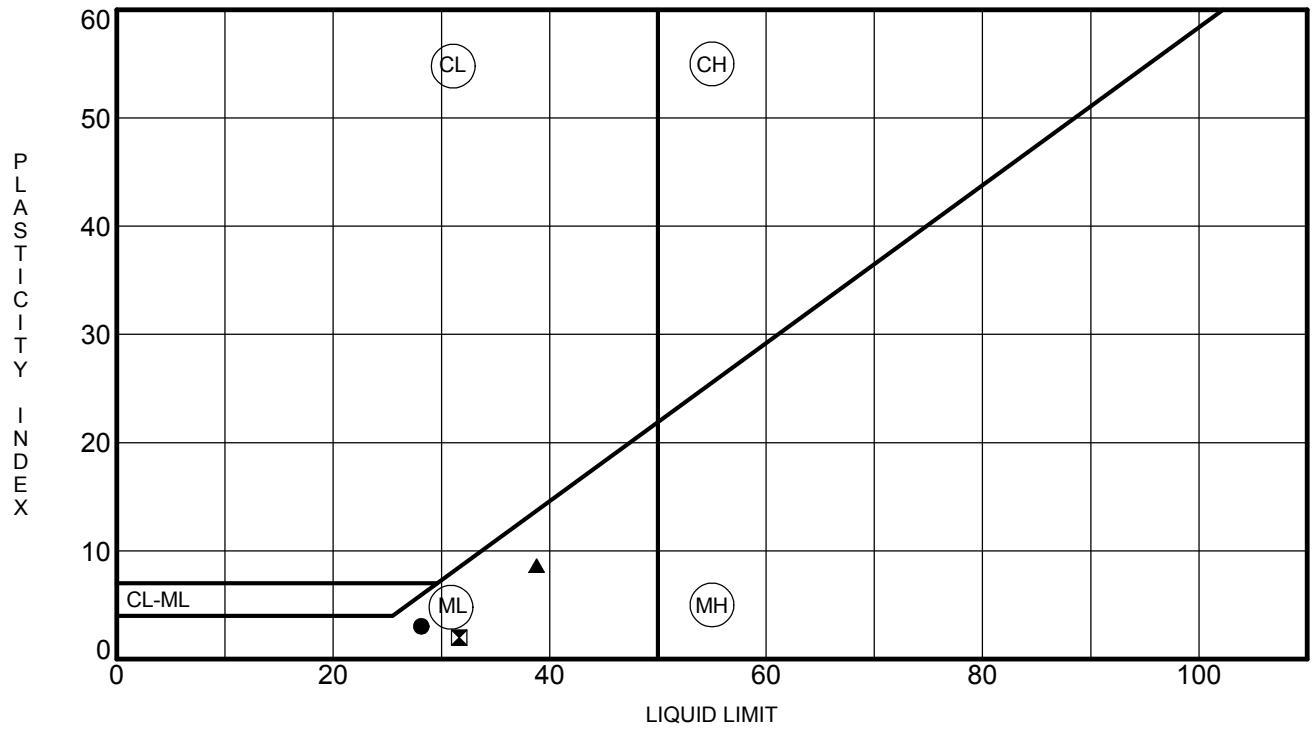

	Sample No. & Depth (ft.)	Liquid Limit	Plastic Limit	Plasticity Index	% Pass #200 Sieve	Unified Soil Classification Description
●	922+00_03_15-20 17	28	25	3		
⊠	922+00_05_25-30 29	32	30	2	86.4	SILT(ML)
▲	922+00_17_87.5-97.5 90	39	30	9		

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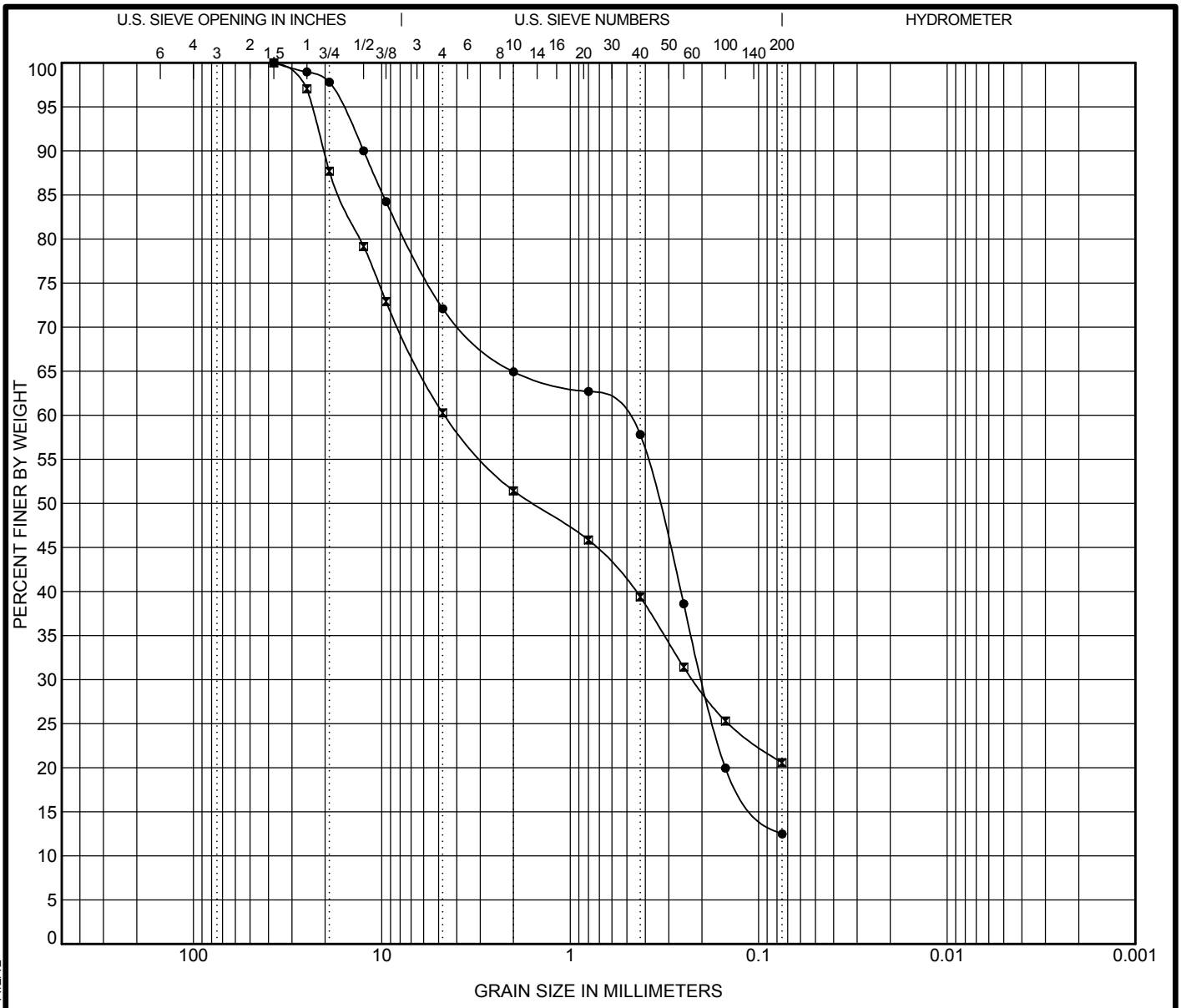

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample No. & Depth (ft.)	Classification	LL	PL	PI	Cc	Cu
● 856+00_08_35-40 38					**1.16**	**9.47**
⊠ 856+00_15_70-75 73						

Sample No. & Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● 856+00_08_35-40 38	**37.5**	**0.564**	**0.197**		**27.9**	**59.6**	**12.5**	
⊠ 856+00_15_70-75 73	**37.5**	**4.63**	**0.222**		**39.7**	**39.7**	**20.6**	

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GRAIN SIZE DISTRIBUTION

Project: Feather River West Levee Reach 13
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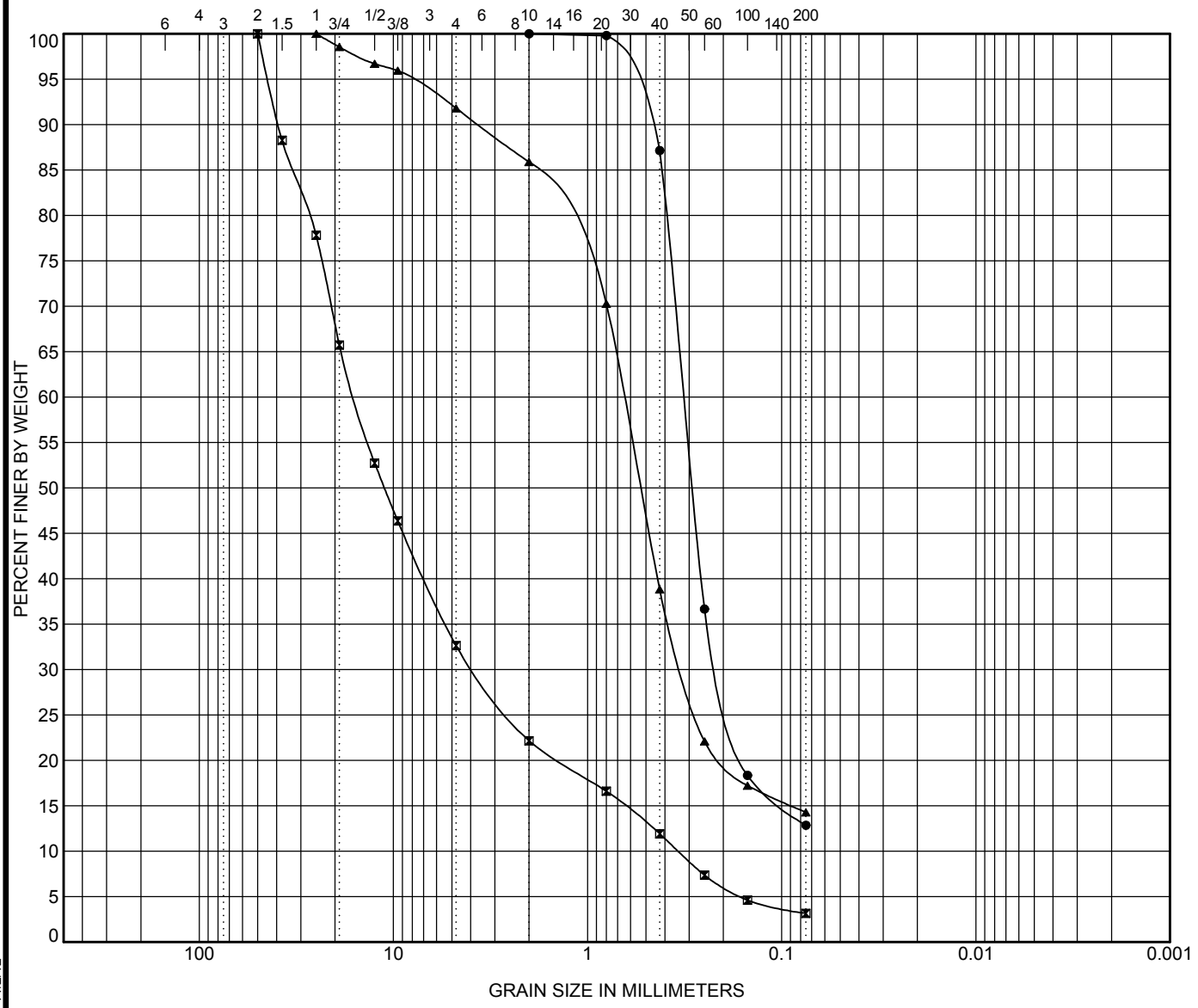

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample No. & Depth (ft.)	Classification	LL	PL	PI	Cc	Cu
● 866+00_06_30-35 34						
⊠ 866+00_12_70-80 74	**WELL-GRADED GRAVEL with SAND(GW)**				**2.72**	**46.50**
▲ 866+00_15_100-110 105						

Sample No. & Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● 866+00_06_30-35 34	**2**	**0.32**	**0.208**		**0.0**	**87.1**	**12.9**	
⊠ 866+00_12_70-80 74	**50**	**15.797**	**3.823**	**0.34**	**67.4**	**29.5**	**3.1**	
▲ 866+00_15_100-110 105	**25**	**0.651**	**0.321**		**8.2**	**77.5**	**14.3**	

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GRAIN SIZE DISTRIBUTION

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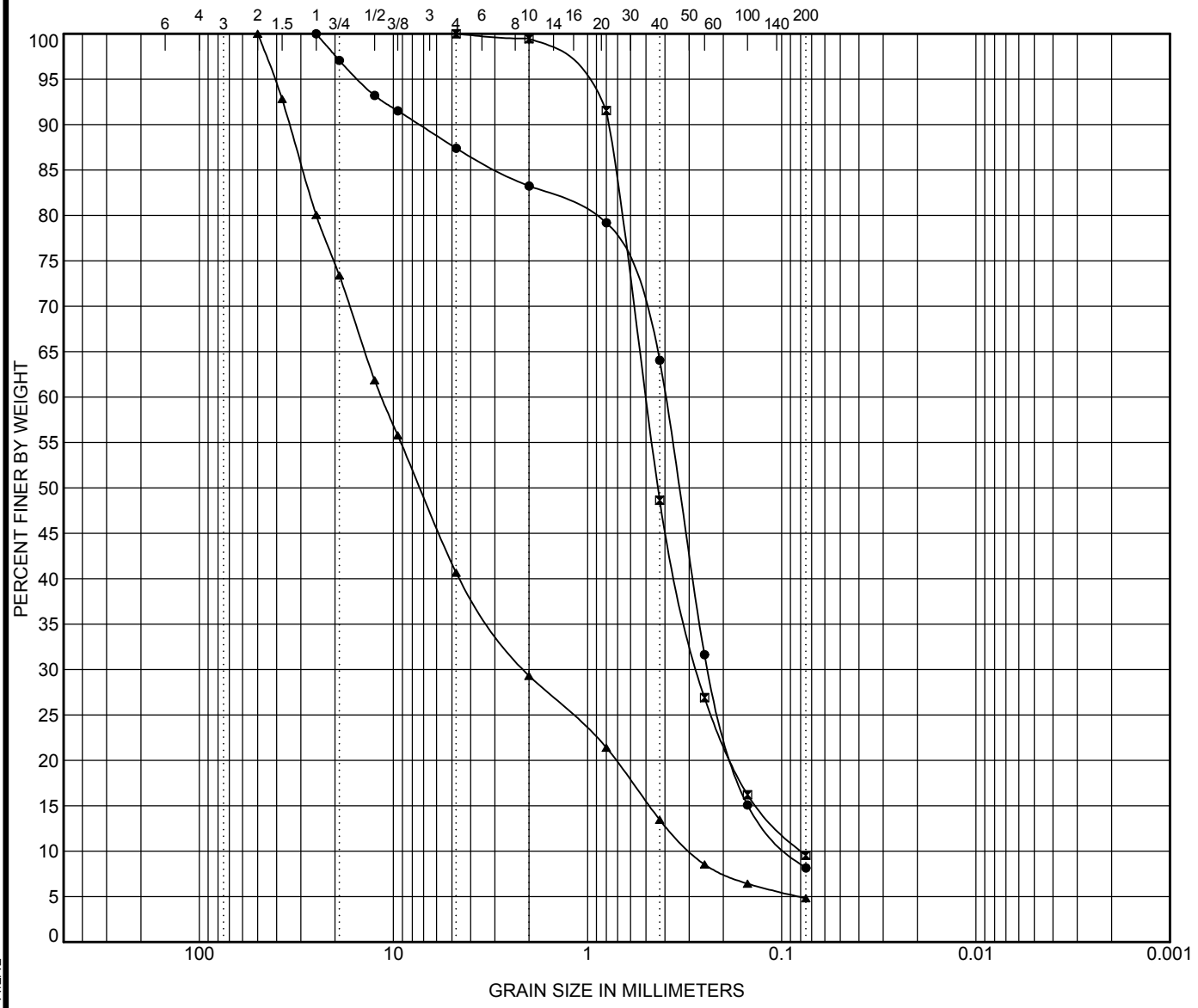
GRAIN SIZE URS-DWR S9197-06-26 FEATHER RIVER WEST LEVEE REACH 13.GPJ US LAB.GDT 11/2/12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample No. & Depth (ft.)	Classification	LL	PL	PI	Cc	Cu
●	879+00_01_00-05 2.5					**1.57**	**4.41**
⊠	879+00_09_40-45 42					**1.84**	**6.39**
▲	879+00_11_50-55 52	**WELL-GRADED GRAVEL with SAND(GW)**				**1.32**	**39.28**

	Sample No. & Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	879+00_01_00-05 2.5	**25**	**0.398**	**0.238**	**0.09**	**12.6**	**79.2**	**8.2**	
⊠	879+00_09_40-45 42	**4.75**	**0.502**	**0.27**	**0.079**	**0.0**	**90.5**	**9.5**	
▲	879+00_11_50-55 52	**50**	**11.498**	**2.108**	**0.293**	**59.3**	**35.9**	**4.8**	

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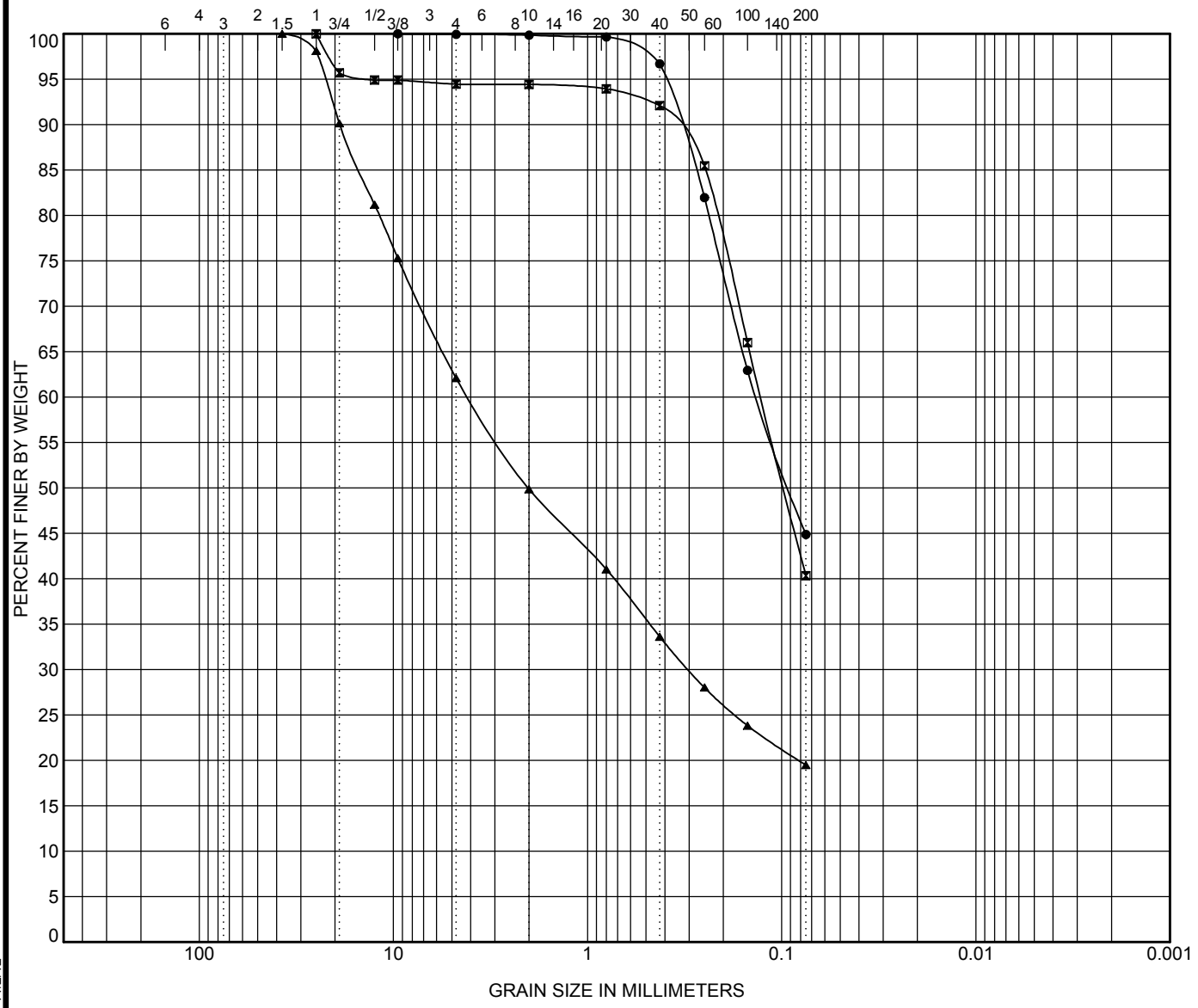

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample No. & Depth (ft.)	Classification	LL	PL	PI	Cc	Cu
● 893+00_08_30-40 32						
⊠ 893+00_10_50-60 59.5						
▲ 893+00_15_95-105 104						

Sample No. & Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● 893+00_08_30-40 32	**9.5**	**0.134**			**0.1**	**55.1**	**44.9**	
⊠ 893+00_10_50-60 59.5	**25**	**0.128**			**5.6**	**54.1**	**40.3**	
▲ 893+00_15_95-105 104	**37.5**	**4.1**	**0.302**		**37.9**	**42.6**	**19.5**	

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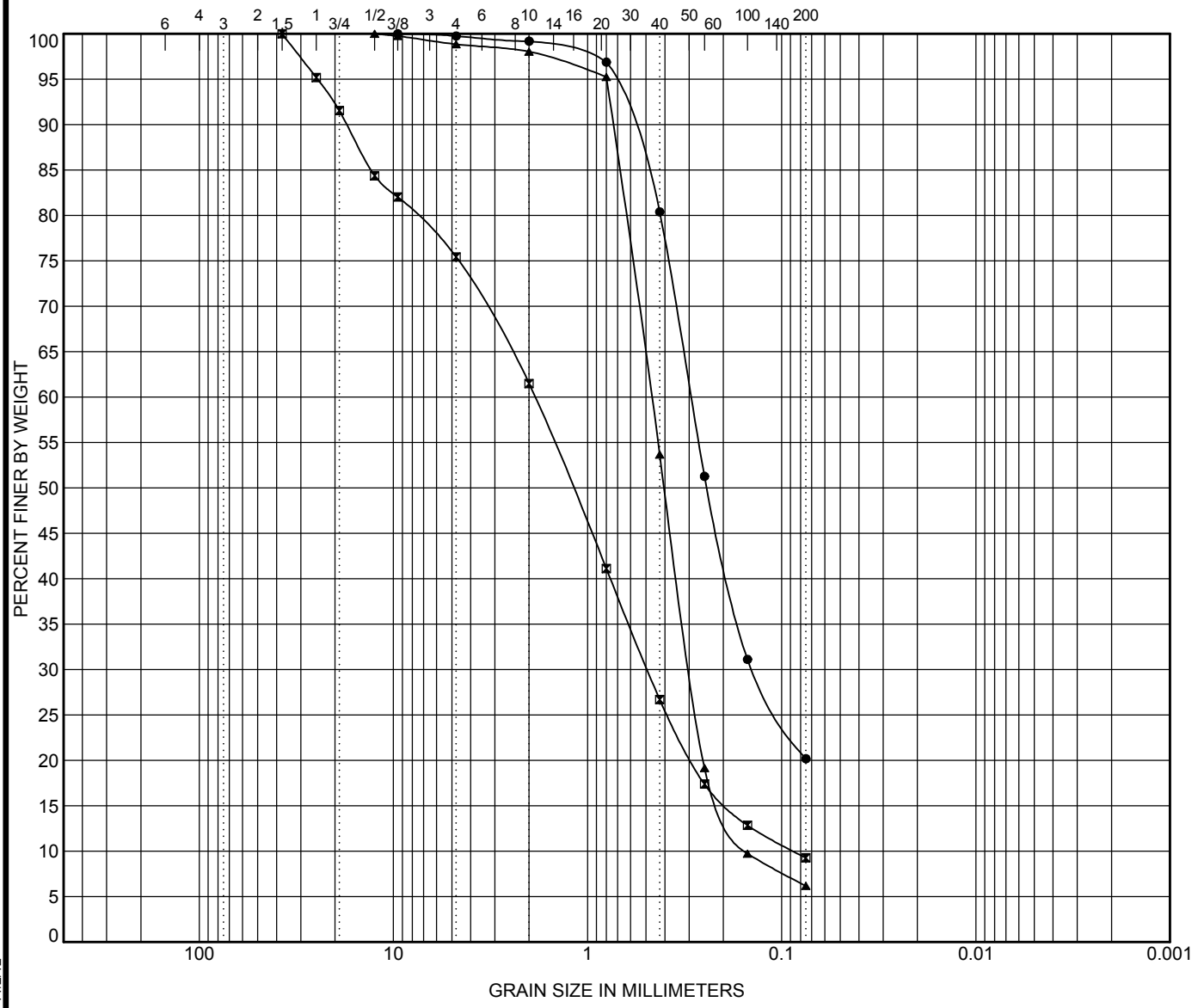
GRAIN SIZE URS-DWR S9197-06-26 FEATHER RIVER WEST LEVEE REACH 13.GPJ US LAB.GDT 11/2/12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample No. & Depth (ft.)	Classification	LL	PL	PI	Cc	Cu
●	900+00_07_30-40 32						
⊠	900+00_15_85-90 89					**1.49**	**21.63**
▲	900+00_19_105-110 106					**1.23**	**3.07**

	Sample No. & Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	900+00_07_30-40 32	**9.5**	**0.293**	**0.14**		**0.3**	**79.6**	**20.2**	
⊠	900+00_15_85-90 89	**37.5**	**1.871**	**0.491**	**0.086**	**24.6**	**66.2**	**9.3**	
▲	900+00_19_105-110 106	**12.5**	**0.468**	**0.295**	**0.152**	**1.2**	**92.7**	**6.2**	

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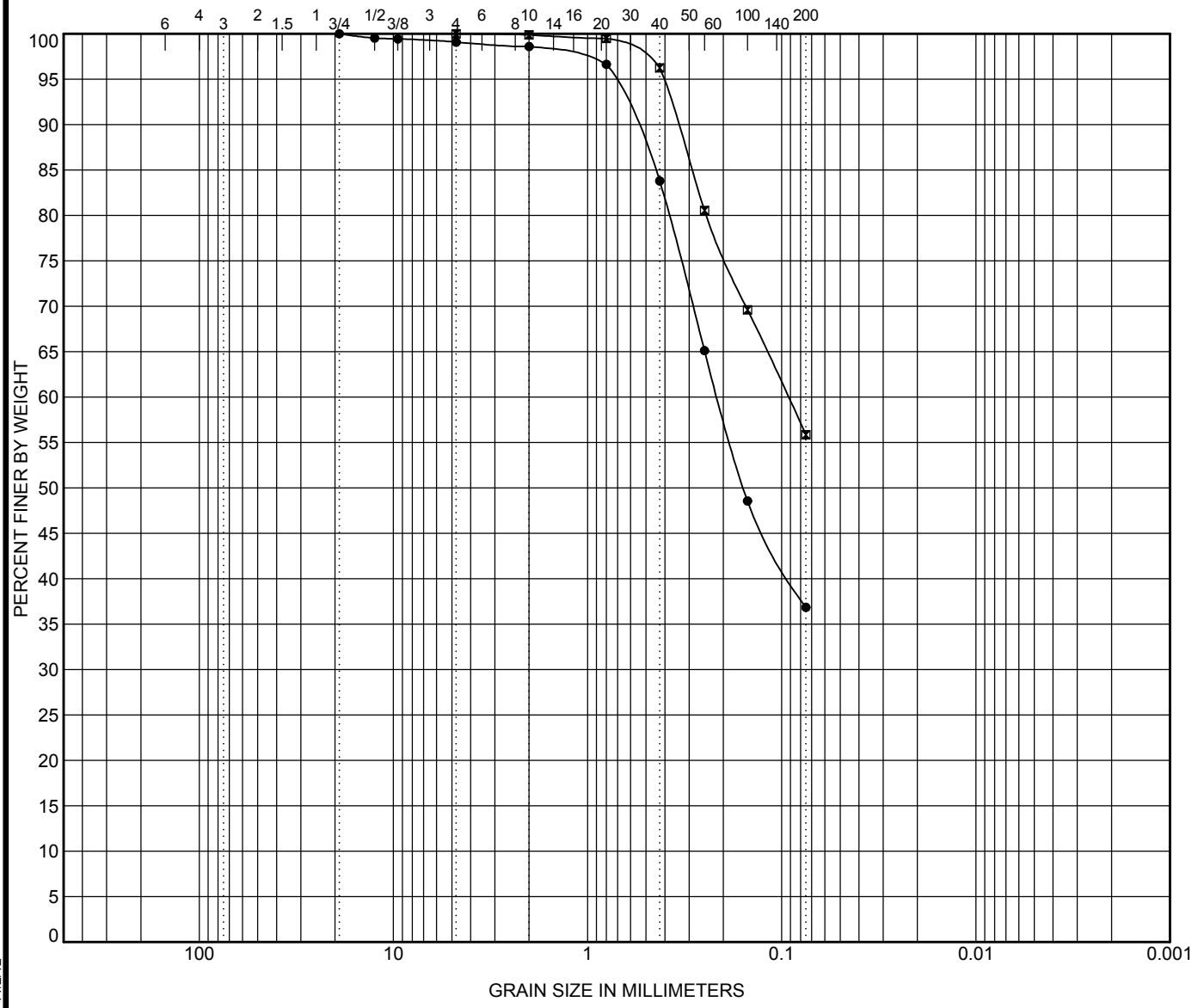

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample No. & Depth (ft.)	Classification	LL	PL	PI	Cc	Cu
●	914+50_06_25-30 28						
⊠	914+50_09_50-55 52	**SANDY SILT(ML)**	**20**	**18**	**2**		

	Sample No. & Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	914+50_06_25-30 28	**19**	**0.214**			**0.9**	**62.2**	**36.8**	
⊠	914+50_09_50-55 52	**4.75**	**0.092**			**0.0**	**44.2**	**55.8**	

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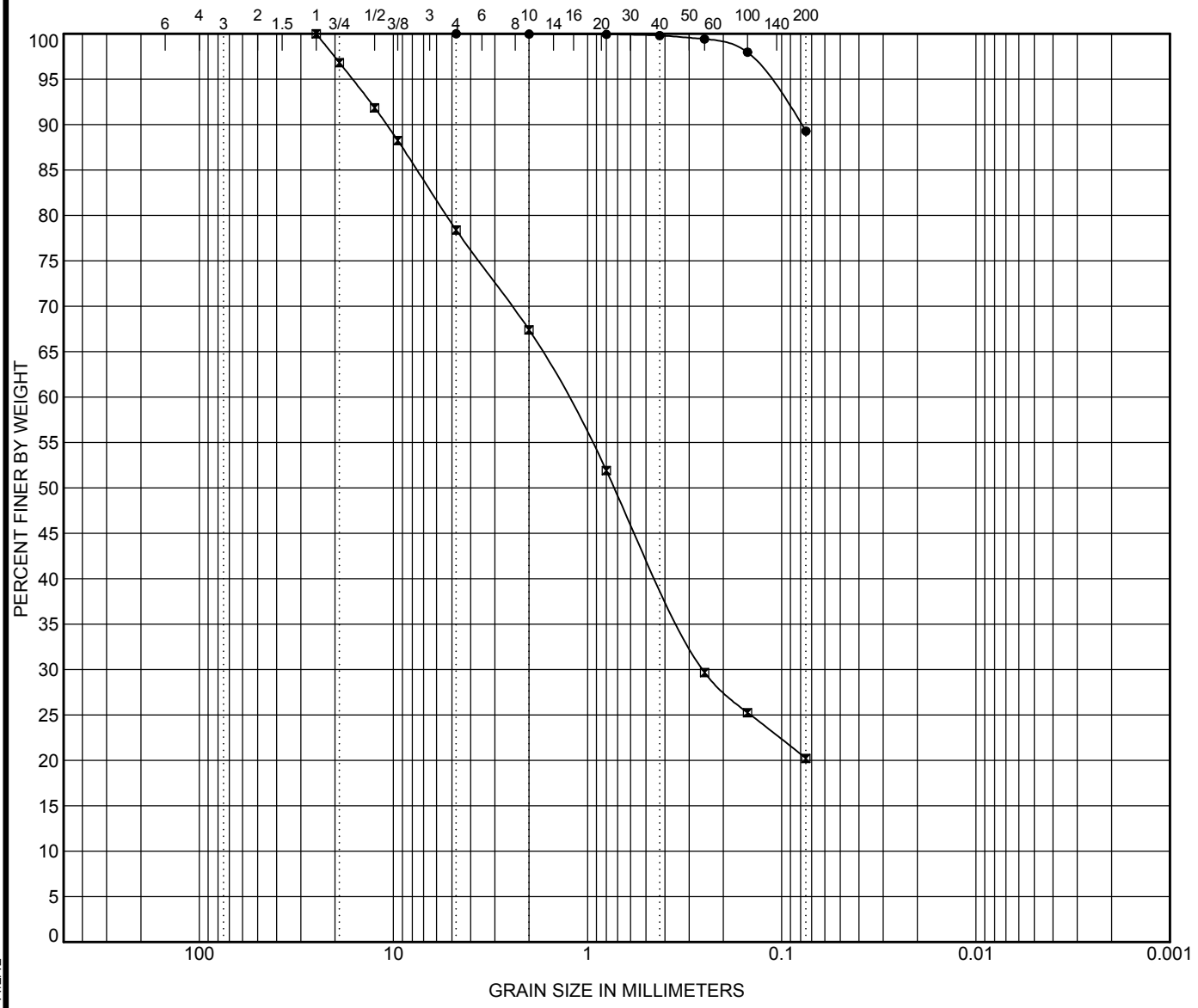
GEOCON

GRAIN SIZE DISTRIBUTION

Project: Feather River West Levee Reach 13
Location:
Project Number: Project No. S9197-06-26
URS Project No. 17326868

GRAIN SIZE URS-DWR S9197-06-26 FEATHER RIVER WEST LEVEE REACH 13.GPJ US LAB.GDT 11/2/12



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Sample No. & Depth (ft.)	Classification	LL	PL	PI	Cc	Cu
● 922+00_04_20-25 24						
⊠ 922+00_15_80-85 82						

Sample No. & Depth (ft.)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● 922+00_04_20-25 24	**4.75**				**0.0**	**10.7**	**89.3**	
⊠ 922+00_15_80-85 82	**25**	**1.291**	**0.254**		**21.6**	**58.2**	**20.2**	

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GRAIN SIZE URS-DWR S9197-06-26 FEATHER RIVER WEST LEVEE REACH 13.GPJ US LAB.GDT 11/2/12